Selected Aspects of Price Formation in Commodity Markets

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Abstract
The thesis is driven by the strategic importance of crude oil, and aims to contribute to the knowledge on crude oil pricing and markets by conducting three investigative undertakings. The first examines the ability of crude petroleum to act as a safe haven asset for investors in equity markets around the start of international violent conflicts and wars. The second investigates the price differentials between US domestic benchmark crudes and the global marker Brent around the start of upstream production disruptions. The third empirical examination explores the presence of abnormal behaviour in the vicinity of the start dates of US sanctions on net exporting and importing nations, and builds on these findings to estimate gains accrued to, and losses inflicted on, the US economy. The thesis reports a number of findings. First, it shows that crude oil prices register a significant abnormal rise around the start of violent conflicts and wars. The significant portion of this abnormal increase accumulates well before the outbreak of crises. The thesis also reports a significant abnormal decline in the valuations of US and international equities around the start of these events. Secondly, the thesis builds on these findings, and demonstrates that crude oil possesses the ability to act as a safe haven from stock markets around the start of these events. Third, the thesis reports significant tightening in the price spreads around the start of unscheduled production outages. These findings are shown to be robust even after accounting for extreme weather conditions, changes in petroleum stocks, and costs of logistics. Fourth, the thesis reports significant abnormal changes in the valuations of crude oil around the start of US sanctions. The direction and magnitude of these changes depend on whether the targeted nation is a net exporter or importer. Fifth, the thesis builds on these findings, and reports gains and losses to the US economy due to the imposition of sanctions. These findings contribute to the academic literature, and highlight a number of implications for equity investors, insurance companies, oil traders, and policy makers in the US and other net importing and exporting nations. These implications concern the energy security of the US and other nations, the use of oil in hedging and diversification, the role of benchmarks in pricing, and the economic consequences of the US foreign policy.
Acknowledgments

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Undoubtedly, my heartfelt appreciation goes to my family for their unlimited support and love. Their hard work paved the way for the materialisation of my aspirations. I am also indebted to my maternal grandmother in Jordan and paternal grandmother in Palestine for their prayers during my journey in doctoral studies.

Palestine, 1949 – A 22 year old man was approached by curious nearby villagers who noticed him standing by the road with his suitcase. He was waiting for a taxi that would take him to the coach station. “Where to?” they asked. “To Kuwait” he replied. “Where is that” they asked in wonder. “I do not know, but they say it is somewhere near Iraq”. This was my late grandfather, who, for the next 41 years, would be working for the Kuwait Oil Company (KOC). This thesis is dedicated to my late grandfather, for whom the KOC was his fifth daughter. It is also dedicated to my late aunt who sadly passed away four days following my defence of this thesis, to my father, Amin, my mother, Hanan, my sisters, Suha and Hala, my brother, Tarik, his wife, Noor, and my lovely niece, Zain.
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<td>American Petroleum Institute</td>
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<td>ASCI</td>
<td>Argus Sour Crude Index</td>
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<tr>
<td>Bbl/d</td>
<td>Barrel per day</td>
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<td>BP</td>
<td>British Petroleum</td>
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<td>CME</td>
<td>Chicago Merchantile Exchange</td>
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<td>EIA</td>
<td>Energy Information Administration</td>
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<td>ETF</td>
<td>Exchange Traded Fund</td>
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<td>ETN</td>
<td>Exchange Traded Note</td>
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<td>EU</td>
<td>European Union</td>
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<td>FOB</td>
<td>Free On Board</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>ICB</td>
<td>International Crisis Behaviour</td>
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<td>ICE</td>
<td>IntercontinentalExchange</td>
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<td>IEA</td>
<td>International Energy Agency</td>
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<td>LLS</td>
<td>Light Louisiana Sweet</td>
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<td>Mb/d</td>
<td>Million barrel per day</td>
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<td>MSCI</td>
<td>Morgan Stanley Capital International</td>
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<td>NDAA</td>
<td>National Defence Authorization Act</td>
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<td>NYMEX</td>
<td>New York Merchantile Exchange</td>
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<td>OFAC</td>
<td>Office of Foreign Assets Control</td>
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<td>OPEC</td>
<td>Organisation of Petroleum Exporting Countries</td>
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<td>OPIC</td>
<td>Overseas Private Investment Corporation</td>
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<td>PADD</td>
<td>Petroleum Administration for Defence District</td>
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<td>SPRs</td>
<td>Strategic Petroleum Reserves</td>
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<td>UK</td>
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<td>UN</td>
<td>United Nations</td>
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<td>US</td>
<td>United States</td>
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<td>TIES</td>
<td>Threat and Imposition of Sanctions</td>
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<tr>
<td>WTI</td>
<td>West Texas Intermediate</td>
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‘Those that have not seen [oil] burn, may rest assured its light is no moon-shine; but something nearer the clear, strong, brilliant light of day, to which darkness is no party… a light fit for kings and royalists and not unsuitable for Republicans and Democrats.’


I. Introduction

In a remote corner of Pennsylvania in the second half of the 19th century lay Titusville, an improvised village at the time, which was destined to be associated with the start of a new chapter in the history of mankind. The year 1859 marked not only the drilling of the first oil well there, but also the start of an epoch in which crude oil would become interwoven into the fabric of human life. Since then, crude petroleum has been fuelling visions and hubris on a grandiose scale, and propelling marches of folly. Underlying all of these ventures has been the quest for the ultimate prize of mastery in the fields of economics, politics, and battlefields (Yergin, 2012).

Ever since the drilling of Titusville’s well, humanity has become more addicted to what the fossil fuel has to offer, and has taken what appear to be quantum leaps forward towards the ‘petro-civilisation’ (Klare, 2008:36). While the United States (US) has been at the centre of these transformations, the past 20 years have witnessed significant increases in the demand for oil from India and China (Klare, 2008; Energy Intelligence, 2011; Yergin, 2012). These two nations have been emulating and imitating the civilian and military oil consumption habits of the US (Klare, 2008). It is a development that may add more complexity to the global geopolitical landscape (Klare, 2008; United States Joint Forces Command, 2010).

Perhaps unsurprisingly, the global oil market has been shaped by an entangled web of relationships among national and international political processes, events, and vested economic and political interests (Klare, 2008; Yergin, 2012). Both theoretical and empirical evidence suggest that the forces of supply and demand could be anchored in these convoluted relationships (Alquist and Kilian, 2010; Baumeister and Peersman, 2013b). Consequently, the prices of crude petroleum not only reflect changes in these relationships, but also exert an influence on them. To begin with, hikes in the price of oil can have detrimental economic consequences (Hamilton, 1983; Kilian, 2008c). For example, it is reported that seven out of eight recessions

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1 Throughout this thesis, the terms crude oil, fossil fuel, crude petroleum, and hydrocarbon fuel will be used interchangeably.
in the US following the Second World War were preceded by hikes in oil prices (Hamilton, 1983). Additionally, significant changes in the valuations of oil can lead to critical political ramifications on both the national and international levels (Colgan, 2011).

Put differently, underpinning the façade of the oil market is an interaction between supply and demand, which is embroiled in the quest for control of the resource; anxiety about its supplies; and concerns over the vagaries of its prices (Klare, 2008; Yergin, 2012). This complexity is the prime inspiration for the empirical undertakings of this thesis. It embarks on exploring aspects of the price formation processes of crude oil within the context of this intricate web of relationships and events. Thus, the thesis aims to investigate and answer three main research questions.

1.1 The Research Questions

The first venture is an examination of the ability of crude petroleum to act as a safe haven asset; i.e., as a financial shelter, for investors in the US and international equity markets during periods of violent international conflicts. This consists of a twofold investigation. The first aims to capture the timing and magnitude of abnormal valuations of oil and equities on and around the start dates of crises. The findings of this former examination provide impetus for conducting a formal test regarding the safe haven property of oil.

I specifically focus on international crises that were triggered by acts of violence. This choice is driven by the devastating human and physical costs brought to bear by the outbreak of such conflicts. Consequently, I source the start dates from the International Crises Behaviour project (ICB). This database provides detailed information on various aspects of international conflicts. Thus, I explore the nature of abnormal behaviour and the safe haven property of oil in the period surrounding the outbreak of 49 violent international crises, and 32 wars.

First of all, I employ a standard event study methodology that allows for capturing the magnitude and timing of abnormal returns on oil and stocks. Secondly, I specify a model to formally test the safe haven ability of oil. This model builds on that proposed by Baur and Lucy (2010). As will be discussed in due course, there is more than one definition of what constitutes a safe haven asset. However, the definition I adopt in this thesis is not only concise, but also testable. Additionally, this methodology allows for an examination of the ability of oil to act as a hedge against US and world stock markets.
The second empirical investigation aims to explore the effect of supply disruptions on the relationship between two of the most prominent crude oil benchmarks; Brent and West Texas Intermediate (WTI). The current pricing system is built on price relationships among the globally traded grades of oil. The crude oil pricing system has gone through various turbulent phases of development since the 1950s (Fattouh, 2011; Energy Intelligence, 2011; Yergin, 2012). These processes have reflected not only market needs, but also geopolitical changes and adjustments in the balance of power (Fattouh, 2011; Energy Intelligence, 2011).

The current pricing system emerged after the collapse of oil prices in the mid-1980s (Fattouh, 2011). At the centre of this system is the role of a marker crude oil. Crudes bought and sold in the global market are priced off a benchmark by adding or subtracting a differential that reflects quality differences, location, and the natural yield of petroleum products (Energy Intelligence, 2011; Fattouh, 2011). The role of these marker crudes came to exist due to their prolific physical base, relatively more transparent trading, and security of supply (Fattouh, 2011; Energy Intelligence, 2011).

Changes in the price spread between two benchmarks reflect the prevailing conditions in different markets. Thus, the spread between WTI and Brent allows one to view differences between the US and international markets. This is because WTI has been serving as a primary marker in the US, while Brent has been the prominent benchmark in the Atlantic basin (Energy Intelligence, 2011). The importance of this price relationship has been highlighted since February 2012, as the price differential has featured in the reports submitted to the US Congress under the National Defence Authorization Act (NDAA).

Consequently, I examine the price differential between WTI and Brent during periods of unplanned oil production outages in members of the Organisation of Petroleum Exporting Countries (OPEC). Unscheduled disruptions can occur due to unplanned maintenance, weather conditions, accidents, and acts of sabotage and terrorism. The choice of OPEC is determined by the sheer size of its share of global production and reserves (Klare, 2008; Fattouh, 2011; Yergin, 2012). The presence of a special function on the Bloomberg Terminal allows for collecting data on such occurrences. Thus, my investigation focuses on 50 unplanned disruptions.

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2 Viewing the spread from this angle is suggested by the Energy Information Administration (EIA) following an inquiry into the reasons underlying the featuring of the price differential in publicly available governmental reports.
3 These reports are available online at: www.eia.gov/analysis/requests/ndaa/
Moreover, I examine the price differential between Light Louisiana Sweet (LLS) and Brent around the same events. This is because the landlocked nature of WTI has been affecting the responsiveness of this crude’s prices to developments on the international markets (Fattouh, 2011; Energy Intelligence, 2011). On the other hand, LLS has the advantage of being produced and traded on the Gulf Coast, the most significant US refining centre. These attributes have turned LLS into a de facto benchmark (Energy Intelligence, 2011). Thus, an examination of LLS-Brent represents a robustness exercise. Additionally, examining LLS-Brent allows one to take a view as to whether the proximity to the Gulf Coast, and therefore more competition with international crudes, could give rise to a different reaction to disruptions from that observed for WTI-Brent.

The third empirical investigation is twofold. The first part examines the effect of economic sanctions on crude oil prices, while the second attempts to estimate the economic costs or benefits arising from that effect. The deployment of economic coercion has been a tool of influence for more than 2000 years (Eaton and Engers, 1999; Kozhanov, 2011). The imposition of such measures has been viewed as an effective substitute for the use of violence in the settlement of disputes (Mastanduno, 2007; Hufbauer et al., 2007). However, sanctions can bring to bear significant human and economic costs, which transform such measures into, metaphorically, an axe rather than a scalper (Biglaiser and Lektzian, 2011; Lektzian and Biglaiser, 2013).

Thus, I examine sanctions programmes imposed by the US on two different groups of nations. One comprises measures of economic coercion imposed on members of OPEC and other net exporters of crude petroleum. The other group consists of sanctions imposed on countries that are net importers of oil. The choice of the US as an initiator of such measures is driven by the fact that it is a major international power. Equally importantly, the frequency with which sanctions are deployed has increased since the end of the Cold War (Caruso, 2003; Hufbauer et al., 2007).

Consequently, I focus on the dates on which these programmes started. These dates are extracted from the Threat and Imposition of Sanctions (TIES) database and the Office of Foreign Assets Control (OFAC) of the US Department of the Treasury. An event study framework is employed in order to capture the magnitude and timing of abnormal returns on the fossil fuel. Moreover, the effect of sanctions on oil prices could be perceived as an externality. Therefore, I estimate a VAR model, and utilise the useful analytical technique of Impulse Re-
sponse Function. I then build on these estimates and the findings from the event study, and report the costs incurred by, or gains accrued to, the US economy due to the use of sanctions.

### 1.2 Summary of Motivations and Underpinning Rationales

This thesis is motivated by a number of specific factors. First of all, oil is at the heart of global politics and economics (Klare, 2008; Yergin, 2012). Additionally, the importance of both the fossil fuel and the events that this thesis examines are bound to increase in the light of the rise of China and India (Klare, 2008). The extent to which the two nations will cooperate in their quest for more oil may have a significant bearing on markets, pricing and international politics in the future (Klare, 2008; United States Joint Forces Command, 2010). Importantly, the willingness of both the US and China to accommodate each other’s ambitions and needs is a further critical factor in that context (United States Joint Forces Command, 2010). Consequently, historical, present, and future considerations all call for investigating and answering the three research questions.

Secondly, violent conflicts, unplanned production outages, and sanctions all have an effect on the forces of supply and demand. Unexpected cuts in supplies may arise from wars and measures of economic coercion, and this in turn can cause an appreciation in prices (Kilian, 2008c; 2009; Baumeister and Peersman, 2013a). Importantly, these events heighten uncertainty regarding the availability of future supplies, which causes a shift in expectations and a subsequent rise in precautionary demand (Kilian, 2009; Baumeister and Peersman, 2013b; Kilian and Murphy, 2013). The sensitivity of this particular component of demand to such events could increase due to the steeping of the global demand curve, and the erosion of excess production capacity (Baumeister and Peersman, 2013b).

Thirdly, the currently operating system of pricing and trading crude oil highlights the relevance of these events to prices. This is because the shift to the current market-based system has occurred at the expense of the quality and availability of information (Stevens, 1995; 2005; Mabro, 2005; Kilian, 2008b). This, in turn, has caused the trading of oil to be based on beliefs (Stevens, 1995; 2005). Moreover, the presence of active paper markets has offered access to traders who may not possess sufficient knowledge of the functioning of the industry (Stevens, 1995). These factors have, arguably, contributed to the rise in volatility and the increase in the role of precautionary demand (Stevens, 2005 Baumeister and Peersman, 2013b). These conditions could amplify the effect of unplanned disruptions and exogenous political events on prices.
Fourth, different political interests and various facets of political risk have been shaping the oil industry, markets, and pricing for decades. A critical factor that adds further political complexity is the unequal distribution of this resource among nations (Klare, 2008). Consequently, the attention of major powers is attracted to specific regions, where they may also put in place a military presence (United States Joint Forces Command, 2010; Colgan, 2011). Additionally, oil revenues could propel foreign policy adventurism (Klare, 2008; Colgan, 2011). The intertwining relationship between oil and politics explains the choice of examining the effects of violent conflicts, unplanned disruptions, and sanctions. These events either represent a materialisation of politically-driven risk, or they could bring to bear significant political and military consequences. While the former is pronounced in the case of wars and sanctions, the latter could be ascertained in the case of unplanned disruptions.

Fifth, the three investigations combined show that where risks arise, opportunities follow. This thesis adopts the viewpoints of participants in the oil and financial markets, as well as those of policy makers. This allows for assessing the findings from various perspectives. It also permits the presentation of a homogenous set of implications that are relevant to different parties. These range from considerations of energy security and foreign policy, to speculative trading and hedging opportunities. Thus, all of the aforementioned factors combine and provide the thesis with an element of oneness.

1.3 Summary of Findings
1.3.1 Crude Oil, Equities, Conflicts and the Safe Haven Property
The investigation into the effect of violent international conflicts and wars on the valuations of crude oil and equities starts with an event-study analysis. A number of interesting findings emerge from this examination. First of all, the returns on crude oil register significant abnormal increase during the 100 trading days surrounding the start date of a violent conflict. Secondly, this abnormal behaviour is more pronounced in terms of magnitude on and around the outbreak of wars. Thirdly, an interesting finding pertains to the timing of the abnormal returns. A significant portion of the increase in the returns on crude petroleum accumulates well before the start of these conflicts. Fourthly, the valuations of US and world equity indices show a significant abnormal decline on and around the start of crises. Wars and severe conflicts give rise to negative abnormal returns of a larger magnitude. Fifth, the timing of the abnormal behaviour is a startling finding. In stark contrast to oil, a significant portion of abnormal returns occurs during the 50 trading days after the start of conflicts. This finding suggests
that participants in equity markets may not possess or pay attention to the same information as their counterparts in the crude petroleum markets.

Consequently, the findings above hint at the need for a safe haven asset for investors in stock markets during such crises. The abnormal behaviour of oil suggests that it can perform the role of a financial shelter. I formally test this safe haven property by adopting the methodological framework of Baur and Lucey (2010). The findings from this analysis show that crude oil can act as a safe haven for investors in US and world stock markets during times of international conflicts and wars. Additionally, the findings show that oil is an effective hedge for equities. A formal portfolio optimisation analysis is conducted, and showed that a well-diversified portfolio should allocate 17.34% of its holdings to crude oil. These findings are significant not only for equity investors, but also for insurance companies that provide coverage against losses arising from wars and political conflicts.

1.3.2 The WTI-Brent Spread during OPEC Supply Disruptions

Examining the changes in the price differential between two of the world’s most prominent benchmarks offers a view of the relationship between the US and world oil markets. This is particularly important during events of unplanned production outages in members of OPEC. Additionally, investigating the price spread between LLS and Brent during these events sheds light on how different locations are echoed in price relationships. The analysis is built on linear models that account for these events and control for a number of variables.

A number of findings are documented with regard to the behaviour of the price differentials. First of all, unscheduled outages in production give rise to significant tightening in the WTI-Brent spread. This finding is robust even after controlling for seasonality; changes in the stocks of oil and products; weather conditions; infrastructural bottlenecks; political conflicts; and the cost of logistics. Secondly, the LLS-Brent price differential shows less tightening than that observed for WTI-Brent. This latter finding could be attributed to the close proximity of LLS to the US Gulf Coast. Thirdly, the findings document the importance of the stocks of petroleum products in shaping the price relationships among benchmark crudes. Fourthly, the results also demonstrate the role of the cost of transportation, storage and insurance in influencing the price differentials.

The findings above allow for a reflection on the relationship between the US and world markets. Apparently, the tightening of both price spreads during disruptions suggests that markets outside the US are more responsive to supply disruptions. Additionally, imports
priced off Brent appear to have been more expensive than those priced off WTI during disruptions. This highlights the risk that unplanned outages pose to energy security and the world economy. The findings also hint at the potential to hedge or exploit the changes in price spreads using the vibrant paper markets.

### 1.3.3 Crude Oil and US Sanction Programmes

Changes in the prices of the fossil fuel may have an important bearing not only on economic welfare, but also on the effectiveness of foreign policy. Thus, I firstly examine whether the valuations of crude oil register abnormal behaviour on and around the start dates of US sanctions against oil importers and exporters. I specify two event windows of different lengths, and report the following findings. First of all, the valuations of oil register a significant and positive abnormal behaviour on and around the start dates of economic coercion measures against net oil exporters. Secondly, the significant portion of the abnormal returns accumulates well before the start of these programmes.

Thirdly, the returns on the fossil fuel show a significant negative abnormal behaviour in the vicinity of the start dates of sanctions against net importers of oil. Despite the differences in the direction of the abnormal behaviour between the two samples, the timing aspect is similar. This suggests that oil markets anticipate the introduction of these programmes at least 100 trading days in advance. Fourthly, I build on these findings, and show that the US incurs economic losses due to the rise in oil prices that are associated with the imposition of sanctions. Fifth, economic coercion against a net importer of oil brings about real economic benefits for the US. These findings represent external effects that should be taken into account in the design of sanctions. Moreover, the results highlight the importance of adopting a forward-looking approach to the development of US foreign policy.

### 1.4 Summary of Contributions

The thesis contributes to the existing knowledge in five areas. First of all, each of the research questions is formulated and empirically approached in order to address a specific gap in the academic literature. While the safe haven property has been examined for gold and currencies, these investigations did not focus on specific events that could give rise to human and economic calamities. Similarly, a number of aspects concerning crude oil price differentials have been explored. However, the effect of production outrages on the price spreads between the benchmarks is an area that has so far been left untapped. By the same token, while the economic effects of sanctions have been examined from various perspectives, the impact that
these measures could have on crude oil prices, and the externalities that may arise from such an influence, are areas that call for an investigation.

Secondly, and from the viewpoint of participants in equity markets, the findings of the thesis show that oil can be beneficial in hedging against some types of political risk. The documented ability of oil to provide financial shelter for investors in stock markets suggests that the fossil fuel could be used in hedging and diversification. This is also relevant for insurance companies. Business entities and agencies, such as the US government’s Overseas Private Investment Corporation (OPIC), provide insurance coverage against the risk of wars and political violence. Consequently, an exposure to crude oil for hedging and diversification could be facilitated via the vibrant paper markets that range from futures and swaps, to exchange traded funds. Moreover, and relatedly, the safe haven property of oil and the presence of the paper markets that could facilitate the use of oil in diversification both highlight the potential role that financialisation could play in the global oil markets.

Thirdly, unexpected physical disruptions in production are shown to exert an effect on the price differentials. This finding highlights both the necessity for hedging such a risk, and the opportunities for speculation on the movement of these price spreads. The existence of futures and options, in which the price differentials are the underlying asset, can facilitate these financial transactions. Furthermore, the result points to the effect of disruptions on energy security. The tightening of the price spread suggests that a portion of the imports have been costing more to procure during disruption periods. This implication calls for reconsideration of policies related to the type of benchmarks used in pricing, the status of the existing infrastructure, and the management of oil stockpiles.

Fourthly, the results of this thesis show that measures of economic coercion can be associated with significant changes in the valuations of oil. These changes represent external effects, which could have significant economic and political consequences. Therefore, the design of sanctions and the calculations of their costs and benefits should take into account such externalities. Moreover, while sanction programmes are shown to affect the oil markets, variations in oil prices could affect the effectiveness of economic coercion. US foreign policy, via its effect on oil prices, can also have consequences for the energy security of other nations that may not be involved in the dispute.

Fifth, the utilisation of violence or the deployment of sanctions can be associated with a significant impact on the prices of assets. Thus, the findings of the thesis highlight the im-
portance of adopting a forward-looking approach to the developments of the foreign policies of major powers. The timing of the negative abnormal valuations of equities suggests that investors in stocks may not possess the same level of information as their counterparts in the oil markets. However, even oil traders may need to enhance their information regarding the nature of sanction programmes in order to avoid overshooting reactions. This is an implication that is particularly relevant to investors in the US markets; as such market participants may be more able than others to engage with US policy makers.

The remainder of this thesis is organised as follows. The next chapter contextualises the three research questions within four interconnected areas. These are the characteristics of oil, the framework of supply and demand, the oil markets, and the political risk dimension. The three empirical investigations are presented in the third, fourth and fifth chapters, respectively. The sixth chapter concludes and presents the policy implications.
II. Context: The Commodity, Supply and Demand, Markets, and Political Risk

The aim of this chapter is to contextualise the three empirical investigations within the theoretical and empirical evidence from academic and professional literature, in addition to important historical developments. The discussion of four key dimensions highlights the motives underlying the thesis, justifies the choice of the asset and events, and points to the linkages among the three empirical examinations. Section 2.1 discusses the attributes of the commodity, the rise of the economic importance of oil, and its industry. Section 2.2 presents a discussion of the fundamental determinants of oil prices, while section 2.3 discusses the evolution of the pricing and trading systems of oil. Section 2.4 is dedicated to discussing various aspects of political risk.

2.1 Crude Oil: An Overview

2.1.1 The Characteristics

Crude petroleum is referred to as a hydrocarbon fuel, simply because it consists of a continuum of carbon and hydrogen chains of varying lengths (Energy Intelligence, 2011; Hermann et al., 2013). A more complex definition describes oil as ‘a mixture of hydrocarbons that exists in liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities’, which may include small amounts of hydrocarbons in a gaseous phase and non-hydrocarbons such as sulphur and different metals.4

The basic reason for the attractiveness of oil is chiefly found in its prolific energy content relative to other fuels. A barrel of oil represents 0.159 cubic metres in volume terms. This volume contains around 5.8 million British thermal units (BTUs) (Energy Intelligence, 2011:10). For natural gas, however, 164.6 cubic metres hold that same level of thermal content (ibid). Energy Intelligence (2011:10) estimates that 40 cubic feet of natural gas will burn with the same amount of heat as that generated from burning just one litre of heavy fuel oil. Moreover, while a log of wood contains 24,500 BTUs, a gallon of gasoline holds a thermal content equivalent to 5 logs (ExxonMobil, 2014:3). Electricity wise, the energy content of a gallon of gasoline stands at 36 kilowatts an hour (kWh); equivalent to 13000 AA batteries or 4000 smart phone batteries (ibid: 4).

4 Energy Information Administration: Definitions, Sources and Explanatory Notes, available online at www.eia.gov/tools/glossary/index.cfm?id=C
It is essential to highlight that crude oil is not homogenous. This is due to variations in the chemical compositions of the various crudes. The constituent chemical compounds vary in terms of the number of carbon atoms in each molecule and the chemical bonds among the atoms (ICCT, 2011; Hermann et al., 2013). Consequently, these differences give rise to different classes of hydrocarbons. The three broad classes of hydrocarbon compounds in crude petroleum are paraffins, aromatics, and naphthenes (ICCT, 2011). For example, aromatics have a higher ratio of carbon to hydrogen (C/H) than naphthenes, which in turn have a higher (C/H) ratio than paraffins (ibid). The variations in the chemical attributes materialise in differences in both the physical and other important characteristics of oil.

In terms of physical appearance, oil varies from a heavy black sludge to an almost colourless light liquid. An important characteristic that differentiates the various grades of the fossil fuel is density. This density is measured by the American Petroleum Institute gravity (API gravity), which compares the density of crude petroleum to that of water; a measure referred to in degrees (Fattouh, 2011; Energy Intelligence, 2011; Hermann et al., 2013). Simply put, a crude oil with an API gravity of less than 10 degrees would sink, while oil with an API gravity of above 10 would float.

The density categorises a grade of oil as light, medium or heavy. However, various professional sources provide different cut-off points for what constitutes light, medium or heavy crude. Hermann et al. (2013) refer to light crude oil as having an API gravity between 35 and 40 degrees, while a heavy grade has an API between 16 and 20 degrees. Energy Intelligence (2011) defines a light grade as having an API above 34 degrees, while a heavy grade has an API of between 10 and 22.3 degrees.

The importance of density is reflected in the relative ease with which oil can be produced, transported and refined. For example, light hydrocarbon fuels can be extracted and pumped via pipelines with relative ease, which lowers the operating cost (Hermann et al., 2013). Moreover, variations in density are a critical factor in determining the natural yield of petroleum products that can be obtained from refining. These products also vary in their chemical composition. Consequently, the petroleum products are subdivided into light, middle distillates, and heavy. Light products include liquefied petroleum gases (LPG), naphtha, and gasoline. Middle distillates comprise kerosene, heating oil and diesel, while residual fuel oil is an example of a heavy product (ibid).
Light grades of oil yield more of the light and valuable products, and less of the heavier products through simple refining (EIA, 1996; Energy Intelligence, 2011). For example, under simple refining processes, a grade of oil with an API of 21 degrees offers 20% gasoline and 25% residual fuel oil (Energy Intelligence, 2011:92). Under the same processes, oil with an API of 38 degrees yields 38% gasoline and 8% residual fuel oil (ibid). While density is a primary factor in classifying different types of oil, a secondary characteristic is the sulphur content (Fattouh, 2011; Energy Intelligence, 2011; Hermann et al., 2013). Under this criterion, oil is categorised as sweet if it contains less than 0.5% sulphur. A grade of oil that has a sulphur content of between 0.5% and 1.5% is medium sour, while a sulphur content of more than 1.5% renders oil sour (Energy Intelligence, 2011). The sourer the crude, the more refining that is required to remove the sulphur.

In addition to density and sulphur content, a refiner will consider the acidity of the oil, or the extent to which the oil is corrosive, which is measured by the Total Acidity Index (TAN) (Energy Intelligence, 2011; Hermann et al., 2013). Higher acidity can cause corrosion of the equipment used in refineries (Energy Intelligence, 2011), thus requiring the installation of special units that are capable of handling these crudes (Hermann et al., 2013). Crude oil’s pour point and Reid Vapour Pressure (RVP) are two additional factors that refineries consider (Energy Intelligence, 2011). The former refers to the lowest temperature at which oil readily flows, while the latter is a measure of the oil’s volatility; i.e., the rapidity with which it evaporates (ibid).

More complexity is added by dividing sweet grades of oil into further subcategories. A sweet crude can be of a high or low pour point. Additionally, sweet oil can be naphthenic or paraffinic (Energy Intelligence, 2011). The former is more suitable in the production of gasoline, while paraffinic crudes yield a feedstock that is particularly suitable for the petrochemical industry (ibid). All of these attributes are presented in the so-called assays. The various qualities and natural yields are determined and presented in the assay of a crude oil under standardised scales of measurement and techniques. These assays allow a refiner to conduct a meaningful comparison in order to determine which grade to procure in order to maximise the production of valuable products with minimum cost (Energy Intelligence, 2011). An assay also permits an understanding of how the qualities of a specific grade of oil change over time (ibid).
All of the above attributes would be considered by a refiner when procuring oil, which eventually contributes to setting the price of each grade relative to other competing crudes (EIA, 1996; Fattouh, 2011; Energy Intelligence, 2011). Broadly speaking, light and sweet grades are the most sought after by producers and refiners (EIA, 1996; Fattouh, 2011; Energy Intelligence, 2011; Hermann, et al., 2013). This fact is reflected in the pricing of the light and sweet grades relative to the heavier and sourer counterparts. The former should trade at premium to the latter. This is a pricing relationship that reflects the relative ease of production, transportation and refining, in addition to the higher natural yield of valuable products (EIA, 1996; Energy Intelligence, 2011; Hermann, et al., 2013). This is an important factor that explains the dominance of light and sweet grades of oil, such as Brent and WTI, as benchmark crudes in the current pricing system (Energy Intelligence, 2011; Hermann et al., 2013).

Ironically, it is the discount of heavy crudes relative to their lighter counterparts that provides the incentive for installing complex refining units capable of handling these heavy grades (EIA, 1996; ICCT, 2011; Canadian Fuels Association, 2013). This is because these refining units are capable of converting the heavier petroleum outputs into lighter and more valuable products. These complex units yield a higher volume of valuable products than simple refineries running light grades. This, in turn, is reflected in the higher refining margins enjoyed by the complex refineries (EIA, 1996; Quarls et al., 2006). However, the discounts have to be large enough to justify the substantial investment expenditure required to install the conversion and deep conversion units (EIA, 1996; ICCT, 2011; Energy Intelligence, 2011; Canadian Fuels Association, 2013; Hermann, et al., 2013).

2.1.2 The Rise of Economic Importance

While the birth of the modern oil industry can be traced back to the capitalist venture that culminated in the Titusville well, the knowledge of oil’s existence and uses is deeply rooted in antiquity. Seepages of bitumen- an oozy and semi-solid substance- have been tapped for thousands of years (Yergin, 2012). Perhaps unsurprisingly, its most famous source was a location in Babylon in ancient Mesopotamia back in 3000 B.C., where Baghdad stands today (ibid).

These seepages of bitumen have been tapped for various ends. Bitumen was used as building mortar in Babylon and Jericho, in preserving the Egyptian mummies, and as a weapon set alight to frighten the enemies of Alexander the Great (Yergin, 2012; Hermann et al., 2013). Records of its medicinal values and pharmaceutical uses can be traced back to the first century A.D. (Yergin, 2012). In ancient times, this substance was used for healing wounds; curing
aching teeth; soothing cough; and relieving fever and shortness of breath. Moreover, the continuous burning of the seepages and the escaping gases formed the basis for the worship of fire in the ancient Middle East (ibid).

In more modern times, specifically in the 18th century, the prime usage of oil was for illumination. In Austria and Eastern Europe, the development of refining technology allowed the distillation of crude oil in order to extract an illuminant necessary to extend the swaths of the day (Yergin, 2012). A small industry emerged in that part of Europe involving 150 villages, all of which participated in the manual digging of a shaft to extract and subsequently refine crude petroleum. In 1859, in Europe, estimates suggest that 36,000 barrels were produced (ibid). What this infant industry lacked was the technology of drilling, which would allow the exploitation of the natural resource on a grand scale.

The spread of economic development, brought about by industrialisation, further underlined the necessities of an illuminant to extend the working day, and a lubricant for the machines of the age. The Titusville venture aimed to capitalise on the prospects of producing kerosene from oil through distillation in order to satisfy those needs (Yergin, 2012). The utilisation of salt boring in Titusville, which had been in existence for more than 1500 years in China, was the critical step towards the economic exploitation of this natural resource. By the end of the 18th century, a global and multinational industry had emerged with oil discoveries in Russia and Asia (Yergin, 2012). Just when the prospects of the industry had been jeopardised by Edison’s electricity demonstration, new doors to substantial opportunities were opened. ‘[A] new civilisation was born’, when the gasoline-powered internal combustion engine was developed, and subsequently due to the significant military-related decisions in anticipation of and during the First World War (ibid: xvi).

The refining of oil yields various petroleum products that propel our modern modes of transportation, provide heating, and serve as feedstock for the petrochemicals industry. Such are the diverse uses of oil that it can be traced in final products such as fertilisers, deodorants, eyeglasses, tires, plastics and synthetic fibres, and even in heart valves and other medical equipment (Energy Intelligence, 2011). In the 21st century, oil propels 13,500 fixed-wing passenger jets and 650 million road vehicles, not to mention the asphalt used in paving the

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5 The two Greek words kero and elaion are, respectively, wax and oil. Thus, Kerosene was a made-up name for marketable purposes, which was invented by Dr Abraham Gesner in 1850s. Gasoline at the time was a useless by-product that could hardly be sold, and ended up being run at night into rivers (Yergin, 2012: xvi, 6-7).

6 The list is actually longer. See www.eia.gov/energyexplained/index.cfm?page=oil_refining for a diverse list of products that can be traced to crude petroleum.
highways and roads, which is derived from crude oil (Energy Intelligence, 2011:7). Oil not only fuels these machines, but its derivatives are even used in the manufacturing of various components such as seats, tires, and jets’ window shutters (ibid).

Apparently, ‘it is oil that makes possible where we live, how we live, how we commute to work, how we travel—even where we conduct our courtships. It is the lifeblood of suburban communities’ (Yergin, 2012: xvi). Consequently, one may not be surprised to know that the global production of liquid fuels rose from just below 10 million barrels per day (mb/d) in 1946 to around 34 (mb/d) in 1966 (Yergin, 2012: 779). It stood at 86 (mb/d) in 2013 (BP, 2014). This astounding increase in production has been met with a similar astonishing rise in consumption. The demand for liquid fuels rose from 33 (mb/d) in 1966 to 91 (mb/d) in 2013 (Yergin, 2012; BP, 2014). These patterns have been driven by the substantial developments in the refining and petrochemical industries (Energy Intelligence, 2011; Yergin, 2012).

A critical development that has been emerging since the 1990s is the economic rise of China and India, which could have significant economic and political ramifications for the oil markets and global politics in the future (Klare, 2008; United States Joint Forces Command, 2010). In the particular case of China, the country’s leadership took a strategic decision to allow and facilitate the ownership of automobiles in the 1990s in an attempt to stimulate growth (Klare, 2008). Estimates suggest that the Chinese are laying down 1000 kilometres of four lane highways every year (United States Joint Forces Command, 2010:26).

The above developments have been reflected in the tremendous increase in China’s oil consumption, from 1.7 (mb/d) in 1980 to a startling 7.4 (mb/d) in 2006 (Klare, 2008: 63-64). The Chinese demand for more oil could be destined for further increases in the future. While the US has one passenger car per 1.3 residents, the comparable ratio in China is one car per 30 residents (Hamilton, 2012:15). Additionally, China’s annual petroleum consumption per person stood at 2.5 barrels in 2010, compared to 6.7 and 22.4 barrels per person in Mexico and the US, respectively (ibid). These numbers allow for apprehending both the prospects of oil demand, and the implications that such trends could bring to bear for oil markets and international stability (Klare, 2008).

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2.1.3 The Oil Industry

The substantial surge in oil production and consumption has been echoed in the emergence of a mammoth-like industry. Ranked in terms of revenues, five out of the top ten corporations on the Fortune Global 500 ranking are oil and gas companies.\(^8\) Undoubtedly, the historical edifice of the industry had been Standard Oil (Energy Intelligence, 2011; Yergin, 2012; Hermann et al., 2013). The sheer size of this corporation can be apprehended, when one recalls that the roots of corporate titans such as Chevron, BP, Exxon and ConocoPhillips can be traced back to Standard Oil; hence it is dubbed ‘the mother of all grandmothers’ (Hermann et al., 2013:12).\(^9\) Other corporate giants have also emerged outside of the umbrella of Standard Oil, such as Royal Dutch/Shell, Total, and Eni (Yergin, 2012; Hermann et al., 2013).

The industry comprises three main segments. The upstream focuses solely on exploration and production (E&P), while the midstream encompasses the logistical aspect. The downstream represents the refining and marketing sides of the business (Fattouh, 2011; Energy Intelligence, 2011; Yergin, 2012; Hermann et al., 2013). A number of points should be highlighted in relation to these segments, which reflect the highly intricate nature of both this commodity and the industry. First of all, major international oil companies operated along the entire value chain from the upstream to the downstream between the 1950s and the mid-1970s. This operational vertical integration offered these companies almost perfect knowledge on the state of oil markets (Stevens, 1995; 2005).

However, the structure was dismantled following the wave of nationalisations in the 1970s, a development that signalled a shift in power to OPEC (Stevens, 2005). This meant that international oil companies had to search for new oil discoveries outside the realm of OPEC. These attempts have been focusing on locations that are more challenging in terms of technology and geopolitics, and they were also more costly (Energy Intelligence, 2011; Hermann et al., 2013). Examples of such endeavours are exploration and production in deep waters and in the Caspian region. Operations in deep waters- over 1000 metres in depth- have been gaining momentum, and supply from such sources represents the key driver of growth in global production (Hermann et al., 2013). The importance of these projects is reflected in the fact that 11% of the oil reserves of international oil companies are from deep waters (ibid).

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\(^8\) [www.fortune.com/global500/](http://www.fortune.com/global500/)

\(^9\) For more details, see the family tree of the International Oil Companies (IOCs) in Hermann et al. (2013:16)
Secondly, the upstream encompasses very complex, lengthy, highly risky, and costly operations. Such projects comprise the processes of exploration and appraisal, field development, the management of both production and the subsequent decline in aging fields, and the final decommissioning of an oil field (Energy Intelligence, 2011; Hermann et al., 2013). In 2013, global capital expenditures in oil and gas exploration and production reached a staggering $682 billion (Barclays, 2013). While the development stage occupies the lion’s share of the cost base, significant spending is required even at the decommissioning stage (Hermann et al., 2013). Astonishingly, it is estimated that the size of the North Sea’s decommissioning market is $40 billion (ibid).

Moreover, the high risk nature of such ventures is reflected in the rates of success in making a discovery of a commercial quantity of oil. Hermann et al., (2013) examined such rates across 109 countries and 107,772 wells from 1951 to 2010. During that timeframe, and despite the significant advancements in technologies, they show that the average combined success rate of exploration and appraisal was 31%. Additionally, significant time lags are evident between exploration activities and actual production. For example, the lag between the peak in discovery and that of production was 12 years in the case of the North Sea (ibid).

Thirdly, the high cost of oil projects is not confined to the upstream sector. Building a new refinery takes between five and seven years, and costs between $7 and $10 billion for permission and construction (Canadian Fuels Association, 2013). In the US, total capital expenditures in the refining sector reached almost $53 billion between 2005 and 2010 (Andrews et al., 2010). Additionally, refineries in the US spent around $112 billion on environmental improvements between 1990 and 2008 (American Petroleum Institute, 2011). Factors such as the location, refining capacity, type of crude to be processed, and the level of complexity all affect the costs (Quarls et al., 2006; Canadian Fuels Association, 2013; Hermann et al., 2013).

Fourthly, the service industry exists along the chain from the upstream to the downstream, and companies in this industry provide a wide variety of services. These range from seismic surveys and engineering design, to construction, drilling and maintenance. It is a $50 billion market, and the extent of the tightness in this market is a factor that influences the costs of exploration and production (Energy Intelligence, 2011; Hermann et al., 2013). Furthermore, a factor that highlights the sheer size of the oil industry is the emergence of an entire sector that specialises in offering logistical and catering services just for the offshore oil platforms (Hermann et al., 2013).
The discussion of costs, particularly those associated with the upstream, brings forth the key issue of the break-even price of oil for a producer. Essential for the determination of this price level is the cost of producing a barrel of oil. This aggregates the three segments of upstream costs, namely exploration, capital and operating costs (Hermann et al., 2013). The largest component is the capital costs, which encompass costs of engineering design, procurement of machineries, construction, and project management costs. Operating costs aggregate day-to-day operating expenses from the chemicals used in production to logistics and catering-related costs. A number of factors can significantly affect the cost per barrel such as the availability of qualified labour, the prices of commodities, foreign exchange markets, the complexity of a project, competition, and the conditions of the service industry (ibid).

Apparently, the break-even price can be viewed through more than one prism. From a net exporter’s point of view, it is the price at which the government can still balance its budget. For example, this price varies among the members of OPEC from $136 and $124 to $92 and $59 for Iran, Nigeria, Saudi Arabia, and Kuwait, respectively (Reuters, 2014 a). From a private company’s perspective, the break-even price is the necessary level to generate sufficient cash flows to service its debt and maintain investments in operations. This has been pronounced in the recent discussions regarding the ability of the US debt-fuelled shale oil production to weather the decline in prices (Arnsdorf, 2014; EIA, 2014b; The Economist, 6th December 2014).

It is important at this point to summarise, and reflect on, the discussion above with regard to what this thesis aims to examine. The choice of examining the valuations of crude oil is motivated by the highly complex nature of this commodity; this complexity is due to varying intrinsic attributes resulting in more than 150 different types of crudes (Canadian Fuels Association, 2013). The choice of the asset is also driven by the central role that oil occupies at the heart of the global economy. This is a role that is bound to continue with the increasing demand from emerging nations. This reliance on the hydrocarbon fuel dictates an examination of the behaviour of its prices around international conflicts, unplanned disruptions, and sanctions.

Moreover, the discussion of the various characteristics of oil and the tremendousness of its industry allows for a reflection on the choice of events. While the discussion of political risk in section 2.4 will further demonstrate the relevance, a brief illustration is due here. First of all, in an ideal world, a refinery would be built to run all possible grades or blends in order to
supply the mix of products that local or international markets demand. However, due to the astounding capital expenditures needed, refineries are built to handle specific types of crudes or blends with the aim of maximising a specific mix of products (ICCT, 2011; Fattouh, 2011; Energy Intelligence, 2011). This brings to bear significant economic and political consequences.

A case in point is the European refining sector. Due to the fact that oil produced from the North Sea is characterised as light and sweet, European refineries have been built to maximise the production of gasoline (KPMG, 2012). Consequently, these refineries have not been able to fully meet the rising demand for middle distillates in Europe. The economic implications of this have materialised in the form of excess gasoline supply, and a squeeze on profitability (ibid). There has been an equally important implication that has geopolitical ramifications. The shortage in diesel and middle distillates had to be met from Russia via imports of either crude or petroleum products. 72% of the total Russian crude and petroleum products exports have been destined for Europe, particularly Germany, the Netherlands and Poland (EIA, 2015b).

Secondly, while the quest of giant corporations for oil in various geographical areas in the world contributes to the diversification of supplies, these ventures have their antidotes. West Africa and the Caspian region are good examples. The search for oil drove many the international oil companies to explore and subsequently produce from West Africa’s offshore fields. However, the facilities of these corporations- mainly in Nigeria- have been the target of numerous attacks by the local population or insurgents aiming at sabotage or mere theft (Energy Intelligence, 2011). These attacks have led, on many occasions, to an unanticipated cut in production and supply to international markets. Such occurrences are included in the sample of events around which the WTI-Brent spread is examined.

Moreover, while the Western IOCs’ quest for oil in the Caspian is profit-driven, their presence brought the attention of US policy makers to the vitality of this region. This rising interest focused not only on establishing a strong foothold for these IOCs, but also on the strategic issue of transportation. The fact that the Caspian Sea is landlocked meant that oil had to be transported via pipelines to prospective markets. The two most economically feasible routes were via either the Russian pipelines network, or across Iran to the Gulf. However, neither of these was chosen, and the least economically rational route was adopted and built (Klare, 2008). Additionally, the Russians and the Chinese have been increasing their efforts to coun-
ter-balance the rising American influence, and all of these dynamics have been culminating in a rise in military presence, the forming of coalitions, and the arms trade (ibid).

2.2 The Price Formation of Crude Oil: Through the Prism of Supply and Demand

Understanding the factors that drive the formation of crude oil prices is imperative in the light of what this thesis aims to examine. Specifically, the interaction between supply and demand is particularly useful for apprehending how unplanned outages and exogenous political events can affect prices. This is because oil price movements are driven by imbalances-or expectations about such occurrences-in the market (Adelman, 1990; Stevens, 1996; 2005). Thus, it is the interaction between supply and demand that generates the price, while aiming to restore the balance in the market place. Those forces are affected by a number of factors over both the short- and the long-term, which consequently impact how oil prices are determined (Stevens, 1995; 1996; Huntington et al., 2014).

2.2.1 The Long and Short-term Factors Driving Demand and Supply

The global demand for petroleum products underlies that for crude oil (Stevens, 1995; 1996). Thus, the demand curve could be perceived as comprising three different segments, each of which differs in its price elasticity. In the most vertical segment, demand is determined in the short-term by the number of appliances that burn petroleum products, the utilisation of their capacity, and their efficiency (Stevens, 1996). The decision on how much of the capacity to utilise offers some flexibility to respond to price changes (Stevens, 1995). However, these factors are assumed to be fixed over the short-term, which consequently leads to inelasticity (Stevens, 1995; 1996). In the long run, a shift to the right or left is driven by changes in the stock of appliances and the efficiency with which they operate (Stevens, 1995).

Two more elastic segments correspond to two different price ranges. At very low prices, global demand is more elastic due to the presence of dual firing capacity in the manufacturing sector in the US, and the power sector in Europe (Stevens, 1995). Such dual-fired units can produce electricity using two or more input fuels.\(^\text{10}\) The elasticity of the upper segment of the demand curve increases when prices are high due to the dependence on imports (Stevens, 1996). This is because procuring oil becomes more expensive at such price levels, which could force deprivation to become a fact of life (Stevens, 1995; 1996).

\(^\text{10}\) Some of these units use a primary fuel continuously, while an alternative fuel can be used in emergencies or as a start-up (www.eia.gov/tools/glossary/index.cfm?id=D).
Huntington et al. (2014) identify a number of variables that could influence demand in the long run. One such factor is income elasticity of demand in the context of growth and industrialisation. In emerging economies, a rise in income brings about a rapid increase in vehicle ownership. Based on estimates of income elasticities in developing nations, demand for oil should increase as fast as GDP. This is in contrast to estimates on income elasticities in the developed world, which suggest that demand for oil should grow half as fast as the GDP of these industrialised nations. This will be further driven by stabilisation in vehicle ownership rates, and a rise in the number of purchases of vehicles running on alternative fuels.

Technological progress is another factor that could influence demand for oil in the long run. Technological advances affect demand and create an element of irreversibility, even when oil prices retreat to low levels. Such progress could be uncorrelated with price changes, which renders it exogenous. An example of such a development is the rise in fuel efficiency in the aviation industry via design improvements, which preceded the price hikes of the 1970s. On the other hand, an endogenous change is triggered by price shocks; an example of this is the shift in the automobile industries towards designing more fuel-efficient vehicles. Technology could affect demand via the production of alternative vehicles that can be solely run on competing fuels such as compressed natural gas and biofuels.

An essentially important factor is the price elasticity of demand over the long-term. To re-iterate, this is driven by the changes in the stock of oil-burning appliances, their efficiency, and decisions regarding utilisation (Stevens, 1995). Estimates suggest that the price elasticity of demand has been declining in the US and within the members of the Organisation for Economic Cooperation and Development (OECD) (Huntington et al., 2014). Moreover, fuel subsidies can influence elasticity, because they create a wedge between the final price of petroleum products and the international price of oil. Such subsidies are employed by many countries outside the OECD, and their removal could make demand more responsive to oil price changes (ibid).

The global supply side is driven by the extremely low marginal cost of production, which makes producers willing and able to produce at low price levels (Adelman, 1990; Stevens, 1995; 1996). One underlying assumption is a constant and similar marginal cost of production across different producing regions over the short-term (Stevens, 1995). The very low variable

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11 Huntington et al. (2014), and references therein, are the source of this discussion, as their work is a survey of the various models employed to forecast crude oil prices over both the short- and long-term.
costs find their root in the physical nature of oil as a fluid fuel with immense energy content. These attributes give rise to tremendous technical economies of scale, which, in turn, are reflected in the capital intensity of the production function (Stevens, 1995; 1996).

While the oligopolistic nature of the oil industry allows producers to exert a rent above the marginal cost of production, those producers are still willing to supply at low prices (Adelman, 1990; Stevens, 1995; 1996; 2005). The fixed to variable cost ratio is high and sufficient to induce oil companies to produce in order to generate cash flows and an acceptable rate of return on current production (Stevens, 1995). Additionally, governments appear to have very high discount rates, and their thirst for revenues overcomes future price expectations (Adelman, 1990; Stevens, 1995). Thus, except for expectations of very high prices, governments, through the national oil companies, will continue producing at low prices (Stevens, 1995; 1996).

Moreover, when faced with a rise in the price of oil due to a surge in demand, oil producers respond by utilising the available spare production capacity (Stevens, 1996). In the short-term, the ability to respond is constrained by the limitations on this excess capacity (Stevens, 1995). For example, capacity could be offline due to wars, sanctions, unplanned outages, or maintenance programmes (Stevens, 1996). In the long run, shifts in the supply curve to the left are caused by depletion or a lack of maintenance of existing fields, while a shift to the right occurs via investments that transform oil-in-place to proven reserves (ibid).

Both demand and supply are driven in the short-term by changes in both interest and US foreign exchange rates, and uncertainty surrounding these factors (Huntington et al., 2014). Variations in these factors could contribute to altering consumption, supply, and storage decisions. An additional influential factor in the short run is the flow of news and information on macroeconomic performance, movements in major financial markets, prices of other commodities, and natural disasters and unforeseen extreme weather conditions. Importantly, news related to potential uprisings or international political tension could affect demand (ibid). This has been empirically documented in the case of the US invasion of Iraq. Rigobon and Sack (2005) report a significant positive impact of Iraq war-related news on crude oil prices.

A key question is how can the interaction among the above driving factors be characterised over time? Stevens (2005) alludes to cyclical versus structural changes in these factors, and
subsequently in the prices of crude oil.\textsuperscript{12} Cyclical fluctuations in the price of oil reflect similar changes in the underlying factors. The outcome of such changes means that the increase in price will eventually be followed by a decline. On the other hand, the coefficients associated with the quantitative and qualitative factors could change in response to structural shifts. An example of such structural changes is, arguably, represented by the behaviour of fossil fuel prices since 2004. Such a shift materialised due to the erosion of spare production capacity, and a significant rise in demand from emerging nations (Stevens, 2005; Askari and Krichene, 2008; Hamilton, 2012). However, structural versus cyclical movements remain claims or hypotheses, and can only be ascertained in hindsight (Stevens, 2005).

While the above discussion represents a summary of the variables that shape oil prices over the short- and long-term, it is essential for the introduction of the role of shocks in crude oil markets. Shocks to supply and demand are a critical factor in the price formation process of crude oil, mainly in the short-term (Huntington \textit{et al.}, 2014). The impact of these shocks on prices can be further amplified by short- and long-term changes in the above-mentioned factors (Kaufmann \textit{et al.}, 2004; Baumeister and Peersman, 2013a; Huntington \textit{et al.}, 2014). Key issues are the endogeneity between oil prices and the driving factors, how changes in these factors magnify the effect of shocks, and the role of disruptions and exogenous events in triggering shocks. These issues are presented in the following subsection.

\textbf{2.2.2 Shocks to Demand and Supply}

It is important to highlight a number of issues surrounding the relationship between the prices of the fossil fuel and its driving factors. The price of crude oil is endogenous with respect to the factors underlying supply and demand (Kilian, 2008a; b; c; 2009). This endogeneity implies a reverse causality (Kilian, 2008c). This form of causality suggests the presence of bi-directional effects between changes in prices and the factors driving supply and demand (ibid). The fundamental factors change over time, which gives rise to a dynamic relationship with crude oil prices. The evidence on this evolving relationship is found in price shocks.

Over time, shocks have witnessed changes in their origins, timing, magnitude, and persistence (Kilian, 2008c; 2009). Importantly, the consequences of these changes for both the economy and the prices of oil have also varied (Kilian, 2008c; 2009; Baumeister and Peersman, 2013a). The price hikes associated with the Arab oil embargo and the Iranian revolution

\textsuperscript{12} Stevens (2005) refers to the structural versus the cyclical school, each of which offers an explanation for the upward oil price trajectory after 2004. It must be stated, however, that Stevens do not cite specific papers that are categorised under each of these schools.
have given rise to the view that shocks are caused by exogenous events (Kilian, 2008c). Consequently, the attention of researchers has been focused on isolating such exogenous shocks in order to examine their economic effects (See for example Hamilton, 2003; Kilian, 2008a; b).

However, the effects of supply-driven shocks on the economy and oil prices appear to have weakened over the decades (Kilian, 2008c; 2009; Kilian and Murphy, 2013). This could be due to the gradual decline in the cost share of oil in economic output, particularly in the US (Kilian, 2008c). Moreover, doubts have been raised regarding whether price shocks have been driven solely by supply disruptions (Kilian, 2008c; 2009). For example, evidence suggests that some exogenous political events have not been associated with price hikes, and vice versa (Kilian, 2008c). This has brought about the argument that shocks to demand could also affect oil prices and the economy, either solely, or in combination with, shocks to supply (Kilian, 2008c; 2009; Baumeister and Peersman, 2013b).

Demand shocks not only give rise to different price and economic reactions, but also could have more than one source (Kilian, 2008c; 2009; Baumeister and Peersman, 2013a). An unexpected shift in the global business cycle could materialise in a shock to the aggregate global demand for oil and industrial commodities. Moreover, traders could react to rising political tension by accumulating oil stocks on either a speculative or precautionary basis. This reaction could trigger a demand-side shock (Kilian, 2008c; Kilian and Murphy, 2013; Baumeister and Peersman, 2013b).

The origin of the shock matters, as it determines the magnitude, timing, and persistence of the price trajectory. It also defines the nature of the response of economic parameters. On the one hand, while a shock to global demand leads to a long and persistent increase in oil prices, it causes an initial rise in real output growth (Kilian, 2009). On the other hand, a surge in demand for oil on a precautionary basis leads to an immediate increase in the price of the fossil fuel, and causes a persistent decline in real output growth rates (ibid). However, it is essential to highlight that while the effects of supply-driven shocks have been declining over time, large swings in demand cannot solely explain the significant changes in prices (Kilian, 2008b; c; Baumeister and Peersman, 2013b).

The discussion above leads to a key dimension that allows a better understanding of how political events and unplanned disruptions could affect prices. An unexpected surge in demand, when combined with highly inelastic supply curve, can generate significant swings in prices in response to the occurrence of disruptions (Kilian, 2008a; b; Baumeister and Peers-
man, 2013b). Specifically, the effect of an exogenous supply shock could be amplified by the strength of the global business cycle, constraints on excess production capacity, high cost share of oil in output, and high price volatility (Kilian, 2008a; Askari and Krichene, 2008; Baumeister and Peersman, 2013b). The presence of these factors could magnify the shock to prices even in the absence of a physical shortfall in supplies. Exogenous political events could heighten uncertainty about the availability of future supplies (Alquist and Kilian, 2010; Baumeister and Peersman, 2013b). The rise in uncertainty could cause a shift in expectations, subsequently triggering precautionary demand (Kilian and Murphy, 2013; Baumeister and Peersman, 2013b).

A number of critical developments have caused the comingling of different shock-driving factors, and could lead to large price swings in response to physical production outages and exogenous political events. These developments have not only evolved in parallel, but also reinforced each other. In summary these developments are the gradual erosion of spare production capacity, the unexpected rise in aggregate demand from emerging economies, and the increased weight of precautionary demand in oil markets. The outcomes are more tightness in the markets, heightened uncertainty, and deeper effects arising from political events and disruptions (Stevens, 1995; 1996; 2005; Askari and Krichene, 2008; Huntington et al., 2014).

First of all, the oil industry has maintained excess production capacity for decades. This is because spare capacity confers political and economic power (Stevens, 2005). Additionally, the cost of replacing a barrel of oil has been overshadowed by the price, which has been an incentive for producers to install new capacity (Adelman, 1990; Stevens, 2005). This accrued rent has been the outcome of either favourable geology that gives rise to a low cost of production, or the manipulation of the markets (Stevens, 2005). Also, governments have been offering favourable fiscal terms to companies in order to encourage further exploration and production (Stevens, 1995). Increasing the revenues from oil sales or taxes has been driving the behaviour of governments (ibid).

The addition of capacity has also been a precautionary measure to counter sudden shortages that may arise from wars or unexpected events (Stevens, 2005). Furthermore, the oil industry has been characterised by its herd behaviour over the course of its history. This, in turn, implies that the accumulation of spare capacity cannot be traced to the actions of a single producer over time. Rather, the industry as a whole has been embarking on installing new capacity in response to favourable price prospects (Stevens, 1995; 1996; 2005). Finally, Saudi Ara-
ibia’s decision to maintain prices at low and stable levels required maintaining excess capacity that would enable the country to manage shocks (Stevens, 2005).

However, the erosion of excess production capacity has been a critical development, which could have a significant bearing on future markets (Stevens, 2005). This has been due to the lack of investment, and the tremendous rise in demand from emerging nations (Stevens, 2005; Askari and Krichene, 2008; Hamilton, 2012; Huntington et al., 2014). More specifically, there was a focus on value-based management in the oil industry during the 1990s, which simply meant returning earnings to shareholders (Stevens, 2005). This, in turn, led to reducing the cash flows available for capital expenditures (ibid). The emergence of such a trend could be due to the low and stable price levels during the last decade of the 20th century, and expectations that prices would stay at these levels for a long period of time (Stevens, 2005; Saporta et al., 2009).

Corporations have not been alone in reducing capital spending; governments too have diverted expenditures towards domestic issues (Stevens, 2005). Moreover, the late 1990s witnessed a wave of mergers and acquisitions among oil companies, which gave rise to a concentrated industry (Stevens, 2005). This high concentration has been allowing upstream companies to squeeze the flows of cash into the oil service sector. This has been affecting the ability of service companies to expand their capacity, which, subsequently, has affected the installation of new production capacity (ibid).

Consequently, any surge in demand or shortages in supply have had to be met with existing levels of spare capacity. To complicate matters further, there are variations in the interpretations or definitions of what capacity is (Stevens, 1995; 1996; Kilian, 2008b). For example, a critical difference exists between maximal sustainable and nominal capacity. While the former represents 90% of the latter, in practice the maximal sustainable level of production can only be known after trial (Kilian, 2008b). Consequently this leads to the implied assumption that the system would be fully utilised if production reached 90% of nominal capacity (ibid). The erosion of spare capacity has been the case, when producers have faced an unexpected rise in demand from emerging nations (Saporta et al., 2009). Between 1995 and 2005, 43% of the growth in global petroleum consumption could be attributed to eight emerging countries (Hamilton, 2012). The rise in consumption from these specific nations was even more pronounced between 2005 and 2010 (ibid).
A further critical development is the decline in the price elasticity of global demand for oil (Hamilton, 2008; Baumeister and Peersman, 2013a; Huntington et al., 2014). This has been due to shifts towards the use of alternative fuels in the manufacturing and power sectors in industrialised nations, and improvements in energy conservation (Baumeister and Peersman, 2013a; Huntington et al., 2014). The decline in oil input per unit of output has also been caused by economic growth driven by the service sector (Baumeister and Peersman, 2013a). Furthermore, there has been a rise in the share of the transportation sector in total oil consumption. While oil is the primary fuel used in this sector, the demand from transportation is characterised by low price-elasticity (ibid).

Importantly, the rise in consumption from emerging economies and the erosion of excess production capacity, have also contributed to the steepening of the demand curve. Demand for oil in emerging nations tends to be less responsive to changes in oil prices, and the rising share of these countries in global consumption could explain the decline in global price-elasticity (Baumeister and Peersman, 2013a). Moreover, the erosion of spare capacity signals tightness in the markets (Kaufmann et al., 2004). Tight markets can increase the weight of the more inelastic speculative and precautionary components of global demand, which subsequently reduces elasticity (Adelman, 1990; Baumeister and Peersman, 2013a). These components of demand can be triggered by either small disruptions, or even the anticipation of such shortages (Adelman, 1990; Kilian and Murphy, 2013; Baumeister and Peersman, 2013a; b).

To summarise, the factors underlying the interaction between the supply of, and demand for, oil can explain the effect of exogenous political events and physical disruptions on oil prices. An abnormal rise or fall in the price of the fossil fuel can occur in response to either physical shortfalls in supplies, or the prospects of such occurrences. A lack of new capacity leads to the erosion of existing spare production capacity, when aggregate demand for oil rises. The resulting tightness can result in a portion of that demand arising on a precautionary or speculative basis. This particular component is triggered by shifts in expectations regarding the flow of future supplies. In other words, market participants become more sensitive to the issue of security of supply during tight market conditions.

These attributes justify the choice of events that either involve an actual disruption, or heighten uncertainty regarding the availability of future supplies. Moreover, the above developments have characterised crude oil markets since the collapse of prices in the mid-1980s (Stevens, 2005; Hamilton, 2008; Baumeister and Peersman, 2013b). This is the period on
which this thesis focuses. The importance of wars, sanctions, and unplanned production outages for the pricing of crude oil is bound to continue into the future. This is conditioned by the willingness and ability of major producers to invest in new capacity, and whether net importers will cooperate or compete in their quest for oil (Stevens, 2005; Klare, 2008; United States Join Forces Command, 2010; Huntington et al., 2014).

2.3 Crude Oil Markets: Towards a Market-based System

The progress towards the dominant role of markets in the trading and pricing of crude oil has emerged following various stable and even volatile phases of evolution since the 1950s. While the current market-based system has been in existence only since the mid-1980s, this transition was preceded by three distinct periods of developments (Stevens, 1995; 2005; Mabro, 2005; Fattouh, 2011). The amalgamation of political and economic events and processes had an influential role in shaping the changes over time. More specifically, developments in the crude oil pricing system have been enforced by shifts in political power, and changes in both the industry and the factors underlying demand and supply (Stevens, 2005; Baumeister and Peersman, 2013b).

At the heart of the developments leading to the current system have been the decline in the quality of information; the rise of the paper markets; and the increasing role of belief in trading (Stevens, 2005). These attributes are among the factors that have contributed to the amplification of supply and demand shocks, heightening of uncertainty, and the increase in the volatility of crude oil prices (Askari and Krichene, 2008; Baumeister and Peersman, 2013b). These developments have also reinforced the precautionary component of demand that arises in response to exogenous political events (Stevens, 1995; 1996; 2005; Baumeister and Peersman, 2013b).

The following subsection presents and discusses the developments in the system over three timeframes. The first is the period between the 1950s and the mid-1970s, which is characterised by the concession system and the dominance of international oil companies. From the mid-1970s to the early 1980s, the system underwent turbulent changes as a shift in power began to transpire from the international companies to OPEC. The final period is that between 1982 and 1986, which witnessed the dominance of OPEC with regard to pricing. Subsection 2.3.2 is devoted to discussing the attributes of the current crude oil pricing and trading system.
2.3.1 The Seven Sisters, the Rise of OPEC, and the 1986 Collapse

The rise of the role of the major international oil companies in the early 1950s was a significant development for the functioning of oil markets. The system through which oil was traded and priced between the 1950s and mid-1970s enjoyed a high degree of stability for two main reasons. First of all, the formation of the Consortium for Iran meant that the seven constituent companies took control of the majority of global oil production outside of the US, China, Canada, and the USSR (Stevens, 2005; Fattouh, 2011; Energy Intelligence, 2011; Hermann et al., 2013). The concession system secured these companies their dominant position (Fattouh, 2011). Secondly, the market and the pricing system were shaped by the structure through which each of these companies operated. Specifically, operational and financial vertical integration secured the stability of supply and demand, and ensured the companies the ability to prevent significant price changes (Stevens, 2005; Fattouh, 2011).

In particular, operational integration was the key to the stability of the system. This is because this form of vertical integration requires the control of the physical flow of crude oil and products along the entire value chain (Stevens, 2005). Crude petroleum had to be exchanged within and among these companies’ affiliates via long-term contracts, which resulted in the underdevelopment of spot markets (Fattouh, 2011). The prices specified by these contracts were not disclosed, as they were regarded as commercial secrets (ibid). However, in order to calculate the revenues accrued to the host government, the companies used the concept of the posted price (Stevens, 2005; Fattouh, 2011).

Consequently, the structure of the industry ensured the superiority of the international companies over others in terms of the costs of transactions and information (Stevens, 2005). This also inhibited the entry of third parties to the market. However, despite the lack of transparency, this period is characterised by high quality information (Stevens, 2005; Fattouh, 2011). The structure of the industry and its mode of operation offered the Seven Sisters almost perfect knowledge about the state of the markets. This, in turn, allowed these companies to adjust their production and prevent significant spikes or declines in prices (Stevens, 2005).

However, critical developments transpired in the 1970s, which represent the second phase of evolution in the pricing system. A number of processes caused a gradual move away from operational vertical integration towards the use of markets. First was the increase in equity participation by host governments (Fattouh, 2011). The second factor was the wave of nationalisations in the 1970s (Stevens, 2005; Fattouh, 2011). Because international oil companies
were forced by these developments to abandon their operational integration, they resorted to the markets to secure supplies. These processes resulted in an increase in the number of transactions on an arm’s length basis at the expense of long-term contracts (Fattouh, 2011). Consequently, the number of traders increased, while the cost of transactions declined (Stevens, 2005).

The pricing system witnessed a number of changes in terms of the price at which oil was transacted during the second phase of development. In addition to the original posted price, the official selling price and the buyback price were also introduced (Stevens, 2005; Fattouh, 2011). This complex system was short-lived, because the lack of transparency did not allow these prices to converge (Fattouh, 2011). A revolutionary move emerged after 1975, when OPEC adopted the concept of a reference or marker crude in pricing. Official selling prices were set relative to this benchmark crude by adding or subtracting a differential on periodic basis. The rise in the number of traders outside of the international companies accelerated following the Iranian revolution, which further advanced the power of OPEC (ibid).

This administered pricing system started a new era, when OPEC successfully introduced a formal quota system in 1982 (Stevens, 1995). This system aimed to manage the excess capacity and orchestrate production in order to defend the reference price (Stevens, 1995; 1996). However, the ability of OPEC to defend its marker price was hampered by the decline in the quality of information on the state of oil markets, an outcome of abandoning the operational vertical integration structure within the oil industry (Stevens, 1995; 2005). The classical problem of cheating in a cartel-like organisation was an additional factor that negatively impacted the effectiveness of OPEC (Stevens, 1995).

These problems culminated in the mid-1980s, when new technologies and the high price environment encouraged producers outside of OPEC to ramp up production (Stevens, 2005; Fattouh, 2011). The rise in production coincided with a decline in the demand for crude oil due to a global economic slowdown (Stevens, 1995; Fattouh, 2011). Two implications arose from the insistence of some OPEC members to either maintain the reference price at its relatively high level, or even call for an increase. First of all, non-OPEC producers resorted to selling in the spot market by undercutting the organisation’s reference price. Consequently, the market share of the organisation dropped from 51% in 1973 to 28% in 1985 (Fattouh, 2011:18). Secondly, the surfacing dispute among the members materialised in the adoption of
a two-tiered pricing structure. This involved the introduction of two reference crudes: one defended by Saudi Arabia, and another supervised by the remaining members (ibid).

However, the erosion of the market share continued. In response, Saudi Arabia, and subsequently other OPEC members, resorted to netback pricing in 1986 in order to defend their market share (Stevens, 1995; Mabro, 2005; Fattouh, 2011). By design, this pricing concept guaranteed refineries a profit margin, which offered the incentive to operate at full capacity (Fattouh, 2011).13 At a time when demand for products had already slowed down due to the global recession, the oversupply of these products dampened their prices and eventually caused the collapse of oil prices. These developments marked the end of OPEC’s administered pricing system, and the beginning of the era of the market-based system (Stevens, 1995; 2005; Fattouh, 2011).

2.3.2 The Rise of the Market-based Pricing System

The most important outcome of the collapse of crude oil prices in the mid-1980s was a transition from the OPEC administered pricing regime to a market-oriented system (Stevens, 2005; Fattouh, 2011; Energy Intelligence, 2011). The rise in equity participation, the wave of nationalisations in the 1970s, and the increase in the numbers of suppliers and buyers, all contributed to the rise in the number of deals on arm’s length and spot bases. Moreover, since the early 1980s, the role of financial or paper markets has increased in the price formation process (Stevens, 1995; 1996; 2005; Fattouh, 2011). Thus, the conditions needed for market-based pricing were available by the time OPEC’s system collapsed.

The market system shares with its direct predecessor the role of a reference crude in pricing. However, the current system leaves the task of identifying the prices of the benchmark crudes to the markets. Moreover, the differentials that are added to or subtracted from the reference crude have become more responsive to market conditions (Fattouh, 2011; Energy Intelligence, 2011). These pricing processes take place through a complex system of interlinked markets (Fattouh, 2011; Energy Intelligence, 2011). At the heart of this structure is the physical market, in which the actual trading of oil cargos takes place. Within this physical layer, oil can be traded on forward or spot bases (Fattouh, 2011). However, even spot prices have an element of forwardness due to the fact that cargos of oil must travel long distances (ibid).

13 Netback pricing sets the price of oil equal to the realised price of petroleum products minus refining and transportation costs (Mabro, 2005; Fattouh, 2011).
On the other hand, the financial layers of the pricing structure encompass futures and options that are traded on regulated exchanges such as the Intercontinental Exchange (ICE) and the Chicago Mercantile Exchange (CME) (Fattouh, 2011; Energy Intelligence, 2011). Additionally, over the counter markets provide further possibilities for trading (Fattouh, 2011). These paper markets have been allowing participants to hedge against or speculate on oil price movements (Fattouh, 2011; Energy Intelligence, 2011). Furthermore, channels or mechanisms, such as the Exchange of Futures for Swaps (EFS), exist in order to interlink the various physical and financial layers, and allow prices to converge (Fattouh, 2011).

The importance of this complex pricing structure is in generating the prices of benchmark crudes. These reference crudes are at the heart of the formula pricing system through which the physical cargos are priced. Several crudes have assumed the benchmark role since the mid-1980s. These include Brent, West Texas Intermediate (WTI), Dubai/Oman, Argus Sour Crude Index (ASCI), and Light Louisiana Sweet (LLS) (Fattouh, 2011; Energy Intelligence, 2011). The benchmark prices that arise from the physical layers of the markets are also used by banks and exchanges in the settlement of derivatives and financial papers, and by governments for taxation purposes (Fattouh, 2011).

For a grade of oil to assume the role of a benchmark, it must exhibit key characteristics. These include a prolific physical production base, a good geographical location, active spot and paper markets, and favourable tax and regulatory regimes surrounding a benchmark (Fattouh, 2011). Importantly, while a large physical base is an important determinant, the absence of the other factors will prevent a grade of oil from acting as a marker. For example, Saudi Arab Light is far more prolific in terms of its physical base than any other benchmark, but lacks the other important attributes of reference crude (Fattouh, 2011; Energy Intelligence, 2011). On the other hand, the combined production of six marker crudes represents only 3.5% of global supplies (Fattouh, 2011:28).

Formula-based pricing has an additional essential component, namely the differential. This spread is added to or deducted from the benchmark, which sets the price at which a specific grade of oil will be transacted (Fattouh, 2011). This differential is set periodically by producers, and a number of factors are considered in determining the size of such a spread. These include the quality of the grade of oil relative to that of the reference crude, the destination, the mode of transportation, and the prices of competing crudes (Fattouh, 2011; Energy Intelligence, 2011).
gence, 2011). Moreover, the prices of petroleum products at the destination play an influential role in setting the differential (Fattouh, 2011; Energy Intelligence, 2011).

In what reflects the power of the markets, an additional dimension is added to formula-based pricing in the form of the ‘equivalent to buyer’ concept (Fattouh, 2011:23). This principle calls for using the average of the benchmark prices during the period surrounding the offloading of the shipment in the destination. Therefore, this concept introduces a risk sharing dimension to formula pricing, which protects sellers and buyers from substantial variations in prices. Moreover, extending the number of days over which prices are averaged not only serves the risk sharing aim, but also reduces the incentive of sellers or buyers to manipulate prices. A buyer, for example, could drop the remaining stock of crude oil in the few days preceding the arrival of shipment, which could negatively affect prices, especially in less liquid markets.14

A key issue at the heart of the market-based system is the quality of information. This problem was evident during the OPEC administered system, but it has become even more pronounced in the current system (Stevens, 1995). It is a consequence of the dismantling of operational vertical integration, a structure that had been providing almost perfect knowledge on the state of markets (ibid). Examples of this problem are numerous. Information on supply and demand is available with a time lag and subject to adjustments and corrections by providers (Stevens, 1995; 2005; Mabro, 2005; Kilian, 2008b).

This problem also involves the critical issue of excess production capacity, because the collection of relevant data was the subject of an educated guess before 1990 (Kilian, 2008b). While the collection of data on spare capacity became more systematic after 1990, it is neither in the public domain, nor disaggregated by country (ibid). Astoundingly, OPEC has been relying on secondary sources to obtain data, not only on the state of the global markets, but also on its members (Mabro, 2005).

A good example that highlights the problem of information is the estimation of the break-even price below which production in North America would come to a halt. Media and professional reports show wide variations in their estimates. While the International Energy Agency claimed that 96% of US shale production remains profitable at $80 a barrel, estimates

14 Such a scenario is not far-fetched, as a source in the industry pointed out that some European companies used to follow this practice in order to cause prices to decline before the arrival of shipments. In response, the supplier began averaging the prices over the entire month within which the cargo would be offloaded.
reported in a Reuters survey suggest that 33% of production is not feasible at that price level (Reuters, 2014b). Moreover, it is reported that the operating cost per barrel of oil sands stands slightly above $25 (Hermann et al., 2013). On the other hand, Reuters’ survey generated an average marginal operating cost per barrel of oil sands of between $89 and $96 (Reuters, 2014a). These discrepancies are also evident in the cases of the North Sea, Russia, deep water projects, and even the Middle East.15

The problem of the quality and availability of information has given rise to the role of beliefs in trading (Stevens, 2005). It is argued that trading on beliefs has been a contributing factor with regard to the increased volatility in the markets (ibid).16 Additionally, the existence of active paper markets has allowed access for financial traders, who may not possess sufficient experience or knowledge about the industry (Stevens, 1995). Interestingly, Tsvetanov et al. (2013) document the presence of bubbles in oil futures contracts of different maturities; with the longer-dated contracts exhibiting prolonged bubbles that coincided with a sharp rise in institutional investors’ participation. They argue, however, that their findings cannot be explained on the basis of excessive speculation carried out by such institutionalised investors due to the lack of relevant data. Therefore, one could argue that the presence of such traders could amplify the problems that arise from the lack of reliable information, and contribute to the rising volatility (Stevens, 1995; 2005). It is further argued that these problems could have contributed to the rise of the importance of the precautionary component of demand for oil (Baumeister and Peersman, 2013b).

How does the operation of the current market-based system matter for the purpose of the investigations in this thesis? The answer to this question is twofold. First of all, more than one benchmark could be used in pricing oil in one specific market. A good example is the US market, where Brent, WTI, LLS and ASCI are utilised as markers (Fattouh, 2011; Energy Intelligence, 2011; Argus, 2014). The choice of the benchmark matters for suppliers of such a market, because it is a decision that has implications for revenues (Fattouh, 2011). This decision also concerns importers and their refiners, because it affects the cost of imports and subsequently links the choice of benchmark to the issue of energy security. These considerations motivate the investigation into the effect of unplanned production outages on the WTI-Brent

15 See also Arnsdorf (2014) and The Economist (6th December, 2014) for more estimations on shale oil costs and break-even prices, and Dawson (2015) on Canadian sand oil costs and break-even prices.
16 The lack of reliable information, which contributes to rising volatility, is cited as the main reason underlying the creation of the Joint Organisations Data Initiative (JODI) by OPEC and the International Energy Agency among others. JODI is an oil and gas database. See www.jodidata.org/about-jodi/history.aspx
and LLS-Brent spreads. This is because this examination allows for devising policy implications that concern both suppliers and US importers.

Secondly, the problem of quality and availability of information could magnify the effect of unplanned production outages and exogenous political events on the prices of crude oil. While such occurrences could raise doubts on the flow of future supplies, uncertainty could be amplified by the lack of reliable information. This in turn could accelerate a shift in expectations, and trigger a rise in demand on a precautionary basis. It is argued that traders acting on such grounds are very sensitive to the heightening of uncertainty (Adelman, 1990; Baumeister and Peersman, 2013b). Put simply, the current market-based system and its underlying problems represent an additional justification for the examination of the behaviour of oil prices on and around the start dates of violent conflicts, sanctions, and unscheduled production disruptions.

2.4 Oil, Violent Crises, Disruptions, and Sanctions: The Political Risk Dimension

The outbreak of a war and the start of a sanctions programme could be perceived as a materialisation of political risk. On the other hand, unplanned disruptions in production may either be the materialisation of such a political risk, or could lead to political consequences. What adds further to these events is the strategic political importance of crude petroleum. This is epitomised in the role that this commodity has been playing in shaping the international political landscape in times of peace and war. Thus, an elaboration on what constitutes political risk is provided in the following subsection, while a discussion of how oil has been at the forefront of political agendas is presented in subsection 2.4.2.

2.4.1 Political Risk: Definitions and the Various Aspects

Globalisation and the integration of capital markets have been facilitating the expansion of businesses across national borders (Bilson et al., 2002). While these trends have brought their blessings, they have also had their antidotes in the form of exposure to various types of political risk (Bilson et al., 2002; United States Joint Forces Command, 2010). The differences in the sources of risk, the nature of activities that are exposed to such a risk, and the outcomes, all lead to viewing and examining political risk from various dimensions. Put differently, the dimension through which political risk can be examined depends on the nature of the party involved (Busse and Hefeker, 2007). Consequently, various definitions have been advanced. These range from an overarching definition that encompasses all possible causes and out-
comes, to a relatively more confined definition that focuses on specific sources and consequences.

A concise view divides political risk into two. The first type is transfer risk. This comprises restrictions on imports and currency transfers, hardening of environmental standards, and the expropriation of revenues (Keillor et al., 2005). The second is ownership risk, which arises from the possibility of nationalisation, forced joint venture, or changes in local ownership requirements (ibid). Apparently, these two types of political risk adopt the perspective of a specific class of international investors. Consequently, they do not take into consideration other possible outcomes such as the effect on the valuations of different assets.

A broader definition describes political risk as ‘the possibility that political decisions, actions, events, or conditions in a country, including those that might be referred to as social, will affect the business environment such that investors will lose money or have a reduced profit margin’ (Howell and Chaddick, 1994:71). This risk could emerge from politically-driven changes in the environment, which result in hard to anticipate discontinuities in business operations (Robock, 1971; cited in Cosset and Suret, 1995). More specifically, political risk comprises political processes that stem from changes in government policies, wars, or political violence, which affect a business entity’s personnel, assets and operations (Jodice, 1985; cited in Bilson et al., 2002). What one can infer from these definitions is the dynamic nature of political risk. It has different facets, emerges from political processes and complex events, and leads to various outcomes for numerous parties through different channels. Perhaps, understandably, many theoretical and empirical examinations have attempted to explore the dynamic nature of this risk and the underlying interaction among its components. Consequently, the body of literature is diverse.

A group of researchers have attempted to explore the nature of the effect of national elections on the valuations of assets and economic variables. The aim of these investigations was either to capture the presence of politically-driven cycles, or explore whether such events have an explanatory power for changes in returns and volatility. Another set of examinations focuses its attention on the impact of political conflicts on asset prices. Other research examines the explanatory power of the estimates of different aspects of political risk. This group also includes examinations of the effect of the various political risk attributes on foreign direct investments and capital flights. A fourth group investigates the effect of political risk on the development of financial markets.
A general consensus on the importance of political risk and political events is evident in the literature. The attention of the media renders political events their relevance for market participants. These events attract media outlets and analysts, which offer financial markets filtered information on political developments (Pantzalis et al., 2000). Consequently, expectations are aggregated and reflected in the valuations of equity markets (Herbst and Slinkman, 1984). An additional reason for the relevance of political risk for asset pricing is the limited ability of the fundamentals to explain changes in the valuations of assets. This gives rise to the importance of examining the capacity of political events or processes to explain variations in asset prices (Wisniewski, 2009; Wisniewski and Moro, 2014).

A number of researchers have provided interesting insights on various aspects of the relationship between economic metrics and national elections. For example, Herbst and Slinkman (1984) document a four-year cycle in the returns on US equities, which peaks in November of the presidential election years. A more specific empirical investigation reports significant differences in the returns on US financial assets between Republican and Democratic administrations (Hensel and Ziemb, 1995). However, the evidence on the relationship between returns and the political orientation of the incumbents is not conclusive. Bialkowski et al. (2007) examine 24 stock markets and 173 different governments, but do not report a significant association between political orientation and equity valuations. A similar finding is reported by Döpke and Pierdzioch (2006) in the case of Germany.

The effect of national elections is not confined to returns. Bialkowski et al. (2008) examine 134 elections in 34 industrialised nations, and report a significant increase in volatility around election dates. The determinants of the magnitude of election-induced volatility are a narrow margin of victory and failure to form a majority government (ibid). Additional insights are provided by Julio and Yook (2012). They examine 248 national elections in 48 countries, and capture cycles in corporate capital expenditure associated with these elections. Specifically, Julio and Yook (2012) report a 4.8% average decline in capital outlays during the period leading up to elections.

Other empirical investigations focus on exploring the explanatory power of political risk. For example, Wisniewski (2009) documents the ability of political factors to explain the deviations between predictions from present value models and actual US stock prices. Further evidence shows that even political communications can explain variations in returns. Wisniewski and Moro (2014) examine whether certain attributes of the communiqués issued by the
European Council meetings have explanatory power for changes in returns around the dates of such meetings. They find the answer to be affirmative. The capacity of politics to explain changes in the valuations of equities is not confined to developed markets. Bilson et al. (2002) report that the explanatory power of political factors is more pronounced in emerging markets than in their developed counterparts. Similarly, Diamonte et al. (1996) show that political risk appears to be an important determinant of the valuations of equities in emerging markets.

The importance of political risk is also reflected in its effect on the development of financial markets. For example, a decline in political risk can be associated with a growth in stock market capitalisation, and a rise in trading volumes (Perotti and Oijen, 2001). However, a conduit is required for the improvement in political risk to materialise. Perotti and Oijen (2001) show that sustainable and rigorous privatisation programmes can contribute to reducing political risk. This is because such programmes test the will of policy makers to reform and adopt a market-oriented regime (ibid). Yarty (2008) highlights a similar finding by examining 42 emerging countries. Yarty shows that improvements in the quality of institutions contribute to a resolution of political risk, which, in turn, positively affects growth in market capitalisation.

Moreover, and perhaps unsurprisingly, political risk and its various facets are important factors affecting foreign direct investments (FDIs). Busse and Hefeker (2007) document significant growth in FDIs in countries that have more stable governments; less risk of internal and external conflicts; more democratic accountability, and a higher quality of law and order. In a similar vein, Vu Le and Zak (2006) investigate the association between capital flights and different components of political and economic risk. They report a significant rise in such flights away from countries suffering from violent uprisings, heightened political uncertainty, and a rise in economic risk.

For the purpose of the investigation in this thesis, a more relevant body of literature is that focusing on the effect of wars and international conflicts on the valuations of assets. The war in Iraq has attracted considerable attention. In this context, empirical examinations show that the war in Iraq was associated with a significant decline in the returns on equities, and a rise in oil prices (Leigh et al., 2003; Rigobon and Sack, 2005). A more comprehensive examination that includes a wider set of conflicts reaches a similar conclusion (See Berkman et al., 2011). Further evidence supports the ability of the prices of assets to echo political and mili-
tary developments. For example, the valuations of government bonds are shown to reflect not only diplomatic efforts, but also developments in the battlefields of the Second World War (Frey and Kucher, 2001; Brown and Burdekin, 2002).

The discussion above gives rise to the question of why political processes and events have an effect on prices. A number of hypotheses have been advanced in an attempt to answer this key question. In the context of the relationship between elections and economic metrics, Nordhaus (1975) proposes the presence of a politically-induced business cycle. Simply put, incumbents attempt to increase their chances of re-election by adopting myopic political and economic policies during the period leading up to elections. Such policies translate into cycles in the returns on equities (Herbst and Slinkman, 1984; Hensel and Ziemba, 1995).

A similar hypothesis is advanced by Bertrand et al. (2007). They link the cycle in the valuations to decisions taken by publicly-traded firms. Politically-connected chief executive officers of such businesses undertake measures, such as increasing the number of employees, in order to help the current incumbents. In general, the design of the political system appears to play an important role in allowing such short-sighted policies to be pursued by politicians. The German political system is designed in a manner that makes it harder for the incumbents to adopt such policies; hence there is an absence of such politically-driven cycles in German equities (Dopke and Pierdzioch, 2006).

While these two hypotheses are helpful in understanding the presence of above average positive returns around the election period, they are less successful in explaining negative returns. A comprehensive approach that could explain the swings in valuations in both directions is based on the heightening and resolution of uncertainty. This hypothesis postulates that firms can delay capital expenditures due to uncertainty regarding the outcomes of elections (Julio and Yook, 2012). Also, investors may require a higher risk premium, which increases the discount rate applied in evaluating the feasibility of expenditures (Busse and Hefeker, 2007). On the other hand, the resolution of uncertainty towards the future incumbents could explain the positive abnormal returns of equities on and directly around the election day (Pantzaslis et al., 2000).

One may argue that while market participants could be uncertain about the outcomes of a national political process or event, investors could face higher uncertainty during wars and international conflicts. These complex events could lead to significant disruptions of economic ties (Frijns et al., 2012). Moreover, wars, violent events, and sanctions are all shown to
have a significant negative effect on economic output (Nordhaus, 2002; Blomberg et al., 2004; Hufbauer et al., 2007; Institute for Economic and Peace, 2011). However, while such events bring to bear significant costs in terms of blood and treasure, accurate estimations of such costs are only attainable in hindsight (Nordhaus, 2002; United States Joint Forces Command, 2010).

Moreover, history is littered with tragic examples of numerous nations engaging in conflicts based on faulty calculations regarding the outcomes. Such miscalculations can arise from the incompetence of policy makers, their ambivalent sense of the actual power of an adversary, or from making the wrong assumptions (Tuchman, 1984; Nordhaus, 2002). Consequently, knowledge of this history can exacerbate uncertainty rather than alleviate it. Put simply, investors have to discount gloomy economic metrics that could be brought to bear by violent crises and sanctions. The uncertainty that market participants face suggests that a higher discount rate will be applied due to higher risk premia (Busse and Hefeker, 2007; Frijns et al., 2012).

To summarise, evidence points to the importance of political risk in asset pricing and the development of financial markets. This forms a motivation that underlies the choice of events that are either political per se, such as wars and sanctions, or that have political roots and consequences. In the context of such events, crude oil appears to be a natural candidate for an investigation. While the fundamentals and prices of oil are affected by political events, its revenues and the imbalance in the distribution of reserves attract and cause political risks. Consequently, the three empirical investigation of this thesis contribute to an understanding of this commodity’s capacity to act as a financial shelter, and- perhaps ironically- to cause economic pain.

2.4.2 Crude Oil and Politics: A Relationship Bound to Continue

The strategic importance of oil stems from the wide uses of its products in the various facets of civilian life, and from the role it has played in warfare. Thus, economic and military considerations give rise to the overarching concern of the security of supplies. The global nature of this commodity means that securing sources of supplies is a matter of pride, image, and political and economic supremacy for major powers. The ethos of major powers’ quest for control of oil is epitomised in the US ‘Carter Doctrine’ in the Middle Eastern Gulf (Klare, 2008). The basic tenet of the doctrine postulates that the US should be the ultimate military power in that region. Failure to do so could mean that another nation would fill the void of
power. In turn, that nation might use its supreme military position in the region to cripple the US and the world economy (ibid).

Historically, the fossil fuel has been used in warfare for thousands of years. The Trojans, the Persians, and the Byzantines, all used it on their battlefields (Yergin, 2012). However, it was not until the 20th century that its significant political and military status emerged. The military developments on the battlefields of the First World War were decisive in rendering oil its significance. Most notably was the decision taken in the First Battle of Marne in 1914 to deploy a Parisian taxi armada in order to mobilise troops to the front lines (ibid). Ultimately, the victory in the Great War was said to be floating ‘upon a wave of oil’, to use the words of Lord Curzon (cited in Yergin, 2012: 167).

However, it was not until the outbreak of the Second World War that the political and military importance of oil culminated. One of the ironies of this war was the role of oil in instigating and subsequently in sealing the fate of battles. The second German attempt to invade Russia in 1942 was aimed mainly at capturing the oil fields of the Caucasus (Energy Intelligence, 2011; Yergin, 2012). The vitality that was assigned to that operation meant that the Germans could not relocate troops to assist the besieged 6th army in Stalingrad (Yergin, 2012). Furthermore, the German tanks in the battle of Stalingrad had to bridge a gap of 30 miles to break from the siege; the oil in the tanks was barely sufficient for a 20-mile journey, however (ibid).

The Japanese experience with oil in the period leading up to and during the Second World War was no less ironic. It is argued that one of the reasons behind Japan’s decision to wage a war was the oil embargo imposed by the Americans, which was perceived as an ultimatum (Energy Intelligence, 2011; Yergin, 2012). While the attack on Pearl Harbour was planned to deal a decisive blow to the US navy, it is argued that capturing the oil fields of the East Indies was the implicit objective (Yergin, 2012). Ironically again, the Japanese aborted the third wave of attacks on Pearl Harbour, the aim of which was the destruction of the Pacific fleet’s petroleum storage facilities. By the end of the war, Japan had effectively become blockaded by the Americans. The shortages of oil, caused by the blockade, severely affected the Japanese military efforts (ibid).

Since 1945, the quest for the control of oil has been frantically swinging between political and economic objectives. A good example emerged at the start of 1950s in the form of collusion between government and business interests in response to the nationalisation of Iran’s oil sector by Mussadaq. The British and American intelligence services jointly conducted Opera-
tion Ajax, which succeeded in toppling Mussadaq; restoring the role of the Shah; and resuming the foreign operations in Iran’s oil fields (Klare, 2008; Yergin, 2012). The Consortium for Iran, or the Seven Sisters, was formed following these events (Klare, 2008; Energy Intelligence, 2011; Fattouh, 2011; Yergin, 2012).

Politics continued to shape the developments in the oil markets and the industry. Since the 1970s, OPEC’s name has become synonymous with shocks to oil prices. These hikes were associated with political events in which members of OPEC were embroiled. One such price shock was associated with the decision of OPEC’s Arab members to impose the infamous embargo on the West (Fattouh, 2011; Yergin, 2012). The second price shock came as a response to the fall of Iran’s Shah, and the outbreak of the Iraq-Iran war, while the 1990 Iraqi invasion of Kuwait gave rise to a third hike in oil prices.

A number of factors and trends have underlined the continuity of the role of politics in the oil markets for decades. First of all, the dependence on crude petroleum in warfare has been increasing since the end of the Second World War. The rise in military consumption has been driven by the increased mechanisation of warfare technologies; long distance mobility requirements; and the rough nature of terrain in war theatres (Deloitte, 2009). In what appears to be the creation of a vicious circle, the increased dependence on oil has heightened the need for logistics and lengthened their chains (ibid). This has meant that more oil is required just to sustain the logistical efforts (Deloitte, 2009; Schwartz et al., 2012). For example, while the fuel consumed by the US air force in air combat operations stood at 31% in 2011, mobility and logistics accounted for 64% of the consumption in that year (Schwartz et al., 2012).

Thus, it may not come as a surprise to know that the US Department of Defence is the largest institutional buyer of oil in the world (Schwartz et al., 2012). Moreover, fuel consumption per US solider per day in the conflicts in Iraq and Afghanistan has increased by a staggering 175% from its level in the war in Vietnam (Deloitte, 2009). The dependence on oil not only gives rise to logistical challenges, but can also have significant human costs as the long logistical convoys become more prone to attack (Deloitte, 2009; Schwartz et al., 2012).

Secondly, the significant dependence on crude oil in civilian and military areas has driven the race among major powers towards securing a foothold in oil-rich regions (Klare, 2008; United States Joint Forces Command, 2010; Khanna and Chapman, 2010; Colgan, 2011). More specifically, this competition has materialised in the civilian and military presence of major powers in order to ensure the safety of facilities and modes of transportation (Klare,
2008; United States Joint Forces Command, 2010). Additionally, the race among major powers is driven by the quest for control, or even denying it to others (Klare, 2008). For example, this competition has culminated in the Middle-Eastern Gulf being termed an ‘American Lake’ due to the unquestioned naval supremacy there of the US (Klare, 2008: 177).

Moreover, international oil companies and major net importing nations have been diversifying sources of supply away from the turbulent region of the Middle East (Klare, 2008; Energy Intelligence, 2011; Hermann et al., 2013). While diversification has its blessings, it also has its problems. Ironically, the quest for new reserves has driven the international oil companies to explore technologically challenging territories, and operate in geopolitically complicated regions (Klare, 2008; Energy Intelligence, 2011). The attention of governments has either followed or accompanied that of businesses. For instance, the abundance of oil in Africa and the presence of international companies were among the essential factors behind the formation of the US Africa Command in 2007 (AFRICOM) (Klare, 2008).

Thirdly, the role of major powers has not only been confined to a physical military presence, but also as exporters of conventional weapons to the oil-rich countries. On the one hand, the US, Russia, France, UK, and China are the top five suppliers of conventional weapons to the developing world, based on their average share of total supplies between 2004 and 2011 (Grimmett and Kerr, 2012). On the other hand, and in terms of the average value of deals between 2004 and 2011, four members of OPEC rank among the top ten purchasers of arms. In particular, Saudi Arabia was the largest buyer between 2004 and 2011, with an average share of 22% of all arm transfers (ibid).

On the one hand, the transfer of arms from major powers to oil producers could be commercially driven. This is because such trade represents a source of financing for the military industrial complexes, and re-channels the revenues from the producing to the consuming nations (Klare, 2008; Khanna and Chapman, 2010). Additionally, one may argue that exports of arms could subsidise the costs of direct military presence. It is estimated, for example, that the cost of the US military deployment in the Middle East was between $28 and $36 billion per year during the 1980s, and $30 to $51 billion per year during the 1990s and early 2000s (Duffield, 2007:182).

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17 Before 2007, the US has been managing its forces through five Unified Combatant Commands. One of which, the Central Command, has the responsibility of securing the flow of oil from the Middle East (Klare, 2008).
Furthermore, supplying weapons could be a tool to allure oil-rich nations to cooperate and secure a foothold for the suppliers of arms (Klare, 2008). Moreover, the dependence of oil producers on the revenues from oil is an additional motive for building-up an arsenal of weapons for defensive purposes (Khanna and Chapman, 2010; Colgan, 2011). Importantly, these trades could be the manifestation of an institutional arrangement between oil-rich nations and major powers. The ultimate aim is to secure the flow of oil supplies and its prices, an objective shared with oil producing countries (Klare, 2008; Khanna and Chapman, 2010). Khanna and Chapman (2010) argue that this arrangement explains their empirical finding of the significant positive association between arms exports and oil imports on the one hand, and arms imports and oil exports on the other.

A fourth factor that contributes to the politics of oil is the nature of the regime in an oil producing nation, which can determine how oil revenues are used. Revenues accrued from oil exports can act as an incentive for the regime to formulate and execute peaceful foreign policies. On the other hand, these revenues can change the rulers’ risk preferences, or motivate aggressive cross-border policies. Such propensity for aggression is what Colgan (2011:1669) refers to as ‘resource-backed aggression’. In this context, a revolutionary regime can utilise oil revenues to build-up an arsenal of weapons and instigate conflicts (ibid). Such actions can cause physical disruptions in oil supplies.

Fifth, the use of oil revenues in pursuing foreign policy objectives or for the self-aggrandisement of rulers means that less wealth trickles down towards local development (Collier and Hoeffler, 2004; Klare, 2008). This gives rise to grievances that can develop into protests and violence. A case in point is Nigeria, where oil facilities have been subjected to attacks by insurgents (Klare, 2008; Energy Intelligence, 2011). Additionally, a rebellion or domestic insurgency could be driven mainly by profiteering motives. Collier and Hoeffler (2004) show that exports of a primary commodity significantly heighten the risk of internal conflict. They argue that an insurgency could become feasible, or even a profitable venture, through the extortion of natural resources.

Finally, a significant factor that could have critical ramifications for the politics of oil is the astonishing economic rise of emerging nations, particularly China and India. The impressive performance of the Chinese economy has meant a rise in the demand for crude petroleum and products. Consequently, China has been active in diversifying its sources of supply, which has led Chinese government-owned companies to Africa (Klare, 2008; United States Joint Forces
Command, 2010). Operating in some contentious countries requires the presence of Chinese personnel to protect the oil facilities, a development that may lead other nations to follow suit and intervene in Africa in the future (United States Joint Forces Command, 2010). Moreover, the awareness of the Chinese strategists of the ability of the US navy to shut down maritime imports of energy has underlined the hunt for oil shipments via pipelines from Russia and the Caspian (Klare, 2008; United States Joint Forces Command, 2010).

The extent to which the rise of China and India will have an effect on the oil markets and international political stability is conditioned by their willingness to cooperate, rather than compete (Klare, 2008). In particular, in the case of China, the future of the oil markets and international politics depends on the strategic course that China takes vis-a-vis the US; i.e., cooperation or competition (Klare, 2008; United States Joint Forces Command, 2010). However, the latter argument is advanced from an American point of view. Worryingly, it is a view that places the burden of the future on Chinese shoulders.

One may argue that the future course of events also depends on the extent to which the US is willing to accommodate China’s ambitions. This is because the US appears to have the most to share, or even to lose, due to the rise of China. As the Athenians argued in the their negotiations with the Spartans, ‘we have done nothing extraordinary, nothing contrary to human nature in accepting an empire when it was offered to us and then refusing to give it up. Three powerful motives prevent us from doing so—security, honour, and self-interest’ (Thucydides, 5\textsuperscript{th} century BC, cited in United States Joint Forces Command, 2010: 6).

In summary, the discussion above highlights evidence on the role of politics in shaping the developments in the oil markets. There is an element of self-fulfilling prophecy or vicious circle in the relationship between oil and political processes and events. While the military presence of a major power in an oil-rich region is intended to secure the flow of the fossil fuel, it gives rise to more tension. By the same token, an oil exporting nation could accumulate weapons in order to defend itself from foreign ambitions. However, this arsenal could also increase the propensity for aggression. Thus, it becomes imperative to examine crude oil valuations around events that are either political in nature, or could have political consequences. This is a primary motive for investigating the behaviour of crude oil returns during international violent conflicts, OPEC unplanned disruptions, and US sanctions.
III. Crude Oil as a Safe Haven Asset during International Conflicts

Abstract

This chapter examines the changes in the valuations of crude oil and equity markets around the start dates of violent international conflicts and wars. The findings show that the fossil fuel registers significant positive abnormal returns on and around the outbreak of crises. This is in stark contrast to the significantly negative abnormal behaviour of equities during the same events. These findings suggest that crude oil could have a role to play in diversifying away and hedging against risk associated with conflicts. This possibility is confirmed by formally examining the safe haven characteristic of oil, and showing that the hydrocarbon fuel does indeed perform as a financial shelter from stock markets during conflicts.

3.1 Introduction

Over the course of its history mankind has been realising marvellous accomplishments from enhancing the quality of life to conquering space and understanding the cosmos. However, the use of violence in settling disputes among nations points to a startling, but recurring irony that has been independent of time and place (Tuchman, 1984). This is because the reservoir of human and physical capitals which have been accumulated over decades can be demolished by wars in a few days, months, or years (Deger and Smith, 1983; Cappelen et al., 1984; Nordhaus, 2002). Whether the act of violence is due to a failure in bargaining among nations, or misgovernment in the form of over- or underestimating the cost of actions, it remains true that ‘war is the ultimate negative-sum game in which the spoils of the victors are much less than the losses of the vanquished’ (Nordhaus, 2002:41).

The ripples of war not only manifest themselves in bloodshed and destruction, but can also be felt in financial markets (Berkman et al., 2011). Thus, a possible avenue in researching the effects of wars is to examine the behaviour of asset prices during such episodes. Additionally, it becomes an imperative to investigate whether there are assets that could serve as a shelter for investments that might be negatively affected by the outbreak of violent conflicts. This chapter instigates this particular hypothesis. Specifically, the chapter examines the nature of the behaviour of crude oil and equity valuations around the start dates of violent international conflicts and wars. The chapter goes a step further and explores the ability of crude oil to act as a safe haven asset for investors in equity markets during such events. The decision to ex-
plore the behaviour of the prices of these assets and the safe haven property of the fossil fuel is based on a number of reasons.

First of all, the gushing of oil from the wells of Pennsylvania marked the beginning of the era of significant dependence on the hydrocarbon fuel. Its derivatives have been propelling our modes of transportation and have been utilised in various products from detergents to perfumes. Thus, the empirical evidence on the detrimental effects of oil price shocks on the economies of nations may not come as a surprise (Gisser and Goodwin, 1986; Ferderer, 1996; Abeysinghe, 2001). For example, Hamilton (1983) shows that seven out of eight recessions in the US after World War II followed a hike in the price of crude petroleum.

Second, and perhaps unsurprisingly, the strategic importance of crude oil in the heart of the global economic system has brought its curse. This is because oil revenues have prompted inter-state conflicts and accumulation of weapons, and fuelled foreign policy adventurism (Fearon and Laitin, 2003; Collier and Hoeffler, 2004; Khanna and Chapman, 2010; Colgan, 2011). Additionally, the face of warfare has changed since the First Battle of the Marne, which marked the first use of the internal combustion engine in the mobilisation of troops on a grand scale (Yergin, 2012).

The role of propelling the machines of war, metaphorically and literally, further increased in World War II, when the hydrocarbon fuel literally sealed the fate of battles (Liddell-Hart, 1953; Yergin, 2012). In that war, the crippling shortage of fuel endured by the Japanese due to the effective US blockade affected even their ability to train their pilots (Yergin, 2012). These conditions culminated in the deployment of the suicide aerial attacks by the Japanese in the Battle of Leyte Gulf. These attacks addressed the problem of insufficient training, saved the fuel needed for the return trip, and caused the maximum possible damage under the prevailing conditions. The importance of the fossil fuel in warfare has intensified, as evidenced by the 175% increase in fuel consumption per US soldier per day between the Vietnam conflict and the wars in Iraq and Afghanistan (Deloitte, 2009).

The above highlights the importance of investigating how asset prices act during violent international conflicts and wars. It also points to the significance of exploring whether crude oil can act as a shelter for investors, if and when equity markets tumble due to the outbreak of such events. Critically, the integration of financial markets within or across national borders may mean a reduction in the diversification benefits, because shocks could be transmitted from one market to another (Arshanapalli and Doukas, 1993; Koutmos and Booth, 1995; As-
gharian and Nossman, 2011). The latter could mean that the negative effects of violent crises on the valuations of assets are exacerbated. It further underlines the necessity to investigate the safe haven property of crude petroleum.

This chapter documents a number of interesting results. Firstly, the findings show positive and significant abnormal behaviour in the valuations of oil around the start dates of 49 violent international conflicts. Also, the chapter shows that this abnormal behaviour is more pronounced around the outbreak dates of 32 wars and the most violent crises. Leigh et al. (2003) and Rigobon and Sack (2005) document a rise in oil prices in response to the rising prospects of a war in Iraq. Thus, the results of this chapter can be generalised to a wider sample of violent international conflicts and a subsample of wars. Secondly, perhaps the most startling finding on this abnormal behaviour pertains to its timing. The significant portion of abnormal returns accumulates well before the start of conflicts. A number of factors could help justify these findings.

To begin with, the rise in crude oil valuations could be the manifestation of a rise in demand from market participants on a psychological basis (Terzian, 1985). Alternatively or additionally, speculative stockpiling may take place by informed traders or those reacting to rising tensions. Kilian and Murphy (2013) show evidence that the latter was evident during the months preceding the Iraqi invasion of Kuwait. Thirdly, the significant reliance on the hydrocarbon fuel in warfare suggests that governments may rationally ramp up their stocks of oil in anticipation of the outbreak of war with an adversary. Such rational stockpiling could also be conducted by other governments as part of measures to ensure their nations’ energy security. The latter may take place especially in the face of a looming crisis that could result in cutting supplies or hindering flows through the maritime chokepoints, such as the Strait of Hormuz.

In relation to stock markets, the chapter shows that US and international equities register a significant decline around the start dates of violent crises and wars. This result provides further support to previous findings on the negative impact of international conflicts and political risk on equities (see for example; Rigobon and Sack, 2005; Wisniewski 2009; Berkman et al., 2011). An astonishing finding is that on the timing of that abnormality. The significant portion of abnormal behaviour in the American and international equity indices occurs after the start of the events. This is in stark contrast to the timing of abnormal returns on oil. Thus, the findings suggest that investors in stock markets may not be as informed as their counterparts in oil markets.
The findings above on the contrasting behaviour of oil and equities give rise to the possibility to use the fossil fuel in diversification. Thus, the chapter adopts the definition of a safe haven asset that is advanced by Baur and Lucey (2010), and documents the ability of crude petroleum to provide shelter for investors in US and international equity markets around the start dates of violent crises and wars. These latter findings open the door for the potential use of oil in diversifying holdings of equities. Such measures could be facilitated by the presence of vibrant paper markets and exchange traded funds (ETFs) in which oil is the underlying asset. Rather than investing in the spot markets of oil, which could entail the inconvenience of taking physical deliveries and storage, investors could go long on futures contracts or ETFs in which oil is the underlying asset.

The remainder of the chapter is organised as follows. The next section reviews the related literature. Section 3.3 elaborates on the International Crisis Behaviour (ICB) database, as well as on the financial series used in the study and their summary statistics. Section 3.4 describes the methodological approach. Results of the event study analysis and safe haven tests are reported in Section 3.5. The final section concludes the chapter and considers practical implications for investors.

**3.2 Literature Review**

**3.2.1 Valuations of Assets during Wars and Conflicts**

The devastating nature of violent conflicts has attracted the attention of researchers in financial economics who examined the effect of such events on asset prices. Broadly speaking, these investigations focus either on the Iraq war of 2003, or the Second World War (WWII). The contribution of this chapter lies firstly in examining a wider sample of events in order to capture the magnitude and timing of abnormal returns of crude oil and equities. Secondly, it explores whether the fossil fuel acts as a financial shelter from stock markets.

The war in Iraq offered a rare opportunity for empirical investigations due to the presence of tradable contracts via a betting platform. These contracts allowed the participant to bet on the probability of Saddam’s fall from power. It has been argued that the prices of the so-called ‘Saddam contracts’ reflected the perceived probability of a war in Iraq (Leigh et al., 2003; Wolfers and Zitzewitz, 2009). Wolfers and Zitzewitz (2009) examine these contracts, and show that the rise in the probability of war is associated with a significant decline in the valuations of equities and an increase in the prices of oil. More specifically, they document a de-
cline of 1.5% in the S&P500, and a rise of $1 per barrel of oil, with a 10% rise in the probability of war.

The rise in the probability of Saddam’s fall may not necessarily suggest an increase in the likelihood of war. This issue has been highlighted by Amihud and Wohl (2004), who examine the prices of these contracts before and during the war. On the one hand, a rise in the prospects of Saddam’s fall could mean a quick conclusion to the war, and therefore a less costly conflict. On the other hand, the increase in the probability of Saddam’s fall could mean uncertainty regarding the length of the war and its costs. However, Amihud and Wohl (2004) suggest that a rise in these probabilities during the war could imply a quick end to the conflict. They empirically show that prices of equities increased, while those of oil decreased with the rise in prospects of the fall of Saddam from power during the war. Before the outbreak of war, however, they report statistically insignificant changes.

The conflicting interpretation of the changes in probabilities offered an incentive to Rigobon and Sack (2005) to examine the impact of the Iraq war from a different perspective. They compile war-related news, aggregate them into a war risk variable, and examine the behaviour of oil and other US financial assets. Rigobon and Sack document a decline in equities, a widening in corporate yield spreads, a surge in oil prices, and a decline in Treasury yields. More specifically, they report a 2.9% rise in the 12 months oil futures prices and a decline of 4.8% in S&P500, both accompanying the increase in war risk.

A more comprehensive attempt to explore the effects of conflicts on the valuations of assets is conducted by Berkman et al. (2011). They source their data from the International Crisis Behaviour Database, and investigate the effect of numerous international political crises on world stock markets. Their findings reveal the devastating effect that conflicts could exert on prices of assets. The crises that they examine are reported to have caused an almost 4% decline per annum in the prices of equities. Interestingly, they show that a belligerent nation witnesses a 2% decline in its equity market at the outbreak of the conflict. It is worth noting that the empirical investigation in this chapter differs from that of Berkman et al. (2011) in two aspects. In this chapter, I employ a different methodological approach in order to capture the behaviour of valuations, and I further perform a test on the safe haven property of oil from stocks around the outbreak of violent crises.

As noted earlier, WWII has attracted the attention of a number of researchers. This has been primarily because of the availability of data on sovereign bonds for some of the nations
involved in that war. These were a series of government debts that had been issued and traded in the markets of Zurich, Stockholm and London, which remained operational during the hostilities. Among these empirical studies is that of Frey and Kucher (2000), who examine whether the valuations of German, Austrian, French, Belgian, and Swiss bonds reflected the developments of WWII. They answer in the affirmative. Their findings show significant declines in the prices of bonds at the outbreak of the war, and when any of the issuers lost sovereignty. The prices of these bonds are found to reflect other major developments, such as the American entry into the war, and the major Soviet counter-offensive.

Brown and Burdekin (2002) consider a similar question, but utilise a unique dataset of two special issues of German sovereign bonds that had been traded in London. Their findings show that the prices of these bonds not only reflected major military developments, but also diplomatic endeavours. Further supportive evidence is advanced by Waldenström and Frey (2002), who examine government bonds of various belligerents that had been actively traded in Stockholm. They show that the prices of these bonds reflected the major events of the war, such as its start and the loss of national sovereignty. Waldenström and Frey report that the Battle of Stalingrad was the most prominently influential event.

In sum, the empirical investigation above suggests two primary conclusions. The first is that prices of assets appear to be reflective of conflicts. Second, the evidence highlights that wars and political crises can have a significant effect in economic terms on the valuations of these assets. The inspiration for this chapter is to use a more comprehensive sample of wars and violent international conflicts, and explore how the values of oil and equities behave around the start of such events. This informs the second aim of this chapter, which is to investigate whether crude petroleum offers a financial shelter from stock markets during hostilities.

3.2.2 Safe Haven Assets: A Financial Shelter during Times of Distress

The discussion of the effect of wars and international political crises highlights the importance of investigating the presence of assets that can act as safe havens for investors during hostilities. Exploring the ability of an asset to act as a financial shelter has, in general, attracted relatively little academic attention. Moreover, the lion’s share of this body of literature focuses its efforts on examining the safe haven property in currencies, bonds, and precious metals mainly during periods of financial distress.

A number of researchers investigate the ability of some currencies to act as safe havens from other assets that are going through tumultuous times. One approach in this direction of
research is to examine whether the changes in liquidity in specific markets correspond to a period of turmoil or heightened uncertainty. This avenue is based on defining a safe haven as a highly liquid asset with low risk (Upper, 2000). An additional definition complements the former and suggests that safe havens are assets that investors purchase during periods of heightened uncertainty (McCauley and McGuire, 2009).

For example, Meurers and Diekmann (2007) argue that financial assets denominated in US dollars enjoy high liquidity and diversity, which underline their ability to shelter investors from turbulence in exchange rate markets. Flows into safe havens are not confined to US dollar denominated assets, however. Upper (2000) examines the liquidity of the German government bond markets during the economic turmoil in Russia during the summer and autumn of 1998. Upper (2000) reports that the average purchases per month of German government bonds by non-residents stood at 11.4 billion DM in the first half of 1998. However, that figure rose significantly to 34.5 billion DM in July and August 1998 in the wake of the de facto default of Russia.

A notable empirical investigation that builds on the aforementioned definitions is Kaul and Sapp (2006). They investigate the liquidity in the Euro-US dollar spot and forward markets around the new millennium. Their findings document significant changes in the liquidity in these markets around that time period, which they associate with safe haven flows into the US dollar. Additional support is provided by Meurers and Diekmann (2007) who show that the US dollar exhibited the safe haven property between 1989 and 2006.

Moreover, Ranaldo and Söderlind (2010) use 16 years of high frequency data, and document that the Euro, Japanese yen, and Swiss franc all show characteristics of a safe haven asset. More specifically, they show that these currencies exhibit an inverse relationship with FX volatility and international stock markets. Habib and Stracca (2012) examine the ability of currencies to act as a financial shelter from a different perspective. They specifically examine the underlining factors that would render a currency a safe haven. Habib and Stracca (2012) show that the most notable driver is a country’s Net Foreign Assets (NFA) position, which represent a proxy for that nation’s external vulnerability. More specifically, they demonstrate that a country’s currency exhibits more characteristics of a safe haven, the less externally vulnerable the nation is.

Within the body of literature are researchers who build their examination on a more specific view of what constitutes a safe haven asset. Baur and Lucey (2010) are the first to offer a
definition that is not only direct, but also measurable and operational. They begin by advancing the notion that a hedge is an asset that is negatively correlated or uncorrelated with another asset on average. On the other hand, for an asset to be a safe haven it should be negatively correlated or uncorrelated with another asset only in times of turmoil. They build on these definitions, and investigate whether gold acts as a hedge or safe haven for stocks and bonds in the US, UK and Germany. Their findings indicate that gold acts as a hedge for stocks in the US and the UK only, while its ability to perform as a hedge for bonds is evident for Germany alone. Moreover, they document the safe haven property of gold from the three stock markets. However, this ability is not evident during extreme conditions in bond markets.

The importance of the contribution of Baur and Lucey (2010) is reflected in the subsequent research that adopts their definitions and empirical approach. Baur and McDermott (2010) build on the proposed definitions of Baur and Lucey (2010), and show that gold acts as both a safe haven from, and hedge against, stock markets in the US and major European markets. They further document that during the recent financial crisis gold acted as a strong safe haven for investors in stock markets of the most developed countries. On the other hand, Lucey and Li (2014) document the ability of silver, palladium, and platinum to act as safe havens from US markets, when gold fails to do so.

Other researchers have also adopted the definitions of Baur and Lucey (2010), and focused their examination on gold and exchange rate markets. Here, however, the evidence is not conclusive. For example, Reboredo (2013) documents the ability of gold to act as an effective safe haven from, and hedge against, US dollar exchange rate movements. Similarly, Ciner et al. (2013) show that the ability of gold to act as a safe haven is most evident during extreme movements in US dollar exchange rates. On the other hand, Joy (2011) finds that gold effectively acts as a hedge against the US dollar exchange rates, but does not exhibit the safe haven property.

In sum, while the evidence in the literature is enlightening, there remains an apparent gap. This is mainly because the empirical investigations primarily focus on periods of market distress without emphasis on the nature of the underlying events that cause turbulence. Additionally, the attention is mostly directed at exploring this financial shelter property in currencies and precious metals. Thus, this chapter aims to contribute to the literature in two ways. First of all, it focuses its examination on wars and violent international conflicts. Moreover, the chapter investigates the ability of crude oil to act as a safe haven from US and international
equity markets during these events. This contribution not only addresses a gap in the literature, but also has implications for portfolio investment and risk management.

3.2.3 Crude Oil and Equity Markets: A Convoluted Relationship?

The theory of equity valuation asserts that both corporate cash flows and discount rates echo economic conditions. Thus, the relationship between oil and equities is formed through the impact of oil price changes on macroeconomic variables (El Hedi et al., 2012; Abul Basheer et al., 2012). More specifically, the effect on employment, sentiment, and monetary policy are potential channels through which changes in oil valuations may affect equity prices (Nandha and Faff, 2008). Moreover, the impact of an oil price shock may be even more pronounced for a net oil importing country with low foreign reserves, limited access to capital markets, and weak policy framework (Masih et al., 2011).

A number of papers empirically examine the relationship between crude oil and equity markets in the context of the aforementioned channels. Jones and Kaul (1996) use the standard cash flow-dividend valuation model to examine whether stock markets in the US, Canada, the UK, and Japan rationally capture the impact of oil price shocks. They hypothesise that in an efficient market the response of equities to oil shocks could be fully explained by the reaction of current and future cash flows and expected returns to the oil hikes. Their findings indicate that stock markets in the US and Canada are efficient in evaluating an oil price shock, while the markets in the UK and Japan show a significant over-reaction that cannot be explained within the framework of rational asset pricing.

Other researchers examine whether the oil price represents a pervasive state variable that is priced or rewarded by stock markets. The evidence is inconclusive, however. For the US stock market, Chen et al. (1986) find that the oil price is not a systematic variable, and therefore insignificant in pricing relative to other variables. Hamao (1988) conducts a robustness test of Chen et al. (1986) using Japanese data, and reaches a similar conclusion. On the other hand, Kaneko and Lee (1995) extend the sample period, and examine both US and Japanese data. While their findings are in the same vein as Chen et al. (1986) with regard to the US market, they show that oil price is a systematic variable that is priced in the Japanese market.

The relationship between oil prices and stock markets is also examined in the context of a dynamic interaction with macroeconomic variables. Again, the outcomes of empirical examinations are conflicting. Using a VAR model and utilising monthly observations from 1947 to 1996, Sadorsky (1999) examines the dynamic interaction among real oil prices, S&P500, US
industrial production, and interest rates. Sadorsky’s findings show that oil price changes exert significant effects on the macro variables. Furthermore, oil price shocks have a statistically significant negative and immediate effect on the US stock market. Ewing and Thompson (2007), on the other hand, present contrasting evidence. Using monthly observations from 1982 to 2005, they find that oil prices lag changes in US industrial production. More surprisingly, oil prices are found to lag changes in the S&P500 by 6 months, which suggests that the stock market can be used to predict oil prices.

The evidence on the nature of the relationship between oil and equities is further complicated by cross-country examinations. Driesprong et al. (2008) investigate whether returns on the stock markets of 48 countries can be predicted using changes in oil prices. They find that changes in three crude oil benchmark prices have a negative impact on the valuations of equities in net oil importing nations. Similar evidence is provided by Park and Ratti (2008), who examine the reaction of stock markets in the US and 13 European countries to hikes in oil prices. They show that shocks to oil prices exert a significant negative impact on stock market returns. Only returns on the Norwegian equity market exhibit a significant positive reaction to these shocks.

On the other hand, Bhar and Nikolova (2009) examine the reaction of stock markets in Brazil, Russia, India, and China (BRIC) to oil price shocks using weekly data from 1995 to 2007. Their results show that oil price changes do not have a significant impact on the returns of Brazilian, Indian and Chinese stock markets. The Russian stock market valuations, on the other hand, show a significant positive reaction to oil price changes. The absence of a significant impact on the stock markets of the four constituents of BRIC may be surprising. However, an examination of the G7 countries shows that oil price shocks do not exert a significant impact on each of seven countries’ composite equity indexes (Lee et al., 2012).

Further evidence on the absence of a significant impact comes from Nandha and Ham-moudeh (2007), who report that oil price changes do not show a significant impact on the returns of 15 countries from the Asia-Pacific region. To complicate the issue even further, Bas-shar and Sadorsky (2006) show that oil price changes have a significant positive impact on the returns of 21 emerging stock market indices. Thus, evidence from cross-country examinations on the nature of the relationship between oil prices and stock markets is inconclusive.

Other empirical investigations on sector-specific and cross-sector indices reach relatively non-conflicting findings. Elyasiani et al. (2011) examine the impact of changes in the one-
month NYMEX WTI oil futures prices on the stock indices of 13 industrial sectors. Employing daily data from 1998 to 2006, they show that oil price changes have a significant positive impact on oil-related and oil-substitute sectors, while both the financial and oil-user sectors show significant negative reactions. Aggarwal et al. (2012) document evidence on the sensitivity of US transportation industry. They employ monthly data on oil prices and 71 companies listed on the S&P transportation index, and show that stock returns of transportation companies are negatively affected by oil price increases.

On a worldwide level, and out of 35 global industrial sectors’ stock indices, 28 exhibit significant negative reactions to oil price increases (Nandha and Faff, 2008). Nandha and Faff (2008) also show that only returns on the global index of the oil and gas sector show a significant positive reaction to oil price increases. The latter finding affirms both the results of Elyasiani et al. (2011) regarding the US oil and gas sector and those pertaining to the European oil and gas sector in El Hedi (2011) and El Hedi and Nguyen (2010).

The evidence from the cross-sector examinations indicates that the oil and gas industry exhibits a reaction to oil price shocks opposite to that of other industries. This finding is further supported by a number of empirical investigations. Ramos and Veiga (2011) specify an international factor model and use monthly data in order to explore the impact of oil price changes on the returns of the oil and gas sectors in 34 countries. They show that oil price changes have a positive and significant impact on the returns of these oil and gas sectors.

Similarly, Oberndorfer (2009) examines the impact of changes in the prices of crude oil, natural gas, and coal on the Eurozone energy stocks. Oberndorfer divides the energy sector into utilities and oil and gas, and report interesting findings. Oil price hikes are found to exert a positive impact on the oil and gas stock returns, while the opposite influence is evident for the utilities sector. Oil price hikes are also found to exert a more significant impact than those of coal and gas.

Furthermore, returns on the stocks of the oil and gas industry in the UK are found to react positively and significantly to hikes in Brent prices (El-Sharif et al., 2005). For the American oil and gas industry, Hammoudeh et al. (2004) show that oil futures can explain future movements in the stock prices of US independent oil companies that are engaged in exploration, refining, and marketing. Similarly, Huang et al. (1996) report that changes in oil futures prices lead the returns on the stocks of the US oil companies. Oil price increases are also examined in the context of their impact on accounting measures such as the Return on Equity.
(RoE). Dayanandan and Donker (2011) find that WTI oil price increases have a significant and positive impact on the RoE ratios of listed oil and gas companies in the US stock market. The positive and significant impact of oil price hikes on the equity returns of the oil and gas sector is also present in Canada (Boyer and Filion, 2007) and Australia (Faff and Brailsford, 1999).

Interestingly, the positive reaction to oil price hikes not only characterises the equity returns of the oil and gas industry, but also the equity markets in net oil exporting countries. But what is differentiating a net oil exporting country, and subsequently its stock market’s reaction to oil price hikes, from a net oil importing one? For a net oil exporting country, oil price increases will be reflected in higher national income, which, if brought back to the economy, would be expected to stimulate economic activity and thus the national stock market (Bjørnland, 2009). The bulk of this evidence stems from examinations of stock markets in Norway and the Arab states of the Gulf.

Returns on stock markets in the member states of the Gulf Cooperation Council are shown to have significant positive reactions to oil price hikes (El Hedi et al., 2011). Among the five Arab states of the Gulf, Saudi Arabia is shown to have more positive responsiveness to price hikes (Bashar, 2006). The positive reaction is also exhibited by the Norwegian stock market in response to hikes in the price of WTI (Hammoudeh and Li, 2005), Brent crude (Bjørnland, 2009) and Arabian Light crude (Gjerde and Saettem, 1999).

In sum, and broadly speaking, the evidence on the relationship between crude oil and equity markets is inconclusive. However, the relationship between crude petroleum and the valuations of the oil and gas equities appears to be less convoluted. Missing from the literature is evidence on whether crude oil could act as a financial shelter from equities during periods of international conflicts and wars. This chapter aims to address this gap, first by capturing changes in the valuations of oil and equities around the outbreaks of conflicts. This analysis empowers the subsequent investigation of the ability of oil to act as a safe haven from stocks during such events. By doing so, the chapter highlights the risks associated with wars and conflicts, and points to the potential use of oil in risk management.
3.3 Data

The start dates of international political conflicts are sourced from the latest version of the International Crisis Behaviour (ICB) database (version 10, July 2010).\(^{18}\) The ICB project has been developed by the University of Maryland’s Centre for International Development and Conflict Management. Since its inception, this resource has been used in much academic research in political science and financial economics (see Blomberg et al., 2004; Berkman et al., 2011 in addition to other literature listed on the ICB webpage). ICB provides researchers with a complete list of start dates of conflicts, and describes the level of violence that characterised the start of each crisis. The ICB codebook refers to this latter variable as the ‘trigger reason’ (denoted TRIGGR), and measures it on a scale from 1 to 9.

The conflicts that this chapter examines are those that started with a trigger reason scoring 6 and above. Thus, the chapter excludes these conflicts that started with the withholding of economic aid, verbal protests, diplomatic sanctions, and non-violent acts. The scores considered in this chapter are those referring to conflicts that were triggered by a demonstration of force; mobilisation of army; internal challenge to the regime; and indirect and direct violent acts. Therefore, a sample labelled International Conflicts is constructed from 49 crisis start dates. Moreover, the chapter examines a sub-sample of 32 trigger dates of the most severe and violent conflicts - labelled the War sample. Such events erupted via border clashes, invasion of airspace, large-scale attacks, or full-blown war.\(^ {19}\)

The empirical investigation starts from January 1989. This is driven by two considerations. First, the year 1989 followed the collapse of oil prices in the mid-1980s and the associated shift towards a market-based pricing system. This latter move meant that prices became more reflective of the conditions of supply and demand (Fattouh, 2011). These developments materialised due to Saudi Arabia’s decision to protect its market share rather than OPEC’s official prices, and its refusal to act as a swing producer (Kaufmann et al., 2004; Yergin 2012). Secondly, the availability of data on US and world equity indices dictated the choice of starting from 1989. The availability of data on conflicts sets the end year of the analysis in 2007.

The price of crude oil is Brent current month Free On Board (FOB) in US dollars. Brent is characterised as a blend of sweet and light grades of oil produced from the offshore fields in the North Sea (Fattouh, 2011). The equity indices are the MSCI US equities index, MSCI All

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\(^{18}\) The data collection is available at www.cidcm.umd.edu/icb/.

\(^{19}\) The trigger date is coded as SYSDATE. The paper utilises the actor-level data.
Country World Index (MSCI World), and MSCI All Country World Index excluding the US (MSCI World excl. US). These series are all sourced from Thomson Reuters Datastream. Table I below reports the descriptive statistics for the continuously compounded returns on oil and all three equity indices, while Figure I depicts the evolution of their prices.

An interesting finding in Table I pertains to the mean returns on world equities excluding the US, which is the lowest among all assets. Both crude oil and US stocks perform the best in terms of unadjusted performance for risk. However, the fossil fuel registers the highest volatility among these assets, with a daily standard deviation of almost 2.31%. The broader diversification of world equities is reflected in the lower standard deviation than that reported for the American index. Figure I captures three noticeable movements in the prices of Brent crude. The first is a surge in crude petroleum prices, which corresponds to the Iraqi invasion of Kuwait and the subsequent loss of millions of barrels of production from both countries. However, the rise did not prove permanent, as prices started a gradual decline. Secondly, the fossil fuel valuations appear to exhibit a period of stability during the 1990s. Maintaining the price at these relatively low levels has been a critical factor underlining the low investment in new production capacity (Stevens, 2005; Saporta et al., 2009). Thirdly, oil appears to enter a new era during the 2000s as its prices started a gradual rise. This could be driven by the increase in the final demand for petroleum by an average of 2% per annum between 2003 and 2007 (Saporta et al., 2009). Most of the surge in demand was largely unexpected and had to be met within the existing production capacity (ibid). Between 2000 and 2007, the price of oil moved from a low of $17.5 in November 2001 to a high of $96.05 in the same month of 2007. The movements of the valuations of the three stock market indices share a very similar path. Stock markets appear to increase gradually at the start of the 1990s. The rise accelerated from the first half of 1990s, but it was later interrupted by a decline associated with the Asian and Russian crises. However, the recovery appears to have been quick, and equities continued an upward path till the early years of the 2000s. The effect of the burst of the dot-com bubble is evident and reflected in the tumbling of all indices. However, stocks show a remarkable recovery between 2004 and 2007.

20 The MSCI World Index aggregates stock market fluctuations in 46 equity markets (23 developed and 23 emerging). The index is free float-adjusted market capitalisation weighted. The price movements in each of these individual markets are denominated in local currency, so the analysis primarily focuses on stock price movements, rather than the foreign exchange risk. Please visit www.msci.com for details on methodology.
Table I: Descriptive Statistics

This table reports the descriptive statistics for the daily returns on Brent crude oil and the equity indices of MSCI US, MSCI World, and MSCI World excluding the US for the period between January 1989 and December 2007.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>25th Percentile</th>
<th>Median</th>
<th>75th Percentile</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSCI US</td>
<td>0.0341%</td>
<td>0.9706%</td>
<td>-0.4227%</td>
<td>0.0221%</td>
<td>0.5261%</td>
<td>4956</td>
</tr>
<tr>
<td>MSCI World</td>
<td>0.0249%</td>
<td>0.7615%</td>
<td>-0.3457%</td>
<td>0.0555%</td>
<td>0.4151%</td>
<td>4956</td>
</tr>
<tr>
<td>MSCI World Excl. US</td>
<td>0.0198%</td>
<td>0.8326%</td>
<td>-0.3683%</td>
<td>0.0547%</td>
<td>0.4515%</td>
<td>4956</td>
</tr>
<tr>
<td>WTI Crude Oil</td>
<td>0.0353%</td>
<td>2.3066%</td>
<td>-1.0875%</td>
<td>0.0000%</td>
<td>1.2433%</td>
<td>4956</td>
</tr>
</tbody>
</table>
3.4 Methodology

3.4.1 Unconditional Effect of Political Crises

In order to capture the timing and magnitude of the changes in the valuations of crude oil and equity indices around the start dates of conflicts, a window of 101 daily intervals is specified and centred on the trigger dates of conflicts. The window captures 50 trading days before and after the event day (Day 0). Secondly, the framework of an event study outlined in Campbell et al. (1997) is adopted. Specifically, a constant mean return model, which is a model for ‘normal returns’, is employed. Notwithstanding its simplicity, it obtains similar estimates to
those from the more complicated models, which attests to its comparability (Brown and Warner, 1980; 1985). Thus, it is assumed that:

\[ R_{jt} = \alpha_j + \varepsilon_{jt}, \]  

(1)

where, \( \varepsilon_{jt} \sim N(0, \sigma^2) \), and \( t \in (-200, -51) \). While \( j \) denotes the underlying asset, \( t \) denotes the underlying daily intervals, \( \alpha_j \) is the constant or mean return of the underlying asset, and \( R_{jt} \) is the return of the asset in a specific daily interval \( t \). Model (1) is estimated on a pre-event window with a length of 150 daily intervals, henceforth the estimation window. Each asset’s abnormal returns are calculated using the parameter estimates from model (1), thus:

\[ \hat{AR}_{tk} = R_{jt} - \hat{\alpha}_k, \]  

(2)

where \( t \in (-50, 50) \), \( \hat{AR}_{tk} \) denotes the abnormal returns on the underlying asset \( j \) for event \( k \) computed from the start of the estimation window to the end of event window, and \( \hat{\alpha}_k \) denotes the mean of returns observed in the estimation window \((-200, -51)\) for event \( k \). The cumulative abnormal return for event \( k \) is defined as:

\[ \overline{AR}_t = \frac{1}{N} \sum_{k=1}^{N} \hat{AR}_{tk}. \]  

(3)

Where \( N \) is the number of events, therefore, cumulative average abnormal return \( CAAR_{ij} \) is given by:

\[ CAAR(t_{1}, t_{2}) = \sum_{i=t_{1}}^{t_{2}} \overline{AR}_t, \]  

(4)

where \((t_{1}, t_{2})\) denotes the event window. Estimates of CAARs represent total returns directly attributable to the start of conflicts and their statistical significance is assessed using the \( t \)-statistic described in Kothari & Warner (2007).

3.4.2 Stationarity and Cointegration

Investigating the safe haven property of crude oil requires firstly an examination of the stationarity and the presence of cointegration among the time series in order to avoid spurious results. Therefore, the Augmented Dickey Fuller test (Dickey and Fuller, 1981) is conducted to investigate whether each of the series contains a unit root. The lag length is determined using the Schwarz Information Criterion (Schwarz, 1978) assuming a deterministic trend. The test is performed on the levels, first differences, and log returns of each of the series. Moreo-
ver, an examination of cointegration will be necessary, if the unit root tests show that, for example, both oil and the US stock index are non-stationary in the levels.

In economic terms, cointegration suggests the presence of shared factors that cause two series to exhibit similar movement over time (Granger, 1981; Engle and Granger, 1987). A reduction in diversification benefits may arise due to the presence of such a long-term relationship between two assets (Hammoudeh et al., 2004). Therefore, the absence of cointegration clears the way for an examination of the ability of oil to act as a financial shelter. This is because the presence of this property points to the potential use of crude petroleum in diversification.

To conduct this testing, consider the \( (2 \times 1) \) system \( Y_t \) consisting of the Brent and MSCI US series, as well as two other \( (2 \times 1) \) systems, where the MSCI US will be replaced sequentially with MSCI World and MSCI World excluding US. The aim is to find a model for each system. The question remains whether the series are cointegrated or not, therefore the ADF Engle-Granger residual-based test is run (Engle and Granger, 1987) twice, where sequentially each component of each \( Y_{it} \) for \( i = 1, 2 \) will be the left hand side variable.

3.4.3 Safe Haven Econometric Methodology

This chapter adopts an approach similar in spirit to that advanced by Baur and Lucey (2010) in order to formally test the safe haven property. In their paper, Baur and Lucey investigate whether gold can financially shelter investors in stock and bond markets during periods of distress. Their definition of market turmoil is that in which returns on assets fall below certain levels. These levels, however, are arbitrarily specified. The approach of this chapter differs from theirs in that the period of market distress is defined as that surrounding the start of violent international crises and wars. Therefore, the following regression is run using daily observations:

\[
R_{Brent,t} = C + \beta_1 R_{Stock,t} + \beta_2 R_{StockConflict,t} + \epsilon_t, \tag{5}
\]

where the error term \( \epsilon_t \) is assumed to be independently and identically normally distributed with mean zero and variance equal to \( \sigma^2 \). \( R_{Brent,t}, R_{Stock,t} \) are the returns on Brent crude oil, and on a given stock market index at time period \( t \), respectively. \( R_{StockConflict,t} \) is an interaction term between the variable \( R_{Stock,t} \) and the dummy variable \( D_{Conflict,t} \), where \( D_{Conflict,t} \) is equal to 1 in the event window (-50, 50) centred on the conflict trigger date, and 0 otherwise. Three different stock market indices are used (MSCI US, MSCI World, MSCI World excl.
US), which allows an examination of the safe haven property from the perspectives of US, international and non-US stock market investors.

The approach of Baur & Lucey (2010) suggests that if $\beta_1 \leq 0$, crude oil, then, shows the characteristics of a hedge asset. The fossil fuel exhibits the ability to act as a safe haven from stocks, if $(\beta_1 + \beta_2) \leq 0$. This is because a safe haven is defined as an asset whose returns are negatively correlated or uncorrelated with another asset during times of distress. Thus, failure to reject the null hypothesis $(\beta_1 + \beta_2) \leq 0$ attests to the ability of oil to offer shelter when it is most needed. The $p$-values for this null hypothesis are based on a standard one-sided $t$-test in the computations that follow.

3.5 Empirical Analysis

3.5.1 Unconditional Effect of Political Crises: Event-Study Results

The empirical investigation starts with the event study framework outlined in the methodology section. The estimates of cumulative average abnormal returns (CAARs) with the corresponding test statistics are reported in Table II, while the graphic depiction of the evolution of CAARs is presented in Figure II. The first noticeable observation pertains to the positive abnormal behaviour of crude petroleum arising on and around the outbreak of wars. The fossil fuel registers 15.39% positive abnormal returns during the 101 days window centred on the start day of a war, which is significant at 1%.

Interestingly, but perhaps unsurprisingly, the abnormal behaviour of crude valuations is larger than that documented in the International Crisis sample in Panel B of Table II. The behaviour of crude oil during the 101 daily interval window centred on the trigger date of an international crisis is a statistically significant and positive 10.47%. One may be tempted to suggest that the almost 5% difference could be interpreted as a war premium on the valuations of crude oil over those witnessed during conflicts with less severe violence.

A further interesting finding pertains to the timing of abnormal behaviour in crude oil valuations, which is clearly shown in Figure II. In both samples, the abnormal behaviour of the fossil fuel starts well before the outbreak of a conflict. This finding is supported by the estimates of CAARs in Table II. Crude petroleum registers a positive abnormal return of 9.04% during the 50 days preceding the start of a war, which is, again, significant at 1%. The fossil fuel still shows a statistically significant and positive 6.35% abnormal valuations from day zero and 50 days thereafter. Thus, it is apparent that the significant portion of abnormal returns occurs before the start of a conflict. This timing aspect is confirmed when viewing the
results of the International Crisis sample. While oil shows a positive 3.82% on and following the trigger date of a crisis, its abnormal valuations prior to the outbreak measures 6.64%.

The results are in line with findings in the literature. Wolfers and Zitzewitz (2009), Rigobon and Sack (2005), and Leigh et al. (2003), all document a significant increase in crude oil prices associated with the rise in the risk of war in Iraq. Thus, using the samples of 32 wars and 49 international conflicts, the findings of this chapter could be generalised, and offer further support to the previous evidence on the nature of the relationship between crude oil prices and international conflicts. In order to understand these findings, it can be useful to recall the striking dependence on petroleum in modern warfare. Between 2003 and 2011, the US military demand for fuel in Afghanistan rose by 920% (Schwartz et al., 20012:52). Deloitte (2009) highlights the vital need for long logistical lines to supply the necessary fuel to the military units in the theatre of war. The irony, however, lies in the fact that these logistical convoys heighten the demand for fuel, and have increasingly become prone to attacks (ibid).

Moreover, the decision to start a conflict or embark on a war may not necessarily be transparent, despite what could be at stake. The details of such endeavours are crafted in closed circles, and shrouded in secrecy. Thus, the nature of abnormal behaviour and its timing could have more than one root cause. First of all, the significant rise in valuations and its timing could be a reflection of a rise in rational stockpiling by governments ahead of military operations. Secondly, stockpiling could be conducted by other governments not directly involved in the conflict, as a measure to ensure the energy security of their nations. Specifically, governments may ramp up reserves in anticipation of a cut in supplies due to the potential effect of the conflict on physical production, transportation lanes, and chokepoints. Thirdly, the presence of positive abnormal returns could be the reflection of a rise in precautionary demand for oil. In such a case participants in crude oil markets are arguably psychologically driven.

For example, following the Iranian revolution, Terzian (1985:260) notes that “everybody was anxious to hang on to as much of their own oil as possible, until the situation had become clear. The shortage was purely psychological, or ‘precautionary’ as one dealer put it”. Moreover, a rise in demand for crude petroleum could take place on a speculative basis. Kilian and Murphy (2013) document a significant rise in oil stockpiling in the months preceding Kuwait’s invasion. They attribute the surge in stockpiles to speculative demand by traders in oil.
Table II: Cumulative Average Abnormal Returns (CAARs)

This table reports cumulative average abnormal returns (CAARs) in periods around the war/crisis trigger dates. Panel A. reports the CAARs for Brent crude oil and the US and world equity indices for an event window of 101 daily intervals centred on the start dates of 32 wars. Panel B. reports CAARs for the same assets during a window of 101 daily intervals centred on the start dates of 49 violent international conflicts. A constant mean return model has been used to estimate the values of the CAARs and the $t$-statistics for the null hypotheses that the respective CAARs are equal to zero are given in the parentheses. These test statistics have been calculated in line with Kothari and Warner (2007, p. 11). ***, ***, * denote statistical significance at 1%, 5% and 10% level, respectively.

<table>
<thead>
<tr>
<th></th>
<th>Brent Crude Oil</th>
<th>MSCI US</th>
<th>MSCI World</th>
<th>MSCI World excl. US</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A. Cumulative Average Abnormal Returns for the War Sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAAR(-50,50)</td>
<td>15.3952%***</td>
<td>-5.5061%***</td>
<td>-4.7576%***</td>
<td>-4.2732%***</td>
</tr>
<tr>
<td></td>
<td>(4.1092)</td>
<td>(-2.8125)</td>
<td>(-3.3750)</td>
<td>(-3.0651)</td>
</tr>
<tr>
<td>CAAR(-50,-1)</td>
<td>9.0439%***</td>
<td>-1.8105%</td>
<td>-1.4936%</td>
<td>-1.1964%</td>
</tr>
<tr>
<td></td>
<td>(3.1556)</td>
<td>(-1.3122)</td>
<td>(-1.4486)</td>
<td>(-1.1312)</td>
</tr>
<tr>
<td>CAAR(0,50)</td>
<td>6.3513%**</td>
<td>-3.6957%**</td>
<td>-3.2639%***</td>
<td>-3.0768%***</td>
</tr>
<tr>
<td></td>
<td>(2.6185)</td>
<td>(-2.6575)</td>
<td>(-3.4138)</td>
<td>(-3.4170)</td>
</tr>
<tr>
<td><strong>Panel B. Cumulative Average Abnormal Returns for the International Crisis Sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAAR(-50,50)</td>
<td>10.4678%***</td>
<td>-4.2442%***</td>
<td>-4.5278%***</td>
<td>-4.8578%***</td>
</tr>
<tr>
<td></td>
<td>(3.5432)</td>
<td>(-2.8446)</td>
<td>(-4.5542)</td>
<td>(-4.8560)</td>
</tr>
<tr>
<td>CAAR(-50,-1)</td>
<td>6.6447%***</td>
<td>-2.0537%*</td>
<td>-1.8589%**</td>
<td>-1.7478%**</td>
</tr>
<tr>
<td></td>
<td>(3.2382)</td>
<td>(-1.9353)</td>
<td>(-2.6290)</td>
<td>(-2.4433)</td>
</tr>
<tr>
<td>CAAR(0,50)</td>
<td>3.8231%*</td>
<td>-2.1904%**</td>
<td>-2.6688%***</td>
<td>-3.1100%***</td>
</tr>
<tr>
<td></td>
<td>(1.7984)</td>
<td>(-2.0675)</td>
<td>(-3.8030)</td>
<td>(-4.4810)</td>
</tr>
</tbody>
</table>
Figure II: Cumulative Average Abnormal Returns around Conflict Trigger Dates

<table>
<thead>
<tr>
<th>Panel A. The War Sample</th>
<th>Panel B. The International Crisis Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brent Crude Oil</td>
<td>Brent Crude Oil</td>
</tr>
<tr>
<td>MSCI US</td>
<td>MSCI US</td>
</tr>
</tbody>
</table>

The diagrams illustrate the cumulative average abnormal returns around conflict trigger dates for Brent Crude Oil and MSCI US indices, separately for the War Sample and the International Crisis Sample.
The graphs above plot Cumulative Average Abnormal Returns (CAARs) in the (-50,50) event windows, where day 0 denotes the war/crisis trigger date. The CAARs are measured on the vertical axis, while days relative to the event appear on the horizontal axis. Panel A shows the diagrams for a sample of 32 wars, while the graphical depictions in Panel B are based on 49 instances of severe international crisis.

markets, who were either well-informed or responding to rising tension in the Middle East. Table II also reports the estimates of CAARs for the US and world equity indices. The findings pertaining to the nature of abnormal behaviour of stock markets are in stark contrast to these documented for oil. All equity indices exhibit significant negative abnormal valuations on and around the outbreak of wars. Additionally, the results for the International Crisis sample show similar behaviour. However, it appears that equities are slightly more responsive to the outbreak of wars than to the start of less violent conflicts. For example, the stock market index of the American market registers 5.51% negative abnormal returns during the 101 days
for the War sample, which is significant at 1%. This compares to a negative abnormal returns of 4.24% on and around day 0 of a less severe conflict.

A striking finding relates to the timing of these changes. Figure II and Table II both show that the significant portion of abnormal behaviour occurs from the day of an outbreak of war and 50 days thereafter. Out of the 4.27% significantly negative abnormal returns for world equities excluding the US registered during a war, a statistically significant and negative 3.07% accumulates during the partial window from day zero to day 50. This timing aspect is shared among the two other indices.

Noticeable differences arise, however, among equities as reflected in the estimates of CAARs for the International Crisis sample. First of all, the US equity index shows more symmetrical abnormal returns than those exhibited by the world indices on and around the start of an international conflict. Additionally, and unlike the results for the War sample, the magnitude of abnormal behaviour of US stocks in the International Crisis sample is less than that registered by the two world indices. These variations in magnitude may suggest that investors in US markets are less responsive than their international counterparts to the outbreak of less violent conflicts. Alternatively, the differences may indicate the better ability of US investors to both anticipate conflicts with less severity, and incorporate news and information.

The results on the nature of the abnormal behaviour of stock markets add further support to the findings in the literature. Wolfers and Zitzewitz (2009) report a decline in US equities associated with a rise in the probability of war in Iraq. Leigh et al. (2003) document similar findings for US stock markets, and show that the heightened probability of war also depresses world equities. Rigobon and Sack (2005) present further evidence showing the association between the rise in the risk of war in Iraq and a significant decline in US equities. Moreover, Berkman et al. (2011) show that world stock markets suffer an almost 4% loss of returns per annum due to wars and international conflicts.

A number of factors could assist in comprehending the changes in the valuations of equities. To begin with, violent conflicts and wars can bring significant negative human, economic and political outcomes. While military spending may have a positive economic effect, a number of negative unintended consequences could outweigh such a gain. The Institute for Economics and Peace (2011) reports a deterioration in a number of US economic indicators during most of the nation’s wars. These include a spiralling public debt, increase in taxation, decline in consumption and investment as share of GDP, and heightened inflation. Also, invest-
ments in education, infrastructure and high-tech industries could be displaced due to the government’s crowding out effect (ibid).

The severe economic consequences are highlighted by Organski and Kugler (1977), who estimate that 15 to 20 years are required for a defeated nation to reclaim its antebellum status. They further show that the economic recovery could be hindered by the victorious nation through exploitation. A further dimension is the effect that conflicts can exert on the political stability within belligerent nations, and subsequently on their economies. The instability of a political regime is found to Granger-cause a decline in economic growth (ibid). Thus, one may argue that this adds further uncertainty or complexity to the task of calculating the economic implications of wars.

Moreover, the accuracy of any calculations of the costs of violent conflicts can only be known in hindsight, hence the metaphorical description of war as a ‘giant roll of the dice’ (Nordhaus, 2002:40). Miscalculations of such costs on the part of policy makers have been evident over the history of mankind with devastating consequences (Tuchman, 1984; Nordhaus, 2002). This might be best described by the eloquent words of Lord Chatham in the House of Lords in 1777. He declared unequivocally how the British nation had been seduced into a ruinous war in America ‘by the arts of imposition, by its own credulity, through the means of false hope, false pride and promised advantages of the most romantic and improbable nature’ (cited in Tuchman, 1984:270).

Simply put, wars are costly, or as the US Vice-Admiral A. C. Davis argued ‘it must be understood that there is no cheap way to fight a war, once committed’ (cited in Tuchman, 1984:317). Perhaps unsurprisingly, attempting to forecast such costs in advance could yield estimates that are scattered over a wide spectrum. Nordhaus (2002) estimated, for example, that the Iraq war would cost the US $99 billion in the event of a favourable outcome. On the other end of the spectrum, the cost could climb to a staggering $1.9 trillion, most of which is not attributable to direct military cost.

An additional case in point is the tragic American experience in Vietnam. The essence of US military doctrine in that conflict called for launching an aerial bombing campaign that would break the will of the North Vietnamese (Tuchman, 1984). This doctrine had been based on two assumptions. The first is that the US is big enough to withstand the economic costs of the war. Secondly, that the enemy would do its calculations rationally and reach the conclusion that peace is less costly than war. However, the will of Hanoi had not been broken and its
calculations were made outside of the boundaries of rationality that the Americans envisaged. To add insult to injury, a report by the CIA in the late 1960s estimated that for each $1 of inflicted damage on the Vietnamese, the US incurred a cost of $9.6 (Tuchman, 1984:434).

Consequently, it is apparent that conflicts and wars give rise to economic uncertainty, which could cloud investors’ judgment and dampen their ability to accurately evaluate consequences (Chen and Siems, 2004; Amihud and Wohl, 2004). Amihud and Wohl (2004) argue that such an environment elevates risk premium, thus leading to a decline in stock prices. All of the aforementioned suggests that investors would react negatively to the outbreak of violent crises and wars. This is especially the case since financial markets carry the hard burden of assessing the outcomes and consequences of conflicts (Wolfers and Zitzewitz, 2009).

In summary, the findings show that the outbreak of wars and violent international conflicts give rise to a significant positive abnormal behaviour in the valuations of crude oil. The significant portion of abnormal returns accumulates well before the start of the crisis. These results are found to be in stark contrast to the findings on the abnormal returns of US and world equities. Stock markets register significant negative abnormal returns during wars and violent crises. Moreover, the significant portion of this decline occurs from day zero onwards. Capturing these abnormal valuations permits the investigation to be extended in order to explore whether crude petroleum could act as a safe haven asset from stocks during such calamities.

3.5.2 Unit Roots and Cointegration

The findings presented in the previous section capture the abnormal behaviour in the valuations of crude oil and equities on and around the outbreak of wars and conflicts. These results also point to the potential use of the fossil fuel to protect investors in stock markets against such risk. The latter inference calls for a further examination of the safe haven property of oil, which firstly requires an investigation of the stationarity of the series. Table III below presents the results of the Augmented Dickey Fuller test assuming the equation contains an intercept and a trend. The lag selection is based on the Schwartz Information Criterion (Schwartz, 1978). The estimates in Table III show that the levels of each series are non-stationary, while the first differences and returns are indeed stationary.

The aforementioned results require a further examination of cointegration. The absence of cointegration suggests that oil and stock markets are segmented from each other rather than integrated from investors’ perspective. This segmentation could be the outcome of the absence of a long-term relationship among the assets. The results of the cointegration tests are summarised in Table IV. The
Table III: Unit Root Test

This table contains the ADF test statistics for the level, first differences, and continuously compounded returns of the four series for the time from 2 January 1989 to 31 December 2007. ***, **, * denote statistical significance at 1%, 5% and 10% respectively.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Levels</th>
<th>First Differences</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brent Crude Oil</td>
<td>-0.5646</td>
<td>-70.9040***</td>
<td>-69.7256***</td>
</tr>
<tr>
<td>MSCI US</td>
<td>-1.8314</td>
<td>-72.0846***</td>
<td>-71.1929***</td>
</tr>
<tr>
<td>MCSI World</td>
<td>-1.7313</td>
<td>-47.5993***</td>
<td>-47.7139***</td>
</tr>
</tbody>
</table>

Table IV: Cointegration Tests

This table reports in Panel A the ADF Engle-Granger $\tau$-statistic applied to residuals of the regression $y_{it} = c + \rho_j y_{jt} + \epsilon_t$ with a one-to-one mapping between (1, 2) and {i, j}. The co-integration tests are performed for three different pairs of variables. Each variable pairing defines a system of two equations, which leads to two ADF tests. ***, **, * denote statistical significance at 1%, 5% and 10% level respectively.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Left hand variable</td>
<td>ADF</td>
<td>ADF</td>
<td>ADF</td>
</tr>
<tr>
<td>$y_{1t}$ (Brent)</td>
<td>-0.6735</td>
<td>-0.9403</td>
<td>-1.4267</td>
</tr>
<tr>
<td>$y_{2t}$ (MSCI US)</td>
<td>-1.1585</td>
<td>-1.5584</td>
<td>-2.0602</td>
</tr>
</tbody>
</table>
Panel A. reports Pearson correlations between Brent crude oil and each of the equity indices during the (-50, 50) event windows for 32 wars which occurred between January 1989 and December 2007. Panel B presents the correlations during (-50, 50) event windows for 49 international conflicts. *p*-values for the correlation coefficients are given in parentheses.

### Panel A. Pearson Correlations during the Instances of War

<table>
<thead>
<tr>
<th>Pearson Correlation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brent &amp; MSCI US</td>
<td>-0.0949</td>
</tr>
<tr>
<td></td>
<td>(0.0000)</td>
</tr>
<tr>
<td>Brent &amp; MSCI World</td>
<td>-0.0901</td>
</tr>
<tr>
<td></td>
<td>(0.0000)</td>
</tr>
<tr>
<td>Brent &amp; MSCI World excl. US</td>
<td>-0.0663</td>
</tr>
<tr>
<td></td>
<td>(0.0011)</td>
</tr>
</tbody>
</table>

### Panel B. Pearson Correlations during Instances of International Crisis

<table>
<thead>
<tr>
<th>Pearson Correlation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brent &amp; MSCI US</td>
<td>-0.0908</td>
</tr>
<tr>
<td></td>
<td>(0.0000)</td>
</tr>
<tr>
<td>Brent &amp; MSCI World</td>
<td>-0.0780</td>
</tr>
<tr>
<td></td>
<td>(0.0000)</td>
</tr>
<tr>
<td>Brent &amp; MSCI World excl. U.S.</td>
<td>-0.0493</td>
</tr>
<tr>
<td></td>
<td>(0.0084)</td>
</tr>
</tbody>
</table>

tests are conducted for three different pairings of variables; each pairing forms a two-equation system with two ADF residual tests.

### 3.5.3 Safe Haven Analysis

The first step in exploring the safe haven property of crude oil is to examine the simple Pearson correlations between the returns in the vicinity of violent conflicts and wars. Table V above documents negative correlations between the returns on oil and each of the equity indices on and around the outbreak of wars. The null hypotheses of no correlation are strongly rejected. Similarly, the correlations between returns during the period surrounding the start of violent international crises are all negative. The null hypotheses are rejected too. These findings shed some light on the relationship between these assets, and suggest the ability of oil to act as a safe haven from stocks during hostilities. Deploying the methodology of Baur and Lucey (2010) offers more rigorous evidence.

Table VI below reports the estimation results for different variations of the safe haven regression equation (5). The first noticeable observation pertains to the estimates of *β1*, which is
either statistically significant and negative, or insignificant. In light of the definition advanced in Baur and Lucey (2010), this finding demonstrates that investors in stock markets can use crude oil as a hedge. The result could be understood in light of theoretical arguments that underpin the findings of non-positive \( \beta_1 \). The rise in oil prices could lead to an increase in input costs. However, the ability of the private sector to pass through the rise in costs may be partial or limited, which consequently depresses cash flows and equity valuations. Moreover, the rise in oil prices could bring forth ramifications for discount rates. This could occur if the appreciation in the prices of the fossil fuel ignites inflation, which in turn could lead central bankers to raise interest rates.

The findings are broadly in line with empirical evidence which documents a negative or weak relationship between the returns of the fossil fuel and equity markets. Sadorsky (1999) examines the impact of oil price shocks on US stock markets. Sadorsky shows that hikes in the prices of the fossil fuel exert a significant negative effect on US equities. Jones and Kaul (1996) report detrimental effects of oil price shocks on the stock markets of Japan, the US, the UK, and Canada. Similar findings are also reported for equity markets in emerging countries (see Abul Basher et al., 2012).

On the other end of the spectrum, Chen et al. (1986) and Hamao (1988) show that oil prices are not a systematic risk factor, and therefore do not play a significant role in the pricing of stocks in the US and Japan. Moreover, a number of researchers report evidence that suggests a more convoluted picture. This is because the appreciation in crude oil prices is shown to have a positive effect on the valuations of stocks in the oil and gas sector (Faff and Brailsford, 1999; El-Sharif et al., 2005; Nandha and Faff, 2008).

Second, the reported estimates in Table VI show that \( (\beta_1 + \beta_2) \) is less than 0 for all the equity indices. The null hypotheses that \( (\beta_1 + \beta_2) \leq 0 \) cannot be rejected based on all of the \( t \)-tests, which points to the safe haven property of crude petroleum. Put differently, the hydrocarbon fuel registers significant positive valuations, when such returns are most needed. A caveat ought to be highlighted, because an exposure to oil is not a risk-free endeavour. This commodity is prone to the whims of global markets, and faces competition from alternative sources of energy. Despite this, the empirical investigation demonstrates the ability of the fossil fuel to financially shelter participants in stock markets during times of political calamity.
### Table VI: Modelling Oil Returns

This table presents estimation results for regressions where the daily return on crude oil is modelled as a function of stock market returns $R_{stock}$ and stock market returns interacted with a conflict dummy variable. This dummy takes the value of 1 in the (-50, 50) event windows centred on a conflict trigger date, and 0 otherwise. The table also reports the R-square, and the corresponding F-statistic, for the test of overall significance of the regression with the corresponding p-value. Moreover, the table reports the summed value of slopes and the p-value for the null hypothesis that oil is a safe haven in times of war or international crisis. Parameter standard errors are given in the parentheses. ***, **, * denote statistical significance at 1%, 5% and 10% level, respectively.

#### Panel A. Safe Haven Regressions Based on the Instances of War

<table>
<thead>
<tr>
<th></th>
<th>MSCI US</th>
<th>MSCI World</th>
<th>MSCI World excl. US</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>0.0004</td>
<td>0.0004</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td>(0.0003)</td>
<td>(0.0003)</td>
<td>(0.0003)</td>
</tr>
<tr>
<td><strong>$R_{stock}$</strong></td>
<td>-0.1098**</td>
<td>-0.0442</td>
<td>0.0632</td>
</tr>
<tr>
<td></td>
<td>(0.0485)</td>
<td>(0.0628)</td>
<td>(0.0582)</td>
</tr>
<tr>
<td><strong>D_{Conflict}×$R_{stock}$</strong></td>
<td>-0.1269*</td>
<td>-0.2385***</td>
<td>-0.2517***</td>
</tr>
<tr>
<td></td>
<td>(0.0673)</td>
<td>(0.0860)</td>
<td>(0.0789)</td>
</tr>
<tr>
<td>R-square</td>
<td>0.6200%</td>
<td>0.4700%</td>
<td>0.2800%</td>
</tr>
<tr>
<td>F-stat regression</td>
<td>15.3835</td>
<td>11.8029</td>
<td>6.8388</td>
</tr>
<tr>
<td>p-value</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0011</td>
</tr>
<tr>
<td>$(\beta_1+\beta_2)$</td>
<td>-0.2367</td>
<td>-0.2827</td>
<td>-0.1886</td>
</tr>
<tr>
<td>Safe Haven p-value</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.9998</td>
</tr>
</tbody>
</table>

#### Panel B. Safe Haven Regressions Based on the Instances of International Crisis

<table>
<thead>
<tr>
<th></th>
<th>MSCI US</th>
<th>MSCI World</th>
<th>MSCI World excl. US</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>0.0004</td>
<td>0.0004</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td>(0.0003)</td>
<td>(0.0003)</td>
<td>(0.0003)</td>
</tr>
<tr>
<td><strong>$R_{stock}$</strong></td>
<td>-0.1061**</td>
<td>-0.0619</td>
<td>0.0359</td>
</tr>
<tr>
<td></td>
<td>(0.0531)</td>
<td>(0.0689)</td>
<td>(0.0651)</td>
</tr>
<tr>
<td><strong>D_{Conflict}×$R_{stock}$</strong></td>
<td>-0.1162*</td>
<td>-0.1788**</td>
<td>-0.1724**</td>
</tr>
<tr>
<td></td>
<td>(0.0686)</td>
<td>(0.0881)</td>
<td>(0.0817)</td>
</tr>
<tr>
<td>R-square</td>
<td>0.6000%</td>
<td>0.4000%</td>
<td>0.1600%</td>
</tr>
<tr>
<td>F-stat regression</td>
<td>15.0395</td>
<td>10.0133</td>
<td>3.9762</td>
</tr>
<tr>
<td>p-value</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0188</td>
</tr>
<tr>
<td>$(\beta_1+\beta_2)$</td>
<td>-0.2222</td>
<td>-0.2407</td>
<td>-0.1365</td>
</tr>
<tr>
<td>Safe Haven p-value</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.9971</td>
</tr>
</tbody>
</table>
In summary, the findings show that the fossil fuel possesses the ability to perform as a safe haven for investors in equity markets during intense conflicts and wars. The importance of findings is underlined by three factors. The first is the nature of events. The future outbreak of hostilities may not be easily foreseen and represents a factor that is shrouded in uncertainty. Secondly, when such events occur, the results show that equities plummet significantly. Thirdly, contagion or a domino effect is found to be present among stock markets (Markwat et al., 2009; Bodart and Candelon, 2009; Syllignakis and Kouretas, 2011), which may hinder the effectiveness of cross-border diversification in equities. Therefore, crude oil should feature permanently in portfolios in an attempt to hedge against the risk arising from conflicts.

In addition to investors in equity markets, insurance companies may benefit from an exposure to crude petroleum. OPIC - which is a US government agency - and numerous corporations offer insurance coverage against risks arising from political conflicts and wars. This coverage varies from a protection against declared and undeclared wars to that against the confiscation of funds. The products that these providers offer will differ depending on the location, taxation, and regulatory aspects and types of assets. Consequently, insurance providers may wish to hedge conflict-associated risk through an exposure to oil in their portfolios.

### 3.5.4 Portfolio Optimisation

The findings from the safe haven analysis hint at both the potential use of crude oil in diversification, and the benefits arising from including oil in an investment portfolio. Consequently, the aim of this section is to identify the weights of the optimal portfolio, which yields the highest returns per level of risk. Specifically, I adopt the viewpoint of an international investor who holds positions in world equities and world real estates.\(^\text{21}\) Therefore, the portfolio is constructed from crude oil, world equities and real estate investment trusts, and it covers the entire period of analysis from January 1989 to December 2007.

I follow the procedure outlined in Peterson (2012) in conducting the portfolio analysis. The analysis begins with calculating excess returns over the US three month treasury rates. Subsequently, the covariance matrix is constructed from the excess returns, and the analysis proceeds into formulating the efficient frontier. The latter step requires identifying the minimum variance portfolio, which represents a combination of assets that has the lowest level of risk on the efficient frontier. In order to do so, the portfolio’s standard deviation is minimised with

\(^{21}\) World real estates is proxied here by the movements in the valuations of World-Datastream Real Estate Investment Trusts Price Index.
respect to the portfolio weights subject to the constraints that the sum of weights is equal to one, and the portfolio’s return is equal to a certain value. The final step is to identify the optimal risky portfolio, which requires the maximisation of the portfolio’s Sharpe ratio subject to the constraint that the sum of weights is equal to one.

The aforementioned procedure does not restrict short selling. Therefore, the analysis is replicated under the assumption of long positions only. The findings from the analysis are presented in Table VII below. The first noticeable finding in Table VII pertains to the optimal risky portfolio, in which 17.34% is allocated to crude oil. Interestingly, the findings also show that the weights of crude oil and real estate holdings increase gradually, while the allocations to world equities decline along the efficient frontier. At 1.99% of daily excess returns per unit of risk, portfolio seven is the optimal combination of the three assets, which maximises returns for each unit of risk.

3.6 Conclusions
This chapter investigates the nature of the behaviour of the valuations of crude oil and equity markets in the vicinity of the start dates of violent international political conflicts and wars. Utilising the ICB database, the chapter focuses its examination on 49 violent conflicts, and a sub-sample of 32 crises which started as full-blown wars or saw severe violence at the outset. The chapter firstly employs a standard event study methodology, which captures the magnitude and timing of abnormal behaviour in the fossil fuel and stock markets’ returns.

The findings show that crude petroleum registers significant positive abnormal returns on and around the outbreak of conflicts and wars. The significant portion of abnormal returns accumulates well before the start dates of the crises. On the other hand, equity indices suffer significant declines around the trigger dates of conflicts. Interestingly, the timing of the abnormal behaviour of equities appears to start just before the outbreak, and accumulates significantly during the subsequent period. The importance of crude oil at the heart of the global economy, and its role in propelling the war machine, could be underlying reasons behind this positive abnormal behaviour. More specifically, the presence of positive abnormal returns could reflect a surge in precautionary demand (Terzian, 1985), or an increase in speculative stockpiling by informed traders (Kilian and Murphy, 2013).

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22 Restricting short selling does not cause changes in the weights of the ten portfolios in Table VII below. Since the constraints were never binding, all the results in Table VII are reported without short selling constraints.
Table VII: Optimal Portfolio Weights

This table reports the optimal weights for mean-variance efficient portfolios invested in crude oil, world equities and world real estate investment trusts. The minimum variance portfolio is identified by minimising the standard deviation of a portfolio subject to the constraint that the sum of all weights is equal to one. For all other portfolios I minimise the portfolio risk subject to a given level of portfolio return and subject to the sum of portfolio weights being equal to one. The optimal portfolio on this efficient frontier is the one with the highest Sharpe ratio. All calculations are made without imposing short-selling restrictions.

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>(1)a</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)b</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brent Crude Oil</td>
<td>10.8608%</td>
<td>11.9410%</td>
<td>13.0212%</td>
<td>14.1014%</td>
<td>15.1816%</td>
<td>16.2618%</td>
<td><strong>17.3420%</strong></td>
<td>18.4222%</td>
<td>19.5025%</td>
<td>0.0000%</td>
</tr>
<tr>
<td>MSCI World Index</td>
<td>69.8957%</td>
<td>62.0219%</td>
<td>54.1482%</td>
<td>46.2744%</td>
<td>38.4009%</td>
<td>30.5272%</td>
<td><strong>22.6535%</strong></td>
<td>14.7798%</td>
<td>6.9062%</td>
<td>0.0000%</td>
</tr>
<tr>
<td>REITs World</td>
<td>19.2436%</td>
<td>26.0371%</td>
<td>32.8306%</td>
<td>39.6241%</td>
<td>46.4175%</td>
<td>53.2110%</td>
<td><strong>60.0044%</strong></td>
<td>66.7979%</td>
<td>73.5914%</td>
<td>100.0000%</td>
</tr>
<tr>
<td>Portfolio Sharpe Ratio</td>
<td>1.6635%</td>
<td>1.7743%</td>
<td>1.8615%</td>
<td>1.9244%</td>
<td>1.9647%</td>
<td>1.9857%</td>
<td><strong>1.9912%</strong></td>
<td>1.9849%</td>
<td>1.9702%</td>
<td>1.7008%</td>
</tr>
<tr>
<td>Portfolio Mean</td>
<td>0.0113%</td>
<td>0.0122%</td>
<td>0.0130%</td>
<td>0.0138%</td>
<td>0.0147%</td>
<td>0.0155%</td>
<td><strong>0.0163%</strong></td>
<td>0.0172%</td>
<td>0.0180%</td>
<td>0.0188%</td>
</tr>
<tr>
<td>Portfolio Standard Deviation</td>
<td>0.6818%</td>
<td>0.6860%</td>
<td>0.6985%</td>
<td>0.7188%</td>
<td>0.7463%</td>
<td>0.7802%</td>
<td><strong>0.8198%</strong></td>
<td>0.8642%</td>
<td>0.9127%</td>
<td>1.1027%</td>
</tr>
</tbody>
</table>

a Minimum variance portfolio
b Optimal risky portfolio
Additionally, this abnormal behaviour could be traced back to rational stockpiling by governments ahead of military operations, or in an attempt to ensure energy security. The devastation caused by wars and violent conflicts, and the heightened uncertainty with regard to the economic and political outcomes, consequences, and costs could all drive the significant fall in the valuations of equities.

The findings from the event study analysis highlight the need for a financial shelter during such events, and empower the potential use of crude oil in risk management. To shed more light on the ability of oil to perform as a shelter, the chapter adopts the definition of a safe haven asset and the testing approach advanced in Baur and Lucey (2010). The answer as to whether oil is a safe haven is found to be in the affirmative. More specifically, the chapter documents that the hydrocarbon fuel can perform as a safe haven asset from US and world equities in the vicinity of the start dates of wars and conflicts. The importance of this finding and the call for using oil in risk management are driven by three factors.

First of all, the outbreak of political crises could be hard to predict, due either to the unavailability of, or limited access to, information in advance. Secondly, unlike oil, equity markets are shown to exhibit significant negative returns around the trigger date of a conflict. This decline is reported to gain momentum after the outbreak. Thirdly, crisis periods could increase the correlations among equities due to contagion, which in turn would dwarf the benefits from diversifying into stocks only (Chiang et al., 2007).

Consequently, allocating a fraction of a portfolio to crude oil could be a sensible strategy that equity investors may wish to consider. The fossil fuel by itself is not a risk-free endeavour, as it is exposed to shocks arising from the vagaries of demand and supply. However, these risks could be mitigated, and diversification benefits could be harnessed, by taking a long position in oil. El Hedi et al. (2012) and Nandha and Faff (2008) both allude to the usefulness of oil in diversification. This beneficial role could be particularly evident when it is most needed; i.e., during conflicts.

A number of issues relevant to the above recommendation ought to be highlighted at this stage. The presence of vibrant paper markets facilitates the use of oil in diversification, and overcomes the cumbersome task of taking positions in the physical market. Thus, a long position could be taken in oil futures and Exchange Traded Funds rather than acquiring physical ship-
ments of oil, which requires incurring storage costs. For example, the use of oil futures contracts with 18 months maturity in diversifying a portfolio of equities is advocated by Geman and Karroubi (2008).

Moreover, the dynamics of oil markets may only be understood retrospectively by outside observers. Also, the decisions to engage in a conflict or stockpile in anticipation of rising tension could be made in closed circles and shrouded with secrecy. Consequently, it could be more prudent to maintain a long position in oil rather than following a strategy of switching in and out of oil. In this context, the results from the portfolio analysis reveal that 17.34% of a properly diversified portfolio should be allocated to crude oil.

Finally, the findings of this chapter suggest that investors in equity markets should pay more attention to the developments of foreign policy on both the national and global levels. This could be achieved by more engagement with policy makers. This, in turn, would allow for a forward-looking view of national policies and international relations, and could enhance the breadth of information on possible courses of action, outcomes, consequences, and costs of conflicts. This could be more attainable for investors in US markets in particular, considering the active role of that nation on the international arena.
IV. American versus International Benchmarks during Supply Disruptions

Abstract
This chapter investigates the price spread between West Texas Intermediate (WTI) and Brent during periods of supply disruptions. Using a sample of 50 events of OPEC-related unplanned upstream production outages, this chapter documents a statistically significant tightening in the price differential. The findings are robust even after accounting for 22 OPEC-related political conflicts, 104 instances of extreme weather conditions in the Atlantic basin, and the period of infrastructural bottlenecks in and around the Cushing, Oklahoma. The results are further confirmed when examining the spread between Light Louisiana Sweet (LLS) and Brent. These findings suggest the need to hedge against such risks and give rise to speculative trading that can be facilitated using the vibrant paper markets.

4.1 Introduction
The collapse of crude oil prices in the mid-1980s, and the events leading to it, ushered in the demise of the OPEC-administered pricing system and heralded a transition towards a market-based regime. Necessary for the revolutionising of the system has been the emergence of vibrant spot and paper markets, which have enhanced both transparency and price formation processes. At the heart of these developments has been the concept of formula-based pricing in which reference crudes, such as Brent, West Texas Intermediate, or Dubai/Oman, play a vital role.

In its simplest form, the formula-based system prices a grade of crude oil off a benchmark price by adding or subtracting a differential. Factors such as the quality of the grade relative to that of the benchmark, the prices of competing grades, Gross Product Worth (GPW),\textsuperscript{23} and time and location all determine the size of the differential. Notwithstanding the significance of a benchmark’s outright price, this chapter aims to examine the spread between the respective prices of these reference crudes. A number of factors render such an examination important.

\textsuperscript{23} Gross Product Worth is the value of refined products in the market. GPW will differ among crudes since each crude has its own natural yield of petroleum products. Crude Assays are reports published by producers listing the main characteristics of their crudes including natural yields. Additionally, the yield will differ depending on the refining process. Please see Fattouh (2011) and Energy Intelligence (2011) for an in-depth discussion of the evolution of the crude oil pricing regime.
First of all, the essence of the formula pricing system is built around price relationships rather than outright prices; therefore spread trading is the tool through which most crude oil grades are traded in the market (Energy Intelligence, 2011). Secondly, spreads or differentials between the various traded crudes are a vital issue for risk management from the point of view of producers, exporters, importers, and traders (Mabro, 2005). Thirdly, and more specifically, the price differential between WTI and Brent can be viewed as an indicator that allows the investigation of the relationship between the American oil market, and the international, waterborne markets. Moreover, examining the behaviour of the LLS-Brent differential highlights the role played by the location, and exposure to logistical bottlenecks in shaping the responsiveness of different price spreads to international events.

Finally, futures markets provide oil traders with the opportunity to hedge against adverse movements in price differentials. Additionally, speculative investors can exploit potential changes in oil price spreads by taking positions in futures contracts. For example, both the New York Mercantile Exchange (NYMEX) and the IntercontinentalExchange (ICE) offer futures and options contracts with the WTI-Brent spread being the underlying asset. Thus, investigating the behaviour of crude oil spreads is of interest to commercial and speculative traders.

Moreover the relative prices of benchmarks, as reflected in their spread, matter for an importing country whose crude imports are not priced-off one reference crude; the US market is a good example. The spread matters not only for refiners in an importing country, but also for policy makers in relation to the security of supply and cost of building up strategic reserves. Similarly, an oil producer whose exports are destined for one market where more than one benchmark is used might be interested in the spread between these reference crudes.

The above considerations lead this chapter to examine the price spread between WTI and Brent during periods of upstream production disruptions. Specifically, this chapter aims to investigate the fluctuation of the WTI-Brent spread in the vicinity of 50 OPEC–related unplanned production outages between 1987 and 2012. The significance of examining these OPEC-related disruption events is based on two important considerations.

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24 The use of WTI-Brent as a metric was highlighted by the Energy Information Administration in an answer to a query about the featuring of the spread in EIA’s reports, which were submitted to the Congress under the National Defence Authorization Act (NDAA).
Firstly, in December 2011, OPEC accounted for around 42% of the global world production of oil and nonconventional oil, and natural gas liquids, with five of its members being among the top ten world producers (Eni, 2012). Additionally, OPEC’s share stood at 72% of the global oil proven reserves, and eight of its member countries are among the top ten holders of such reserves (ibid). Secondly, the history of oil shocks and OPEC-related decisions, actions, and conflicts has been intertwined since the early 1970s. The 1973 oil embargo by OPEC’s Arab members, the Iranian revolution of 1978, the Iran-Iraq war of 1980, and the 1990 Iraqi invasion of Kuwait, were all accompanied by significant hikes in the price of the fossil fuel (see Hamilton (2011) for a discussion of the history of oil price shocks since the 19th century).

The findings show that periods of unplanned outages are associated with statistically significant tightening in the WTI-Brent Spread. The narrowing in the price differential is further confirmed after accounting for other political conflicts, extreme weather conditions, and the period of infrastructural constraints. The results are robust when examining the price differential between Brent and Light Louisiana Sweet (LLS), the de facto light and sweet crude benchmark on the US Gulf Coast (Energy Intelligence, 2011; Argus, 2014). Interestingly, the magnitude of the responsiveness of the LLS-Brent spread to disruptions is less than that exhibited by WTI-Brent. Put simply, whilst waterborne crudes appear to be more responsive to disruptions, the results indicate that imports priced off Brent can become relatively more expensive. Additionally, and from the viewpoint of a US oil producer, the findings reveal that the close proximity of domestic crudes to the US Gulf coast gives rise to better price responsiveness to outage events.

The chapter is organised as follows. The next section provides an overview of the crude oil pricing regime and introduces the two reference crudes, Brent and WTI. Section 4.3 reviews the literature, and section 4.4 moves on to present the data utilised in the chapter and descriptive statistics. Section 4.5 introduces the methodology, while section 4.6 discusses the results and the robustness tests. Section 4.7 concludes the chapter by discussing the relevance of its findings and the implications for various parties.

4.2 Crude Oil Pricing Regime and the Role of Benchmarks
Although the use of formula pricing was initially introduced in 1986 by the Mexican national oil company PEMEX, the role of a reference price has existed since the late 1970s and early 1980s (Mabro, 2005; Fattouh, 2011; Energy Intelligence, 2011). That period witnessed the emergence of
the Saudi Arab Light as the reference crude in the OPEC-administered pricing system, and Forties and later Brent as the North Sea’s benchmark (Energy Intelligence, 2011).

The introduction of markers and the gradual emergence of spot trading required crudes that are characterised by their high production volume, security of supply, consistent quality, and diversity of sellers (Energy Intelligence, 2011). The events of 1986 led to a market environment in which Brent and WTI were chosen as international reference crudes, because they held the necessary characteristics of a benchmark and had well-established spot and paper markets to allow for relatively transparent trading.

Brent is a light and low sulphur blend of crudes that is produced from offshore fields in the North Sea. Brent is the primary reference in the global oil market as on daily basis it is benchmarking two thirds of oil that is physically traded on both a spot and term-contract basis (Fattouh, 2011; Energy Intelligence, 2011; ICE, 2013). Its spot, forward, and futures markets are mutually dependent and their linkages form the Brent pricing complex (Energy Intelligence, 2011). Dated Brent refers to the spot market of the Brent complex and virtually all of the trades in the European and African spot markets are linked to the dated Brent price (ibid). Moreover, supplies sold into European markets on a term-contract basis are also priced off dated Brent, while sales of African crudes into the US are directly or indirectly linked to the Brent pricing complex (Fattouh, 2011; Energy Intelligence, 2011).

WTI is the chief benchmark for pricing imports of the fossil fuel into the market of the largest consumer and importer of oil in the world, the United States (Fattouh, 2011; Eni, 2012). WTI is a blend of US domestic crudes of high quality, with an API gravity of 39° and a sulphur content of 0.45%, rendering it a light and sweet blend (Energy Intelligence, 2011:92, CME Group, 2013). Unlike Brent, which is waterborne, WTI is transported via pipelines and deliveries of its cargos take place at the US major storage centre at Cushing (Fattouh, 2011; and Energy Intelligence, 2011; CME Group, 2013). WTI has been the reference grade underlying the NYMEX light and sweet futures contracts since 1983. These trading instruments not only enhanced the visibility of a rather landlocked crude, but also increased the transparency of its price formation process (Fattouh, 2011; Energy Intelligence, 2011). Open interest in the NYMEX light and sweet futures con-

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25 Brent blend has an API gravity of 37.6° and sulphur content of 0.41%. Full Brent Assay on: www.exxonmobil.com/crudeoil/about_crudes_brent.aspx
tracts increased from 121,428 in December 1987 to 1,473,345 contracts in the same month of 2012.²⁶

4.3 Literature Review

As mentioned earlier, formula pricing is at the heart of the current pricing system, which in turn points to the importance of differentials among the prices of the various competing crudes in the oil market. Despite that, the investigation into these interrelationships has attracted relatively little academic attention. Additionally, the area that occupies the lion’s share of empirical investigations is that which explores the extent of regionalisation versus unification of oil markets.

The question of the regionalisation of oil markets originates from Weiner (1991) who examines the claim that the oil market is ‘one great pool’ (Adelman, 1984:5). Weiner hypothesises that if oil markets were fragmented, then prices of the same crude arising in different regions would move independently. In such markets, the cost of transportation would be larger than regional price differentials, thus hindering adjustments through arbitrage. By examining the prices of six different grades of crude oil in five geographical regions, Weiner shows strong evidence of regionalisation in oil markets. However, this evidence is inconclusive, as subsequent empirical research provides evidence supporting the ‘one great pool’ hypothesis (Gülen, 1999; Ewing and Harter, 2000; Bentzen, 2007; Hammoudeh et al., 2008; and Fattouh, 2010), or documents an accelerated move towards unification (Kleit, 2001). It is worth noting that while the latter papers utilise data mostly from the 1990s onwards, Weiner (1991) examines the period from 1980 to 1987 which preceded the inception of the current pricing regime.

Further insights into the nature of interrelationship between WTI and Brent are provided by investigating spillover effects between their markets. In an attempt to explore the leader market, Lin and Tamvakis (2001) investigate information transmission mechanism between NYMEX and IPE (later ICE) futures markets. When considering over-lapping trading between the two markets, Lin and Tamvakis document spillover effects running in both directions.

However, WTI’s leading role has been questioned since 2007. This is due to the accumulation of historical stock levels at Cushing and infrastructural bottlenecks that hindered the movement of oil to the major refining centre on the US Gulf Coast (Hammoudeh et al., 2008; Fattouh, 2011;

Energy Intelligence, 2011). Kao and Wan (2012) document the dramatic retreat of WTI’s role as a benchmark relative to Brent over time. Specifically, they show that during periods of WTI-related contango and discount to Brent, the US benchmark’s ability to process news deteriorates, while Brent dominates the information-share.

The lack of evidence on the behaviour of the spread between the two most prominent benchmarks during periods of unplanned production outages and political conflicts comes as a surprise. This is despite the intertwining history of oil shocks and geopolitical events (Hamilton, 2011; Darbouche and Fattouh, 2011) and the significant role that the fossil fuel has been playing in propelling the war machine since World War I (Yergin, 2012). Deloitte (2009), for example, estimates that US military consumption of fuel in Iraq and Afghanistan stands at 22 gallons per soldier per day, a staggering 175% increase from its level in the Vietnam conflict.

The literature has not been silent though, on the effect of wars on the outright price of crude oil. Empirical evidence captures the significant appreciation in oil prices during wars and violent political conflicts (Leigh et al., 2003; Rigobon and Sack, 2005; Omar et al., 2014). Therefore, this chapter aims to address a gap in the literature by examining the behaviour of the WTI-Brent price differential around the start of 50 events of unscheduled outages in OPEC’s production. By doing so, the chapter contributes to the existing literature on crude oil spreads, and offers insights into the interrelationship between the world’s most prominent benchmarks.

4.4 Data
The chapter uses end of month data from May 1987 to December 2012 on the prices of three grades of oil and a number of explanatory variables. The year 1987 is chosen as it followed the dramatic collapse of oil prices, Saudi’s refusal to act as the swing producer, and the ultimate change in OPEC’s policy from defending its marker price to protecting its market share (Kaufmann et al., 2004; Yergin, 2012). The availability of data on the prices of dated Brent dictates the choice of the starting month. Monthly observations are chosen due to explanatory variables that are not available with higher sampling frequencies.

The dataset consists of spot prices of West Texas Intermediate (WTI) for delivery in Cushing, Free On Board (FOB) dated Brent prices, and spot prices of Light Louisiana Sweet (LLS). All prices are in US dollars. Additional US-based explanatory variables are utilised in the analysis. These include the industrial production index; crude oil stocks excluding Strategic Petroleum Re-
serves (SPRs); finished motor gasoline stocks; distillates stocks; residual fuel stocks; the cost in US dollars of refinery acquisition of imported crude oil and the US dollar FOB and landed costs of imported oil. The availability of the data dictates the use of US-based control variables.

The data is taken from four sources. The prices of both WTI and Brent are sourced from Datastream, while the LLS prices are taken from Bloomberg. The Federal Reserve Bank of St. Louis Economic Data is the source of the data on US industrial production. The data on FOB and landed costs of imported crudes, the refinery acquisition cost of imported crudes, and stocks of crude oil and products are all sourced from the Energy Information Administration.

The sample of OPEC-related unplanned production disruptions is sourced from Bloomberg. The chapter considers dates on which unscheduled outages in upstream production occurred. Such events may arise due to unexpected extreme weather conditions; explosions; oil leaks or spills; strikes; acts of sabotage; and terrorism and wars. Since such reasons, even when unforeseen, may not result in a production outage, the chapter considers only events that led to an explicit announcement of a disruption. This announcement may take the form of a shutdown in certain units, which brings production to a partial or full halt. Additionally, a producer may declare a force majeure, which is the state in which an oil company will not be able to meet its contractual obligations of delivering the agreed shipments of crude, due to events beyond its control.

The Bloomberg Terminal contains the function NI FIELDOUT, which is designed to provide news on Oil and Natural Gas Field Outages and allows users to scroll through these pieces of news. This function also offers the ability to filter news by key word, source, language and date. The extraction of dates on which unplanned production disruptions occurred follows the procedure described below. First of all, English is the language utilised, and the source of news is ‘all’. Secondly, news is filtered on the basis of each of OPEC’s members. Thirdly, for each member country, dates are further filtered by the range of dates considered in this chapter (i.e. May 1987 to December 2012). Finally, only news that explicitly states the occurrence of an unscheduled disruption is considered. The total number of dates on which such events occurred is 93 between 1987 and 2012.

Since the chapter employs monthly data, the dates on which disruptions occurred must also be aggregated to monthly observations. For example, during November 2012, Eni, Shell, and Exxon all announced unscheduled disruptions in their Nigerian operations on three different days. These
are all dealt with as one event pertaining to November of that year. Thus, the aggregation reduces the number of events from 93 to 50 events of unscheduled production outages.

Finally, and as a part of the robustness tests, I construct two samples comprising two different sets of events, which may have explanatory power. The first contains 22 events of OPEC-related political crises that did not coincide with unplanned outages in production. These events are sourced from the International Crises Behaviour (ICB) project database, (version 10, July 2010), and the Conflict Barometer, which is the main annual publication of the Heidelberg Institute for International Conflict Research (HIIK).

The ICB provides detailed information on international conflicts and countries involved in these crises, and numerous academic studies have utilised its data (see Blomberg et al., 2004; Berkman et al., 2011; Omar et al., 2014, in addition to many other academic papers and books that are listed on the ICB webpage). Among the comprehensive set of data that the ICB provides are the trigger dates of crises and the trigger reason scale. I choose conflicts in which at least one OPEC member was involved. The number of events sourced on that basis is 18 crises occurring between 1987 and 2007.

The use of the 2008-2012 Conflict Barometer publications allows for extending the period of examination beyond 2007. The publication provides detailed information on conflicts occurring in five regional areas. Additionally, it categorises conflicts as new, and reports uptick and downtick changes in the level of violence for continuing crises. The start dates of conflicts included in the sample meet three basic criteria. Firstly, the crisis must involve an OPEC member. Secondly, the conflict must be categorised as either new or with an uptick in its level of violence. Finally, particular dates must be explicitly stated. These include the start date of a new conflict, or the date on which the level of violence changed upwards. This exercise generates four OPEC-related conflicts between 2008 and 2012.

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27 A University of Maryland’s affiliate, the Centre for International Development and Conflict Management has developed the ICB database. ICB dataset is available at: www.cidcm.umd.edu/icb/.  
28 HIIK is located at University of Heidelberg’s Department of Political Science. Conflict Barometer is available at: www.hiik.de/en/konfliktbarometer/index.html  
29 The ICB codebook shows the trigger date under the code SYSDATE, while the trigger reason scale is reported under the code TRIGGR. The chapter uses actor-level data, and chooses conflicts that started by reasons scaled from one to nine.
The second sample involves months during which hurricanes occurred in the Atlantic basin. Hurricanes can have a devastating impact on the US oil industry’s upstream and downstream operations, as was evident in the hurricane season of 2005 and 2008 (US Department of Energy, 2009). Thus, these events may affect the price relationships between US crudes and Brent. To account for their potential impact, I source data on the months in which at least one hurricane occurred from the US National Hurricane Centre’s Tropical Cyclone Reports. This exercise generates 104 months between 1987 and 2012.

Table VIII below reports the summary statistics and unit root test results, while table IX shows the correlations between the spreads and the explanatory variables. Additionally, Figure III depicts the fluctuations in the WTI-Brent and LLS-Brent price differentials, and those of the other explanatory variables. The first noticeable observation pertains to the average log spread between WTI-Brent. Despite the deep discounts of WTI against Brent after 2007, the average differential is positive, reflecting the normal relationship that should exist between these two benchmarks. An additional interesting finding in Table VIII is that the average log spread between LLS and Brent exceeds that of WTI-Brent by 2%. This may reflect the fact that while WTI suffers from its landlocked location at the Cushing storage centre, LLS is directly traded and processed on the US Gulf Coast, which holds 48% of the country’s refining capacity (Andrews et al., 2010).

Table IX reports noticeable findings on the correlations between the price spreads and explanatory variables. Both price differentials show a significant negative correlation with the variable $D_{\text{outages}}$. This finding suggests that the price spreads tighten during periods of unplanned production disruptions. Table IX further shows that the cost of transportation, storage and insurance has a significant positive correlation with the spreads. This is expected, as Brent is waterborne and its marketability in the US would be significantly affected by logistical costs.

Among all petroleum stocks, only residual fuel inventories show a significant positive correlation with WTI-Brent. The graphical depiction of the WTI-Brent differential over time exhibits a stable relationship in which WTI trades at a premium over Brent for most of the sample period. This stability changes significantly after 2007 to deep discounts. This dramatic change is attributed to the significant accumulation of domestic and Canadian crude stocks in the Cushing, in addition to limited pipeline capacity to move these crudes to the US Gulf Coast (Fattouh, 2010; 2011; Energy Intelligence, 2011; Kao and Wan, 2012).
Table VIII: Descriptive Statistics

This table reports descriptive statistics for crude oil spreads and control variables from May 1987 to December 2012. The price differentials, $S_{WTI}^t - Brent^t$ and $S_{LLS}^t - Brent^t$, are expressed as the natural logarithmic difference between the respective prices of the crudes. Transportation, storage and insurance cost, TSIC$^t$, is the logarithmic difference between the refinery acquisition cost of imported oil at time $t$ and FOB and the landed costs of imported oil in the US at time $t$. Industrial production Index in the US, USIP$^t$, and stocks of crude oil, gasoline, distillates, and residual fuel are all expressed as the logarithmic difference between time $t$ and $t-1$. The last column of table VIII reports the ADF test statistics for log price spreads and transportation, storage and insurance cost, and the first difference in log levels for the remaining variables. ***, **, * denote the statistical significance at 1%, 5% and 10%, respectively.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>25th Percentile</th>
<th>Median</th>
<th>75th Percentile</th>
<th>Unit root</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{WTI}^t - Brent^t$</td>
<td>0.0403</td>
<td>0.0732</td>
<td>0.0183</td>
<td>0.0561</td>
<td>0.0845</td>
<td>-4.3470***</td>
</tr>
<tr>
<td>$S_{LLS}^t - Brent^t$</td>
<td>0.0627</td>
<td>0.0367</td>
<td>0.0404</td>
<td>0.0678</td>
<td>0.0834</td>
<td>-7.1112***</td>
</tr>
<tr>
<td>USIP$^t$</td>
<td>0.0018</td>
<td>0.0065</td>
<td>-0.0013</td>
<td>0.0024</td>
<td>0.0057</td>
<td>-4.6439***</td>
</tr>
<tr>
<td>Stocks Crude$^t$</td>
<td>0.0003</td>
<td>0.0305</td>
<td>-0.0218</td>
<td>0.0011</td>
<td>0.0204</td>
<td>-16.2439***</td>
</tr>
<tr>
<td>Stocks Gasoline$^t$</td>
<td>-0.0001</td>
<td>0.0370</td>
<td>-0.0228</td>
<td>0.0009</td>
<td>0.0245</td>
<td>-5.0046***</td>
</tr>
<tr>
<td>Stocks Distillates$^t$</td>
<td>0.0010</td>
<td>0.0633</td>
<td>-0.0325</td>
<td>0.0076</td>
<td>0.0466</td>
<td>-4.3875***</td>
</tr>
<tr>
<td>Stocks Residual$^t$</td>
<td>-0.0002</td>
<td>0.0583</td>
<td>-0.0387</td>
<td>0.0073</td>
<td>0.0391</td>
<td>-15.4306***</td>
</tr>
<tr>
<td>TSIC$^t$</td>
<td>0.0702</td>
<td>0.0566</td>
<td>0.0245</td>
<td>0.0745</td>
<td>0.1137</td>
<td>-9.1245***</td>
</tr>
</tbody>
</table>
Table IX: Pearson Correlations

The table below reports the Pearson correlations between the two crude oil spreads and control variables between May 1987 and December 2012. The p-values for the correlation coefficients are given in parentheses. Price differentials are the difference in the natural log levels at time t. $D_{\text{Outages}}$ is a dummy variable that takes the value 1 in a 3 month window surrounding the month in which a production outage occurred in an OPEC member country; and zero otherwise. $D_{\text{Autumn}}$, $D_{\text{Winter}}$ and $D_{\text{Spring}}$ are dummy variables taking the value 1 in the autumn, winter and spring seasons, respectively; and zero otherwise. TSIC is the difference between the natural log of refinery acquisition cost and natural log of FOB and landed cost of imported oil at time period t. The remaining variables are expressed as the first difference between their natural log levels at time period t.

<table>
<thead>
<tr>
<th></th>
<th>$SP_{\text{WTI}_t-Brent_t}$</th>
<th>$SP_{\text{LLS}_t-Brent_t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{\text{Outages}}$</td>
<td>-0.4378 (0.0000)</td>
<td>-0.3178 (0.0000)</td>
</tr>
<tr>
<td>$D_{\text{Autumn}}$</td>
<td>-0.0455 (0.4266)</td>
<td>0.0163 (0.7762)</td>
</tr>
<tr>
<td>$D_{\text{Winter}}$</td>
<td>0.0207 (0.7175)</td>
<td>0.0490 (0.3912)</td>
</tr>
<tr>
<td>$D_{\text{Spring}}$</td>
<td>0.0543 (0.3426)</td>
<td>0.0218 (0.7030)</td>
</tr>
<tr>
<td>USIP</td>
<td>-0.0090 (0.8750)</td>
<td>-0.0733 (0.1992)</td>
</tr>
<tr>
<td>Stocks Crude t</td>
<td>0.0385 (0.5005)</td>
<td>0.0897 (0.1160)</td>
</tr>
<tr>
<td>Stocks Gasoline t</td>
<td>-0.0106 (0.8537)</td>
<td>0.0305 (0.5936)</td>
</tr>
<tr>
<td>Stocks Distillates t</td>
<td>0.0419 (0.4642)</td>
<td>0.0594 (0.2989)</td>
</tr>
<tr>
<td>Stocks Residual t</td>
<td>0.0945 (0.0987)</td>
<td>0.0928 (0.1041)</td>
</tr>
<tr>
<td>TSIC t</td>
<td>0.5071 (0.0000)</td>
<td>0.4340 (0.0000)</td>
</tr>
</tbody>
</table>
Figure III: Fluctuations of Crude Oil Spreads and Control Variables

The diagrams below plot the crude oil spreads and control variables used in this study from May 1987 to December 2012. WTI-Brent and LLS-Brent are the price spreads in US dollar per barrel. The US industrial production index is seasonally adjusted (2007=100). Stocks of crude oil (excluding Strategic Petroleum Reserves), gasoline, distillates and residual fuel are all in millions of barrels. Transportation, storage and insurance cost (TSIC) are in US dollars per barrel.
Stocks of the fossil fuel and other petroleum products exhibit interesting features. Average percentage changes for each of the stocks is very close to zero. In figure III crude oil stocks show a downward decline from the early 1990s to 2002, and a subsequent increase until the end of 2012. The 1990s coincided with attempts to increase efficiency by decreasing the need for storage (EIA, 1996; Energy Intelligence, 2011). The build-up of stocks during the 2000s could be explained on the basis of higher imports. The EIA data show that the average amount of US crude imports between 1993 and 1997 was 7.362 million bbl/d, while the average for the period 2003-2007 was 10.005 million bbl/d.

Distillate stocks show the most noticeable seasonality among the other petroleum inventories considered. This can be understood in the light of the fact that the demand for heating oil, a middle distillate product, peaks during the winter season. Additionally, residual fuel stocks exhibit a clear downward decline. The EIA data reveal that US net imports of residual fuel gradually diminished from 365,000 bbl/d in 1987 to 161,000 bbl/d in 2000. From 2008 onwards the US actually became a net exporter of residual fuel. Another explanation for the gradual downward movement is the addition of highly complex refining capacity in the US, which started in the early 1980s (EIA, 1996).

Transportation, and storage and insurance costs (TSIC) show a high level of fluctuation, specifically after 2002. This higher variability might be attributed to developments affecting the tankers market. Factors that have strengthened freight rates include rising prospects of a war on Iraq, extreme weather conditions on the US Gulf Coast, the Israel-Lebanon war in 2006, and a rise in floating storage in 2009 (Energy Intelligence, 2011). On the other hand, the cut in OPEC production and the arrival of new

<table>
<thead>
<tr>
<th>Residual fuel Stocks (Million Barrels)</th>
<th>TSIC ($ per Barrel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec-87</td>
<td>Dec-92</td>
</tr>
<tr>
<td>Dec-97</td>
<td>Dec-02</td>
</tr>
<tr>
<td>Dec-07</td>
<td>Dec-07</td>
</tr>
<tr>
<td>Dec-12</td>
<td>Dec-12</td>
</tr>
</tbody>
</table>
shipping capacity in 2007, in addition to the financial crisis, all weakened tankers rates during the 2000s (ibid).

Finally, Table VIII reports the unit roots results using the Augmented Dickey Fuller test, and assuming the equation contains an intercept and a trend. The lag selection is based on Schwartz Information Criterion (Schwartz, 1978). The findings show that the logarithmic price differentials are stationary. Similarly, all of the explanatory variables, expressed in logarithmic differences, are stationary.

4.5 Methodology

4.5.1 Modelling WTI-Brent Price Differential

In order to quantify the behaviour of the WTI-Brent spread around unplanned production outages, I introduce an event window of three monthly intervals centred on the month in which a disruption occurred; this is called the trigger month. Additionally, I propose a number of control variables and specify the following model:

\[
S_{\text{WTI}-\text{Brent}} = C + \beta_1 D_{\text{Outages}} + \beta_2 D_{\text{Autumn}} + \beta_3 D_{\text{Winter}} + \beta_4 D_{\text{Spring}} + \beta_5 USIP_{t-1} + \beta_6 Stocks_{\text{Crude}} + \beta_7 TSIC_{t-1} + \beta_8 S^W_{\text{WTI}-\text{Brent}} + \epsilon_t
\]

(1)

where the error term \(\epsilon_t\) is assumed to be independently and identically normally distributed with mean zero and variance equal to \(\sigma^2\). \(S_{\text{WTI}-\text{Brent}}\) is the difference between the natural logarithm of the prices of WTI and Brent at time period \(t\). \(D_{\text{Outages}}\) is a dummy variable, which takes the value 1 if it falls within the three month event window; and zero otherwise. \(D_{\text{Autumn}}\), \(D_{\text{Winter}}\), and \(D_{\text{Spring}}\) are dummy variables, which take the value 1 for months in Autumn (September, October, November), Winter (December, January, February), and Spring (March, April, May), respectively; and zero otherwise. \(USIP_{t-1}\) is the continuously compounded percentage change in the US industrial production index between time period \(t\) and \(t-1\), included with one month lag in order to avoid the endogeneity problem. \(Stocks_{\text{Crude}}\) is the continuously compounded percentage change in the US crude oil stocks excluding SPRs between time period \(t\) and \(t-1\). \(TSIC_{t-1}\) is the transportation, storage and insurance cost of imported crude oil into the US at time period \(t-1\). This cost is the difference between the natural logarithm of the US refinery acquisition cost of imported crude oil and the FOB and landed costs of

\[30\] The inclusion of US industrial production with a one-month lag is supported by the findings of Ewing and Thompson (2007). They show that US industrial production leads the price of WTI by one month. Their findings concur with those of Serletis and Shahmoradi (2005) who document that natural gas prices lag US industrial production.
imported crude oil. $\text{Sp}_{\text{WTI}_{t-1}-\text{Brent}_{t-1}}$ is the one monthly interval-lagged WTI-Brent log price differential.

Model (1) accounts for potential control variables that would explain the fluctuation in the WTI-Brent price differential. However, to account for the potential explanatory power of petroleum products, I additionally model the spread as a function of the US stocks of gasoline, distillates, and residual fuel. Therefore:

$$\text{Sp}_{\text{WTI}_t-\text{Brent}_t} = C + \beta_1 D_{\text{Outages}} + \beta_2 D_{\text{Autumn}} + \beta_3 D_{\text{Winter}} + \beta_4 D_{\text{Spring}} + \beta_5 \text{Stocks}_{\text{Gasoline}} + \beta_6 \text{Stocks}_{\text{Distillates}} + \beta_7 \text{Stocks}_{\text{Residual}} + \beta_8 TSI_{t-1} + \beta_9 \text{Sp}_{\text{WTI}_{t-1}-\text{Brent}_{t-1}} + \epsilon_t,$$

where $\text{Stocks}_{\text{Gasoline}}$, $\text{Stocks}_{\text{Distillates}}$, $\text{Stocks}_{\text{Residual}}$ are the continuously compounded percentage changes in the stocks of motor gasoline, distillates, and residual fuel between time $t$ and $t-1$, respectively. The remaining variables are identical to those in model (1). Finally, in order to obtain statistically consistent estimates of the variance-covariance matrix, I estimate models (1) and (2) using the Newey-West standard errors approach.

4.5.2 Models Explanation

A number of points should be highlighted in relation to the variables on both sides of regression equations (1) and (2). First of all, the use of the difference in the natural logarithm of the prices of two different crudes is evident in the literature; it is arguably more appropriate to express the price differential as a percentage of the fossil fuel’s price (Weiner, 1991; Fattouh, 2010). The addition of the variable $\text{Sp}_{\text{WTI}_{t-1}-\text{Brent}_{t-1}}$ in both models is to account for persistence in the price differential.

Secondly, I postulate a negative sign for the variable $D_{\text{Outages}}$ in models (1) and (2). Put differently, the spread between the two benchmarks may tighten as a result of unplanned outages in OPEC. Brent is the benchmark of the light and sweet waterborne crudes in the Atlantic basin (ICE, 2013). Additionally, seaborne transportation accounted for two-thirds of the fossil fuel that was transported globally in 2009 (Energy Intelligence, 2011). The importance of waterborne crudes was demonstrated

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31 The choice of including one monthly interval preceding and following the trigger month can be justified on the basis of the length of an oil tanker’s voyage to the US from Sullom Voe in the UK. Such a voyage is estimated to require approximately 16 days to reach Corpus Christi in the US (Energy Intelligence, 2011: 65). Considering that this chapter utilises monthly data, a one monthly interval is a reasonable approximation for the length of that voyage.
following the Arab spring and the Fukushima incident, both of which placed upward pressure on the prices of these crudes (Büyükşahin et al., 2013).

In stark contrast, WTI and other US domestic crudes are landlocked and heavily dependent on the pipeline infrastructure, which accounted for almost 54% of US crude transportation in 2012 (Frittelli et al., 2014). These features have made the US crudes vulnerable to infrastructural bottlenecks and pipelines-related incidents, and resulted in disconnecting these crudes from the global markets (EIA, 1996; Fattouh, 2010; 2011; Energy Intelligence, 2011; Kao and Wan, 2012). Disconnection from the global oil markets can have significant economic costs. A case in point is the Canadian crudes, which are pipelined. The landlocked location of Canadian crudes forces producers to sell their oil at a discount compared to international prices with daily losses estimated at $50 million (Canadian Chamber of Commerce, 2013).

Thirdly, Brent destined to the US trades at a discount compared to WTI under normal market conditions, although both crudes are of similar quality. The price structure reflects the economics of transportation, which enables traders and refiners to economically import and process Brent in the US (EIA, 2013). The US market is characterised by fierce competition among oil exporters, which forces them to incur transportation-related costs (Fattouh, 2011). This is in contrast to crudes destined to Asia where buyers bear the transportation costs, which in turn gives rise to the ‘Asian Premium’ (ibid: 24).

In order to control for the financial aspects of logistics, I construct a rough approximation of the transportation, storage and insurance costs, which is denoted TSIC.³² This variable is constructed as the difference between the natural logarithms of the refinery acquisition cost of imported crude oil and the FOB and landed costs of imported crudes. The difference between these costs yields an aggregate approximation of the costs of seaborne transportation, storage and insurance. Taking into account that these costs may depend on the spot price of the fossil fuel, the variable TSIC is incorporated into models (1) and (2) with a one month lag.

Finally, regression equations (1) and (2) control for the potential role of crude oil and products stocks in crude oil pricing. Petroleum inventories are necessary to ensure the smooth functioning of a supply system in which inputs and outputs are delivered in batches (EIA, 1996; Ye and Shore, 2002;

³² Following communication with EIA to inquire about the availability of a dataset on logistics-related costs, I was informed that a rough approximation of these costs could be calculated using existing data on imports that are available on www.eia.gov. The approach is as explained above and follows EIA’s recommendation.
Energy Intelligence, 2011). Additionally, the fact that different grades of oil have different qualities necessitates storage in order to segregate these crudes along the supply chain (EIA, 1996). Stocks also have an important economic role as a marginal source of supply, and can indicate the state of balance or imbalance in the market (EIA, 1996; Ye and Shore, 2002; Ghouri, 2006; Kaufmann et al., 2008).

4.6 Empirical Results

4.6.1 WTI-Brent Spread, OPEC-related Events and Control Variables

Table X below shows the estimation results of models (1) and (2). The first noticeable observation relates to the statistically significant and negative $\beta_1$ coefficient in both regression equations. The results indicate that during periods in which unplanned production outages occur, the WTI-Brent spread narrows. This does not necessarily suggest that the two benchmarks move in opposite directions during such episodes. Omar et al., (2014), for example, document economically and statistically significant positive abnormal returns for WTI during violent international conflicts. The results from models (1) and (2) may instead suggest that Brent is more responsive to these events than WTI. This finding may be unsurprising for a number of reasons.

As discussed earlier, Brent is a waterborne crude that is transported to the major refining centres in Europe and the US (EIA, 1996; Fattouh, 2011). This is in stark contrast to WTI, which is landlocked and exposed to infrastructural bottlenecks. Therefore, in times of unmet international demand arising from OPEC outages, Brent would be expected to appreciate in value more radically. Additionally, in the case of outages in the production of competing crudes in the Atlantic Basin, the Brent price may rise to reflect the shortage and higher demand for it. Nigeria, whose crudes are exported to the US and other markets, witnessed major unplanned outages during the sample period. In February 2003 and 2006 Nigeria was forced to shut 37% and 20% of its oil production, respectively, due to intensified fighting in the Niger Delta.

Libya is an additional example. The country lost 1.6 million bbl/d of its production during the few months following the February 2011 revolution (Darbouche and Fattouh, 2011). The loss of high quality Libyan crudes exerted upward pressure on similar quality grades of oil in the Atlantic basin in order to attract more of these crudes into Europe (ibid). Thus, one would reasonably expect that such events would result in higher demand for alternative waterborne crudes like Brent, which happens to
Table X: WTI-Brent

This table presents estimation results for the regression equations (1) and (2). Under model (1) the monthly natural log difference between the prices of WTI and Brent is modelled as a function of OPEC-related production disruptions, seasonal dummies, first difference in the natural log levels of US industrial production with one month lag, the natural logarithmic change in crude stocks excluding SPR, the transportation, storage and insurance cost (TSIC) with one month lag, and the one month lagged price differential. Model (2) replaces both the crude stocks and US Industrial production in (1) with natural logarithmic changes in gasoline, distillate and residual stocks. \( D_{\text{Outages}_t} \) takes the value of 1 in a three-month event window centred on the month in which event occurred; and 0 otherwise. The table also reports the R-square, and the corresponding F-statistic for the test of the overall significance of the regression with the corresponding \( p \)-value. Parameter standard errors are given in the parentheses. ***, **, * denote the statistical significance at the 1%, 5% and 10% levels, respectively.

<table>
<thead>
<tr>
<th>Regression Estimates for Events of OPEC Unplanned Production Outages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model (1) Regression Estimates</strong></td>
</tr>
<tr>
<td><strong>Constant</strong></td>
</tr>
<tr>
<td>( D_{\text{Outages}_t} )</td>
</tr>
<tr>
<td>( D_{\text{Autumn}_t} )</td>
</tr>
<tr>
<td>( D_{\text{Winter}_t} )</td>
</tr>
<tr>
<td>( D_{\text{Spring}_t} )</td>
</tr>
<tr>
<td>USIP(_{t-1})</td>
</tr>
<tr>
<td>Stock(_t) Crude (_t)</td>
</tr>
<tr>
<td>TSIC(_{t-1})</td>
</tr>
<tr>
<td>Sp(_{\text{WTI}_t-1-Brent_t-1})</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>R-square</strong></td>
</tr>
<tr>
<td><strong>F-stat regression</strong></td>
</tr>
<tr>
<td><strong>P-value</strong></td>
</tr>
</tbody>
</table>
be supplied from a secure source. The rise in demand for seaborne crudes from secure sources could also be driven by precautionary measures, as pointed out by Terzian (1985:260) with regard to the Iranian revolution and subsequent production disruption: “[…] Everybody was anxious to hang on to as much of their own oil as possible, until the situation had become clear. The shortage was purely psychological, or ‘precautionary’ as one dealer put it”.

Kilian and Murphy (2013) report a significant increase in fossil fuel inventories prior to the 1990 invasion of Kuwait. They attribute the rise in stocks to either traders responding to the rising tension in the Middle East, or actions of informed players in anticipation of that event. The rise in demand due to events of disruptions is reasonably expected to favour waterborne over landlocked crudes, especially when such oil is produced from a secure source, as is the case with Brent.

The results in Table X also show a statistically significant widening in the spread between WTI and Brent during spring relative to the summer season. This finding can be better understood in the light of the relative importance of gasoline in the US. The transportation sector accounts for 67% of US petroleum use (Davis et al., 2013:1-1). Gasoline is the fuel of choice and the demand for it accounts for 51% of the total US demand for petroleum products (API, 2011:30). The inadequate upgrading capacity for the poorer quality grades of oil and the tightest quality specifications for gasoline during summer are factors that place upward pressure on the prices of the higher quality crudes (EIA, 1996; Energy Intelligence, 2011). The relative increase in prices is pronounced for the higher quality domestic crudes such as WTI during the run-up to the summer driving season, which starts in late May (EIA, 1996).

Additionally, Table X shows a statistically significant and negative relationship between crude oil stocks and the price differential. This finding demonstrates the importance of stocks in acting as a cushion by supplying the marginal barrel (Kaufmann et al., 2008). Moreover, the negative relationship between the spread and US crude stocks may point to the vulnerability of WTI to infrastructural bottlenecks (Fattouh, 2010; 2011; Energy Intelligence, 2011; Kao and Wan, 2012). Kao and Wan (2012) demonstrate that during periods of contango, the ability of WTI to process and reflect relevant news deteriorates.

33For example, the gasoline produced per barrel of Brent in an East Coast refinery represents 53% of the total volume of refined products, and contributes 59% to the total revenues (EIA, 1996: 123).
The estimations in Table X attest to the role of transportation, storage and insurance costs in the relationship between the two benchmarks. The statistically significant and positive regression coefficient suggests that as cost increases, the spread widens, indicating that Brent becomes less attractive for US refiners. This finding concurs with evidence that points to the significant role of transportation costs in the pricing relationships among crudes in various regions (Weiner, 1991; EIA, 1996; Alizadeh and Nomikos, 2004). A further interesting finding in Table X pertains to the relationship between the price differential and its lagged value. The statistically significant and positive regression coefficient in regression equation (1) suggests a persistent relationship between current and past price differentials. The persistence in the spread may reflect the consistency in freight rates or the quality of these crudes.

The second column of Table X reports the estimation results of regression equation (2). In addition to confirming the results of model (1), the findings point at the role of residual fuel stocks. The increase in residual fuel stocks may indicate a higher level of utilisation of the simple refining capacity at a time when the conversion and deep conversion units are fully utilised. The rise in the utilisation of simple refining capacity may alternatively occur when a significant portion of the complex capacity is offline, due, for example, to extreme weather conditions on the U.S. Gulf Coast.

A simple refinery (hydroskimming or topping) cannot alter the natural yield of products obtained from crude oil (EIA, 1996; Quarls et al., 2006; ICCT, 2011). Thus, these simple refineries opt to procure oil that has a high natural yield of light products, which subsequently places upward pressure on the prices of light and sweet crudes. Additionally, heavier crudes would suffer further discounts to induce demand from simple refineries. The combined effect would result in an increase in the stocks of residual fuel, and a rise in the prices of light and sweet oil, which may be more pronounced for domestic US crudes than foreign oil (EIA, 1996; Quarls et al., 2006).

In summary, the findings suggest that periods of unplanned outages in upstream production in OPEC give rise to a tightening price differential between WTI and Brent. This finding may not be surprising. Brent is a waterborne crude that competes with other grades of oil in the major refining centres in US and Europe (Fattouh, 2011). In contrast, WTI is landlocked and can be heavily influenced by internal infrastructural issues that are unrelated to events in the international oil market.

The models in this chapter provide additional supporting evidence for the role of the stocks of crude oil and petroleum products in influencing pricing relationships among crudes. In particular, the posi-
tive relationship between residual fuel stocks and the price spread concurs with the theoretical framework in EIA (1996) and Quarls et al. (2006). Finally, the results point to a persistence in the price differential that might be explained on the basis of consistent crude qualities and freight rates.

4.6.2 Robustness Tests: LLS-Brent, and Other Political, Infrastructure and Weather Events

The aim of this section is to examine the price differential between Brent and an alternative US domestic light and sweet crude that does not suffer from similar logistical problems to those experienced by WTI. Light Louisiana Sweet (LLS) is the de facto light and sweet crude oil benchmark on the US Gulf Coast (Energy Intelligence, 2011; Argus, 2014). In addition to its high quality, LLS is praised for its close proximity to the Gulf Coast region. This region hosts 35% of the total number of refineries in the US, and holds 48% of the total refining capacity in the country (Andrews et al., 2010; Fattouh, 2011; Energy Intelligence, 2011). Therefore, LLS is not exposed to the logistical problems faced by WTI. Consequently, examining the spread between LLS and Brent provides robustness for the results presented in the previous section.

The robustness exercise involves replacing the WTI-Brent differential with the natural log price spread between LLS and Brent in regression equations (1) and (2). An additional change is the replacement of the lagged WTI-Brent spread on the right-hand side of both equations with the lagged LLS-Brent spread. The estimation results from both equations are reported in Table XI below. The first observation to note in Table XI pertains to the statistically significant and negative regression coefficient associated with the dummy of OPEC outages. This finding further supports the results of the previous analysis. This is an interesting finding as it demonstrates that the relative strengthening of Brent prices is evident in the most significant refining region in the US.

This further attests to the prominent role of Brent as a global benchmark for waterborne crudes. However, the LLS-Brent differential appears less sensitive than WTI-Brent to disruptions. The results in Table XI also reveal that the LLS-Brent price differential behaves similarly to the other explanatory variables. LLS-Brent widens during the spring season compared to summer, which affirms the higher US seasonal demand for domestic light and sweet crudes.
Table XI: LLS-Brent

This table presents the estimation results for regression equations (1) and (2). Under model (1) the monthly natural log difference between the prices of LLS and Brent is modelled as a function of OPEC-related production disruptions, seasonal dummies, the first difference in the natural log levels of US industrial production with one month lag, the natural logarithmic change in crude stocks excluding SPR, the transportation, storage and insurance cost (TSIC) with one month lag, and one month lagged price differential. Model (2) replaces both the crude stocks and US Industrial production in (1) with the natural logarithmic changes in gasoline, distillate and residual stocks. The \( D_{\text{Outages}_t} \) takes the value of 1 in a three-month event window centred on the month in which the event occurred, and 0 otherwise. The table also reports the R-square, and the corresponding F-statistic for the test of the overall significance of the regression with the corresponding p-value. Parameter standard errors are given in the parentheses. ***, **, * denote the statistical significance at the 1%, 5% and 10% levels, respectively.

Regression Estimates for Events of OPEC Unplanned Production Outages

<table>
<thead>
<tr>
<th>Model (1) Regression Estimates</th>
<th>Model (2) Regression Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td><strong>Constant</strong></td>
</tr>
<tr>
<td>0.0223 (0.0041)</td>
<td>0.0192 (0.0060)</td>
</tr>
<tr>
<td><strong>D_{\text{Outages}_t}</strong></td>
<td><strong>D_{\text{Outages}_t}</strong></td>
</tr>
<tr>
<td>-0.0072** (0.0034)</td>
<td>-0.0066** (0.0033)</td>
</tr>
<tr>
<td><strong>D_{\text{Autumn}_t}</strong></td>
<td><strong>D_{\text{Autumn}_t}</strong></td>
</tr>
<tr>
<td>0.0055 (0.0037)</td>
<td>0.0075 (0.0062)</td>
</tr>
<tr>
<td><strong>D_{\text{Winter}_t}</strong></td>
<td><strong>D_{\text{Winter}_t}</strong></td>
</tr>
<tr>
<td>0.0041 (0.0053)</td>
<td>0.0132 (0.0095)</td>
</tr>
<tr>
<td><strong>D_{\text{Spring}_t}</strong></td>
<td><strong>D_{\text{Spring}_t}</strong></td>
</tr>
<tr>
<td>0.0074* (0.0038)</td>
<td>0.0086 (0.0053)</td>
</tr>
<tr>
<td><strong>USIP_{t-1}</strong></td>
<td><strong>Stocks_{\text{Gasoline}_t}</strong></td>
</tr>
<tr>
<td>-0.2014 (0.4037)</td>
<td>-0.1010* (0.0595)</td>
</tr>
<tr>
<td><strong>Stocks_{\text{Crude}_t}</strong></td>
<td><strong>Stocks_{\text{Distillates}_t}</strong></td>
</tr>
<tr>
<td>-0.0464 (0.0512)</td>
<td>0.0543 (0.0469)</td>
</tr>
<tr>
<td><strong>TSIC_{t-1}</strong></td>
<td><strong>Stocks_{\text{Residual}_t}</strong></td>
</tr>
<tr>
<td>0.2038*** (0.0379)</td>
<td>0.0588* (0.0323)</td>
</tr>
<tr>
<td><strong>Sp_{\text{LLS}<em>{t-1}-\text{Brent}</em>{t-1}}</strong></td>
<td><strong>TSIC_{t-1}</strong></td>
</tr>
<tr>
<td>0.3896*** (0.0699)</td>
<td>0.2059*** (0.0351)</td>
</tr>
<tr>
<td></td>
<td><strong>Sp_{\text{LLS}<em>{t-1}-\text{Brent}</em>{t-1}}</strong></td>
</tr>
<tr>
<td></td>
<td>0.3798*** (0.0720)</td>
</tr>
</tbody>
</table>

| **R-square**                  | **R-square**                  |
| 0.4040                         | 0.4181                         |
| **F-stat regression**          | **F-stat regression**          |
| 25.2481                        | 23.7084                        |
| **P-value**                    | **P-value**                    |
| 0.0000                         | 0.0000                         |
The transportation, storage, and insurance cost also has a statistically significant and positive relationship with the price differential. Interestingly, the LLS-Brent spread shows similar persistent behaviour over time. Table XI reports additional interesting findings regarding the relationships between the LLS-Brent differential and stocks of petroleum products. Changes in gasoline stocks are found to have a statistically negative effect on the LLS-Brent spread. The Gulf Coast’s significant share of the total US refining capacity suggests that LLS would be more responsive to the build-up of gasoline stocks than WTI. Table XI also documents a statistically significant and positive relationship between the differential and changes in residual fuel stocks. This affirms the role of residual fuel as a barometer for price relationships. To put this into context, 87% of the 8.9 million bbl/d of refining capacity on the Gulf Coast is highly complex (API, 2011: 21).

As a further robustness test, I control for both the period of infrastructural bottlenecks in and around the Cushing, and the potential explanatory power of two different sets of events. The first is a sample of 22 OPEC-related political conflicts that did not coincide with disruptions. The second includes 104 monthly intervals in which hurricanes occurred in the Atlantic basin.\(^{34}\) Therefore:

\[
S_{\text{WTI}-\text{Brent}} = C + \beta_1 D_{\text{Outages}} + \beta_2 D_{\text{Conflicts}} + \beta_3 D_{\text{Landlocked}} + \beta_4 D_{\text{Hurricanes}} + \\
\beta_5 TSI_{t-1} + \beta_6 S_{\text{WTI}_{t-1}-\text{Brent}_{t-1}} + \epsilon_t,
\]

where the error term \(\epsilon_t\) is assumed to be independently and identically normally distributed with mean zero and variance equal to \(\sigma^2\). \(D_{\text{Conflicts}}\) is a dummy variable that takes the value 1 if it falls in a three-month event window in which an OPEC-related conflict not coinciding with a disruption occurred; and zero otherwise. \(D_{\text{Landlocked}}\) is a dummy variable that takes the value 1 after February 2007; and zero otherwise. \(D_{\text{Hurricanes}}\) is a dummy variable taking the value 1 for each month in which at least one hurricane occurred; and zero otherwise. All of the remaining variables are identical to those in models (1) and (2).

The construction of \(D_{\text{Landlocked}}\) follows Büyükşahin et al., 2013. They identify the period after February 2007 as one that witnessed storage constraints in the Cushing due to increased US and Canadian production. Additionally, that period experienced transportation bottlenecks, which hindered the

\(^{34}\) According to the National Hurricane Centre, the Atlantic basin includes the Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico. The Tropical Cyclone Report for every hurricane in every year since 1958 is available on www.nhc.noaa.gov.
Table XII: Price Spreads, Outages, Conflicts, Infrastructure and Hurricanes

This table presents the estimation results for regression equation (3). Under model (3) the monthly natural log differences between the prices of WTI and Brent and LLS and Brent are each modelled as a function of OPEC-related production disruptions, OPEC-related conflicts not coinciding with disruptions, the period of infrastructural bottlenecks, extreme weather conditions, transportation, storage and insurance cost (TSIC) with one month lag, and one month lagged respective price differential. $D_{\text{Outages}_t}$ takes the value 1 in a three-month event window centred on the month in which the event occurred; and 0 otherwise. $D_{\text{Conflicts}_t}$ takes the value 1 in a three-month event window centred on the month in which a conflict in OPEC occurred, and zero otherwise. $D_{\text{Landlocked}_t}$ takes the value 1 from March 2007 to December 2012; and zero otherwise. $D_{\text{Hurricanes}_t}$ takes the value 1 for months in which at least one hurricane occurred; and zero otherwise. The table also reports the R-square, and the corresponding F-statistic for the test of the overall significance of the regression with the corresponding p-value. Parameter standard errors are given in the parentheses. ***, **, * denote the statistical significance at the 1%, 5% and 10% levels, respectively.

<table>
<thead>
<tr>
<th></th>
<th>$Sp_{\text{WTI}_t-Brent_t}$</th>
<th>$Sp_{\text{LLS}_t-Brent_t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>0.0155 (0.0048)</td>
<td>0.0282 (0.0061)</td>
</tr>
<tr>
<td>$D_{\text{Outages}_t}$</td>
<td>-0.0112** (0.0052)</td>
<td>-0.0072** (0.0037)</td>
</tr>
<tr>
<td>$D_{\text{Conflicts}_t}$</td>
<td>-0.0055 (0.0042)</td>
<td>-0.0016 (0.0035)</td>
</tr>
<tr>
<td>$D_{\text{Landlocked}_t}$</td>
<td>-0.0235*** (0.0087)</td>
<td>-0.0016 (0.0089)</td>
</tr>
<tr>
<td>$D_{\text{Hurricanes}_t}$</td>
<td>-0.0045 (0.0039)</td>
<td>-0.0015 (0.0026)</td>
</tr>
<tr>
<td>$\text{TSIC}_{t-1}$</td>
<td>0.1312*** (0.0501)</td>
<td>0.1944*** (0.0459)</td>
</tr>
<tr>
<td>$Sp_{\text{WTI}_t-\text{Brent}_t}$</td>
<td>0.6603*** (0.0783)</td>
<td>0.3871*** (0.0780)</td>
</tr>
<tr>
<td><strong>R-square</strong></td>
<td>0.6980</td>
<td>0.3990</td>
</tr>
<tr>
<td><strong>F-stat regression</strong></td>
<td>115.5671</td>
<td>33.2001</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

movement of crudes from the Cushing to the US Gulf Coast. The WTI-Brent price differential is replaced by the LLS-Brent spread in equation (3) as an additional robustness check. Table XII above reports these regression estimates. The results in Table XII confirm the previous findings and show that periods of production outages in OPEC give rise to a statistically significant tightening in both price differentials. This result is maintained even after accounting for the period of infrastructural bottlenecks, other OPEC-related conflicts and extreme weather conditions. A noticeable finding in Table
XII relates to the fluctuations of both price spreads after February 2007, as captured by the regression coefficient $\beta_3$ in model (3). While the WTI-Brent spread shows a statistically significant narrowing during the period of bottlenecks, the LLS-Brent differential exhibits insignificant fluctuation throughout that same time frame. This finding emphasises the landlocked nature of WTI, and highlights LLS’s close proximity to the US major refining centre. Table XII further shows that both price differentials do not exhibit significant fluctuations during OPEC-related conflicts that occurred without supply disruptions. This finding suggests that spreads are more sensitive to unplanned outages than disruption-free political conflicts. It could also indicate that traders in oil markets may be effective in evaluating the potential effect of a political event on crude production.

Overall, the findings from the robustness test confirm the negative effect of unplanned disruptions in OPEC on the price differential between WTI and Brent. This tightening is robust even after accounting for the period of significant infrastructural constraints, extreme weather conditions, and disruption-free political conflicts. Furthermore, the insensitivity exhibited by LLS-Brent to the Cushing-related bottlenecks highlights the importance of both maritime transportation and a crude’s location. Finally, the absence of significant fluctuations in the price spreads during disruption-free conflicts points to the ability of market participants to effectively assess the potential effects of political developments on upstream production.

### 4.7 Conclusion

This chapter examined the behaviour of the price differential between West Texas Intermediate (WTI) and Brent during periods of supply disruption. Using Bloomberg’s Oil, Natural Gas Field Outages service, a sample was constructed, consisting of 50 events of unplanned oil production outages in OPEC from 1987 to December 2012.

By specifying three regression models, and incorporating a number of explanatory variables, I demonstrated that supply disruptions give rise to a tightening spread between the two global benchmarks. This finding suggests that the prices of Brent strengthen relative to those of the US counterpart during such episodes. During periods of production outages, demand for waterborne crudes from secure sources rises to cover the shortage (Darbouche and Fattouh, 2011). Moreover, the increase in demand can be precautionary in nature (Adelman, 1982; 1990; Terzian, 1985; Kilian and Murphy, 2013).
In contrast to Brent, WTI is a landlocked domestic crude, and its exposure to infrastructural bottlenecks results in its prices being disconnected from those of other international crudes (Fattouh, 2010; 2011; Energy Intelligence, 2011; Kao and Wan, 2012). Although supplies of both crudes are relatively secure, Brent has the advantage of being waterborne. Additionally, it competes with other crudes in the major refining centres on both shores of the Atlantic (Fattouh, 2011). Simply put, the characteristics of Brent suggest that its prices could be more responsive than those of WTI to events and developments concerning the security of crude oil supplies in the world. Therefore, the findings of this chapter attest to the prominent role of Brent as a benchmark in the pricing of oil, particularly in the Atlantic basin.

The chapter further showed that the differential between LLS and Brent exhibits less tightening than that documented between WTI and Brent during the same events. The close proximity of LLS to the Gulf Coast—where it competes with international crudes—could be an essential factor in explaining why its differential to Brent is relatively less responsive to disruptions. Therefore, disruptions could lead to a situation where international crudes become relatively more expensive than their American counterparts. Additionally, producers of crudes that are further away from the coast appear to be at a comparative disadvantage, relative to those in the major refining centres, in particular on the Gulf Coast.

The findings of this chapter further demonstrate the importance of crude oil, gasoline and residual fuel stocks. These stockpiles represent a barometer for the state of balance in the petroleum markets and act as marginal sources of supply. Consequently, the patterns underlying their build-ups or draw-downs could be insightful for understanding price differentials. Moreover, the costs associated with transporting, storing, and insuring shipments of the fossil fuel were found to have a significant positive effect on the price spreads.

These findings have a number of policy and practical implications. First of all, the findings highlight the comparative disadvantage that has been suffered by the refining centre on the US East Coast relative to its counterparts, inland and on the Gulf Coast. This is because the absence of an adequate transportation infrastructure has resulted in a situation in which these refineries have been reliant on imports of crude oil from abroad that are priced off Brent (Andrews et al., 2010; Energy Intelligence, 2011; EPRINC, 2013). Therefore, enhancing US energy security calls for connecting the East Coast refining centre with adequate and sustainable transportation infrastructure.
While the shale revolution extended a lifeline to the refineries on the East Coast in the form of supplying cheaper domestic crudes, this was made possible only through the use of a more expensive mode of transportation, namely shipping by rail (EPRINC, 2013; EIA, 2014a). The reliance on rail became viable in the light of the high price environment that prevailed until mid-2014. The current declines in oil prices, which started in June 2014, might lead to an environment in which more expensive transportation modes are halted, and thus the dependence on imports resumes. Whether or not such a scenario materialises, investing in a permanent infrastructure would mean that the East Coast refineries always have access to domestic crudes. It would also mean, in the case of a return to imports, that a domestic benchmark rather than an international marker could be used in pricing, thus eliminating the price risk arising from disruptions.

Secondly, the findings underline the importance of investing in a sustainable infrastructure that can bypass the Cushing, and directly connect inland producers to the major refining centres on the US Gulf Coast. This is because the chapter showed that the closer a crude is to the Gulf Coast, the more responsive its prices are to international events. The presence of logistical bottlenecks has been causing domestic shale production- priced off WTI- to sustain significant discounts (EIA, 2012b; EPRINC, 2013). While such discounts benefit refiners, they exert downward pressure on wellhead values at a time when shale producers have to sustain a debt fuelled-production. The price discounts of Bakken crude to WTI were one of the reasons for the rise in asset impairments by 30 publicly traded tight oil producers between the third quarter of 2013 and same period in 2014 (EIA, 2014b).

The losses could affect other stakeholders. It is estimated, for example, that $3 million of lost state revenues are endured due to a $1 discount on the price of North Dakotan crude (EPRINC, 2013). Thus, policy makers could work closely with the industry in order to explore avenues through which the commercial, legislative, and bureaucratic environments could be enhanced to encourage the investments required to alleviate the logistical constraints. It is reported, for example, that the time taken to process infrastructure permits has increased significantly due to a sub-

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35 Estimates suggest that it costs $15 per barrel to ship oil by rail to New York Harbour from Bakken. This compares to only $5 per barrel to move oil by pipeline (EIA, 2012d; EPRINC, 2013).
36 See for example (The Economist, December 6th, 2014; EIA, 2014b; Alloway, 2014) on the reliance of shale producers on capital markets.
stantial rise in the number of applications, and the requirement to coordinate with different agencies (ibid).  

Thirdly, further steps could be taken to gradually enhance the visibility of LLS and eventually replace the landlocked WTI as a benchmark for light and sweet crudes. The presence of futures contracts with LLS being the underlying asset could be a step in the right direction. Additionally, Houston is emerging as a storage hub, similar to Cushing (EPRINC, 2013), but with the comparative advantage of being in close proximity to the refining complexes on the Gulf Coast. Some OPEC members have already switched from using WTI as a marker to using the Argus Sour Crude Index (ASCI) (Fattouh, 2011; Energy Intelligence, 2011). The choice of ASCI as a benchmark can be justified on the basis of the quality of oil imports. Since, however, the significant portion of shale production is of light and sweet quality (EIA, 2014a), LLS could be a viable reference by virtue of its quality and location.

Fourthly, the presence of vibrant futures exchanges opens the door for participants to use derivative instruments for hedging and speculative purposes. The IntercontinentalExchange (ICE) provides market participants with the opportunity to trade the spread between Brent and WTI (ICE, 2014). The ICE also offers futures contracts on Light Louisiana Sweet, which would suggest the potential for customised price differential trading. Similarly, traders have the opportunity to trade the WTI-Brent spread through a variety of financial instruments provided by the CME group. Among these financial products is the WTI-Brent Financial Futures Contract Specs, which is financially settled and can be traded on open outcry or electronically (CME, 2009a). CME also offers electronic trading in the WTI-Brent Crude Oil Spread call and put options with the WTI-Brent (ICE) Bullet Swap contract underlying these options (CME, 2009b). The use of these instruments would prove beneficial for oil producers, refiners, trading houses and speculators.

Finally, the events that this chapter examined can be challenging to anticipate in advance, which may suggest the need for continuous exposure to the WTI-Brent spread. This implication is similar in spirit to that proposed by Omar et al., (2014). They argue that investment positions in oil should be a

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37 This recommendation is in spirit with that advanced by Deutch et al. (2006) which called for a joint effort by the government and the industry to increase the efficiency of the US energy transportation infrastructure by making it less vulnerable to natural disasters and terrorism activities.

38 The IntercontinentalExchange (ICE) provides these derivative instruments (ICE, 2015).
stable feature of a well-diversified portfolio because the ‘dynamics of the oil price may be understood only with the benefit of hindsight’ (ibid: 30).
V. Crude Oil Pricing and the Statecraft: Lessons from US Economic Sanctions

Abstract

This chapter explores the presence of abnormal behaviour in crude oil prices around the start dates of US sanctions against members of OPEC and other net exporters, as well as net importers of crude oil. The chapter shows that the valuations of the fossil fuel witness significant and negative decline when sanctioning a net importer, while measures against net exporters and OPEC members give rise to significant positive abnormal behaviour. These abnormal returns could be the reflection of market participants’ anticipation of disruptions in supply and demand for oil due to impending sanctions. The significant changes in the valuations of oil due to sanctions, and the associated critical implications suggest that the status of an adversary nation in petroleum markets should be given careful consideration in the formulation of foreign policy.

5.1 Introduction

“He who knows neither his opponent nor himself will surely be imperilled in every battle”

(Sun Zi’s Art of War, 6th century B.C.)

Economic coercion has been a tool of cross-border influence for more than two thousand years. The use of such measures can be traced back to ancient Greece, when Athens imposed a trade embargo on Megara in 432 BC (Eaton and Engers, 1999; Kozhanov, 2011). However, the utilisation of the economic lever in foreign policy has been either foreshadowing, or complementing military force until the end of World War II (Hufbauer et al., 2007). The atrocities of great wars have given rise to the importance of designing and deploying instruments that can act as a credible substitute to violence (Barber, 1979; Steil and Litan; 2006; Mastanduno, 2007; Hufbauer et al., 2007; Kaempfer and Lowenberg, 2007). Indeed, the relative weight of economic sanctions in the arsenal of foreign policy has increased in the post-World War II era, and their usage has become a recurring feature in international relations (Drury, 2001; Caruso, 2003; Hufbauer et al., 2007).

Despite the frequent deployment of economic sanctions, questions have been raised regarding the effectiveness of these measures (Pape, 1997; Hufbauer et al., 2007). Sanctions can inflict significant economic costs on the targeted nation, the country imposing them, and on third parties
A possible avenue in the research would be to investigate the effect of economic sanctions on asset prices. This chapter aims to examine that particular avenue. Specifically, the chapter investigates the presence and nature of abnormal behaviour in crude oil valuations around the start dates of sanctions imposed by the US on two different groups of nations. The first consists of members of OPEC and other net exporters of crude oil, while the second group represents the net importers of oil. Numerous factors render this investigation important.

First of all, crude oil is, metaphorically, the blood in the veins of what Klare (2008:36) describes as the ‘petro-civilisation’. The world’s consumption of the fossil fuel stood at 89 million barrels per day in 2011, and increased by an annual average of 1.3% between 2000 and 2011 (Eni, 2012). Thus, it occupies a central role in the global economic system. This is reflected in the empirical evidence on the detrimental effects of oil shocks on the economies of nations that are net importers of crude oil (Gisser and Goodwin, 1986; Feferer 1996; Abeysinghe, 2001). For example, Hamilton (1983) shows that shocks to the price of oil preceded seven out of the eight post-World War II economic recessions in the US.

Moreover, Hamilton (2011) documents the intertwined nature of the histories of political conflicts and petroleum. The rising dependence on petroleum goes beyond daily civilian uses, as is evident in the staggering increase in fuel consumption by the US military (Deloitte, 2009; Schwartz et al., 2012). Additionally, emerging powers such as China and India are embracing and emulating the civilian and military consumption habits of the US (Klare, 2008). Therefore, the strategic importance of crude oil dictates an examination of its prices around events, such as sanctions. Such an investigation is further necessitated in the light of the argument that there is a rapidly transpiring shift towards a ‘tough oil’ era (Klare, 2008). Some authors argue that in such an epoch oil is becoming harder to find and extract, which in turn may give rise to higher geopolitical tensions (ibid).

Secondly, the importance of economic coercion in the armoury of the US foreign policy has increased especially since the country’s hegemony reached its apogee in the post-Cold War era (Askari et al., 2005; Hufbauer et al., 2007; Kaempfer and Lowenberg, 2007; Biglaiser and Lektzian, 2011; Lektzian and Biglaiser, 2013). Despite being used as a tool short of violence, sanctions can have significant human cost too. Sanctions on Iraq following the first Gulf war may have been responsible for the death of more than 567,000 Iraqi children (Pape, 1997:110).
2011). The US is the primary sender of sanctions in nearly 50% of the cases recorded in the Threat and Imposition of Sanctions (TIES) database.\textsuperscript{40} The economic and military superiority of the US, and its leading role in the utilisation of economic punishment, both motivate this investigation into the effect that its sanctions may have on the prices of the fossil fuel.

Consequently, exploring abnormal behaviour in the valuations of crude oil sheds light on externalities that can have economic and foreign policy implications. This, in turn, allows for drawing conclusions and recommendations for US policy makers, which can contribute towards better design and deployment of sanctions with less negative external effects. Additionally, the investigation provides statesmen of other nations with a better understanding of the effects of US foreign policies on oil markets, which can have an impact on the economic welfare of their nations.

This chapter provides a number of contributions. First of all, it shows that US sanction programmes give rise to significantly different abnormal crude oil valuations. Secondly and more specifically, crude oil returns exhibit significant and positive abnormal behaviour around the start dates of 50 sanctions against OPEC members and other net exporters of the fossil fuel. On the other hand, the valuations of oil register significant declines around the start dates of 68 economic coercion programmes on net importers. Thirdly, robustness measures indicate that oil markets are more sensitive to the developments of the foreign policy of the US than those of other nations.

Additionally, oil markets appear to be more responsive to unilateral programmes than to multilateral measures. Interestingly, oil prices do not behave abnormally around either the dates on which threats to use sanctions were issued, or the start dates of threatened measures. Strikingly, the largest negative and positive abnormal returns are reported around sanctions without prior threat. Finally, I build on these findings and roughly estimate the losses inflicted on, and gains accrued to, the US economy. On average, the abnormal rise in crude oil valuations around the start of sanctions against a net exporter can cause accumulated losses of almost 0.20% of GDP, or $31.8 billion in monetary terms, after two years. On the other hand, and on average, the abnormal decline in oil prices due to the start of measures against a net importer can generate accumulated gains of almost 0.25% of GDP, or $39.4 billion in monetary terms, after two years.

\textsuperscript{40} Available online at: http://www.unc.edu/~bapat/TIES.htm
These findings point to critical ramifications and policy implications. Firstly, the economic outcomes of sanctions are not confined to changes in either trade flows or direct investment. These measures can impact other facets of economic activity such as prices of assets. This clearly suggests that such externalities should be accounted for in the design and calculation of the gains and benefits of sanctions. This is because these external effects can hamper, or enhance, the popularity of economic coercion among voters and the various domestic business interests. Secondly, the effects on oil prices can harm the US foreign policy through hurting the economies and energy security of its allies and friendly nations. This is more pronounced in the case of positive changes in the valuations of crude petroleum, and represents a negative externality that may hinder the ability of US policy makers to utilise sanctions that require concerted actions.

Thirdly, a significant rise or fall in the prices of crude oil can help an adversary nation. An increase in oil prices undermines the effectiveness of sanctions that target an oil exporting country. For example, Iran’s sabre-rattling and its threats to close the Strait of Hormuz may be a tactic aimed at increasing the price of oil in order to offset the negative effect of sanctions on revenues (El-Katiri and Fattouh, 2012; Van de Graaf, 2013). On the other hand, a decline in oil prices due to sanctions against a net importing nation can be perceived as compensation for the restriction of economic ties, thus hindering the effectiveness of economic coercion. Put differently, while sanctions could be intended to contain, deter or punish a certain act, they may actually fuel it through their effect on oil prices.

Fourth, the aforementioned ramifications suggest that US policy makers should assign higher weight to consideration of oil markets in the design and deployment of economic measures. A critical element of such consideration is the status of the adversary nation as a net importer or exporter of oil. More specifically, similar reporting requirements to those under the National Defence Authorization Act (NDAA) could be introduced on a permanent basis. This would contribute towards a better and up-to-date understanding of the state of oil markets, and allow for swifter and more effective design and utilisation of sanctions with less negative externalities.

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41 NDAA requires the Energy Information Administration (EIA) to submit reports to Congress on the state of oil supplies excluding those from Iran within 60 days of enactment, and every 60 days thereafter (see EIA, 2012a). NDAA is available online at: www.gpo.gov/fdsys/pkg/BILLS-112hr1540enr/pdf/BILLS-112hr1540enr.pdf (pages 350-351).
Fifth, the threat of using sanctions is a channel through which US policy makers announce what constitutes misconduct by an adversary, their expectations, and the nature of response in case of non-compliance. Such announcements appear to calm markets down. While it may not always be feasible for US policy makers to issue threats prior to the start of sanctions, better communication of expectations and the nature of a potential action can contribute to the resolution of uncertainty. Finally, the findings of this chapter suggest that policy makers in energy intensive countries must be forward-looking with respect to the development of US foreign policy. The same applies to commercial and speculative traders in oil markets. Industry players in the US may be able, to a greater extent than their foreign counterparts, to engage with US policy makers in order to enhance the breadth of information on impending sanctions, and thus eliminate some sources of uncertainty.

This chapter is organised as follows. The following section discusses the definition of sanctions, as well as their rationale, objectives, and limitations. It also reviews the literature on both the costs of economic coercion, and oil pricing in the context of exogenous events. Section 5.3 presents the data and summary statistics. The methodology and discussion of the empirical results are included in sections 5.4 and 5.5, respectively. Finally, section 5.6 concludes and presents policy implications.

5.2 Literature Review

5.2.1 Economic Sanctions: Rationale, Objectives, and Limitations
Economic sanctions can be defined as measures targeting another nation through limiting or ending economic ties in order to force a change in the target’s policies.\textsuperscript{42} The design and deployment of economic sanctions are part of the decision making process of foreign policy (Baldwin, 1985; Steil and Litan, 2006). This process is also referred to as statecraft, which encompasses all of the activities undertaken by policy makers when faced with cross-border challenges in the form of objectives to achieve or values to protect (Sprout and Sprout, 1971). The rationale underlying statecraft in general, and economic sanctions in particular, can be viewed through more than one dimension.

\textsuperscript{42} Threat and Imposition of Sanctions (TIES) Database Codebook v. 4.13, available online at: www.unc.edu/~bapat/tiesusersmanualv4.pdf
First of all, the use of economic coercion is embedded in the relationship between power and the powerful (Baldwin, 1985; Steil and Litan, 2006). This is because the exertion of power, or to use Baldwin’s words, “to get others to do what they would not otherwise do”, requires instruments (1985:9). Lasswell (1958:27) summarises these methods of influence by arguing that “the fate of an elite is profoundly affected by the ways it manipulates the environment; this is to say, by the use of violence, goods, symbols, practices”. In the context of international relations, the tools of influence are propaganda, diplomacy, economic statecraft, and military statecraft (Baldwin, 1985). According to Baldwin, the use of sanctions falls under the category of economic statecraft.

Secondly, sanctions inflict economic damage on the targeted country. The deeper the economic wounds, the more likely it is that the target will yield to the demands of the sender (Caruso, 2003). Additionally, the higher the degree of economic integration with the sender, the higher the costs endured by the targeted country (ibid). Thus, the use of economic punishment implicitly assumes that the sender is large enough to cause damage to the target’s economy, while still being capable of bearing the brunt of cutting or limiting economic relations. For example, Hufbauer et al., (2007:5) argue that “big powers, especially the United States, have used sanctions precisely because they are big and can seek to influence events on a global scale”.

Thirdly, parallels can be drawn between the rationale of sanctions and the three bourns of criminal law; i.e., punish, deter, and rehabilitate (Hufbauer et al., 2007). For instance, Askari et al., (2003a; cited in Askari et al., 2005:42-43) broadly classify sanctions on the basis of whether they are used for coercive purposes, to send a signal of displeasure, or with the sole aim of punishment. This general classification also reflects the trade-off between the cost of sanctions and cost of inaction that policy makers face in some cases (Hufbauer et al., 2007). Thus, while rehabilitation may not be attainable through the use of sanctions, accomplishing punishment and deterrence may still satisfy the sender country (ibid).

Fourthly, domestic political considerations in the sender country could provide a rationale for the utilisation of economic measures against a nation (Barber, 1979; Hufbauer et al., 2007). The imposition of sanctions can be an attempt to appease domestic electors, or to prepare for stricter actions (Hufbauer et al., 2007). Additionally, these sanctions can intensify patriotic zeal or quell the public’s call for retaliation, and therefore invigorate domestic support for the government.
(ibid). However, the extent of the importance of such domestic considerations is debatable (Drury, 2001; Hufbauer et al., 2007). Drury (2001), for example, investigates foreign and local factors that may motivate the American president to impose economic sanctions. Drury shows that domestic considerations play a marginal role relative to foreign factors in the president’s decision to impose sanctions.

Moreover, one possible approach to understanding the rationale of sanctions is through their objectives. Barber (1979) argues that a government can entertain more than one objective when designing and deploying this economic instrument. According to Barber, the primary objectives revolve around the actions of the targeted country, while the expectations and status of the sender nation can be viewed as secondary in nature. On the other hand, the tertiary objectives are those concerned with third parties, the international system, its structure and mode of operation (ibid). However, Barber further asserts that, in the long-term, the weights assigned to different objectives in any particular case may shift.

Finally, foreign policy objectives and considerations of national security motivate the action of bringing economic pressure to bear against a nation (Askari et al., 2005). The objectives of sanctions that are driven by national security are diverse. Sanctions can be imposed in order to disrupt actual military operations, or to force the abandoning of plans for martial adventurism. Additionally, such economic measures can be deployed to deprive the target of vital economic resources, thereby retarding its build-up of military capabilities. On the other hand, foreign policy has a different set of objectives. These goals range from regime change and human rights issues, to counter-narcotics and targeting international terrorism.

Despite the rich history of utilising economic tools in international relations, the effectiveness of these measures is subject to serious doubts (Barber, 1979; Pape, 1997; Eaton and Engers, 1999; Drury, 2001; Hufbauer et al., 2007). Pape (1997) points to the persistent failure of economic sanctions in accomplishing foreign policy objectives. However, he advances the notion that economic pressure can still be a component of the “American way of war” (1997:110). Hufbauer et al. (2007) document a success rate of only 34% among all of the post-World War I cases that they examined. Additionally, they show that this success rate depends on the nature of the objectives being pursued. For example, the success rate is only 30% in cases in which the aims are to cause a

---

43 Hufbauer et al., 2007 is source of the discussion that follows on the different objectives.
major alteration in the target’s policy, destabilise its regime, or curtail the build-up of its military capabilities. Where the goal is to hinder minor military operations, the success rate declines to 20%.

A number of limitations may have been responsible for impairing the effectiveness of sanctions. Firstly, Hufbauer et al. (2007) argue that the rise of economic powers in Europe and Asia meant a relative decline in the US position in the global economy. They further point to the US’ gradual approach in imposing sanctions -which in many cases even lack completion- as another factor affecting effectiveness.\(^{44}\) Secondly, the exertion of economic pressure could be hampered when the target is required to yield to an action that it fiercely rejects (Hufbauer et al., 2007). In this context, Drury (2001) shows that the president of the US may abstain from imposing sanctions when the targeted nation responds stoutly.

Moreover, the deployment of economic punishment may result in counter-effects, in the form of galvanising the target country’s people around its government (Hufbauer et al., 2007). The effectiveness of sanctions is also limited by the conflicting business and political interests between the target state and groups inside the sender nation or its allies (Hufbauer et al. 2007; Kozhanov, 2011). In such cases, a sanction programme may be reticent and timid in its design and utilisation (Hufbauer et al., 2007). Finally, punitive economic measures may also represent profitable business opportunities for the so-called ‘black knights’, who are the advantageous allies of the target nation or its relatively small economic partners (Hufbauer et al., 2007; Kozhanov, 2011; Van de Graaf, 2013).

\textbf{5.2.2 Economic Sanctions: Cost to Sender and Target}

A critical aspect of sanctions is the economic costs endured not only by the targeted nation, but also by the sender country. The use of such measures can also bring to bear economic consequences for third parties like the target’s neighbours or its trading partners. This chapter contributes to the literature by exploring sanctions-associated costs and benefits from a different perspective. This is done by examining the behaviour of crude oil prices around the start dates of sanctions imposed by the US. Documenting abnormal behaviour allows for deducing a rough approx-

\(^{44}\) Hufbauer et al. (2007:168) reflect on this particular point and recommend to ‘Slam the hammer, don’t turn the screw’ in the utilisation of sanctions.
imation of the costs inflicted on, and gains accrued to, the US economy due to the utilisation of sanctions.

A number of common factors among countries would determine the magnitude of the real economic losses that arise from the imposition of sanctions. These are the size and structure of a country’s economy; its geographical location; its relationship with world markets; the nature of the goods and services that it trades; and global supply and demand for these goods and services (Askari et al., 2005). Furthermore, the decline of the economic hegemony of the US, the ascendance of other economic powers, and the increase in global economic interdependence have all played a role in either deepening or blunting the economic impact of sanctions (Askari et al., 2005; Steil and Litan, 2006; Hufbauer et al., 2007).

It may not come as a surprise that researchers have been interested in capturing the impact of sanctions on trade flows, considering that one may perceive these economic measures as synonymous to a trade embargo. Caruso (2003) examines the effect of US sanctions on the country’s bilateral trade with 49 targeted nations. Caruso shows that while moderate sanctions have a positive but insignificant effect on bilateral trade, comprehensive sanctions result in a significant reduction in trade flows. In a similar vein, Yang et al. (2004) report a significant negative effect on the US’ total trade with nations targeted by comprehensive sanctions. Interestingly, when investigating the effect of all sanctions programmes on US exports to targeted nations, they report average annual losses of $15 billion between 1989 and 1998. Hufbauer et al. (2007) investigate the effect of sanctions on trade in the context of an overall examination of effectiveness. They show that 90-96% of US-Target nation bilateral trade is wiped out due to the imposition of comprehensive sanctions.

Other researchers have focused specifically on the costs suffered by the US due to its economic sanctions against other nations. The frequent utilisation of economic coercion can force third-party nations or their businesses to avoid commercial activities with US firms for fear of being caught in a sanction episode (Hufbauer et al., 1997). This risk became more pronounced after the enacting of the Helms-Burton Act and the Iran/Libya Act in the mid-1990s. These acts introduced secondary sanctions against third parties’ economic dealings with Cuba, Iran, and Libya. Moreover, sanctions may negatively affect American businesses even after being lifted. A nation that was the target of US sanctions may perceive American firms as unreliable (ibid).
Hufbauer et al. (1997) specifically examine the effect of US sanctions on the bilateral trade flows with 26 targeted nations, and report losses to US exports between $15 billion and $19 billion in 1995 due to sanctions. Furthermore, their estimations suggest that in the absence of an offsetting effect, the reduction in exports subsequently translates to losses of 200,000 jobs in the export sector. These losses would, in turn, result in an annual loss of $1 billion of export-sector wage premium. Further evidence on the costs of sanctions for the sender country is reported by Biglaiser and Lektzian (2011). They examine the impact that sanctions have on US foreign direct investment in the targeted nations. Their findings show that US businesses disinvest from targeted countries a year before the imposition of sanctions. The disinvestment is more pronounced when higher cost to a targeted country is expected, or in cases where the UN offers backing for the US decisions.

Researchers have also investigated the nature of the economic effect of sanctions on countries that are not involved in the episodes. Third parties, such as trading partners of the target and sender, may either benefit or suffer from an episode of sanctions. The deployment of economic punishment against a nation may create its antidotes through the phenomena of backsliding and sanction-busting. The former refers to the diversion of trade flows by a target country to other nations in order to evade sanctions (Drezner, 2000). Sanction-busting occurs due to incentives to the private sectors in other countries to capture business with the target at the expense of the sender nation (ibid). On the other hand, economic coercion may lead to significant losses to uninvolved nations through the network effects (Van Bergeijk, 1995). These represent negative spillovers as the effect of sanctions reverberates from the target to its trade partners and subsequently to the ‘trade partner’s trade partners and so on’ (ibid: 451).

Caruso (2003), additionally, investigates the effect of US sanctions on the bilateral trade between each of the 49 targeted countries and the G7 group. His findings are mixed, in that moderate unilateral US sanctions have a significant positive impact on trade flows between targets and G7. More specifically, Caruso shows that if such sanctions were not imposed, bilateral trade with G7 would have been 17% less. On the other hand, the network effect is at work in the case of multilateral or extensive unilateral sanctions (ibid). Slavov (2007) provides support for the presence of the network effect by showing that countries neighbouring the nation targeted by UN sanctions suffer negative economic costs in terms of trade losses. These losses are justified on the basis of increases in transportation and transaction costs, in addition to the disruption of trading ties (ibid).
On the other hand, Yang et al., (2004) show that comprehensive unilateral US sanctions result in a positive increase in bilateral trade between target countries and the EU and Japan. Lektzian and Biglaiser (2013) document similar findings with relation to foreign direct investments. They show that while foreign investments flow into nations targeted by US sanctions, American firms disinvest. They argue that this not only hurts US businesses, but also provides the target country with capital, which in turn may impact the effectiveness of sanctions. Interestingly, they document a significant increase in French investments in targeted nations even when the UN is involved in the sanction episode. Apparently, the French are not an exception. Hufbauer et al. (1997) show that American businesses have been replaced in Cuba by foreign firms from Belgium, Canada, Germany, Ireland, Italy, Mexico, the Netherlands, and Spain.

A noticeable exception to the aforementioned studies is Canes (2000), who examines the effect of the Iraq-related multilateral sanctions on the economic output of that country, and 80 other nations. Canes shows that while Iraq is the most severely affected by the sanctions, the biggest winners are other oil exporters. On the other hand, while there is a slight effect on the GDPs of the majority of the other countries, that effect is negative and more pronounced for Iraq’s neighbours, such as Turkey and Jordan.

The aforementioned findings highlight the importance of examining the behaviour of crude oil prices around the start dates of sanctions. Capturing abnormal returns demonstrates that the effects of sanctions are not restricted to disrupting trade flows or foreign direct investments; the economic ripples of sanctions are felt in the form of changes in asset prices. This is because significant abnormal behaviour in the prices of the fossil fuel can lead to serious implications for the target, the sender, and other nations.

5.2.3 Exogenous Political Events and Crude Oil Prices

Crude oil has been interwoven into the fabric of daily life. The strategic importance of this commodity extends to fueling the war machine. This role has been assumed by the fossil fuel since World War I, and culminated in World War II when petroleum effectively sealed the fate of battles (Liddell-Hart, 1953; Yergin, 2012). The dependence on petroleum in warfare has increased as reflected in the 175% rise in fuel consumption per US soldier per day between the Vietnam conflict and the wars in Iraq and Afghanistan (Deloitte, 2009). Oil revenues not only act as a trigger to intrastate conflicts, but can also fuel the build-up of military capabilities, which assist for-
eign policy adventurism (Fearon and Laitin, 2003; Collier and Hoeffler, 2004; Khanna and Chap-
man, 2010; Colgan, 2011).

A number of researchers have attempted to investigate the relationship between crude oil prices and political conflicts. Leigh et al. (2003) and Rigobon and Sack (2005) both report an apprecia-
tion in crude oil prices that was associated with the heightened risk of war in Iraq. Omar et al. (2014) document a significant positive abnormal movement in crude oil prices around the start dates of international violent conflicts. They further show that this abnormal increase is more pro-
nounced for their sub-sample of 43 wars.

Economic sanctions can be perceived as an exogenous event of political nature. In fact, the in-
famous first shock to the price of crude petroleum resulted from the Arab oil embargo of the
1970s, which was an act of economic coercion. Consequently, the question arises as to how such
events affect oil prices. The Arab embargo and the Iranian revolution have given rise to the view
that shocks are triggered solely by physical supply disruptions, which in turn are caused by politi-
cal events (Kilian, 2008c). Over time, however, theoretical and empirical evidence has shown that
shocks to demand can also affect oil prices and the economy. This effect materialises either on its
own, or in combination with supply-driven shocks (Kilian, 2008c; 2009; Baumeister and Peers-
man, 2013b).

Consequently, political events can affect oil prices not only by disrupting supplies, but also
through triggering changes in specific components of global demand for oil. Specifically, traders
can react to rising geopolitical tension by accumulating oil stocks on either a speculative or pre-
cautionary basis. Such a reaction can trigger a demand-side shock (Kilian, 2008c; Alquist and
Kilian, 2010; Kilian and Murphy, 2013; Baumeister and Peersman, 2013a; b). This is because ex-
genous political events can heighten uncertainty about the availability of future supplies (Alquist
and Kilian, 2010; Baumeister and Peersman, 2013a; b). This rise in uncertainty can cause a shift
in expectations, subsequently triggering precautionary demand (Baumeister and Peersman, 2013a;
b; Kilian and Murphy, 2013).

The effect of these shocks can be amplified by constraints on spare production capacity, unex-
pected shifts in aggregate demand, and changes in the weight of precautionary demand in oil mar-
kets. This is because these factors cause markets to tighten. In turn, this tightness heightens uncer-
tainty about the flow of supplies, when there is increasing political tension (Stevens; 1995; 2005;
Askari and Krichene, 2008; Huntington et al., 2014). Therefore, an unexpected surge in demand, when combined with a highly inelastic supply curve, can generate significant swings in prices, not just in response to a physical disruption, but even to the mere threat of such an occurrence (Kilian, 2008c).

By design, the use of economic coercion is intended to restrict or limit trade flows or other forms of commercial activity between at least two nations. From the viewpoint of participants in oil markets, the details of a sanctions programme cannot always be known in advance, which heightens uncertainty. Missing from the literature are answers to the questions of whether and how crude oil prices abnormally behave around the start dates of economic sanctions. Thus, this chapter aims to answer these questions by specifically exploring the nature of abnormal behaviour in crude oil prices around the start dates of US sanctions. Capturing abnormal oil returns also allows for exploring external benefits or losses arising from sanctions, which can affect the effectiveness of such measures.

5.3 Data and Descriptive Statistics

5.3.1 US Sanctions and Crude Oil

In order to explore the presence of abnormal behaviour in crude oil prices, I conduct the examination using the start dates of US sanctions programmes. These dates are extracted from two sources. The first is the latest version of the Threat and Imposition of Sanctions (TIES) data (version 4.0, 2013). This database provides numerous details on economic sanctions such as the countries involved, starting dates, and type of sanctions. The second source is the Office of Foreign Assets Control (OFAC) of the US Department of the Treasury. Considering that that the TIES database covers sanctions up to the year 2005, the OFAC’s documents allow for extending the investigation to cover a more recent period.

OFAC is responsible for enforcing and managing US sanctions programmes. OFAC’s list of sanctions offers access to information on each programme, which includes the ‘Overview of Sanctions’ document and the Executive Orders issued by the US president for each episode. Specifically, the issue date of an Executive Order (EO) in which the US president declares a national emergency, or expands a national emergency, is regarded as the start date of a new sanctions pro-

---

45 See Morgan et al. (2014) for a description of different aspects of the dataset. To access the dataset, please visit: www.unc.edu/~bapat/TIES.htm
gramme. Therefore, the date on which the US president announces additional measures based on a previously declared national emergency does not represent the start of a new programme. Adopting this procedure of inclusion and exclusion ensures that the expansion of analysis beyond 2005 is compatible with the definitions based on which TIES data is compiled.\footnote{46}

I focus specifically on two groups of nations that have been targeted by US sanctions. The first consists of members of OPEC and other net exporters of crude oil, while the second group contains net importers of the fossil fuel. In what follows, I label the former as the “net exporters sample”, while the latter is the “net importers sample”. The start date of the sanctions is placed in one or other sample depending on whether the targeted country was a net exporter or importer of oil in the year in which the sanctions started.\footnote{47}

I choose to start the entire analysis from the year 1987 as this year marked a shift to a market-based system for trading and pricing crude oil (Kaufmann et al., 2004; Yergin, 2012). The net importers sample consists of 68 start dates of US economic coercion measures covering the period between 1987 and 2010. The year 2010 is chosen because the relevant OFAC data on sanctions against net importers are available up to that year. For the net exporters, the sample contains 50 start dates of sanctions from 1989 to 2011. Following the transition towards a market-oriented system, the first case of sanctions against an exporter was recorded in 1989. The year 2011 marks the latest year in which relevant OFAC data is available for sanctions against net exporters. The price of crude oil is the Brent current month Free On Board (FOB) in US dollars. The price series is sourced from Datastream. Figure IV below depicts the evolution of Brent prices during the period of examination, while Table XIII reports summary statistics on the fossil fuel returns.

The average daily return of crude oil is almost 0.03\% with a 2.31\% daily standard deviation. Four main noticeable observations are captured in Figure IV. The first is the hike in the price of crude petroleum in 1990, which is attributed to the Iraqi invasion of Kuwait and the associated loss of millions of barrels of crude production from both countries. Crude oil markets were in a ‘buyer’s market’ mode during the late 1980s and 1990s (Van De Graaf, 2013). This would explain

\footnote{46}{For example, several additions of economic coercion measures against Iran during the 2000s have been based on EO 12957 of March 15, 1995. I would like to thank Dr Navin Bapat, TIES database co-investigator, for his helpful comments – particularly on how to deal with dates of EOs.}

\footnote{47}{The data on exports and imports are sourced from the Energy Information Administration. Data on exports are available on an annual basis only. This data is available from 1986. Data can be accessed through: www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm}
Table XIII: Brent Current Month (FOB) Descriptive Statistics

This table reports descriptive statistics for the period January 1987 to December 2011 for daily returns on Brent Crude Oil.

<table>
<thead>
<tr>
<th></th>
<th>Brent (Returns %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.0294%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.3061%</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>-1.1060%</td>
</tr>
<tr>
<td>Median</td>
<td>0.0000%</td>
</tr>
<tr>
<td>75th Percentile</td>
<td>1.2151%</td>
</tr>
<tr>
<td>Observations</td>
<td>6522</td>
</tr>
</tbody>
</table>

the second observation of the relatively modest and stable prices of crude oil in the 1990s. Thirdly, Figure IV also shows the upward trajectory of crude oil, which started in the early 2000s.

During the first decade of the new millennia crude oil markets moved to a ‘seller’s market’ mode of operation (Van de Graaf, 2013). This shift transpired due to the unexpected rise in demand for petroleum in the 2000s (Saporta et al., 2009). Additionally, the period of relative calm in the 1990s, and the expectations that prices would remain low, have both resulted in low investment in new upstream production capacity (Stevens, 2005). Thus, the rise in demand had to be met with the already existing levels of spare capacity. The fourth noticeable observation relates to the significant decline in the price of the fossil fuel during the second half of 2008. Between July and December of that year, the price of crude oil tumbled from almost $145 per barrel to $34 per barrel. The price appears to recover gradually between 2009 and 2011, ending up at almost $108 per barrel in December 2011.
5.3.2 US Output and Crude oil

The database of the Federal Reserve Bank of St. Louis (FRED) is the source of the US GDP series, while crude oil prices are sourced from Datastream. Both series are quarterly, because this is the highest frequency that is available for GDP. Table XIV below reports the summary statistics for both series. Table XIV also shows the unit root results using an Augmented Dickey Fuller test (Dickey and Fuller, 1981), assuming that the equation contains an intercept and a trend, and utilising the Akaike Information criterion for lag selection (Akaike, 1974). Table XIV documents average growth in real US output at 0.7%. Brent crude is shown to have average quarterly returns of 1.4% during the period and a relatively high volatility of 21%. Additionally, Table XIV shows that the real GDP growth rates and real crude returns are both stationary.

48 The nominal GDP series is sourced from FRED, and deflated using the GDP deflator, which is from the same database. The Brent series is deflated using the same GDP deflator. Data is from Q1 1971 to Q4 2011.
Table XIV: US GDP and Brent Crude Descriptive Statistics

This table reports descriptive statistics for the period January 1971 to December 2011 for quarterly growth rates of real US Gross Domestic Product ($GDP_{growth \ t}$), and real continuous returns on Brent current month (FOB) crude oil ($Crude\ returns\ t$).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>25&lt;sup&gt;th&lt;/sup&gt; Percentile</th>
<th>Median</th>
<th>75&lt;sup&gt;th&lt;/sup&gt; Percentile</th>
<th>Unit Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>$GDP_{growth\ t}$</td>
<td>0.7142%</td>
<td>0.8438%</td>
<td>0.3372%</td>
<td>0.7602%</td>
<td>1.1262%</td>
<td>-4.4141***</td>
</tr>
<tr>
<td>$Crude\ returns\ t$</td>
<td>1.4527%</td>
<td>20.9255%</td>
<td>-6.9620%</td>
<td>-0.2615%</td>
<td>10.0112%</td>
<td>-11.6153***</td>
</tr>
</tbody>
</table>
### 5.4 Methodology

#### 5.4.1 Event Study Framework

In order to capture the timing and magnitude of the behaviour of crude oil valuations around the start dates of sanctions, an event window of 201 daily intervals is specified and centred on the start dates of sanctions. The window captures 100 trading days before and after the event day (Day 0).

I additionally specify a 101 daily intervals window centred on the day of the event in order to explore the nature of abnormal behaviour in a shorter timeframe. The length of the latter window corresponds to that in Omar et al. (2014). They investigate the abnormal behaviour of crude oil during 101 daily intervals centred on the trigger dates of violent international conflicts and wars.

Secondly, I adopt the framework of an event study outlined in Campbell et al. (1997). Specifically, I use a constant mean return model, which is a model for ‘normal returns’. Despite its simplicity, it is comparable to more sophisticated models as it often obtains similar estimates (Brown and Warner, 1980; 1985). Thus, it is assumed that:

\[
R_{Crude_t} = \alpha_{Crude} + \varepsilon_t, 
\]

where \( \varepsilon_t \sim N(0, \sigma_t^2) \), and \( t \in (-250, -101) \). \( t \) denotes the underlying daily intervals, \( \alpha_{Crude} \) is the constant or mean return of crude oil, and \( R_{Crude_t} \) is the return of the fossil fuel in a specific daily interval \( t \). Model (1) is estimated on a pre-event window with a length of 150 daily intervals, henceforth the estimation window. I compute the crude abnormal returns using the parameter estimates from model (1), thus:

\[
\hat{AR}_t = R_{Crude_t} - \hat{\alpha}_k, 
\]

where \( t \in (-100,100) \), \( \hat{AR}_t \) denotes the abnormal returns on crude oil for event \( k \) computed from the start of the estimation window to the end of event window, and \( \hat{\alpha}_k \) denotes the mean of returns observed in the estimation window (-200,-51) for event \( k \). The average abnormal return for event \( k \) is defined as:

\[
\hat{AAAR}_t = \frac{1}{N} \sum_{k=1}^{N} AR_{t,k}, 
\]

where \( N \) is the number of events. Therefore, the cumulative average abnormal return \( CAAR_{ij} \) is given by:
where \((t_1, t_2)\) denotes the event window. Estimates of CAARs represent average abnormal returns per event that are directly attributable to the start of sanctions, and their statistical significance is assessed using the \(t\)-statistic described in Kothari & Warner (2007).

5.4.2 Measuring Economic Costs and Benefits of Sanctions

In order to capture the cost inflicted on, and benefits accrued to, the US economy due to the imposition of sanctions, I utilise the technique of accumulated generalised impulse responses introduced by Pesaran and Shin (1998). The deployment of this analytical technique requires estimating the following VAR model expressed in the following system of equations:

\[
\begin{align*}
GDP_{\text{Growth}_t} &= \gamma_1 + \sum_{i=1}^{4} \phi_i GDP_{\text{Growth}_{t-i}} + \sum_{j=1}^{4} \beta_j \text{Crude}_{\text{Returns}_{t-j}} + u_{1t}, \\
\text{Crude}_{\text{Returns}_t} &= \gamma_2 + \sum_{j=1}^{4} \delta_j GDP_{\text{Growth}_{t-j}} + \sum_{i=1}^{4} \alpha_i \text{Crude}_{\text{Returns}_{t-i}} + u_{2t},
\end{align*}
\]  

where the structural shocks \(u_{1t}\) and \(u_{2t}\) are white noise processes, each with a zero mean, standard deviation of \(\sigma_1\) and \(\sigma_2\), respectively, and zero covariance. \(GDP_{\text{Growth}_t}\) is the natural logarithmic difference in real US gross domestic product between time \(t\) and \(t-1\). \(\text{Crude}_{\text{Returns}_t}\) is the first difference in the natural logarithm of the real price of Brent current month Free On Board in US dollars, while \(i\) and \(j\) are the number of lags to be included in the model above. The inclusion of four lags is based on the Akaike Information Criterion (AIC) (Akaike, 1974).

A useful analytical technique in the VAR toolbox is the impulse response function (IRF). Simply put, this tool introduces an increase of one standard deviation in the residual of one of the variables in the system at time period \(t\). Then, IRF tracks the accumulated response of another variable to the introduced innovation – while holding other variables in the system constant- until it reverts back to equilibrium. I deploy the accumulated generalised impulse response function of Pesaran and Shin (1998), because it has the advantage over other techniques of being invariant to the ordering of variables. Subsequently, monetary losses or gains are:

\[
\text{OLG}_n = (AIR_n) \times CAAR (\text{−100,100}) \times GDP_{Q4,2011},
\]
where $\text{OLG}_n$ are the US output losses or gains at time period $n$, $\text{AIR}_n$ is the accumulated generalised impulse response function of real GDP growth at time period $n$ in response to one unit shock to real crude oil returns, and $n$ is the number of quarters after the shock. Put differently, the estimate of accumulated generalised impulse response function at each quarter $n$ is multiplied by crude oil CAARs at the 201 daily intervals window. This generates the estimated average percentage loss or gain to the US GDP at respective quarter $n$. A rough estimation of output losses or benefits in monetary terms in quarter $n$ is captured by multiplying the percentage loss or gain by the level of nominal output in the fourth quarter of 2011.⁴⁹

### 5.5 Empirical Results and Discussion

#### 5.5.1 Event Study Results

Table XV below reports the estimates of crude oil cumulative average abnormal returns (CAARs) during event windows of 201 and 101 daily intervals for the samples of net exporters and net importers. Additionally, Figure V below depicts the evolution of crude CAARs during the 201-day window. The first noticeable finding in Table XV pertains to the statistically significant and positive 10.26% abnormal returns of crude oil during the 201-day window. An additional striking finding is reflected in the graphical depiction of CAARs in Figure V, which clearly captures the timing of abnormal behaviour. The positive crude petroleum abnormal valuations occur well before the start dates of sanctions. This is reflected in the statistically significance and positive 8.5% abnormal returns during the 100 daily intervals preceding the start of economic coercion against net exporters. Moreover, the estimates of CAARs during the shorter window confirm the findings, and attest to the timing aspect of crude abnormal valuations.

Table XV reports estimates of crude oil CAARs during the two event windows centred on the start dates of sanctions against net importing nations. The findings represent a startling contrast to those reported for net exporters. The valuations of oil exhibit abnormal behaviour not only in the opposite direction, but also with even greater magnitude in absolute terms. The fossil fuel registers statistically significant and negative abnormal returns of 12.7% during the 201-day window. Interestingly, the 101 days starting from day zero capture a bigger portion of the decline than that registered for the 100 preceding days. Out of 12.7% negative CAARs, a statistically significant and negative abnormal return of 7.3% accumulates from day zero onwards. The ob-

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⁴⁹ Nominal US GDP in the fourth quarter of 2011 is $15.7853$ trillion.
servations are reflected in the graphical depiction of crude oil CAARs in Panel B of Figure V. The finding with regard to the timing is more pronounced for the shorter window.

**Table XV: Estimates of CAARs - Net Exporters and Net Importers Sample**

This table reports cumulative average abnormal returns (CAARs) of crude oil in periods around the start dates of 50 and 68 US sanctions on net exporters and importers of crude oil, respectively. A constant mean return model has been used to estimate the values of the CAARs and the t-statistics for the null hypotheses that the respective CAARs are equal to zero are given in the parentheses. These test statistics have been calculated in line with Kothari and Warner (2007, p. 11). ***, **, * denote statistical significance at 1%, 5% and 10% level, respectively. The table reports CAARs estimates for an event window of 201 days and a shorter window of 101 days.

<table>
<thead>
<tr>
<th>Panel A. 201-Day Event Window</th>
<th>Net Exporters</th>
<th>Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>10.2574%**</td>
<td>-12.7013%***</td>
</tr>
<tr>
<td></td>
<td>(2.1205)</td>
<td>(-3.0714)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>8.4616%***</td>
<td>-5.3555%*</td>
</tr>
<tr>
<td></td>
<td>(2.7382)</td>
<td>(-1.7304)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>1.7958%</td>
<td>-7.3458%***</td>
</tr>
<tr>
<td></td>
<td>(0.4845)</td>
<td>(-2.6664)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B. 101-Day Event Window</th>
<th>Net Exporters</th>
<th>Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-50,50)</td>
<td>9.6523%***</td>
<td>-5.9336%**</td>
</tr>
<tr>
<td></td>
<td>(2.7695)</td>
<td>(-2.1071)</td>
</tr>
<tr>
<td>CAAR (-50,-1)</td>
<td>6.8852%***</td>
<td>-2.6903%</td>
</tr>
<tr>
<td></td>
<td>(2.9764)</td>
<td>(-1.3020)</td>
</tr>
<tr>
<td>CAAR (0,50)</td>
<td>2.7671%</td>
<td>-3.2433%*</td>
</tr>
<tr>
<td></td>
<td>(1.0660)</td>
<td>(-1.6775)</td>
</tr>
</tbody>
</table>

The results on the positive abnormal behaviour of oil, around the start of sanctions, could be the reflection of traders’ reactions to the impending sanctions. On the one hand, traders face the possibility that sanctions against a net exporter may disrupt the flow of oil supplies. Traders react to such prospects by building-up stocks of crude petroleum. This stockpiling can take place on either a speculative or precautionary basis. A similar observation regarding an increase in oil...
stocks in response to rising political tension is documented by Kilian and Murphy (2013) in the months prior to the Gulf crisis of 1990.

**Figure V: Crude Oil CAARs around Start Dates of Sanctions**

**Panel A. Net Exporters Sample: 201 Daily Intervals Event Window**

The graph in Panel A. above plots cumulative average abnormal returns (CAARs) in (-100,100) event window centred on the the start dates of sanctions against net exporters of crude oil. The graph in Panel B. depicts crude CAARs in (-100,100) event window centred around the start dates of sanctions against net importers of oil. In both windows day 0 denotes the start date of a sanction programme. The CAARs are measured on the vertical access, while days relative to the event appear on the horizontal axis.
On the other hand, market participants could respond to the prospective use of sanctions, and the subsequent utilisation of these measures, by releasing their stocks of crude oil. By definition, sanctions restrict some or all of the facets of trading and economic activities. These measures can reduce the demand for oil from a net importing nation, if they restrict the target’s imports of oil. Alternatively, the expected or actual economic pain caused by sanctions can also lead to a decline in demand from the net importer. Interestingly, the timing of positive and negative abnormal returns suggests that traders’ response is faster in the case of sanctions against net exporters than net importers. Crude oil is a natural resource that is not distributed evenly across the world (Klare, 2008). Understandably, economic and political attention and interests could be attracted to those nations that produce and export more than they import and consume.

A critical issue for understanding the presence and timing of abnormal behaviour is the amount of information available for market participants on the nature of sanctions. Prior evidence suggests that American businesses do possess information on the type of measures that could be brought to bear against a nation, but these firms may not be aware of the exact details of these sanctions (Biglaiser and Lektzian, 2011). By the same token, oil traders can find themselves operating with limited information on the nature of the looming measures of economic coercion, and the consequences for oil markets. The presence of such an environment can heighten uncertainty and cause a sudden shift in expectations. Consequently, this uncertainty can exacerbate responses not only to an imminent disruption, but also to the mere threat of such an occurrence.

Oil traders can be uncertain regarding two main aspects. The first concerns details of the sanctions programmes. Market participants may lack information on whether impending sanctions involve restrictions on the trade flow of crude oil. Relatedly, traders may not be aware of whether the utilisation of sanctions will be a concerted action by a coalition of nations. It is argued that unilateral sanctions may simply lead to a diversion of energy trade flows, rather than taking supplies off the markets (Askari et al., 2005; Kozhanov, 2011; El-Katiri and Fattouh, 2012; Van de Graaf, 2013). Additionally, impending sanctions could include extra-territorial measures to punish third parties for their involvement with the targeted nation. Such measures would impair the ability of US subsidiaries and foreign firms to bypass the sanctions.

The second aspect of uncertainty relates directly to factors underlying the fundamentals of oil markets. In this context, extremely important sources of uncertainty are the overall level of spare
production capacity, and the willingness of major suppliers to act as swing producers. Such a producer would be willing to utilise its spare capacity to cover shortages in supplies. Additionally, when faced with outages in demand for oil, the swing producer would cut back its production in order to defend prices from significant declines. Critically, it is worth noting that bringing spare capacity online may not necessarily calm traders down. This is because markets would be left with a limited cushion, and thus exposed to potential supply or demand shocks. Further factors that may heighten uncertainty are spare capacity in tankers markets and levels of stocks of crude oil and petroleum products.50

Relatedly and of equal importance is uncertainty with regard to the levels of spare production capacity of crude petroleum of different qualities. This is because while Saudi Arabia holds a significant portion of global spare capacity, it is argued that the country’s ability to ramp-up or cut production is more pronounced for medium and sour grades of oil (El-Katiri and Fattouh, 2012; Houser and Mohan, 2012). Such an issue was highlighted in 2011, when 70% of Iranian crude exports to European members of IEA were heavy grades (El-Katiri and Fattouh, 2012).51 With limited availability of similar quality crudes, it was expected that European refiners would incur higher costs due to procuring substitutes for Iranian heavy oil (ibid).

In sum, the findings of the chapter reveal that crude oil valuations witness significant abnormal behaviour around the start dates of US sanctions. The direction and magnitude of the abnormal behaviour vary depending on the nature of the targeted nation. Sanctioning net exporters of petroleum gives rise to a significant positive increase in returns. On the other hand, the fossil fuel returns exhibit a significant negative abnormal decline when a net importing nation is sanctioned. The decline is larger, in absolute terms, than that associated with measures against net exporters.

5.5.2 Sanctions, Crude Oil, and Economic Costs and Benefits

The aim of this section is to provide a rough estimation of the cost inflicted on, or the benefit accrued to, the US economy due to the significant changes in the fossil fuel prices. Previous research has shown that sanctions bring to bear costs not only to targeted countries, but also to senders and even third party nations (Hufbauer et al., 1997; Canes, 2000; Caruso, 2003; Yang et

50 For a detailed discussion of the importance of spare production capacity and other oil markets-specific factors in the context of sanctions, see Alhajji (2005); Houser and Mohan (2012); El-Katiri and Fattouh (2012); Van de Graaf (2013).

51 IEA is the International Energy Agency. Crude oil is broadly characterised by its density as measured by the American Petroleum Institute gravity (API), and Sulphur content. The higher the API is, the lighter the crude. The higher the sulphur content is, the sourer the crude (Energy Intelligence, 2011; Fattouh, 2011).
This section attempts to contribute to that body of evidence through making use of the documented estimates of abnormal behaviour in crude oil returns.

In order to estimate the losses to the US economy, I use the positive CAARs, obtained from the 201-day window centred on the start of sanctions against net exporters, in model (7). Panel A. in Table XVI below shows that the abnormal rise in oil valuations can result in accumulated losses of almost 0.07% of US GDP or $10.9 billion in monetary terms (as expressed in 2011 US dollars) by the end of the first year. While these losses almost triple by the end of the second year, the first quarter of third year shows the largest losses, which reach 0.21% of GDP or $33.2 billion in monetary terms (as expressed in 2011 US dollars).

The results are in similar vein with the findings of Canes (2000), who shows that the US and most of the countries that he examines suffer losses to their real output in the range between 0 and -0.25%. Additionally, these estimated losses represent an addition to the costs of sanctions, which have been captured in the literature. For example, Hufbauer et al. (1997) report losses to US exports in the range of $15 to $19 billion in 1995 due to sanctions episodes on 26 targeted countries. Caruso (2003) further shows that US sanctions on 49 targeted nations resulted in average annual losses of $15 billion to US exports between 1989 and 1998. Caruso also reports that these losses ranged from $12 billion to $23 billion during that time period.

The findings of this chapter further allow for an additional contribution to the literature on the economic outcomes of sanctions. Documenting a significant decline in crude prices allows for capturing positive externality. Thus, in order to estimate the economic benefits accrued to the US due to a fall in oil prices, I use the 201-day negative CAARs in model (7). Panel B. in Table XVI below shows interesting findings. The accumulated gains to the US economy reach almost 0.09% of GDP or $13.5 billion (as expressed in 2011 US dollars) by the end of the first year. The end of the second year witnesses an almost tripling of gains, and by the first quarter of the third year the accumulated gains peak at 0.26% of GDP or $41.11 billion (as expressed in 2011 US dollars). Simply put, the economic gains outweigh the losses. Therefore, the findings of this section shed more light on the costs and benefits to the US economy arising from the utilisation of the economic lever in foreign policy.
Table XVI: Estimations of Accumulated Economic Effect on US Output

This table reports estimations of output losses or gains to the US economy at quarter \( n \) using model (7). \( n \) represents the number of quarters that follow one unit shock to real crude oil returns. Panel A. shows the estimates of the effect on US output in percentages and monetary terms ($) at quarter \( n \), which arise due to abnormal behaviour of crude oil returns around the start of sanctions against net exporters of crude oil. Panel B. reports the estimates of the effect on US output in percentages and monetary terms ($) at quarter \( n \), which arise due to the negative abnormal behaviour of crude oil returns around the start of sanctions against net importers. The monetary losses or gains are estimated using nominal US GDP at fourth quarter 2011, which is equal to $15.7853 trillion.

<table>
<thead>
<tr>
<th>Quarter ( n )</th>
<th>A. Effect on Output – Net Exporters</th>
<th>B. Effect on Output – Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(% of GDP)</td>
<td>($ Billions)</td>
</tr>
<tr>
<td>1</td>
<td>0.0188%</td>
<td>2.96</td>
</tr>
<tr>
<td>2</td>
<td>0.0183%</td>
<td>2.89</td>
</tr>
<tr>
<td>3</td>
<td>-0.0493%</td>
<td>-7.78</td>
</tr>
<tr>
<td>4</td>
<td>-0.0690%</td>
<td>-10.89</td>
</tr>
<tr>
<td>5</td>
<td>-0.1611%</td>
<td>-25.43</td>
</tr>
<tr>
<td>6</td>
<td>-0.1943%</td>
<td>-30.67</td>
</tr>
<tr>
<td>7</td>
<td>-0.1948%</td>
<td>-30.74</td>
</tr>
<tr>
<td>8</td>
<td>-0.2014%</td>
<td>-31.79</td>
</tr>
<tr>
<td>9</td>
<td>-0.2103%</td>
<td>-33.20</td>
</tr>
<tr>
<td>10</td>
<td>-0.2096%</td>
<td>-33.09</td>
</tr>
<tr>
<td>11</td>
<td>-0.2100%</td>
<td>-33.16</td>
</tr>
<tr>
<td>12</td>
<td>-0.2096%</td>
<td>-33.08</td>
</tr>
<tr>
<td>13</td>
<td>-0.2066%</td>
<td>-32.61</td>
</tr>
<tr>
<td>14</td>
<td>-0.2052%</td>
<td>-32.40</td>
</tr>
<tr>
<td>15</td>
<td>-0.2053%</td>
<td>-32.41</td>
</tr>
<tr>
<td>16</td>
<td>-0.2047%</td>
<td>-32.31</td>
</tr>
<tr>
<td>17</td>
<td>-0.2042%</td>
<td>-32.24</td>
</tr>
<tr>
<td>18</td>
<td>-0.2042%</td>
<td>-32.24</td>
</tr>
<tr>
<td>19</td>
<td>-0.2041%</td>
<td>-32.21</td>
</tr>
<tr>
<td>20</td>
<td>-0.2041%</td>
<td>-32.21</td>
</tr>
</tbody>
</table>

More specifically, targeting a nation that is a net exporter of crude petroleum may bring to bear economic losses to the US economy through a rise in the price of oil. However, when sanctioning a net importer of the fossil fuel, propitious externality in the form of a decline in crude petroleum valuations is accrued. This decline would result in economic gains to the US output. These
findings should not be viewed as an incentive to sanction a net importer on the one hand, and a disincentive to economically punish a net exporter on the other hand. Rather, these estimates of gains and losses are externalities that should be accounted for in the overall calculation of costs and benefits in order to ensure a better design and implantation of economic coercion programmes.

5.5.3 Robustness Analysis: Examining Different Aspects of Sanctions

The aim of the following analysis is to explore whether different aspects of US sanctions give rise to variations in the magnitude and timing of crude oil abnormal returns. This robustness exercise covers the period from 1987 to 2005. This is dictated by the availability of data on the various aspects of sanctions from the TIES database.

Panel A of Table XVII below reports the 201-day cumulative average abnormal returns (CAARs) for crude oil around the start of US unilateral sanctions against net exporters and importers. Additionally, Panel B presents the 201 daily intervals CAARs for multilateral measures against both groups of nations. The first noticeable finding in Panel A is the statistically significant and positive 11.7% abnormal returns during the 201 days centred on the start date of unilateral US sanctions against net exporters. The significant portion of the positive abnormal returns accumulates during the 100 trading days prior to the start of the unilateral measures. In contrast to the positive abnormal returns, statistically significant and negative abnormal returns are recorded around the start of unilateral economic coercion against net importers.

Interestingly, Panel B shows that the only statistically significant abnormal behaviour is recorded for the sub-event window between day -100 and day -1 for net exporters. Moreover, the start dates of multilateral measures against net importers are not associated with statistically significant abnormal returns. These results may not be surprising. Multilateral sanctions can take longer than unilateral programmes to draft and implement, because such measures require working with other nations directly or through an international body. This suggests that oil traders can have the time and information to understand the breadth and depth of the foreign policy response, which can lead to the resolution of uncertainty. A further aspect is whether crude oil prices behave abnormally around the start dates of sanctions imposed by other nations and institutions on net exporters and importers.
Table XVII: Estimates of CAARs - US Unilateral versus Multilateral Sanctions

This table reports cumulative average abnormal returns (CAARs) of crude oil around the start dates of 36 and 51 US unilateral sanctions on net exporters and importers of crude oil, respectively. The table also reports the CAARs around the start dates of 10 and 11 US multilateral sanctions against net exporters and importers, respectively. A constant mean return model has been used to estimate the values of the CAARs and the t-statistics for the null hypotheses that the respective CAARs are equal to zero are given in the parentheses. These test statistics have been calculated in line with Kothari and Warner (2007, p. 11). ***, **, * denote statistical significance at 1%, 5% and 10% level, respectively.

Panel A. 201 Daily Intervals CAARs around the Start Dates of Unilateral Sanctions

<table>
<thead>
<tr>
<th></th>
<th>Net Exporters</th>
<th>Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>11.6772%**</td>
<td>-10.4210%**</td>
</tr>
<tr>
<td></td>
<td>(2.1549)</td>
<td>(-2.2062)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>8.0322%**</td>
<td>-6.6631%*</td>
</tr>
<tr>
<td></td>
<td>(2.2473)</td>
<td>(-1.9152)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>3.6450%</td>
<td>-3.7579%</td>
</tr>
<tr>
<td></td>
<td>(0.8936)</td>
<td>(-1.1722)</td>
</tr>
</tbody>
</table>

Panel B. 201 Daily Intervals CAARs around the Start Dates of Multilateral Sanctions

<table>
<thead>
<tr>
<th></th>
<th>Net Exporters</th>
<th>Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>14.8998%</td>
<td>-7.5526%</td>
</tr>
<tr>
<td></td>
<td>(1.2234)</td>
<td>(-0.7324)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>11.7296%*</td>
<td>-1.4128%</td>
</tr>
<tr>
<td></td>
<td>(1.6714)</td>
<td>(-0.1955)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>3.1702%</td>
<td>-6.1398%</td>
</tr>
<tr>
<td></td>
<td>(0.3179)</td>
<td>(-0.8314)</td>
</tr>
</tbody>
</table>

Panel A. of Table XVIII below reports oil CAARs in the vicinity of the start dates of other senders’ sanctions against net exporters and importers. For the purpose of comparison, Panel B. of Table XVIII presents oil CAARs around the start of US sanctions against the two groups of nations, which occurred between 1987 and 2005. The findings clearly reveal the absence of abnormal returns around the start dates of other senders’ economic coercion measures against either group of nations. This observation suggests that it is the US foreign policy that attracts the attention of markets, perhaps understandably because of the status of the US as a super economic and military power.
Table XVIII: Estimates of CAARs - US Sanctions versus Other Senders’ Sanctions

This table reports cumulative average abnormal returns (CAARs) of crude oil around the start dates of 35 and 105 other senders’ sanctions on net exporters and importers of crude oil, respectively. The table also reports the CAARs around the start dates of 46 and 62 US sanctions against net exporters and importers of crude oil, respectively. A constant mean return model has been used to estimate the values of the CAARs and the t-statistics for the null hypotheses that the respective CAARs are equal to zero are given in the parentheses. These test statistics have been calculated in line with Kothari and Warner (2007, p. 11). ***, **, * denote statistical significance at 1%, 5% and 10% level, respectively.

**Panel A. 201 Daily Intervals CAARs around the Start Dates of Other Senders’ Sanctions**

<table>
<thead>
<tr>
<th></th>
<th>Net Exporters</th>
<th>Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>-5.9705%</td>
<td>-0.7257%</td>
</tr>
<tr>
<td></td>
<td>(-0.9507)</td>
<td>(-0.2498)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>-6.7554%</td>
<td>-1.6277%</td>
</tr>
<tr>
<td></td>
<td>(-1.4157)</td>
<td>(-0.7589)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>0.7849%</td>
<td>-0.9020%</td>
</tr>
<tr>
<td></td>
<td>(0.1928)</td>
<td>(-0.4598)</td>
</tr>
</tbody>
</table>

**Panel B. 201 Daily Intervals CAARs around the Start Dates of US Sanctions**

<table>
<thead>
<tr>
<th></th>
<th>Net Exporters</th>
<th>Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>12.3778%**</td>
<td>-9.9121%**</td>
</tr>
<tr>
<td></td>
<td>(2.4690)</td>
<td>(-2.2122)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>8.8360%***</td>
<td>-5.7316%*</td>
</tr>
<tr>
<td></td>
<td>(2.8302)</td>
<td>(-1.7273)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>3.5418%</td>
<td>-4.1805%</td>
</tr>
<tr>
<td></td>
<td>(0.9035)</td>
<td>(-1.3818)</td>
</tr>
</tbody>
</table>

Additional important aspects are whether the valuations of oil exhibit abnormal behaviour around the dates on which threats to utilise sanctions were made, and whether abnormal behaviour can still be observed around the start dates of sanctions with such a prior threat. The TIES database offers a unique opportunity to examine this aspect, because this source contains the dates on which the threats were made.\(^{52}\) This feature also allows for an examination of those sanctions programmes that started without a prior threat.

\(^{52}\) For details on the threat and its issuing, see Threat and Imposition of Sanctions (TIES) Data 4.0 User’s Manual Case Level Data, available online at: http://www.unc.edu/~bapat/tiesusersmanualv4.pdf
Table XIX: Estimates of CAARs - US Sanctions without Prior Threat

This table reports cumulative average abnormal returns (CAARs) of crude oil around the start dates of 20 US sanctions not preceded by threat on net exporters of crude oil. The table also reports the CAARs around the start dates of 20 US sanctions not preceded by threat on net importers of crude oil. A constant mean return model has been used to estimate the values of the CAARs and the t-statistics for the null hypotheses that the respective CAARs are equal to zero are given in the parentheses. These test statistics have been calculated in line with Kothari and Warner (2007, p. 11). ***, **, * denote statistical significance at 1%, 5% and 10% level, respectively.

<table>
<thead>
<tr>
<th>Panel A. Sanctions Against Net Exporters and OPEC Members</th>
<th>Brent Crude Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>17.1571%**</td>
</tr>
<tr>
<td></td>
<td>(2.2689)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>12.1131%***</td>
</tr>
<tr>
<td></td>
<td>(2.7099)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>5.0440%</td>
</tr>
<tr>
<td></td>
<td>(0.8266)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B. Sanctions Against Net Importers</th>
<th>Brent Crude Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>-21.9429%**</td>
</tr>
<tr>
<td></td>
<td>(-2.6002)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>-14.6497%**</td>
</tr>
<tr>
<td></td>
<td>(-2.1320)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>-7.2933%</td>
</tr>
<tr>
<td></td>
<td>(-1.4863)</td>
</tr>
</tbody>
</table>

Table XIX above reports the 201 daily intervals CAARs around the start dates of sanctions against net exporters and importers that were not preceded by a threat. Additionally, Table XX below presents the 201-day CAARs for the threat dates and start dates of threatened sanctions against both groups. Table XIX shows interesting findings. Crude oil returns register astounding positive and statistically significant abnormal returns of almost 17.2%, when the US sanctions a net exporting nation without issuing a prior threat. Again, the period prior to the start of sanctions witness the accumulation of a significant portion of CAARs, which is also statistically significant. Table XIX also reports striking findings for sanctions against net importers. The valuations of the fossil fuel exhibit statistically significant and negative abnormal behaviour of almost 22%. Out of the total negative returns, -14.65% accumulates before the start of sanctions.
Table XX: Estimates of CAARs - US Sanctions with Prior Threat

This table reports cumulative average abnormal returns (CAARs) of crude oil around the dates of threats of 26 and 42 US sanctions on net exporters and importers of crude oil, respectively. The table also reports the CAARs around the start dates of 26 and 42 measures with prior threat on net exporters and importers of crude oil, respectively. A constant mean return model has been used to estimate the values of the CAARs and the t-statistics for the null hypotheses that the respective CAARs are equal to zero are given in the parentheses. These test statistics have been calculated in line with Kothari and Warner (2007, p. 11). ***, **, * denote statistical significance at 1%, 5% and 10% level, respectively.

Panel A. 201 Daily Intervals CAARs around the Dates of Threats

<table>
<thead>
<tr>
<th></th>
<th>Net Exporters</th>
<th>Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>11.7350%*</td>
<td>-4.1831%</td>
</tr>
<tr>
<td></td>
<td>(1.8816)</td>
<td>(-0.8063)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>6.4364%</td>
<td>-1.4849%</td>
</tr>
<tr>
<td></td>
<td>(1.4034)</td>
<td>(-0.4093)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>5.2986%</td>
<td>-2.6982%</td>
</tr>
<tr>
<td></td>
<td>(1.2471)</td>
<td>(-0.7243)</td>
</tr>
</tbody>
</table>

Panel B. 201 Daily Intervals CAARs around the Start Dates of Threatened Sanctions

<table>
<thead>
<tr>
<th></th>
<th>Net Exporters</th>
<th>Net Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAAR (-100,100)</td>
<td>8.7014%</td>
<td>-7.4188%</td>
</tr>
<tr>
<td></td>
<td>(1.3092)</td>
<td>(-1.5444)</td>
</tr>
<tr>
<td>CAAR (-100,-1)</td>
<td>6.3152%</td>
<td>-5.0884%</td>
</tr>
<tr>
<td></td>
<td>(1.4462)</td>
<td>(-1.4526)</td>
</tr>
<tr>
<td>CAAR (0,100)</td>
<td>2.3862%</td>
<td>-2.3304%</td>
</tr>
<tr>
<td></td>
<td>(0.4749)</td>
<td>(-0.7065)</td>
</tr>
</tbody>
</table>

Insightful findings are also presented in Table XX above. Crude oil returns exhibit a positive and statistically significant abnormal behaviour only during the 100 days preceding the issuing of a threat to use sanctions against a net exporter. The valuations of the fossil fuel do not register any abnormal changes around the start dates of sanctions against exporters that were preceded by a threat. Moreover, abnormal behaviour is not detected either around the dates of threats against net importers, or in the vicinity of the start dates of threatened sanctions against these importers.

These findings may not be surprising. The issuing of a threat to use sanctions contributes to the resolution of aspects of uncertainty in oil markets. This is because the threat clarifies the in-
tention of US foreign policy makers regarding the adversary nation. Specifically, the threat makes explicit what the US expects from the targeted nation, and what the nature of its reaction would be in the case that the target does not comply. This, in turn, calms the markets. By the time the US decides to deliver on its threat, oil traders have already discounted this possibility. This, in turn, explains the absence of any abnormal behaviour around the start of sanctions with a prior threat.

5.6 Conclusion

This chapter examines the behaviour of crude oil prices around the start dates of US sanctions against two different groups of nations. The first consists of members of OPEC and other net exporters of crude oil, while the second group contains net importers of the fossil fuel. The chapter uses an event-study framework, and documents a number of critical findings with regard to the behaviour of crude oil prices in the context of such political risk.

Firstly, the valuations of crude oil exhibit significant abnormal behaviour around the start dates of US sanctions. However, the magnitude and direction of this abnormal behaviour differ depending on whether the targeted nation is a net importer or exporter of crude petroleum. Secondly and more specifically, crude oil prices experience statistically significant and positive abnormal behaviour around the start dates of economic coercion measures against net exporters of oil. On the other hand, the fossil fuel registers significant and negative abnormal returns around the start dates of sanctions against net importers.

Thirdly, the results of the robustness analysis indicate that oil markets are more sensitive to the developments of US foreign policy than those of other nations. The findings also suggest that traders appear more responsive to unilateral sanctions than to multilateral measures. Furthermore, markets appear less responsive to both the issuing of a threat of sanctions, and the actual start of the threatened measures. Interestingly, the largest abnormal returns are recorded for US sanction programmes that were not preceded by a threat. These findings demonstrate the importance of making foreign policy expectations explicit to markets.

Fourth, I attempt to build upon the aforementioned findings and provide a rough estimation of the losses incurred by, and benefits accrued to, US output. The estimations suggest that while positive abnormal returns can cause losses to the US economy, the gains accrued from the negative abnormal behaviour in oil valuations compensate for the costs. These latter findings add to
the body of literature on the costs of sanctions, and point to externalities that can affect the effectiveness of sanctions.

The magnitude of crude oil abnormal behaviour and its timing could be driven by market participants’ responses to potential disruptions in supply and demand due to impending sanctions. Faced with such prospects, traders may react by building up petroleum reserves or releasing and selling stockpiles of oil. Such responses could be either psychologically driven (Terzian, 1985), or based on rational or speculative motives (Kilian and Murphy, 2013). Oil traders can find themselves operating in an uncertain environment. This uncertainty could stem from a lack of knowledge on the depth and breadth of the looming economic coercion measures. Furthermore, the extent of economic hurt inflicted by sanctions upon a net importer of petroleum is an additional source of uncertainty.

Another source relates to the extent to which sanctions are a concerted action, or whether the economic punishment will include third parties and US subsidiaries. The role of large petroleum consumers and suppliers, and whether these nations will abide by or spoil the sanctions create further uncertainty. An important cause of fear stems from uncertainty surrounding the willingness and ability of major oil suppliers to act as swing producers by bringing spare capacity online, or cutting production to protect prices (El-Katiri and Fattouh, 2012; Houser and Mohan, 2012; Van de Graaf, 2013). Paradoxically, the utilisation of spare capacity may contribute to further uncertainty as markets are exposed to the vagaries of demand and supply (Houser and Mohan, 2012).

Simply put, the findings of this chapter demonstrate that the effect of US sanctions is not confined to changes in trade flows and foreign direct investments. Measures of economic coercion can impact other facets of economic activities, namely the prices of assets. In this context, the documented significant abnormal movement of crude oil prices points to additional economic and political ramifications. These consequences represent externalities that can affect the welfare of the US economy and the economies of its allies, the effectiveness of sanctions, and even world peace and security.

First of all, the prices of the fossil fuel can react differently depending on whether the target is a net exporter or importer of crude petroleum. Consequently, significant changes in the prices of oil can either accrue gains to, or inflict pain on, the US economy. The latter may have repercus-
sions for domestic politics and the popularity of sanctions among voters. Secondly, significant changes in the prices of oil can either appease, or discourage allies, thereby affecting the ability to take concerted actions. A case in point is the most recent episode of sanctions against Iran, which were orchestrated jointly by the US and EU. These measures have affected some members of the EU more than others. Greece, an EU member that is going through economic hardship, has been expected to suffer due to that latest episode of sanctions (El-Katiri and Fattouh, 2012).

Thirdly, a rise in crude petroleum prices may affect the effectiveness of sanctions against a net exporting nation. For example, Iran’s sabre-rattling and threats to close the Strait of Hormuz might be a tactic aimed at heightening uncertainty and increasing prices to offset revenue losses due to sanctions (El-Katiri and Fattouh, 2012; Van de Graaf, 2013). By the same token, the effectiveness of restricting the economic ties with a net importing nation can be hampered by the associated significant decline in the price of oil. This is because a drop in oil prices can subsidise the economic losses of sanctions via a reduction in the value of the energy bill.

Fourthly, sanctions can affect world stability via their impact on oil prices. This is particularly the case in programmes that are accompanied by a rise in prices. An increase in the valuation of oil translates into a larger windfall in revenues for governments of net exporting nations. This income can be used to build-up military capabilities in order to pursue foreign policy objectives, and to take more risks (Colgan, 2011). Put simply, while the use of sanctions is intended to deter, punish, or contain the actions of a net exporter, these measures can fuel the ambitions and foreign policy adventurism of another nation.

Relatedly, oil revenue-backed aggression has been one reason underlying the US military presence in various parts of the world (Klare, 2008; Colgan, 2011), which gives rise to even more externalities. This is because such deployments do not come cheap in terms of treasure and blood. It is estimated that the cost of military presence in the Middle East ranged from $28 to $36 billion per year in the 1980s, and soared to an estimated $31 to 51 billion in the 1990s and 2000s (Duffield, 2007: 182). These represent further negative externalities that the US can incur due to the economic and political consequences of its foreign policy.

These findings suggest that US foreign policy makers should consider the impact on crude oil prices that can be brought to bear by the deployment of sanctions. A critical aspect of such a consideration requires an understanding of the status of the targeted nation in oil markets. There-
fore, US policy makers could consider the introduction of reporting on the state of oil markets similar to that required under the National Defence Authorization Act for the specific case of Iran. However, such reporting should be permanent rather than contingent. This will allow for an up-to-date view and understanding of the state of affairs in the oil markets. This could, consequently, contribute towards a swifter and better design and deployment of the economic lever, with less negative externalities. Such reporting requirements would send a signal to market participants as to the level of importance assigned to petroleum, and the breadth of knowledge possessed by statesmen on the functioning of the oil markets.

Moreover, issuing a threat to deploy sanctions appears to calm down markets. This is because a threat constitutes a channel through which expectations, as well as the nature of the response in case of non-compliance, are all made explicit. While it may not be feasible for US policy makers to issue threats prior to the start of every sanctions programme, better communication of expectations and the nature of potential reaction could contribute towards both the resolution of uncertainty, and reducing negative externalities. The status of the US as a an economic and military superpower, its expansive role on the international arena, and its willingness to demonstrate resolve, all further highlight the need for the aforementioned approaches.

Policy makers in other nations should follow up closely the developments in the US foreign policy. Even if their country is geographically distant from a nation targeted by US sanctions. This is because a rise or fall in oil prices may have a significant effect on their nation’s economic welfare. Similar remarks apply to commercial and speculative traders in oil markets. Understanding the dynamics of the foreign policy of major powers may become imperative, especially in a ‘tough oil’ era, in which crude petroleum will be harder to find and produce. Consequently, expansive demand will be faced with tighter supplies, which will collectively lead to heightened geopolitical risks (Klare, 2008).
VI. Conclusions, Contributions, and Policy Implications

6.1 Summary and Contributions
This thesis examined aspects of the price formation processes in crude oil markets around the start dates of violent conflicts, unplanned production outages, and US sanctions. The investigative undertakings were driven by the significant strategic importance of crude petroleum in the global economy, the influence of political processes on oil markets and pricing, and the commodity’s role in shaping and instigating national and international politics and major events. These considerations drove the thesis to embark on answering three research questions.

The first asked whether crude oil possesses the ability to act as a safe haven asset for investors in equity markets around the outbreak of violent international conflicts and wars. For that purpose, the start dates of these international crises were collected from the International Crisis Behaviour Database (ICB). This examination started with an analysis that aimed to capture abnormal behaviour in the valuations of both oil and equities. This served as a basis for the subsequent investigation into the safe haven property of oil, which utilised a methodological approach in the spirit of that proposed by Baur and Lucey (2010). The examination then took an additional step forward by exploring the weight to be allocated to crude oil in a well-diversified portfolio.

The second investigation aimed to explore the effect of unplanned upstream production outages emanating from members of the Organisation of Petroleum Exporting Countries (OPEC) on the price relationships between crude oil benchmarks. The examination utilised a useful function in the Bloomberg terminal, which offers access to dates on which such disruptions occurred. Unplanned disruptions have been synonymous with significant changes in the outright price of crude oil. This examination specifically focused on the price spreads between benchmarks due to the significant role that these markers play in the pricing system that is currently operating. Specifically, the investigation explored the behaviour of the price spread between West Texas Intermediate (WTI) and Brent, which are two of the world’s most important benchmarks. The analysis further examined the price differential between Light Louisiana Sweet (LLS) and Brent. This investigation also controlled for important variables such as seasonality, stocks of crude oil and petroleum products, extreme weather conditions, the period of logistical bottlenecks, other political events in OPEC, and the cost of logistics.

The third examination aimed to answer the questions of whether US sanctions can affect crude oil prices, and what economic costs or benefits may arise due to such an effect. To this
end, the analysis began by capturing the presence of abnormal behaviour in crude oil valuations around the start dates of US sanctions imposed on two different groups of nations. The first consists of OPEC members and net exporters of crude oil, while the second comprises net importing nations. The start dates of these programmes were sourced from the Threat and Imposition of Sanctions Database (TIES), and the Office of Foreign Assets Control (OFAC) of the US Department of the Treasury. The findings of this analysis provided a basis for investigating the consequences of such abnormal behaviour on the US economy. As a robustness measure, the analysis further examined the nature of abnormal valuations around the start of sanctions of various types.

The answers to each of these research questions addressed a gap in the literature. While the ability of crude oil to act as a safe haven has been examined previously, these investigations did not consider this property in the context of violent conflicts and wars. This is a gap that the first empirical examination aimed to address. Similarly, the academic literature on price relationships between oil benchmarks is relatively scarce, and the second empirical examination targeted a gap in this body of research. Moreover, the literature on the costs of sanctions has focused primarily on the effects on trade flows and foreign direct investments. This body of research has not examined the impact of sanctions on asset prices, and the economic consequences arising from such effects. This is a gap that the third empirical investigation addressed.

The decision to investigate the behaviour of crude oil valuations in the context of the three different sets of events was driven by five specific considerations; all of these combine to provide the thesis with its element of coherence. First, crude oil prices are formed by the interaction between supply and demand. Theoretical, empirical and even anecdotal evidence points to the role of exogenous political events in affecting oil prices through changes in the supply of and demand for oil. Such events can either lead to sudden changes in the flow of supplies, or trigger movements in the precautionary component of global demand, which consequently can cause significant changes in crude oil prices. Changes in the precautionary component of demand can be instigated by shifts in the expectations of market participants with regard to the security of supplies (Adelman, 1982; 1990; Alquist and Kilian, 2010; Baumeister and Peersman, 2013a; b). Variations in crude oil prices can also occur due to a combination of sudden changes in both supply and demand (Kilian, 2008c).
The second consideration driving the choice of the events was the characteristics of the system of trading and pricing oil that is currently operating. While oil markets entered the era of market–based pricing in the second half of the 1980s, the shift occurred at the expense of the quality and availability of information (Stevens, 1995; 2005; Mabro, 2005; Kilian, 2008b). This shift led to a rise in the number of traders who may not possess full knowledge about the specifics of the industry, and an increase in the role of trading on the basis of belief (Stevens, 2005; Mabro, 2005). These developments, when combined with tight market conditions due to the erosion of excess capacity and steepening of the demand curve, can lead to an amplification of the effect of disruptions and exogenous political events on the prices of the fossil fuel (Askari and Krichene, 2008; Baumeister and Peersman, 2013a; b).

Thirdly, the events that this thesis examined either represent a materialisation of political risk, or can lead to important political ramifications. The former is apparent in the case of violent conflicts and sanctions, while the latter is epitomised in the occurrence of disruptions. Fourthly, crude oil is not a homogenous commodity, nor is it evenly distributed. Additionally, humongous capital expenditure is required along the entire value chain from well to pump. On the one hand, these issues mean that it may not be always feasible to build a refining sector capable of handling all grades. This can result in dependence on specific sources of supplies, and exposure to price risk due to wars, production outages and sanctions.

On the other hand, international oil companies must venture into exploration and production in foreign territories. This, in turn, can bring about political risks, the materialisation of which can cause significant changes in oil prices. Finally, the three investigations combine to show that where risks arise, opportunities follow. Consequently, the findings of the three empirical undertakings allow one to deduce a large set of recommendations for investors, and highlight policy implications for decision makers in both the US and other nations.

The thesis provides a number of findings and contributions to the existing knowledge on crude oil pricing and markets. First of all, it shows that crude oil returns exhibit a significant abnormal increase around the start dates of violent international conflicts. These abnormal returns are larger in magnitude in the vicinity of the most violent crises and wars. The significant portion of the abnormal returns accumulates well before the start of conflicts. Secondly, and in stark contrast to the findings on oil, the valuations of US and world equities register a significant abnormal decline around the start of violent conflicts and wars. This decline appears to happen just
before the outbreak of crises, and accelerates in the period following the start day. Thirdly, the thesis empirically demonstrated that crude petroleum can act as a safe haven asset for investors in equity markets in the vicinity of the outbreak of conflicts. This suggests that crude oil should be a permanent component of a well-diversified portfolio. To that end, the thesis showed that a weight of 17.34% should be allocated to oil in a portfolio with an exposure to world equities and real estates.

Fourth, the thesis recorded significant tightening in the WTI-Brent and LLS-Brent price spreads around unplanned production outages in OPEC. The findings showed that the magnitude of the tightening in the case of LLS-Brent was less than that reported for the WTI-Brent. This can be attributed to the close proximity of LLS to the US Gulf Coast, which makes LLS prices more responsive to international developments and less exposed to infrastructural bottlenecks. These findings were shown to be robust even after controlling for seasonality, changes in petroleum stocks, extreme weather conditions, periods of logistical bottlenecks, and the cost of logistics. These findings attest to the supremacy of Brent as a global benchmark, add credit to the use of LLS as a de facto light and sweet benchmark in US domestic markets, and highlight issues related to price risk and energy security.

Fifth, the thesis demonstrated that the start of US sanctions on net exporting nations is accompanied by a significant abnormal rise in the valuations of crude oil. The significant portion of the abnormal increase occurs well before the start of sanctions. Sixth, the findings also showed that crude oil returns register a significant abnormal decline around the start of sanctions against net importing nations. While this decline begins before the start of a programme, it is more pronounced during the period following the start of sanctions.

Seventh, the findings also revealed that crude oil markets are more responsive to the start of US sanctions than to the start of programmes imposed by other nations. Furthermore, the thesis showed that oil markets are more sensitive to unilateral US sanctions than to multilateral measures. Interestingly, the findings documented the largest abnormal changes in the valuations of oil around the start of sanctions that were not preceded by a threat. On the other hand, oil returns do not show abnormal returns around the start dates of sanctions that were preceded by a threat.
Finally, the thesis built on the findings regarding abnormal valuations and estimated the gains accrued to, and losses inflicted on, the US economy. On average, the abnormal rise in oil prices due to the start of sanctions against a net exporting nation can lead to accumulated losses of almost 0.20% of GDP or $31.8 billion (as expressed in 2011 US dollars) after two years. On the other hand, and on average, the abnormal decline in oil valuations around the start of economic coercion against a net importer can cause accumulated gains of almost 0.25% of GDP or $39.4 billion (as expressed in 2011 US dollars) after two years.

The abnormal changes in the valuations of the fossil fuel around the start dates of the three different sets of events can be understood through the prisms of supply and demand. Unplanned production outages represent cuts in the flow of oil supplies to international markets. The effect of a decline in supplies on oil prices can be exacerbated by the reaction of precautionary demand to the announcement of disruptions. Shifts in this specific component of global demand can be triggered by changes in the expectations of traders in oil markets. The case of Iran’s revolution in the late 1970s gives a clear example of how market participants can react merely on psychological basis. “[…] Everybody was anxious to hang on to as much of their own oil as possible, until the situation had become clear. The shortage was purely psychological, or ‘precautionary’ as one dealer put it” (Terzian, 1985:260).

Moreover, changes in supply and demand can also explain the findings on abnormal changes in oil returns around the start of violent conflicts and sanctions. The outbreak of a violent crisis and the start of a sanctions programme can be preceded by rational stockpiling by governments ahead of such events. The rising tension and uncertainty prior to the start of the event can cause a shift in expectations, which trigger changes in inventories on a precautionary or speculative basis. Uncertainty can have two causes. The first is the limited information about the nature of foreign policy action to be pursued, and the associated economic, political and military ramifications. The second is the lack of up-to-date and high quality information on the state of oil markets, particularly the level of spare production capacity.

6.2 Implications for Investors, Traders, and Policy Makers
The findings of the thesis allow for the formulation of a number of recommendations for investors in equity markers, insurance providers, and traders in oil markets. The findings also point to a number of implications for policy makers in the US. These policy implications relate directly to the issues of economic costs and benefits arising from US foreign policy, the country’s energy
security, and the functioning of US domestic oil markets. The findings further permit the drawing up of recommendations for policy makers in nations that are either net importers or exporters of crude petroleum.

6.2.1 Implications for Equity Investors, Insurance Companies, and Oil Traders

First of all, equity investors should maintain exposure to crude oil in their portfolios. This is because the findings showed that while equity valuations suffer a significant abnormal decline around the start of violent conflicts, oil prices register an abnormal increase. The findings also demonstrated that crude oil can act as a safe haven from equities around the onset of such crises. A formal portfolio optimisation analysis, which adopts the viewpoint of an investor in world equities and real estates, suggests that 17.34% of a well-diversified portfolio should be allocated to crude oil.

The above recommendation also applies to insurance companies and governmental bodies that provide insurance coverage against political risk. For example, the Overseas Private Investment Corporation (OPIC), a US government agency, provides political risk insurance. OPIC’s records show that 51% of the settlements of insurance claims since 1987 have been cases of political violence or war damage (OPIC, 2014). Put differently, the outbreak of violent political conflicts and wars can lead to insurance claims, which suggests that exposure to crude oil can act as a hedge for insurance companies.

Admittedly, exposure that requires taking physical delivery can be troublesome as it involves incurring the cost of storage. Therefore, equity investors and insurance companies can benefit from the presence of vibrant paper markets in which crude oil acts as the underlying asset. Futures and options are actively traded on both the New York Merchantile Exchange (NYMEX) and the IntercontinentalExchange (ICE). These contracts can offer exposure to crude petroleum without having to take physical delivery. Geman and Kharoubi (2008), for example, call for the use of the NYMEX WTI futures contracts with 18 month maturity in diversifying a portfolio of equities. Additional tools that allow for exposure to crude oil without physically holding the asset are Exchange Traded Funds (ETFs) and Exchange Traded Notes (ETNs).

Importantly, the decision to use force in a dispute can be shrouded with secrecy. This suggests that rational stockpiling by governments can take place ahead of planned military operations.

53 ETNs offer investors tax advantages over ETFs. However, an investor in an ETN will be exposed to credit risk, because ETN is essentially designed as a combination between a zero coupon bond and an ETF (Balchunas, 2015).
Moreover, violent conflicts and wars are a “giant roll of the dice”, which simply means that the economic, political and military ramifications of the decision to deploy violence in a dispute may only be known in hindsight (Nordhaus, 2002:40). Furthermore, the dynamics of oil prices may be understood only retrospectively by casual observers. Consequently, switching in and out of an oil position based on a subjectively formulated probability of an outbreak of war would not be a prudent strategy. Additionally, oil revenues are mostly captured by the national oil companies on behalf of their governments due to the current structure of the industry (Stevens, 2005). Therefore, exposure to crude oil, rather than equities of the International Oil Companies (IOCs), should be a permanent feature of a well-diversified portfolio.

Secondly, the significant tightening in the price differential between WTI and Brent points to a risk to be hedged, and a speculative opportunity to be exploited. The presence of vibrant paper markets allows traders to use derivative instruments for hedging and speculation. For example, market participants have the opportunity to trade on the spread between Brent and WTI through the IntercontinentalExchange (ICE, 2014). Customised price differential trading is also attainable, because ICE offers futures contracts on the Light Louisiana Sweet (LLS). Moreover, the Chicago Mercantile Exchange (CME) provides a variety of financial instruments aimed at trading the WTI-Brent spread. An example of such a derivative is the WTI-Brent Financial Futures Contract Specs, which is financially settled and can be traded either on open outcry or electronically (CME, 2009a).

Thirdly, investors in equity markets and oil traders should adopt a forward looking approach to international relations and developments. This is because the thesis showed that international political events can be associated with significant abnormal changes in the valuations of oil and equities. This approach to viewing international politics should not be confined to relations between nations, but should also consider internal economic and political developments within major producing nations. This is because such developments can lead to disruptions, as was evident in the cases of both Libya in 2011, and Nigeria between 2003 and 2009 (Darbouche and Fattouh, 2011; Energy Intelligence, 2011). This forward looking view particularly concerns investors in stock markets. This is because the timing of an abnormal decline in equities occurs just before the start of a conflict, which is unlike that observed for oil. This suggests that equity investors are either less informed, or less able to rapidly comprehend the content of information concerning international politics.

Moreover, oil traders should be particularly attentive to US foreign policy developments. The findings of this thesis demonstrated that the valuations of oil can change significantly around the
start of US sanctions programmes, particularly in the vicinity of the start of measures that are not preceded by a threat. Oil traders in the US are perhaps more able than their foreign counterparts to engage with US policy makers in order to achieve a resolution with regard to uncertainty over the objectives and details of foreign policy actions.

6.2.2 Implications for the US Energy Security, and US Domestic Oil Markets

The findings highlight the importance of the concept of a nation’s energy security; i.e., “the reliable and affordable supply of energy” (Deutch et al., 2006:3). Put simply, the energy security of a nation can be compromised in the case of physical disruptions to supplies, an increase in oil prices, and by the economic costs arising from disruptions and a rise in the price (Glaser, 2013). Exposure to price risk is added to the fact that dependence on imported oil represents a threat to national security. A reliance on imports can also add an economic burden to the dependent nation in the form of financing the deployment of military forces in producing regions to secure the flow of supplies. For example, it is estimated that the cost of the US military presence in the Middle Eastern Gulf ranged between $28 and $36 billion per year in the 1980s, and escalated to between $30 and $51 billion per year in the 1990s and early 2000s (Duffield, 2007:182).

Put differently, the findings of the thesis point to the specific exposure to price risk due to physical disruptions, and this exposure is particularly relevant for the US. First of all, the thesis showed that unplanned disruptions in upstream production in OPEC cause a tightness in the price spread between WTI and Brent. A tightening spread means that oil imports into the US priced off Brent become relatively more expensive around the period of production outages. This, in turn, suggests that US refineries on the East Coast have been suffering from a comparative disadvantage relative to their counterparts on the Gulf Coast and inland. This is because of the absence of adequate transportation infrastructure connecting the East Coast with major producing regions within the US, which has meant that these refineries have had to procure foreign oil priced off Brent (Andrews et al., 2010; Energy Intelligence, 2011; EPRINC, 2013).

The East Coast refineries have been benefiting from the shale revolution in the US, especially from North Dakota’s Bakken formation, because the rise in shale production has allowed these refineries to procure cheap domestic oil (EPRINC, 2013; EIA, 2015a). Those refiners have been relying on oil shipments by rail. However, it costs $15 per barrel to ship oil by rail from Bakken to New York Harbour, compared to a cost of only $5 per barrel to move oil by pipeline (EIA, 2012d; EPRINC, 2013). The decline in oil prices that started in the second half of 2014 may call a halt to
the use of more expensive modes of transportation, which subsequently lead to resuming oil imports from abroad. Consequently, enhancing the energy security profile of the US calls for investing in a permanent infrastructure that can ensure that East Coast refineries have access to domestic oil. Such an infrastructure would also allow for the use of a domestic benchmark in pricing rather than an international marker.

Secondly, the rise in shale production serves the strategy that aims to reduce dependence on imports (Glaser, 2013). Therefore, it is of significant importance to facilitate investments in a sustainable infrastructure that avoids the Cushing, Oklahoma, and directly connects inland producers with the major refining centre on the Gulf Coast. This is because the findings showed that the tightening in the LLS-Brent is less than that observed for WTI-Brent around the occurrence of disruption. This can be explained by the close proximity of LLS to the Gulf Coast, which makes its prices more responsive to international events.

The domestic shale production priced off WTI suffered from significant price discounts due to the presence of logistical bottlenecks in and around the Cushing (EIA, 2012b; EPRINC, 2013). The price discounts benefited refineries, but at the same time exerted downward pressure on wellhead values at a time when debt-fuelled production needed to be sustained (EIA, 2012b; EPRINC, 2013). It is argued, for example, that such price discounts to WTI were partially responsible for the rise in asset impairment by 30 publicly traded tight oil producers between the third quarter of 2013 and the same period in 2014 (EIA, 2014b). Simply put, less responsiveness of WTI prices to international events may cause further harm to inland producers, who already have to suffer from deep discounts. This, in turn, could impair the part of the strategy that aims to reduce the dependence on imports.

Therefore, policy makers should work closely with the industry to enhance the commercial, legislative, and bureaucratic environments, which can encourage investments that alleviate the logistical constraints. Reports suggest that there has been a significant increase in the time required to process infrastructure permits due to the rise in the number of applications, and the necessity to coordinate among different agencies (EPRINC, 2013). This recommendation is in line with that of Deutch et al., (2006). They call for a joint effort by the government and industry to increase the efficiency of the US energy transportation infrastructure.

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54 For the reliance of shale producers on capital markers to sustain their production, see (The Economist, December 6th, 2014; EIA, 2014b; Alloway, 2014).
Thirdly, an important implication that arises from the findings of the thesis relates to the use of strategic petroleum reserves not only in response to a physical disruption, but also to prevent a rise in prices on a precautionary or speculative basis. The thesis showed that the significant portion of abnormal changes in oil valuations occur well before the start of violent conflicts and sanctions. This finding regarding the timing coincides with theoretical and empirical evidence suggesting that traders react to the possibility of disruption either on a precautionary or speculative basis (Adelman, 1982; 1990; Terzian, 1985; Kilian, 2009; Alquist and Kilian, 2010; Kilian and Murphy, 2013; Baumeister and Peersman, 2013a; b).

Consequently, the findings of the thesis support the approach called for by Adelman (1982:12; 1990), in which the US government should become the “seller of the last resort, just as the central bank is the lender of last resort”. This is because the aim underlying strategic reserves should be “prevention, not cure […]” (Adelman, 1982:13). Put differently, a strategy of waiting for a physical disruption to occur and then reacting could address the physical shortage in supplies. However, such an approach does not target the economic pain arising from a “runaway price increase” caused by precautionary and speculative demand (Adelman, 1990:5).55

Fourth, the findings of the thesis documented a better responsiveness by Light Louisiana Sweet (LLS) than that of WTI to international events, which supports the use of LLS as a domestic benchmark. A step in the right direction of increasing the visibility of LLS was the creation of paper contracts with LLS being the underlying asset. Such derivative instruments are provided by both the IntercontinentalExchange and the Chicago Merchantile Exchange (CME) (Argus, 2014; ICE, 2015). Moreover, Houston is not only emerging as a major storage hub that competes with Cushing, it also has the comparative advantage of close proximity to the Gulf Coast’s refining complexes (EPRINC, 2013).

While WTI has already been replaced by the Argus Sour Crude Index (ASCI) by some OPEC members, the quality of the oil imports could explain this switch to ASCI (Fattouh, 2011; Energy Intelligence, 2011). However, LLS could be a viable domestic reference crude, when taking into consideration that the significant portion of shale production is of the light and sweet quality (EPRINC, 2013; EIA, 2014a).

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55 According to Adelman (1990), this approach is viewed by opponents as an interference in the functioning of the markets by the government. However, Adelman (1990) argues that the Federal Reserve System should also be prohibited on the same basis.
6.2.3 Implications for the Energy Security of Other Nations

Violent international crises, unplanned disruptions, and sanctions are all events that a net importer or exporter of crude oil may not possess control over. The significant changes in oil prices around the start of such occurrences may affect the economic welfare of nations that are not even involved. Therefore, a number of implications can be highlighted. From the point of view of a net importing nation, the thesis points to the importance of taking measures that reduce the reliance on imports. Such policies and actions can aim to achieve more energy efficiency in order to reduce the consumption of crude petroleum. These measures can also aim to achieve changes in the energy mix, which eventually allocate more weight to sources of energy that are more secure, cleaner, and more sustainable.

Moreover, since projections suggest that crude oil will remain a major source of energy in the foreseeable future, it is imperative to adopt and implement measures that can hedge price risk. One example is the build-up of strategic reserves. Ultimately, a net importing nation must adopt a forward-looking view of the developments in oil markets, which essentially necessitates the use of up-to-date data on the state of oil markets. This, in turn, requires more cooperation among nations and international organisations in collecting and disseminating updated information on oil fundamentals.

Additionally, policies aimed specifically at diversifying sources of oil supplies remain essential. Such measures should not only target the upstream part of the industry; i.e., the sources of supply, but also the entire value chain; i.e., modes of transportation and the refining sector. Put differently, and where possible, a diversification strategy should involve reliance on more than one oil producing region, the use of different modes of transportation, and the presence of a refining sector that is able to handle more than one type of oil.

While the US represents a clear example of a nation taking measures to diversify sources of supply (EIA, 1996; Klare, 2008), China’s efforts are a good case in point. China has been striving to reduce its dependence on oil from the Middle East by producing and exporting oil directly from Africa via the Chinese government’s oil companies (Klare, 2008; United States Joint Forces Com-

56 It is reported that oil will remain the dominant fuel in the transportation sector in 2030 with an estimated share of 89% (BP, 2013). Moreover, it is estimated that crude petroleum will still occupy a major share of global energy demand relative to other fuels by 2040 (ExxonMobil, 2014).
57 The Joint Organisations Data Initiative (JODI) represents an important step towards ensuring the availability and reliability of data. See www.jodidata.org.
mand, 2010). Underlying these efforts is the objective of reducing its dependence on the unstable Middle East (Klare, 2008). Moreover, the Chinese have also been procuring more supplies from Russia and the Caspian region via pipelines (Klare, 2008). The US is unequivocal in terms of announcing its ability – not willingness or intent – to significantly cut Chinese maritime oil imports, as is reflected explicitly in the 2010 United States Joint Forces Command report. The Chinese effort to import more oil via pipelines is a measure aimed to address this fundamental threat (Klare, 2008; United States Joint Forces Command, 2010).

A further case in point that highlights the importance of diversification along the value chain is that of Europe. The refining centre in North Western Europe was designed and built to run light and sweet grades of oil, and maximise the production of light petroleum products (KPMG, 2012). However, structural shifts in demand towards the use of middle distillates caused these refining complexes to have excess supplies of gasoline, and become unable to fully meet the demand for distillates (ibid). Consequently, there has been increasing dependence on Russian supplies of middle distillate products to fill the void (KPMG, 2012; EIA, 2015b), which may have geopolitical ramifications. An additional example comes from Southern Europe, where the refineries that can only run heavy grades of oil were expected to pay more to procure substitutes for the sanctioned Iranian oil (El-Katiri and Fattouh, 2012).

From the point of view of a net exporter of crude oil, the thesis showed that international political events can lead to a significant abnormal decline in the price of the fossil fuel. This is particularly relevant for a nation that depends significantly on oil revenues to finance its budget. It is estimated, for example, that hydrocarbon fuels accounted for 68% of Russia’s exports, and their revenues financed 50% of the country’s federal budget, in 2013 (EIA, 2015b). Mexico serves as an additional example, because oil revenues finance one-third of the country’s federal budget (Meyer et al., 2014; Montes, 2014; Reuters, 2014c).

A decline in the valuations of oil may have severe consequences for the economic welfare of these nations, and even their political stability; with the Russian crisis of 1997 and 1998 being a good case in point (Upper, 2000; Chiodo and Owyang, 2002; Klare, 2008). An approach to hedging against this price risk involves the use of derivatives. For example, it is reported that Mexico has been conducting the largest sovereign hedge programme in oil markets using derivative instruments (Meyer et al., 2014; Montes, 2014). Media outlets have reported that the Mexican programme covered 228 and 215 million barrels of oil exports in 2015 and 2014, respectively (Montes, 2014; Reuters, 2014c).
The programme involves purchasing tranches of put options, which locked in the price per barrel at $76.40 in the 2015 programme (Reuters, 2014c; 2015b). While the use of derivative instruments can help in mitigating price risk, it remains imperative to adopt and implement policies that aim to reduce dependence on oil revenues by creating other sustainable sources of income.

An important implication that concerns both importing and exporting nations is the developments in US foreign policy, which is a similar implication to that highlighted earlier for investors and traders. Policy makers in a nation should closely follow the developments in US foreign policy, particularly those concerning major net exporters and importers of crude oil. The empirical findings of the thesis captured abnormal changes in oil prices, which, depending on a nation’s status as a net importer or exporter, may bring to bear economic and political consequences. Since oil is a global commodity, policy makers should also follow the economic and political processes and events in major net exporting and importing nations, because such developments may lead to repercussions for oil markets and prices.

6.2.4 Implications for US Foreign Policy

The findings of this thesis hold a number of implications for the makers of US foreign policy. First of all, US policy makers should consider the effect that sanctions can bring to bear on the valuations of crude oil. Significant changes in oil prices due to sanctions should be accounted for in the design and calculations of the costs and benefits arising from the use of economic coercion. This is because, as the thesis documented, sanctioning a net exporter can be associated with a significant abnormal rise in oil prices, which can subsequently lead to accumulated losses of 0.20% of GDP in the following two years. On the other hand, if the US imposes sanctions on a net importer, crude oil prices register a significant abnormal decline, which results in accumulated gains of 0.25% of GDP in the next two years.

Put differently, the findings are important, as they show that US sanctions are associated with externalities that can affect the underlying rationale, and the effectiveness of these measures. It is worth noting that history is littered with examples in which a sovereign state adopts a foreign policy that aims to generate economic gains, when actually the economic cost of implementing the policy

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58 It is reported that the programme is traditionally run between August and September each year. Also, the programme in 2015 consisted of tranches of 5 million barrels apiece, and Mexico paid $773 million and $543 million to purchase the put options in 2015 and 2014, respectively (Meyer et al., 2014; Montes, 2014; Reuters, 2014c; 2015b).
far exceeds the potential benefits (Tuchman, 1984). History also shows that a state that embarks on a foreign policy that involves an economic punishment against a nation can end up incurring more economic pain that the target itself (ibid).

A second implication is that the external effects of sanctions may impact the popularity of this foreign policy tool among US voters and domestic business interests, especially in the case of a rise in oil prices. Thirdly, abnormal changes in oil prices may affect the appeal of US foreign policy to its allies, because the energy security and economic welfare of these countries may be negatively affected by unfavourable oil price changes. In turn, this can affect the ability of the US to take concerted actions.

Furthermore, the effect on prices due to US sanctions can undermine the energy security of other major powers such as Russia and China. This is particularly important in a world characterised by an “oil-driven security dilemma”, where China’s power and oil imports are rising, and where the US maintains the capacity to disrupt the flow of imports (United States Joint Forces Command, 2010; Glaser, 2013:114). A conflict, which is made more likely to occur because of this dilemma, can be triggered by political strain on the relationship between the two nations (ibid). The oil-rich Caspian region is a good example of how US foreign policy actions can clash with that of China, and result in the formation of military alliances and a rise in arms transfers (Klare, 2008).

A fourth important implication is that oil price changes can impact the effectiveness of US sanctions programmes, and may lead to further political repercussions. On the one hand, a decline in oil prices associated with the start of sanctions on a net importer can subsidise the economic effect of the programme through reducing the energy bill of the targeted nation. This may affect that targeted nation’s willingness to abide by US demands. On the other hand, the rise in oil valuations that accompanies the start of measures on a net exporter can act as compensation for the targeted nation, thus affecting the effectiveness of economic coercion.

A case in point is Iran’s sabre rattling and threats to close the Strait of Hormuz. It is argued that these were scaremongering tactics that aimed to raise the price of oil in order to compensate for the effect of sanctions on Iran’s oil revenues (El-Katiri and Fattouh, 2012; Van de Graaf, 2013). An increase in oil prices may not only affect the effectiveness of US sanctions against net exporters, but may also lead to international political ramifications, which can materialise through a number of channels.
A rise in oil prices subsequently means an increase in oil revenues. This income can alter the risk preferences of a revolutionary government, fuel its hubris, and motivate it to adopt an aggressive foreign policy (Colgan, 2011). Upward price movements and the resulting rise in revenues can increase the attractiveness of an oil-rich territory, which may lead to foreign aggression or instigate an internal conflict (Collier and Hoffman, 2004; Colgan, 2011; Glaser, 2013). Oil income can also be used by petro-states in building arsenals of conventional weapons (Khanna and Chapman, 2010). Simply put, while the US imposes sanctions in order to deter or punish a nation, it may fuel another dispute or destabilise world peace through the effect on oil prices.

Consequently, US policy makers should assign higher weight to oil markets in the formulation of their foreign policy in general, and the design and implementation of sanctions programmes in particular. This ultimately requires a forward-looking approach to the state of oil markets. Specifically, reporting requirements on the state of oil markets and prices could be introduced on permanent basis. A step of that nature has been adopted under the National Defence Authorization Act for the Fiscal Year 2012 (NDAA). This act requires the US president to evaluate the state of oil markets based on reports submitted by the Energy Information Administration (EIA), and activate sanctions on Iran accordingly. However, the NDAA shows a number of limitations.

First, the act is confined to sanctions on Iran. Secondly, the EIA admits that the “statutory language in the NDAA clearly envisions a report that is primarily, if not exclusively, backward looking in nature”. (EIA, 2012a: 1). Time lags in the collection of data have been forcing the EIA to report estimates on volumes of consumption and supplies of the fossil fuel and its products, rather than actual data. These estimates may under or overstate the tightness of oil markets. For example, the third EIA report of June 2012 states that, based on actual and updated data, the oil markets appear to be looser than estimated in previous reports (EIA, 2012c). Simply put, since the president’s evaluation and decision is based on these reports, the accuracy of the estimates contained in them becomes paramount.

Thus, future reporting requirements could be introduced on permanent basis without being confined to a specific country or programme. Moreover, these reports must at least accommodate the time lag of the data collection in order to avoid over- or under-estimations, which may affect the policy maker’s assessment and decision. Optimally, such reporting may also benefit from a combination of forward and backward looking views on the state of oil markets. This would lead
to a more accurate understanding of the state of petroleum markets, and may result in the relatively swifter design and implementation of sanctions.

6.3 Reflections

A number of considerations call for a reflection on the empirical undertakings of the thesis. These aspects relate to the availability of data on both the fundamentals of oil markets, and the sets of events that the thesis examined. This is a common feature among the three examinations. The availability of data dictated the choice of the time period, the nature of events, and the variables to be accounted for in examining the research questions. These issues highlight future avenues for research on crude oil price formation processes in the context of violent conflicts, unplanned disruptions, and sanctions.

Specifically, and in relation to the first research question, the decision to end the analysis in the year 2007 was dictated by the availability of data on the start dates of conflicts from the latest version of the International Crisis Behaviour (ICB) database. Sources such as the Conflict Barometer publications proved useful when extracting data on a monthly basis. Indeed, the Conflict Barometer publications were used to extract the start dates of OPEC-related conflicts – in the form of month and year – in order to account for such occurrences in examining the WTI-Brent and LLS-Brent price differentials. It is worth noting that the decision to use monthly data in the examination of the price spreads was in itself dictated by the data on control variables such as the cost of logistics, which are only available at a monthly frequency.

In the case of the second research question, future research may consider the start dates of unscheduled disruptions that affect light and sweet grades of oil. This, however, was not attainable in this thesis, because the announcements of such production outages do not specify the affected grade of oil. Moreover, the specific market that will suffer from the occurrence of a disruption is not declared in the announcement. Thus, a potential area of investigation is unplanned outages that affected exports that are distend to the US or European markets.

In relation to the third research question, the Threat and Imposition of Sanctions (TIES) database covers sanctions programmes up to the year 2005. Extending the period of analysis beyond 2005 was feasible due to the presence of relevant documents from the Office of Foreign Assets Control (OFAC) of the US Department of the Treasury. This meant that the investigation had to focus on US economic coercion measures. Additionally, one of the characteristics of the sanc-
tions that the TIES reports is the issue underlying the imposition of the programme. However, the TIES database reports more than one underlying issue for US sanctions, which does not facilitate a meaningful investigation on the basis of this variable.\textsuperscript{59}

Importantly, it would have been more prudent to account for the global fundamentals of oil markets in the three investigations. This, however, was not feasible due to the unavailability of data from either public sources such as the Energy Information Administration, or other resources at my disposal. Data-related issues also arise in the form of the time period covered. For example, the Joint Organisations Data Initiative (JODI) provides useful data on oil markets, but this database covers the period from January 2002 onwards. The time period covered is an issue that is also evident in the case of stocks of crude oil. It would have been useful for the analysis of the price differentials to examine crude oil stocks in the Cushing, but relevant data is only available from 2004.\textsuperscript{60}

Similar issues with data meant that it was not possible to examine the price spread between other international benchmarks. Specifically, investigating the effect of disruptions on the west-east price differential; i.e., the price spread between Brent and Dubai/Oman (Fattouh, 2011), is a potential area for future research. However, exploring this avenue requires controlling for variables in the Asian markets, which consequently necessitates access to relevant data. Moreover, a well-known phenomenon in oil markets is the premium paid by Asian nations to exporters (Stevens, 2005; Fattouh, 2011). Thus, a future research project may explore the nature of the effect of disruptions on the spread between the official selling prices of shipments destined to Asia and Dubai/Oman.

An additional aspect of data availability relates to the aggregation of important variables. For example, data on petroleum stocks outside the US is available, but this data combines crude oil and all petroleum products. The aggregation is also evident in the cases of stocks of crude oil and spare production capacity. In order to maintain quality, storage facilities do not mix different grades of oil (EIA, 1996). However, to the best of my knowledge, data on crude oil stocks by grade of oil is not available.\textsuperscript{61} By the same token, publicly available data on excess capacity is

\textsuperscript{59} The issue underlying the imposition of sanctions is coded ISSUE in the TIES database.

\textsuperscript{60} The data on crude oil stocks is available from the Energy Information Administration (EIA). See www.eia.gov/dnav/pet/pet_stoc_cu_s1_m.htm.

\textsuperscript{61} This was confirmed by the Energy Information Administration (EIA) in an answer to a query on the presence of data on oil stocks of different types.
not disaggregated by type of crude. Therefore, it was not possible to conduct an analysis that solely focuses on the spare capacity and stocks of light and sweet grades of oil. This represents a future avenue for research in which these fundamentals could be accounted for in examining the pricing of a particular grade of oil, and specifically in investigating price differentials.

Future research may also specifically and directly examine how precautionary and speculative components of demand are triggered by violent crises, production outages, and sanctions. Critical to this examination is the identification of periods of time within which crude oil markets are characterised as being tight. In turn, this requires obtaining data on the specifics of global oil fundamentals – to reiterate, this is an issue that hindered the researcher’s ability to conduct such an investigation in this thesis.

Defining tight markets will require controlling for the available spare capacities along the value chain. Specifically, future research may account for the global excess production capacity of different quality crudes, spare capacity in oil tankers and the pipeline segment of the industry, spare storage capacity, and spare capacity in the refining sector. For example, new shipping capacity requires time to come on-line, which means that existing tankers and pipelines may not be able to swiftly respond to sudden changes in supply and demand (Energy Intelligence, 2011). Moreover, a future examination should not only focus on the distillation units that constitute simple refining processes, but should also control for the spare capacities of conversion and deep conversion units.

Furthermore, since the build-up and release of stocks is the suggested mechanism through which changes in precautionary and speculative demand materialise, special attention must be devoted to stocks of crude oil in different parts of the world. For example, the Caribbean region has emerged as a storage centre for crude petroleum; this region has been allowing long-haul exporters to store oil in these facilities for subsequent shipment to US markets on a short-haul basis (EIA, 1996). This highlights the importance of considering such storage centres in future research in order to establish a more comprehensive view of oil markets and prices.

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62 Relevant data may exist but are not freely accessible. For example, data on spare capacity by type of crude is available from at least one source on a monthly basis from 1995 onwards. However, access to this particular data costs $10,000. An experienced source in the industry acknowledged the challenge of obtaining data on the specifics of oil markets, and highlighted this by alluding to a $1 million investment made by his employer – a national oil company of a member of OPEC - in a specialised database provided by Parpinelli Tecnon. This database served alongside other sources of data from providers such as Thomson Reuters, Platts, and Bloomberg.
Additional future research may also examine the effect of violent crises, physical disruptions, and sanctions on the floating storage of oil. This is because anecdotal evidence suggests that storing oil offshore can occur in response to events of a political nature, and the offloading of these shipments may have consequences for oil prices. For example, estimates suggested that Iran had to deploy 56% of its oil tankers capacity, or 33 million barrels, in 2012 due to sanctions that targeted its oil exports (Reuters, 2012). Iran resorted to this move, because its onshore storage capacity was fully utilised, and reducing production could ultimately have resulted in disastrous damage to the operating wells (Van de Graaf, 2013).

Recent estimates have also pointed out that 40 million barrels of Iranian oil have been stored on super tankers off Iran’s shores in order to be sold in international markets following a deal on the country’s nuclear programme (Reuters, 2015a). Reports have suggested that this floating storage hung over the oil markets, because Iran’s expressed its intention to sell at any price in an attempt to regain market share (ibid). These developments are clearly associated with political events, and highlight the importance of empirically examining how events of political nature can shape decisions to utilise floating storage due to rational, and precautionary and speculative motives.

To summarise, the thesis contributed to the literature and highlighted implications for investors and policy makers. The thesis was driven by the strategic economic and political importance of oil. Exploring the above-mentioned future research venues becomes even more important in a world characterised by the rising demand and power of both China and India. It is a world in which both emerging powers have already been emulating and imitating the American military and civilian consumption habits (Klare, 2008; United States Joint Forces Command, 2010). Such a world may witness a heightening in the security dilemma driven by an increasing dependence on oil (Glaser, 2013), which may consequently signify the role of events such as wars, sanctions, and disruptions in the price formation processes of crude petroleum.
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