Diversifying away the Risk of War and Cross-Border Political Crisis

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Abstract

This paper investigates the behavior of crude oil prices, government bonds and stock market indices around outbreaks of severe international crises and wars. Using a constant-mean-return event study, we show that these events are associated with positive and significant abnormal returns on oil and bonds, which means that these two asset classes can potentially shelter shareholders from plummeting equity values during international crises. A formal safe haven analysis confirms this insight. Such price movements may reflect a reallocation of funds across asset classes in response to the events, as well as shifts in the demand for oil due to precautionary, speculative and military motives. We also calculate the weights for optimal portfolios, which could provide insurance against conflict risk.

JEL classification: G11, G12, Q34

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I. Introduction

The effects of wars and conflicts go beyond battlefields and inflict severe damage to human and physical capital with shattering economic consequences (Nordhaus, 2002; Cappelen *et al.*, 1984; Deger and Smith, 1983). Consequently, one may expect the impact of such events to resonate in financial markets in general and stock markets in particular (Berkman *et al.*, 2011). The financial integration of markets within a country or across national borders exacerbates the devastating effect of violent conflicts through a reduction in diversification benefits. As people flee warzones and seek safe shelter, so too does the financial capital. Thus, it becomes an imperative to search for safe haven assets during such political events, as the capital escapes tumbling equity markets. It is the potential presence of such assets and the associated diversification benefits that motivate our paper. More specifically, we consider crude oil and government bonds as potential safe havens for those investing in US and World equities. By 'safe havens', we mean assets with returns uncorrelated or negatively correlated with the stock market index returns around the time of conflict or political crisis outbreak. A 'hedge' would be an asset that would exhibit such property throughout the entire sample period, rather than during crises periods alone, while a 'diversifier' is a non-hedge asset less than perfectly correlated with the stock market index on average (Baur and Lucey, 2010).

The strategic importance of petroleum in the global economic system (Hamilton, 1983), in addition to its current and historical association with wars and political conflicts (Liddell-Hart, 1953; Lieber, 1992; Yergin, 2012), suggest that it may be a possible safeguard against falling stock market valuations during such turbulent periods. Secondly, the theoretical, empirical and anecdotal evidence documents flights from equities to the quality and liquidity of sovereign bonds during financial crises (Hartmann *et al.*, 2004; Caballero and Krishnamurthy, 2008; Baur and Lucey, 2009). We therefore postulate that a positive market reaction may take place for sovereign bonds in times of political disarray. Sovereign debt is an important asset class, as it serves as a benchmark for corporate debt (Fabella and Madhur, 2003; Dittmar and Yuan, 2008), which tends to be less liquid (Hund and Lesmond, 2008). Furthermore, bonds issued by governments in international markets appear to lead other bonds in terms of price discovery (Dittmar and Yuan, 2008).

This paper documents substantial increases in price of crude oil during periods surrounding the outbreaks of wars and international crises. Several authors have observed oil price reactions in response to specific events, like the Gulf War (Lieber, 1992) and the war in Iraq (Leigh *et al.*, 2003; Rigobon and Sack, 2005). Notwithstanding the importance of these two events, our investigation covers a more comprehensive sample of international conflicts, which allows us to derive general conclusions regarding the nexus between war and the market value of crude petroleum. We go on to argue that there may be several reasons why hostilities lead to oil price inflation. First, the demand from the military increases, as large quantities of fuel are required for the navy, aircrafts and armored fighting vehicles. Second, the uncertainty surrounding future supply, and questions regarding the safety of transportation routes, can provoke market participants to engage in panic buying. Third, there may be rational stockpiling on the part of countries striving to preserve their sovereignty and maintain energy security in the face of political turmoil. Last but not least, cross-border conflicts increase the probability of oil embargoes and the use of oil as a tool of warfare. For instance, a number of Arab OPEC members imposed an embargo on oil exports to the US in retaliation for US help extended to Israel in the 1973 Arab-Israeli war (Smith, 2009). As a consequence, oil prices soared and this became known as the first oil crisis.

The paper further shows that sovereign bonds exhibit similar behavior to that of crude oil around eruptions of international conflicts. The fact that market prices are sensitive to political and military actions may have important implications for international investors seeking to diversify their portfolios effectively. The desperate diversification search and risk avoidance often turns into the flight-to-quality, a phenomenon defined as the movement of funds from equities to highly-rated bonds in times of turmoil. The existence of this effect renders bonds an effective instrument for diversification, as pointed out by Baur and Lucey (2009). Furthermore, they show that diversification benefits arising from the flight-to-quality are shown to enhance the financial system's resilience and stability. Similarly, the systemic propagation of financial market crises between, and within, G5 countries is limited by the presence of the flight-to-quality phenomenon (Hartmann *et. al.*, 2004).

Importantly, the effectiveness of cross-border equity diversification is found to decline during periods of heightened uncertainty in stock markets, while the effectiveness of bonds in diversification is shown to increase during the same periods (Connolly *et al.*, 2005). The growing integration between different equity markets has meant that a shock in one market is easily transmitted to another one (Asgharian and Nossman, 2011; Koutmos and Booth, 1995; Arshanapalli and Doukas, 1993). Thus, the search for an effective diversification tool in times of international political crises becomes an imperative in the light of evidence that suggests higher systemic risk in equity markets.

Interestingly, our results also attest to the fact that conflicts depress the values of stock market indices worldwide. This corroborates earlier findings reported in the literature (see, for example, Rigobon and Sack, 2005; Wisniewski 2009; Berkman *et al.*, 2011). The logical implication for stock market investors is that crude oil and sovereign bonds could be useful assets with which to diversify away the price risk associated with war and crisis outbreaks. To verify this idea, we present a formal test for the safe haven property. We adopt a definition of safe haven which is similar to that proposed by Baur and Lucey (2010). Our results confirm the predictions that, from the perspective of stockholders, crude oil and government bonds provide refuge from the risk of war and international crisis. Consequently, investors are advised to take advantage of the unique diversification benefits offered by these two assets. With regard to crude oil, taking delivery in the spot market and storing this commodity is, admittedly, not particularly convenient. However, a long position on futures contracts or an investment in crude oil exchange-traded funds (ETFs) can be used to achieve the same objective.[2]

The remainder of the paper is organized as follows. The next section reviews the related literature. Section III elaborates on the International Crisis Behavior (ICB) database as well as on the financial series used in the study and their summary statistics. Section IV describes our methodological approach. Results of event study analysis, safe haven tests, and optimal portfolio analysis are reported in Section V. This is followed by a description of robustness checks performed and further considerations. The final section concludes the paper and considers practical implications for investors.

II. The Effect of Cross-Border Political Crisis and War on Different Assets

2.1. Oil in Times of Warfare

Not only is crude oil an important investment asset, it has also been a consumer staple since time immemorial. In fact, the history of human civilization and the use of oil are closely intertwined. In the more distant past, kerosene distilled from oil was a popular illuminant used to prolong the productive part of the day for large swaths of the population. Widespread adoption of the internal combustion engine led to society becoming reliant on hydrocarbons to propel its automobiles, ships and airplanes. Oil is used for energy production as well for heating, and its derivatives are inputs in the manufacturing of plastic, synthetic fibers and rubbers, detergents, chemical fertilizers and other petrochemicals. The distillation of crude oil gives a residue of asphalt, a substance utilized for paving roads. The global economy appears to be addicted to oil and consumes about 88 million barrels of it per day (BP, 2012). Perhaps unsurprisingly, academic research has found that oil price hikes and increased price volatility can have detrimental effects on the economies of countries that are net importers of oil (Gisser

[2] Smith (2009: 158) notes that the correlation between the West Texas Intermediate crude oil price and the nearest–dated futures price is 0.9999 when measured in levels, and 0.9357 when measured in daily price changes.

and Goodwin, 1986; Ferderer 1996; Abeysinghe, 2001). At the time of writing his seminal paper, Hamilton (1983) notes that since World War II all but one US recessions occurred following increases in the price of crude petroleum.

Oil may be as much of a curse as it is a blessing. The uneven geographical distribution of documented oil reserves has been a fertile breeding ground for political tension. History is littered with heated disputes over rent allocations and battles for control over oil fields. As natural resources increase the value of the state, they also create incentives for rebel groups to overthrow governments by instigating civil war (Fearon and Laitin, 2003; Collier and Hoeffler, 2004). In order to protect their oil wealth, petrostates tend to import large quantities of conventional weapons (Khanna and Chapman, 2010). Furthermore, according to Colgan (2011), access to oil can provide a source of finance to certain revolutionary governments with a predilection for foreign policy adventurism and military conflict.

Petroleum fuels the war machine - both literally and metaphorically. Availability of oil may determine outcomes on the battlefield and shape military strategies. In the pivotal Battle of Stalingrad, German tanks did not have enough fuel to break out from the siege (Yergin, 2012). The Axis powers also faced a shortage of fuel in Africa when the British sank their tankers. This substantially weakened the Afrika Korps under the command of Erwin Rommel that ultimately surrendered in May 1943 (Liddell-Hart, 1953). Soon thereafter, grappling with extreme oil scarcity forced Japan to resort to Kamikaze attacks. This tactic relied on Japanese suicide pilots crashing their planes filled with bombs into enemy ships, which meant they did not require aviation fuel for the return trip (Yergin, 2012). Clearly, oil becomes a commodity of strategic importance in times of international hostilities.

The role of oil in warfare has risen dramatically since World War II. The driving factors behind that rise are the increased mechanization of wartime technologies, and the long-distance mobility requirement generated by the expeditionary nature of conflicts (Deloitte, 2009). This is reflected in 22 gallons of fuel consumption per U.S. soldier per day in the most recent conflicts in Iraq and Afghanistan; which represents a 175% increase from its level in the Vietnam conflict (ibid. 2009:3). Furthermore, fuel purchases by U.S. forces in Afghanistan have increased from 48 million gallons in 2003 to 489 million gallons in 2011- a staggering increase of almost 920% (Congressional Research Service, 2012:52).

Violent political conflicts can inflate the prices of petroleum due to its vital role in both the global economy and warfare. An emerging body of research is showing that events of a political nature may trigger demand-side reactions leading to significant price changes, even in the absence of supply disruptions (see, for instance, Kilian 2009; Alquist and Kilian 2010; Kilian and Murphy, 2013; Kilian and Lee, 2014). International conflicts may tighten oil markets due to an increase in military demand and rational stockpiling in order to ensure energy security. Political stress may also cause a shift in traders' expectations regarding future oil availability, which can cause a surge in demand based on precautionary and speculative motives (see Terzian, 1985; Kilian 2009; Alquist and Kilian, 2010; Kilian and Murphy, 2013). For example, while Terzian (1985) argues that the price shock associated with the Iranian revolution was caused solely by an increase in precautionary or psychological demand, Kilian and Murphy (2013) document a rise in speculative stockpiling in the months prior to the 1990 Iraqi invasion of Kuwait. Furthermore, as demonstrated by the experience of the 1970s, political events can affect the level of supply of crude oil to international markets (Klare, 2008; Yergin, 2012). The threat of embargoes, refusal of insurance companies to provide coverage for tankers passing through warzones and possible endangerment of transportation routes could further exacerbate pressures on the supply side.

The rise in prices of crude oil suggests it has the ability to act as a safe haven for assets whose valuations tumble during crucial episodes of international crises. Simply put, fossil fuel might be an effective protection against the risks of wars. The presence of an active paper market, and investment vehicles such as exchange-traded funds, may facilitate and expedite the delivery of such diversification benefits.

2.2. Sovereign Bonds in Times of Warfare

The role that government bonds play as a shelter during times of financial turmoil is documented by theoretical and empirical evidence. The safety umbrella of these fixed income securities is reflected in the flight-to-quality and flight-to-liquidity phenomena. Despite sharing a similar investment endpoint (i.e. government bonds), these phenomena differ from each other in that a flight-to-liquidity is characterized by a sudden and strong preference for holding more liquid assets (Vayanos, 2004; Longstaff, 2004), while flight-to-quality refers to shifts from risky assets to safer ones (Baur and Lucey, 2009). Moreover, although credit quality and liquidity are two important attributes of fixed income securities, their importance varies when considered unconditionally or conditionally in times of heightened market uncertainty (Beber *et al.*, 2009*).* During turmoil the importance of liquidity increases significantly and becomes almost an exclusive factor in determining the destination of the flow of funds into and out of the bond market (ibid. 2009).

Despite the differences between the two phenomena, evidence points not only to their presence, but also to the importance of their role in affecting the proliferation of financial crises (Hartmann *et al.*, 2004; Baur and Lucey, 2009). Unanticipated or rare events are responsible for the initiation of most flight-to-quality episodes, and during such occurrences investors unload risky activities and become more conservative. Caballero and Krishnamurthy (2008) present a theoretical model and show that flights to quality can be triggered by heightened Knightian uncertainty or limited aggregate liquidity. Moreover, they argue that Knightian uncertainty explains the common behavioral attributes among investors and across historical flight-to-quality episodes. Empirically, Baur and Lucey (2009) examine the markets of eight developed countries during four financial crises, in addition to the September 11 attacks, and document the frequent and simultaneous occurrence of flight-to-quality during most of the crises.

Additionally, Longstaff (2004) shows that flight-to-liquidity is present and reflected in a significant liquidity premia in U.S. treasury bonds of different maturities relative to bonds issued by the U.S. government agency Refcorp. Interestingly, his exploratory investigation, among other findings, reveals a negative and significant relationship between liquidity premia and changes in consumer confidence for maturities between two and ten years. Further evidence is provided by Goyenko and Ukhov (2009) who show that a positive shock to the illiquidity in the U.S. stock market is typically followed by an increase in the liquidity of U.S. treasury bonds. The status of U.S. treasury bonds as vehicle of choice for investors fleeing markets in periods of turbulences and seeking quality and liquidity is further reinforced by Dungey *et al.* (2009). Their findings indicate that sudden changes in asset allocations away from emerging markets and towards the safety of U.S. treasury bonds explain the positive sign asymmetry in the volatility of treasuries.

The occurrence of flights to quality is also documented for government bond markets outside the U.S. Hartmann *et al.* (2004) investigate the nature of linkages within and across G5 countries and document the presence of flights from stocks to bonds during crisis periods. They further show that stock-bond markets linkages during times of instability do not stop at national borders. Similarly, Briere *et al.* (2012) examine all financial crises between 1987 and 2010 across the markets of the U.S., Japan, U.K. and Euro Zone, and find a tendency towards flight-to-quality. The outbreak of the 1998 Russian crisis offers anecdotal evidence in that non-residents purchases of German government bonds reached DM 34.5 billion in July, from an average per month of DM 11.4 billion during the first half of 1998 (Upper, 2000).

The association of wars and international crises with valuations of fixed income securities is well documented in the literature for the period prior to, and during, World War II. Between 1938 and 1940, sudden shifts in the yields and spreads of Nordic government bonds reflected the significant increase in the perceived probability of war's outbreak (Waldenström and Frey, 2008). Furthermore, five European government bond prices were found to have successfully predicted the course of specific events, such as the Battle of Stalingrad (Frey and Kucher, 2001). Similarly, political and military events during World War II found a reflection in the fluctuations of French government bond prices (Oosterlinck, 2003) and the German counterparts (Brown and Burdekin, 2002). These empirical findings reflect what appears to be a rational reaction on part of the investors who process previously unknown information.

The theoretical and empirical evidence above provides a rationale for examining the potential role of sovereign bonds as a safe haven and their diversification properties. The related literature focuses mainly on historical financial crises, with limited attention to political ones. Our contribution lies in documenting a significant abnormal behavior in the returns of world sovereign bonds accompanying a broader sample of wars and intense political conflicts.

2.3. Stock Prices in Times of Warfare

The fact that military conflicts can have serious ramifications for stockholders has not gone unnoticed in the literature. Arguably, the war on Iraq launched under the George H. Bush administration received the most attention from scholars. Rigobon and Sack (2005) examine the three-month period prior to the engagement of coalition forces in Baghdad and show that increases in the risk of war led to significant falls in US stock prices. Wolfers and Zitzewitz (2009) scrutinize the behavior of ‘Saddam securities’, which were traded on a predictions web page and offered a fixed payoff if Saddam Husain had no control over central Baghdad by a specific date. The perceived probability that Saddam wwould be ousted from power could have been inferred from the prices of these securities. According to the authors, prior to the military engagement, a 10 percentage point increase in the probability of war was associated with a 1.5% drop in the S&P 500 index. These estimates imply an anticipated decline of 15% in equity prices due to the launch of Operation Iraqi Freedom. Amihud and Wohl (2004) argue that once military action started, the increasing likelihood of Saddam’s fall could be viewed as good news, because it signified a swift end to the conflict. They show that, during the war, increases in the probability extracted from Saddam securities were accompanied by raising stock prices. The study by Berkman *et al.* (2011), instead of focusing solely on Iraq, utilizes a large international sample of wars and political crises. The authors corroborate the conclusion that the calamities of hostile conflicts are reflected in decreasing shareholder wealth.

The importance of conflicts, even those that are regional in nature, needs to be emphasized given the empirical evidence suggesting a rise in interdependence among stock markets, and even the presence of risk of contagion. Most of the political crises we consider involve a rather limited number of actors, yet these events seem to resonate globally and are reflected in the world stock index. Such an observation is not particularly surprising considering the findings of the prior literature. Markwat *et al.* (2009) find evidence of the occurrence of a domino effect in the evolution of stock market crashes across the US, Europe, Latin American and Asian countries. Similarly, the contagion effect is documented to run from U.S. and German stock markets and into Central and Eastern European countries (Syllignakis and Kouretas, 2011). Comparable effects have been observed among Latin American and Asian equity markets during the 1994 and 1997 crises (Bodart and Candelon, 2009). Hernández and Valdés (2001) note that contagion could spread through trade, neighborhood and financial links, whereas Darvas and Szapáry (2000) emphasize the role of market sentiment. While all these channels may play a crucial role in crisis propagation, we want to draw attention to another possibility. A local political crisis could push the prices of some important commodities such as oil upwards, and thereby adversely affect other economies and markets.

If international stock markets fall significantly in response to political tensions, one may wonder what steps investors could take to protect themselves against such events. In what follows, we will formally test whether allocating parts of portfolio funds to crude oil and sovereign bonds could provide a shelter in times of political crisis and war. We also endeavor to compute optimal portfolio weights for each of the asset classes.

III. Data

Our sample of international conflicts is taken from the International Crisis Behavior (ICB) project database (version 10, July 2010).[3] This resource has been developed by the Center for International Development and Conflict Management affiliated with the University of Maryland and has been used in numerous academic studies (in addition to the literature listed on the ICB web page, please see Berkman *et al*., (2011) and Blomberg *et al*., (2004)). Not only does the dataset contain a complete list of trigger dates for international crises, but it also describes their severity. We have decided to exclude any non-violent acts of a lesser gravity, such as protests, diplomatic sanctions, or withholding economic aid. The only events considered here are those scoring six and above on the trigger reason scale.[4] Our sample of international crises includes internal challenge to the regime, demonstration of force, movement of the army, mobilization and indirect and direct violent acts. We also create a war sub-sample focusing only on situations where at least one of the actors experienced an episode of direct violence, which could be defined as a border clash or border crossing by military forces, invasion of air space, military operations on the sea and in the air, as well as a large-scale military attack or bombing.

We select the beginning of 1987, right after the third oil crisis, as our sample starting date. This was the point in time when oil prices, previously engineered by the cartel-like behavior of OPEC, became more responsive to market forces. The change was a direct consequence of Saudi Arabia's refusal to act as a swing producer entrusted with the role of adjusting the production volume in order to control the price. A major shift transpired, in that OPEC changed its policy from defending an official crude oil price to protecting its market share (Kaufmann *et al.,* 2004; Yergin, 2012). Some authors would go so far as to refer to the

[3] The data collection is available at http://www.cidcm.umd.edu/icb/.

[4] The trigger reason scale is denoted in the ICB codebook as TRIGGR, while the trigger date is coded as SYSDATE. We used the actor-level data and in instances when the conflict erupted in several countries simultaneously we treated it as one event.

events of 1986 as the "collapse of OPEC" (Barsky and Kilian, 2004). Our empirical inquiry ends in December 2007, which is dictated by data availability in the ICB database. Overall, the final sample comprises 64 instances of severe international crisis, out of which 43 events fall into the category of direct violent acts. In what follows, we label the latter set of events as the "war sample".

The oil price used in our study is the West Texas Intermediate (WTI) spot price for delivery in Cushing, Oklahoma. WTI serves as the benchmark for deliveries into the Americas and is prized for being light and sweet as reflected in its low sulphur content and a high API gravity (Stevens, 2005; Driesprong *et al.*, 2008). To investigate the behavior of government bonds we are taking the view point of an international investor and use Citigroup World Government Bond index. As the data on daily changes in this index was not recorded daily from the beginning of our sample, we had to resort to using the series from January 1995 onwards.[5] As we also intend to analyze the behavior of stock markets around the trigger dates, our dataset includes three different stock market indices, namely S&P 500, MSCI World and MSCI World excl. US[6]. Our choice of the international equity indices is dictated by the length of the series, which easily covers the entire period under investigation and in the case of the MSCI data, the comprehensiveness of countries covered. All of the time series used in this paper were sourced from Thomson Reuters Datastream.

[Insert Table I and Figure I about here]

Table I reports the descriptive statistics for the continuously compounded returns on crude oil, world government bond index and stock market indices. Remarkably, world equities (excluding the U.S. listings) offered the lowest average daily returns among all asset classes. In terms of the performance unadjusted for risk, fossil fuels and U.S. stocks were the

[5] Thus, for the models including the bond index the sample period is shortened. It covers 32 instances of severe international conflicts, of which 21 are crises triggered by direct acts of violence.
[6] The MSCI World Index aggregates stock market fluctuations in 24 developed countries and is free float-adjusted market capitalization weighted. The price movements in each of these individual markets are denominated in local currency, so the analysis focuses primarily on stock price movements, rather than the foreign exchange risk.

strongest performers during our sample period. Crude oil proved to be the most risky asset with a standard deviation of nearly 2.5%. The MSCI world index exhibited lower volatility than the S&P 500, as it is diversified more broadly. As one would expect, the world government bonds proved to be the least risky asset with a standard deviation of only 0.4%.

The graph of petroleum prices in Figure I shows two notable movements. The first is a hike in the per barrel price from $21.54 to $40.65 between August and October 1990. This significant upswing came as a response to the Iraqi invasion of Kuwait and the subsequent loss of 4.3 million barrels of oil production from both countries[7]. The rise was temporary in nature and the prices subsequently returned to their pre-crisis levels in January 1991, remaining stable for the rest of the decade. The second phase corresponds to the gradual rise of oil prices from a low of $17.48 in November 2001 to a high of $98.83 in November 2007. A possible explanation for that remarkable evolution is that the low price of oil during the 1990s and early 2000s, combined with modest price expectations, led to low investment in new capacity within the oil industry (Stevens, 2005). Accompanying the lack of newly added capacity was an increase in final demand for oil between 2003 and 2007 by an average of 2% per annum. A significant fraction of that rise in demand was largely unexpected (Saporta *et al.*, 2009).

The indices of U.S. and world stocks share similar characteristics, in that their trajectory started moving upwards from the mid-1990s and continued a remarkable rise until the burst of the Dot Com bubble in the early 2000s. By 2003, equity prices began another climb which continued to the end of 2007. Thus, the first decade of the new millennium clearly represents an era of inflation in equity and crude oil prices. The figure also attests to the fact that investors holding world government bonds were consistently earning a positive nominal return. The proceeds to holders of these bonds occurred against a backdrop of the recent growth of debt in most mature economies, which can be attributed to abnormally low interest

[7] Energy Information Administration: Petroleum Chronology of Events 1970-2000, available online at http://www.eia.gov

rates and heightened banking globalization (McKinsey Global Institute, 2010). Between 2000 and 2008, the total debt levels for governments and consumers alike rose sharply in the U.S., Japan and other major European nations (McKinsey Global Institute, 2012).

IV. Methodology

4.1 Stationarity and Cointegration

Before starting our investigation, we first examine the properties of time series, namely unit roots and cointegration in order to avoid spurious results later on. Checking for unit roots is done by applying the Augmented Dickey Fuller (Dickey & Fuller, 1981) test to each series separately, namely S&P 500, MSCI World, MSCI World excl. U.S., WTI and World Government Bond Index. The test is performed for data expressed in levels, first differences and log returns. Schwarz Information Criterion (Schwarz, 1978) is used to determine the lag length for the test, which also includes a deterministic trend. If the unit root testing reveals, for instance, that WTI and S&P 500 are non-stationary in the levels, it becomes imperative to examine whether they are cointegrated, or in other words, whether their linear combination is stationary. In economic terms, cointegration implies an equilibrium or long-term relationship in which assets or variables can exhibit similar movements over time due to shared or collective factors (Granger, 1981; Engle and Granger, 1987). The presence of such a relationship may have significant financial implications in the form of diversification benefits reduction (Hammoudeh *et al.*, 2004). The absence of cointegration can empower our later safe haven investigation and provide a basis for good portfolio diversification, as the asset classes will be sufficiently distinct.

To test for the presence of cointegration, let us consider the (2×1) system Y_t consisting of the WTI and S&P 500 series, as well as two other (2×1) systems where S&P 500 will be replaced sequentially with MSCI World and MSCI World excl. US. The aim is to find a model for each system. The question remains whether the series are cointegrated or not, therefore we run the ADF Engle-Granger residual based test (Engle & Granger, 1987) twice, where sequentially each component of each Y_{it} for i = 1, 2 will be the left hand side variable. Similar testing is also performed for the World Government Bond Index. In order to double check the results of the ADF Engle-Granger test, we also perform the Johansen (1991) trace test of the null hypothesis of the existence of h cointegrating relations against the alternative of no restrictions.

4.2 Unconditional Effect of Political Crises

Quantifying the unconditional impact of political crises without controlling for cross-dependencies between variables already provides important insights and serves as a basis for the subsequent safe haven econometric modeling. We analyze 101 daily intervals centered on the trigger dates classified as category 6 to 9 according to the ICB dataset and capturing 50 daily intervals before each trigger date, 50 thereafter and the trigger day itself. Figure II illustrates the timing sequence of the event study. I_o denotes the event date or in other words the conflict trigger date, whereas T_1 and T_2 are the number of days before and after the event date, respectively.

[Insert Figure II about here]

To capture and quantify the behavior of equity prices, crude oil and bonds around the starting dates of conflicts, we employ an event study framework as outlined in Campbell *et al.* (1997). As a model for "normal" returns we assume the constant mean return model:

$$R_{it} = \alpha_i + \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, \sigma_i^2) \tag{1}$$

where t denotes the underlying daily intervals, α_i is the constant or mean return of index i, and R_{it} is the return of index i in a specific daily interval t. Even if the specification of the constant mean return model is fairly straightforward, it often obtains results similar to more sophisticated models (see Brown & Warner (1980, 1985)). Equation (1) is estimated based on a pre-event window, which runs from day $I_{-(T_1+150)}$ to day $I_{-(T_1+1)}$. Using the resulting parameter estimates, we compute the abnormal returns during the event windows:

$$\widehat{AR}_{it} = R_{it} - \hat{\alpha}_i \quad (2)$$

The $\widehat{\mathrm{AR}}$s measure the returns over and above what would have been expected had the event not occurred. To put differently, in absence of the event, one would expect the average of $\widehat{\mathrm{AR}}$s to be zero. Let $\widehat{AR}_{it}^{k}$ denote the $((T_1 + T_2 + 1) \times 1)$ vector of abnormal returns on index i for event k computed between time points I_{-T_1} and I_{T_2} as shown in Figure II. Let ι_j be a $(j \times 1)$ vector of j ones, $1 \leq j \leq T_1 + T_2 + 1$. The cumulative abnormal return for event k and event window j, which starts on or after the I_{-T_1} time point, is then defined as:

$$\widehat{CAR}_{ij}^{k} = \iota_j' \widehat{AR}_{it}^{k} \quad (3)$$

So that the cumulative average abnormal return $CAAR_{ij}$ is given by:

$$CAAR_{ij} = \frac{1}{k} \sum_k \widehat{CAR}_{it}^{k} \quad (4)$$

where k is the total number of events. These CAARs represent total returns directly attributable to the existence of hostilities and their statistical significance is assessed using the *t*-statistic described in Kothari & Warner (2007).

4.3 Safe Haven Econometric Methodology

To formally test whether oil and sovereign bonds have safe haven properties, we adopt an approach similar in spirit to Baur and Lucey (2010). In their paper, Baur and Lucey examine the ability of gold to act as safe haven for investors in financial markets during periods of turmoil. Importantly, they define a period of market distress as one in which returns on a financial asset fall below an arbitrarily specified level. Ours methodology builds on theirs; however the distress is defined as periods surrounding international violent conflicts. We note that the methodological extension of Baur and Lucey (2010) employed here can also be potentially adapted in the context of other dramatic events. Consequently, we run the following linear regression using daily observations:

$$R_{WTI,t} = C + \beta_1 R_{Stock,t} + \beta_2 R_{Stock_{conflict},t} + \varepsilon_t \tag{5}$$

where the error term ε_t is assumed to be independently and identically normally distributed with mean zero and variance equal to σ^2. $R_{WTI,t}$, $R_{Stock,t}$ are the returns on WTI crude oil, and on a given stock market index at time period *t*, respectively. $R_{Stock_{conflict},t}$ 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) centered on the conflict trigger date and 0 otherwise. Three different stock market indices are used (S&P 500, MSCI World, MSCI World excl. U.S.), allowing us to examine the safe haven property from the perspectives of U.S., international and non-U.S. stock market investors. As for World Government Bonds, we additionally perform the same analysis as before, but replace $R_{WTI,t}$ with $R_{Bond,t}$, and specify the following regression equation:

$$R_{Bond,t} = C + \beta_1 R_{Stock,t} + \beta_2 R_{Stock_{conflict},t} + \varepsilon_t , \tag{6}$$

where $R_{Bond,t}$ is the total return of the world bond at time period *t.* According to Baur & Lucey (2010), oil and world government bonds will exhibit characteristics of a hedge, should the respective estimations reveal that $\beta_1 \leq 0$. If $(\beta_1 + \beta_2) \leq 0$, oil and bonds will be defined as safe haven assets, as their returns will be uncorrelated or negatively correlated with stock market index returns in times of conflict. In light of our event-study results, we postulate that fossil fuel and sovereign bonds will act as a shelter from equities during violent political conflicts. Thus, failure to reject the null hypothesis $(\beta_1 + \beta_2) \leq 0$ attests to the ability of oil and bonds to provide protection when it is most needed. In our computations that follow, we provide the *p*-values for this null based on a standard one-sided *t*-test.

Models (5) and (6) above cohere with the definition of a safe haven as "an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil" (Baur & Lucey, 2010:219). To reconfirm the results arising from our regressions, we also provide Pearson correlation coefficients between asset classes around the conflict outbreaks. Simple correlation, however, is quite restrictive since it assumes that the relationship between assets is necessarily a linear one. We go one step further and relax the restriction of linearity by proposing that a safe haven is *an asset that is independent or negatively related with another asset or portfolio in times of market stress*. This definition is more general in the sense that the type of relationship is left unspecified. It could be nonlinear, linear, or even more complex.

In order to test this new, more general definition of a safe haven, we propose to use Kendall's tau (Kendall, 1938; Kendall & Gibbons, 1990). Kendall's tau is a nonparametric test, which neither relies on any assumptions about the distribution or the relationship between two quantities *X* and *Y*, nor on the distribution of *(X,Y)*. This test is essentially used to examine whether two variables *X* and *Y* are dependent or not. Kendall's tau is defined, by taking into account the number of ties in both groups, as:

$$\tau_b = \frac{(n_c - n_d)}{\sqrt{\left(\left(\frac{1}{2}n\,(n-1) - n_1\right)\left(\frac{1}{2}n\,(n-1) - n_2\right)\right)}}, \quad (7)$$

where *n* is the number of observations, are n_c and n_d are the number of concordant pairs and the number of discordant pairs, respectively. Two pairs (x_i, y_i) and (x_j, y_j) for $1 \leq i, j \leq n$ are said to be concordant if $(x_i - x_j)(y_i - y_j) > 0$, and discordant if the product is less than 0. A tie is obtained when the product is equal to zero. $n_1 = \sum_i t_i\ (t_i - 1)/2$, $n_2 = \sum_j u_j (u_j - 1)/2$ and t_i is the number of tied *X* values in the *i-th* group, and u_j is the number of tied *Y* values in the *j-th*. Under the null hypothesis of independence between *X* and *Y*, the expectation of $(n_c - n_d)$ is equal to zero, and one can show that the following test-statistic is approximately standard normally distributed:

$$Z = \frac{(n_c - n_d)}{\sqrt{V(n_c - n_d)}} \quad (8)$$

where $V(n_c - n_d)$is the variance of $(n_c - n_d)$[8].

In order to avoid misleading test results, which may pick up dependencies due to the existence of common factors in the return series put under test, we do not perform the Kendall tau test directly on the return series, but rather on the residual return series stemming from the estimation of an ARMA(1,1) process for each of the return series. In doing so, we are able to exclude all common factors which could affect the return series, and therefore the results of the test.[9]

V. Empirical Analysis

5.1 Unit Roots and Cointegration

Table II below presents the results of the Augmented Dickey Fuller test assuming the equation contains an intercept and a trend, while the lag selection is based on Schwartz Information Criterion (Schwartz, 1978). As anticipated, we see that for each series the levels are non-stationary, whereas the first differences are. We would like to note that application of the ADF test without a trend leads to identical conclusions.[10]

[Insert Table II about here]

The results of the cointegration tests are summarized in Table III below. These tests are computed for six different pairings of variables; each pairing forms a two-equation system with two ADF residual tests. When examining the ADF Engle-Granger test statistic values with the critical values for one regressor, we see that the null hypothesis of h = 0 (i.e. no cointegration) cannot be rejected at 1% level for each constellation of left hand variables. Moreover these results are also confirmed by Johannes's Trace test which indicates that there is no cointegration between our variables. The cointegration tests suggest that a long-run relationship does not exist between the two jointly determined variables in either case. The

[8] The detailed formula for the variance of $(n_c - n_d)$can be found in Kendall & Gibbons (1990).
[9] We would like to thank the referee for pointing this problem out.
[10] Detailed results can be obtained from authors upon request.

absence of cointegration reveals, from the perspective of investors, that oil can be considered segmented rather than integrated with stock markets. To some extent, this could imply that diversification can be achieved through holding a mix of these assets. This result is in line with Apergis & Miller (2009). The same conclusions can be reached when we consider bonds instead of crude oil in the cointegration tests.

[Insert Table III about here]

5.2 US and International Stock Markets

In order to explore how equity indices react to the outbreak of an international conflict, we start our empirical investigation with the event study described in the methodology section. Table IV below reports the estimates of cumulative average abnormal returns (CAARs) with the corresponding test statistics, while Figure III graphically depicts the evolution of CAARs. The results pertaining to equities show a statistically significant abnormal decline in the period surrounding the start of political crises and wars. This is further demonstrated in Figure III. Thus, one could infer that stock market participants perceive warmongering to be, on average, a counter-productive activity.

The findings are unsurprising considering the extent of devastation to physical and human capital that an armed conflict could bring. As Nordhaus (2002: 78) eloquently put it: "...war is the ultimate negative-sum game in which the spoils of the victors are much less than the losses of the vanquished." There is some evidence to show that excessive military spending can exert a negative effect on economic growth and development (Deger and Smith, 1983; Cappelen *et al.,* 1984). Berkman *et al.* (2011) look at the issue from an investor's perspective and argue that wars and international political crises depress the world stock market returns by almost 4% per annum. Rigobon and Sack (2005) further document that the heightened risk of a war on Iraq caused a fall in equity prices.

Our results cohere with the narrative present in the aforementioned studies and show that S&P 500 drops by 4.67% due to war outbreaks in the 101 day event window. This decline is deeper than that observed for the MSCI World Index excl. U.S., possibly due to the relatively more frequent involvement of the US Armed Forces in international conflicts. These findings call for an examination of whether the fossil fuel and sovereign bonds react differently to the start of conflicts. Exhibiting a dissimilar behavior provide impetus for investigating the safe haven property of oil and government debt instruments. This would be a very valuable feature, as alternative ways to insure against war risk may be difficult to find.

[Insert Table IV and Figure III about here]

5.3 Crude Oil

Table IV and Figure III present the findings on the behavior of oil valuations around the start of crises. The first striking result is that WTI crude oil prices increase on average by as much as 12.08% due to war outbreak and by 8.46% due to serious international crisis. This increase is statistically significant and a large fraction of the move occurs prior to Day 0. The oil price inflation could have several root causes, such as increased precautionary demand, military purchases, panic buying, or uncertainty about future supply stemming from the increased likelihood of oil embargoes and a breakdown of trade. The price pressures emerge in advance of conflicts, which may suggest that the military and governments are accumulating reserves ahead of planned operations. In an earlier study, Lieber (1992) notes a surge in crude oil prices during the Gulf War. Similarly, Rigobon and Sack (2005) and Leigh *et al.* (2003) argue that the increased risk of war in Iraq led to crude oil being more expensive. The rise in the prices of the fossil fuel during the Gulf crises might be partially explained by a surge in speculative demand in the period surrounding these two events (Kilian and Lee, 2014; Kilian and Murphy, 2013). Our findings show that these earlier conclusions can be generalized in a sample of 43 wars and 64 instances of international crisis.

Importantly, the diagrams in Panels A and B in Figure III highlight the striking difference in the timing of abnormal price changes between oil and equities. This hints at the possibility that stock investors may not have access to the same information as the major players in the oil market. The oil price seems to anticipate the upcoming conflict at an earlier date than the stock market indices, which start to fall only a couple of days ahead of the trigger date. Some of the war preparations involve an element of secrecy and governments and military, while stockpiling oil in advance of planned operations, are unlikely to share all information with the general public.

The findings of the unconditional analysis suggest that when crises spread throughout the markets, crude oil may provide a useful protection for investors. This, in turn, incentivizes a formal test of the safe haven property of oil in times of political conflicts. To that end, Table V below reports the estimation results for different variations of the safe haven regression equation (5). The first thing to note from Table V is that the estimates of β_1 are either statistically significantly negative or insignificant, indicating that crude petroleum can be used by stockholders as a hedge. Since oil price hikes imply higher input prices and since the cost pass through to consumers may often be only partial, many companies may experience a reduction in cash flows as a result. Moreover, when confronted with a cost-push inflation caused by rising oil prices, central banks may be inclined to raise interest rates; which has ramifications for the discount rates. These theoretical arguments would be consistent with a non-positive β_1.

Broadly speaking, our results are consistent with the existing empirical literature, which reports that the relationship between stock and oil returns is either negative or weak. Jones and Kaul (1996) and Sadorsky (1999) show that oil price growth has a detrimental effect on equity values.[11] On the other hand, Chen *et al.*, (1986) argue that the risk associated with oil price fluctuations is not a significant factor in pricing stocks. The issue is further convoluted

[11] Driesprong *et al.*, (2008) arrive at similar conclusion when examining the effect of an oil price shock on both stock markets of oil-importing countries and the MSCI world equity index. For the effect of oil price shocks on the behavior of the US dollar real exchange rate please see Amano and van Norden (1998).

by the fact that, while petroleum price inflation may be bad news for most sectors of the economy, it is unlikely to hurt companies operating in the oil and gas industry (Faff and Brailsford, 1999; El-Sharif *et al.,* 2005; Nandha and Faff, 2008).

[Insert Table V about here]

Secondly, it can be inferred from Table V that ($\beta_1 + \beta_2$) is smaller than 0 in all of the regressions considered. All of the *t*-tests fail to reject the null hypotheses that ($\beta_1 + \beta_2$) ≤ 0, suggesting that oil is a safe haven that has high payoff in the most turbulent of times. Since the large positive returns from crude petroleum materialize when they are most needed, stock market investors are encouraged to use this commodity to diversify their portfolios. It needs to be noted that oil itself is a risky asset whose price is sensitive to the vagaries of market demand and supply, as well as technological innovations in the field of alternative energy sources. Nevertheless, historical data indicates that it has performed well as a hedge for equities and provided a refuge for those seeking a financial shelter during spells of warfare.

Moving away from the regression analysis, we examine simple Pearson correlation coefficients between the returns on oil and equities during the periods surrounding hostilities. Table VI below reports these estimates which interestingly show that the valuations of WTI and stock markets co-vary inversely during these episodes and the null of no correlation is strongly rejected in all cases. This is testament to the safe haven property discovered earlier. The Kendall's tau tests reported in Table VII below reassuringly confirm these conclusions. We can infer from the statistical property in combination with our new definition of a safe haven that WTI acts as a safe haven for S&P 500, MCSI World and MSCI World excl. U.S. in times of political distress

[Insert Tables VI and VII about here]

5.4 World Sovereign Bonds

The results pertaining to the unconditional impact of political crises on the world government bond index for the period from January 1995 to December 2007 are reported in Table IV and Figure III above. The findings reveal a positive and statistically significant cumulative average abnormal behavior. Bondholders earn on average nearly 1.95% and 3.04% due to the outbreak of war and serious international crisis, respectively. Contrary to the timing of the rise in petroleum CAARs, a large fraction of the increase in bond prices appears to occur from Day 0 onwards. This comparatively delayed reaction could be due to the fact that the investors in fixed income markets are not privy to the same information as governments that stockpile oil ahead of military conflict. Previous examinations captured a significant responsiveness of government bonds to the outbreak of World War II and the subsequent developments in battlefields (Waldenström and Frey, 2008; Oosterlinck, 2003; Brown and Burdekin, 2002; Frey and Kucher, 2001). Thus, our results show that the presence of abnormal behavior in government bonds was not limited to the events of World War II, but has been observed on average during the more recent 21 wars and 32 intense international conflicts.

The significant rise in bonds CAARs might be explained in light of the evidence that suggests the ability of these fixed-income securities to act as a shelter for investors escaping crises in stock markets (Baur and Lucey, 2010). Sporadic or unexpected events force market participants to escape their risky investments and seek the stability afforded by the sovereign bonds (Caballero and Krishnamurthy, 2008). Specifically, the presence of the flight-to-liquidity and flight-to-quality phenomena that mobilize funds from stock markets to government bonds during times of financial turmoil is well documented both theoretically and empirically (Briere *et al*., 2012; Baur and Lucey, 2009; Caballero and Krishnamurthy, 2008; and Hartmann *et al.*, 2004). Interestingly, our findings on the timing and the direction of the abnormal behavior of equity indices corroborate the flight-to-quality rationalization.

The results above provide rationale for an investigation of the ability of bonds to act as a shelter from tumbling equity markets. Table VIII below presents the estimation results from safe haven regression equation (6). The findings show the estimates of β_1 to be negative and statistically significant. This finding can be viewed in light of the relationship between interest rates and equity returns. The impact of interest rate changes on the discount rate, and in turn on the valuation of future cash flows, suggests that these rates are a pervasive state variable (Chen *et al.*, 1986). While high interest rates may inflate the yields accruing to the holders of fixed-income securities, they increase the cost of servicing the debt for corporations and deter investors from buying stocks on margin. Empirical examinations indicate that changes in interest rates have an adverse effect on the equity returns of U.S. financial intermediaries (Bae, 1990), U.S. banks (Elyasiani and Mansur, 1998), and U.K. financial and non-financial firms (Dinenis and Staikouras, 1998). Chen *et al.* (1986) document a significant and negative relation between U.S. stock returns and the spread between long and short-term U.S. treasuries. The effect of interest rate changes is also shown to transcend national borders and exert an impact on equity returns of foreign stock markets (Stevenson, 2002).

[Insert Table VIII about here]

The further examination of ($\beta_1 + \beta_2$) reveals analogous findings to those of the fossil fuel. The *t*-tests fail to reject the null hypotheses that ($\beta_1 + \beta_2$) ≤ 0 in all regressions, suggesting that world government bonds can provide a shelter from war to both U.S. and international investors. The inference is further supported by returning back to the estimates of simple Pearson correlations and Kendall Tau's tests in Table VI and VII above. The results show statistically significant and negative correlation coefficients between the returns on bonds and equities in times of international hostilities. The findings from the nonparametric tests for bonds during the period 1995 to 2007 are even more clear-cut than those documented for oil.

We always reject the null hypothesis that the series are independent, and can conclude that they are negatively dependent.

This evidence reinforces the finding that bonds act as a safe haven in times of financial turmoil (Baur and Lucey, 2010; and Upper, 2000). Our results are also in line with the literature documenting the presence of flights to the quality and liquidity of government bonds. The tendency for a flight of funds from distressed markets towards the safety of sovereign bonds is reported for the U.S., Japan, the U.K., and the Euro Zone (Briere *et al.*, 2012). Baur and Lucey (2009) show similar findings in their examinations of the markets in eight developed countries, while Hartmann *et al.* (2004) document the phenomenon in the markets of G5 countries.

To sum up, our results point to the ability of crude oil and world government bonds to act as safe havens from crumbling stock markets during periods of wars and intense international political crises. The importance of our findings and the underlying necessity of searching for safe haven assets are highlighted by three factors. Firstly, one needs to consider the nature of the events in question. An investor in financial markets might not have complete certainty about the timing of future wars or violent political conflicts. Secondly, stock markets plummet during occurrences of violent political conflicts, which we document in our paper. The third factor is linked to the evidence suggesting the presence of contagion or a domino effect among equity markets of different countries (Syllignakis and Kouretas, 2011; Markwat *et al*., 2009; Bodart and Candelon, 2009). Consequently, our results suggest that crude petroleum and world sovereign bonds should be a permanent component of diversified portfolios in order to protect against war risk.

The potential diversification benefits from an exposure to the fossil fuel and government bonds might also be advantageous to the insurance industry. Numerous insurance corporations provide products designed to protect against war and political risk (they include the U.S. government agency OPIC and other privately-owned insurers). The types of coverage range from protection against currency inconvertibility and confiscation of funds, to assets and income losses due to declared or undeclared wars. The costs and characteristics of such products vary depending on location, type of assets, type of coverage and other regulatory and taxation aspects. It then follows that players in the insurance industry may also wish to consider allocating a proportion of their portfolios to crude oil and world sovereign bonds to hedge the risk arising from selling such products.

5.5 Portfolio Analysis

The results from our preceding analysis hint at the potential diversification benefits from including crude oil and world government bonds in an investment portfolio. We take on the perspective of an international investor who is holding both a position in stocks and real estate, which is proxied here by the movements in the value of the World-Datastream Real Estate Investment Trusts Price Index. By firstly introducing the fossil fuel and subsequently the world government bonds, we aim at identifying the optimal risky portfolios, which generate the highest return per unit of risk. Our first portfolio is constructed from crude oil, world equities and real estate investment trusts, and comprises our entire sample period. The second portfolio has the same constituents with the addition of world government bonds, and covers a shorter period due to the length of the bond series. The optimization procedure that follows is implemented using daily data.

Our optimal portfolio analysis follows the procedure outlined in Peterson (2012). Finding the optimal portfolio weights requires firstly the calculation of excess returns of assets over the U.S. three months' Treasury bill rates, and secondly the construction of a covariance matrix from the excess returns. We then proceed to the formulation of the efficient frontier by minimizing the standard deviation of the portfolio with respect to portfolio weights subject to the constraints that the portfolio return is equal to a certain value and that the sum of portfolio weights is equal to one. We define the minimum variance portfolio as a combination of assets that has the lowest level of risk on the efficient frontier. The final step involves identifying the optimal risky portfolio residing on the frontier, which generates the highest level of return per unit of risk. To this end, we maximize the Sharpe ratio of the portfolio subject to the constraint of its summed weights being equal to one. Since the procedures discussed above do not impose restrictions on short selling, we replicate the same analysis and assume long positions only. We find that almost none of the weights change due to the imposition of short selling constraints. Since these constraints were never binding for 19 out of 20 portfolios considered, we only report optimal weights without short selling constraints. It needs to be noted that different combinations of the optimal portfolio and the riskless asset define the efficient frontier.

[Insert Tables IX and X about here]

A notable finding from Tables IX and X pertains to the allocations of crude oil in both portfolios. The weight of petroleum in an optimal risky portfolio with equities and real estate is 16.53%. This optimal weight is diminished to 6.16% when the portfolio is loaded significantly with world government bonds. This implies that, to a certain extent, bonds can act as a substitute for petroleum when it comes to diversifying the risk. This re-confirms our earlier findings from the event study analysis, where bonds and oil reacted analogously in periods of conflict. The weights on bonds and real estate in two optimal portfolios are substantial, which can be easily rationalized. A common observation is that as we move right from the minimum variance portfolio towards portfolio (9), the weights of crude oil and real estate investment trusts increase gradually along the efficient frontier. The opposite is reported for government bonds and world equities. It can also be inferred from the tables that the introduction of world government bonds into the portfolio has the advantage of generating a higher return per unit of risk. The Sharpe ratio for this all-inclusive portfolio stands at almost 3.74%, which is consistent with the notion of broad diversification generating a better risk-return trade-off.

VI. Further Considerations[12]

In their seminal paper, Baur and Lucey (2010) find that gold can act as a safe haven asset in times of stock market collapses. Therefore, it would be interesting to verify whether this property is maintained during periods of political crises. Our analysis indicates that prices of this precious metal do not change significantly in the event window and that the null hypothesis of the safe haven cannot be rejected. At the same time, gold had the lowest daily return of all the assets considered in this paper (0.0139%). This can be attributed to poor investment performance in the early sample years. Between the beginning of January 1987 and the end of December 2000 the total continuously compounded return on gold was as low as -35.94% and it is only in this millennium that the price of this precious metal started to recover. As a result, in our portfolio optimization problem, gold is completely dominated by other assets and the results indicate that it should not be a part of the optimal portfolio.

We also examine the question of whether high-rated corporate bonds act in a similar way to the sovereign bonds described in the paper. On one hand, our results for stock prices suggest that the perceived value of corporate assets falls during times of crisis, which could have negative repercussions for corporate debt repayment. On the other hand, investors who flee stock markets in times of political tensions may seek safer investment alternatives and bonds of creditworthy corporations could be considered one such alternative. We used the US Corporate AAA index and AAA-A Emerging Markets Corporate index compiled by Bank of America Merrill Lynch and available from the Federal Reserve Economic Data (FRED) at the St. Louis Fed. Although the CAARs on these total return indices in the (-50,50) event window were statistically insignificant, the null hypothesis of a safe haven could not be rejected for nearly all specifications considered. While the safe haven property is exhibited, sovereign bonds could be viewed as a more reliable shelter, since they clearly appreciate in value during an identical event window. This is because national governments, unlike companies, have the

[12] In order to conserve space, the results in this section are summarized. More detailed tables are available from the authors upon request.

mandate to levy taxes and, in some countries, could use seigniorage revenue to repay the debt. Consequently, the value of underlying physical assets may not be as important as in the corporate case and sovereign bonds will, to a larger extent, benefit from panicked investors shifting their money from stock markets to safer alternatives.

Another issue of interest is whether the strength of oil price response to international political tensions has changed over time. After all, following the oil price shocks in the 1970s, most countries tried to reduce their dependence on fossil fuels by developing other energy sources, such as bio fuels, as well as solar and wind technologies. The global economy's appetite for energy has however been progressively increasing and, despite the aforementioned diversification efforts, the consumption of petroleum has risen. According to data provided by U.S. Energy Information Administration, the total consumption level of 63.1 million barrels per day in 1987 escalated to 91.2 million barrels in 2013. These considerations may influence the magnitude of our abnormal returns throughout the duration of our sample. To examine this possibility, we regressed our CARs against a time trend and concluded that the passage of time had no statistically significant effect on oil market response. In other words, the abnormal price reaction that can be expected nowadays would not be materially different from that registered in the past and global addiction to oil has not been lessened.

As a robustness check, we endeavoured to verify whether the large magnitudes of CAARs reported for oil are driven exclusively by crises involving OPEC members. We want to note that the war on Iraq launched under George Bush Junior's administration is not part of our initial sample, which includes only episodes that started with an immediate challenge to the regime (i.e. trigger to foreign policy crisis of 6 or higher in the ICB database). Operation Iraqi Freedom was preceded by many declarations, coalition-building exercises, significant diplomatic efforts and inspections of Iraqi weapons, which resulted in the severity of the trigger being classified below 6. Secondly, exclusion of the first Gulf War from our sample does not materially change the conclusions reached in this paper. Thirdly, we have constructed a dummy variable for crisis involvement of an OPEC member. However, when we regressed the cumulative abnormal returns in the (-50, 50) window for each of the events against the newly-constructed OPEC dummy, it proved to be statistically insignificant. This means that demand factors are important in determining oil prices in times of political crisis, even in absence of supply disruptions.

It may be argued that the magnitude of oil price response to the emergence of new political conflict could be dependent on ongoing economic conditions. To verify this assertion, we collected monthly data on macroeconomic aggregates for the total OECD. These variables are taken to act as proxies of the global business cycle. More specifically, we obtained year-on-year growth in industrial production and CPI, as well as the harmonized unemployment rate from the Key Short-Term Economic Indicators database.[13] We estimated a number of models that linked our CARs for particular events to values of the macroeconomic indicators recorded in the month of the conflict. Interestingly, the macro variables always appeared statistically insignificant in these regressions. It appears that, in the short-term, political tension takes precedence over business cycle considerations, as the joint effect of military demand, creation of precautionary reserves, speculation, and investors' panic can be substantial.

It can be argued that the assumption of homoscedastic residuals in our safe haven regressions is too restrictive, as the volatility of asset returns tends to cluster in time (Engle, 2001). We performed additional estimation of our regressions using a maximum likelihood method that allows the errors to follow a GARCH(1,1) process. Allowing heteroskedasticity in our models did not alter the main conclusions of our study. The null hypothesis of $(\beta_1 + \beta_2) \leq 0$ could not be rejected in any of the specifications, which re-confirmed that both oil and sovereign bonds have safe haven properties.

VII. Conclusions

[13] Regrettably, the unemployment time series only starts in 1991, which limited the number of observations in the models utilizing this variable.

This paper examined the behavior of WTI crude oil prices, the World Government Bond Index and stock market indices around the dates when international hostilities were triggered. Using the ICB database, we focused on 64 instances of intense international crisis, out of which 43 cases could be classified as full-blown wars. By employing a standard event study methodology, we documented that oil and international sovereign bond index returns tend to be abnormally elevated close to the trigger dates. The magnitude of these price changes was found to be both statistically and economically significant. At the same time, militarized disputes proved to be detrimental to the wealth of both U.S. and international shareholders.

The logical implication arising from such constellations in asset returns is that crude petroleum and world government bonds could have a role to play in risk management. The question of whether oil and bonds can offer protection was formally addressed here using and extending the definition of safe haven put forward by Baur and Lucey (2010). We found that the answer to this question is in the affirmative. Three factors highlight the importance of our findings. Firstly, information related to future outbreaks of violent political conflicts might not be available to investors in advance. Secondly, we document the significant negative effect of wars and intense crises on the returns of U.S. and international equities. Thirdly, correlations between stocks can increase during crisis periods due to contagion, dwarfing any diversification benefits for portfolios invested in shares alone (Chiang *et al.*, 2007). Thus, equity market investors may want to allocate a fraction of their portfolio to crude petroleum and world sovereign bonds. This is in sharp contrast to a strategy of diversifying entirely in stocks; as such strategy may prove incomplete and ineffective in times of market turmoil.

Oil shocks and wars pose significant dangers, but both of these risks can be mitigated by taking a long position on crude oil. Nandha and Faff (2008) and Arouri *et al.* (2012) have previously alluded to the fact that oil could be a useful commodity for the purposes of diversification. We concur and additionally note that the diversification benefits are likely to be particularly evident during periods of international conflict. By the same token, the negative relationship between world government bonds and stocks during periods of international political hostilities calls for the use of the fixed-income securities in diversifying equity portfolios. This is in line with evidence on the presence of flights from stock markets to the safety and liquidity of the sovereign bond markets in times of financial turmoil (Baur and Lucey, 2009; and Hartmann *et al*., 2004).

Several practical issues need to be contemplated at this stage. As physical possession of oil is troublesome for most investors, a long position could be taken in the "paper market" instead. Oil futures and oil ETFs are suitable vehicles to accomplish this goal. Geman and Kharoubi (2008) advocate the use of NYMEX WTI crude oil futures with 18 month maturity to diversify a portfolio of stocks. Furthermore, we do not recommend using oil stocks as a substitute for holding crude petroleum. Given the current industry structure, most of the windfall gains arising from oil price increases accrue to host governments, rather than the international oil companies (Stevens, 2005). Finally, it would not be prudent to switch in and out of an oil position depending on a subjectively perceived probability of war. Governments could stockpile supplies well in advance of any secretly planned military operations and to a casual observer the dynamics of the oil price may be understood only with the benefit of hindsight. In our judgment, oil holdings should be a permanent feature of a well-constructed portfolio. Our results from optimization indicate that a properly diversified portfolio should aim to contain between 16.53% of its value in crude oil, unless the portfolio is loaded heavily on sovereign bonds, in which case the proportion could be lower.

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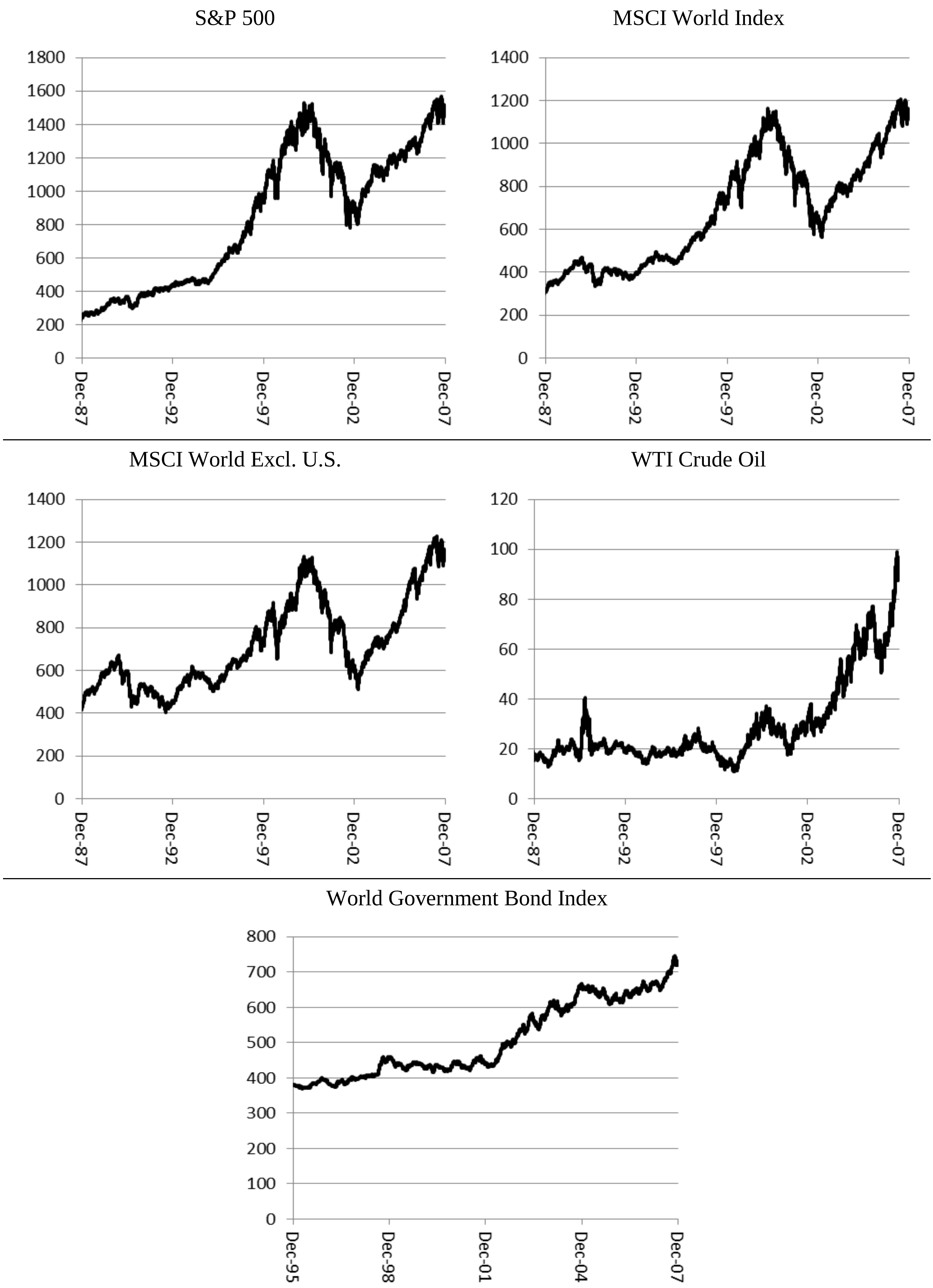
Figure I

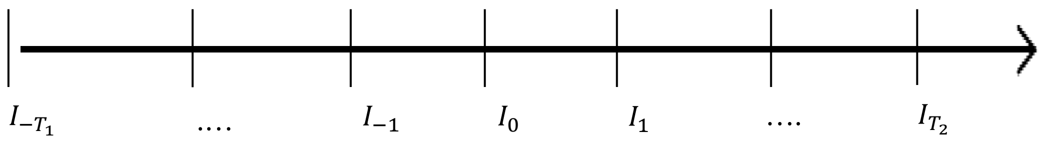
Price Evolution of Different Asset Classes



The diagrams above plot the prices of crude oil and equity indices used in this study starting from January 1987 to December 2007. The graphical depiction of the World Government Bonds Index series is for the period from January 1995 to December 2007.

Figure II

Intervals around the Trigger Date



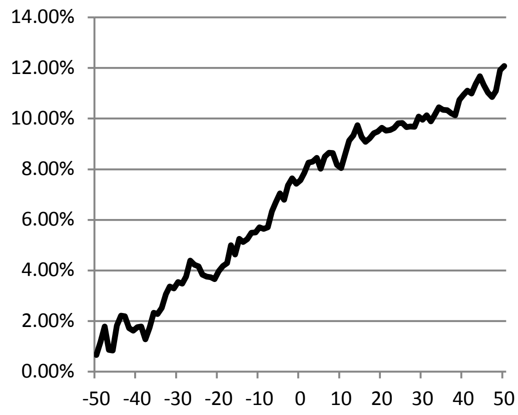
The figure above illustrates the timing sequence of the event study. I_o denotes the conflict trigger date, whereas T_1 and T_2 are the number of days before and after the event date, respectively.

Figure III

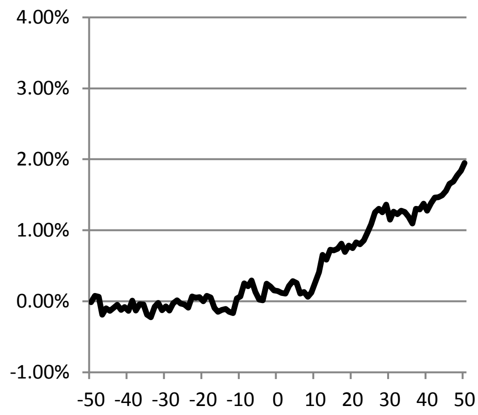
Cumulative Average Abnormal Returns around Conflict Trigger Dates

Panel A. The War Sample

WTI Crude Oil



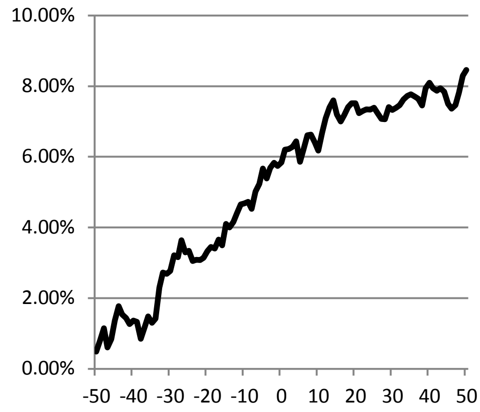
World Government Bond Index



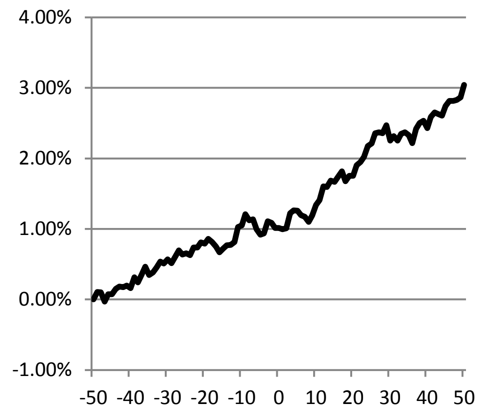
S&P 500

Panel B. The International Crisis Sample

WTI Crude Oil



World Government Bond Index



S&P 500

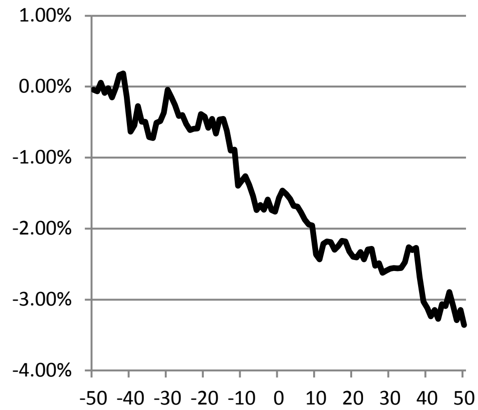
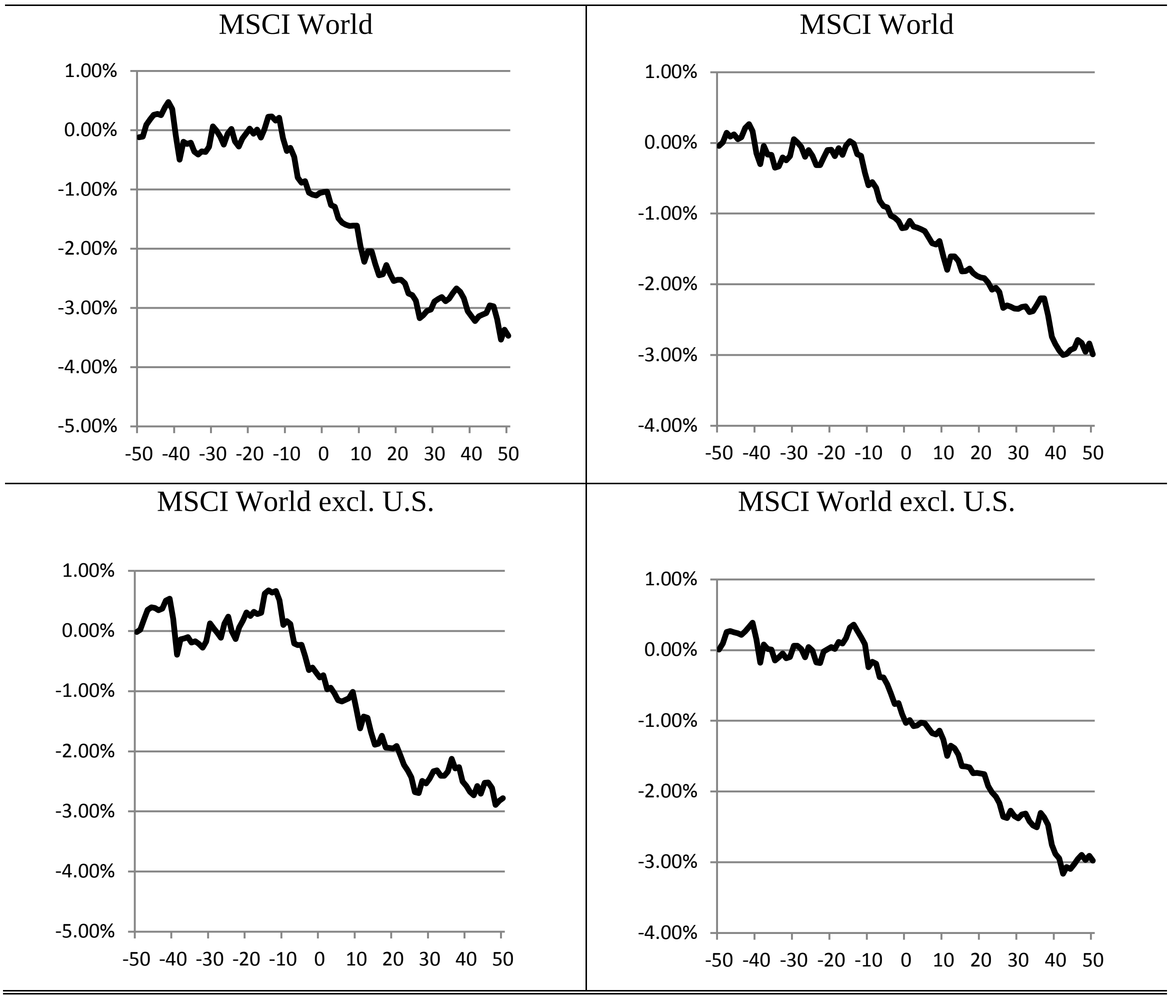


Figure III Continued



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 access, while days relative to the event appear on the horizontal axis. Panel A shows the diagrams for a sample of 43 wars, while the results in Panel B are based on 64 instances of severe international crisis. For the World Government Bond Index, the war sample and the international crisis sample comprise 21 and 32 events, respectively.

Table I

Descriptive Statistics

This tables reports descriptive statistics for the period January 1987 to December 2007, with the exception of the World Government Bond Index for which the sample period runs from January 1995 to December 2007.

	Mean	Standard Deviation	25th Percentile	Median	75th Percentile	Observations
S&P 500	0.0329%	1.0554%	-0.4310%	0.0276%	0.5404%	5478
MSCI World Index	0.0235%	0.8034%	-0.3554%	0.0531%	0.4213%	5478
MSCI World Excl. U.S. Index	0.0175%	0.8832%	-0.3798%	0.0490%	0.4651%	5478
WTI Crude Oil	0.0306%	2.4782%	-1.0761%	0.0000%	1.2075%	5478
World Government Bond Index	0.0243%	0.4039%	-0.2135%	0.0137%	0.2444%	3391

Table II

Unit Root Test

This table contains the ADF test statistics for the level, first differences and continuously compounded returns of the five series for the time from 31 December 1986 to 31 December 2007 for the first four series and from January 1995 to December 2007 for bonds. ***, **, * denote statistical significance at 1%, 5% and 10%.

Variables	Levels	First Differences	Returns
WTI Crude Oil	-0.5794	-79.3544***	-47.6210***
World Government Bond Index	-1.5303	-56.9934***	-56.6607***
S&P 500	-2.0651	-76.0704***	-54.7222***
MCSI World	-1.8237	-50.6641***	-51.3603***
MSCI World excl. U.S.	-1.7425	-51.8431***	-33.6471***

Table III

Cointegration Tests

This table reports in Panel A the ADF Engle-Granger *t*-statistic applied to residuals of the regression $y_{it} = c + \rho_j y_{jt} + \varepsilon_t$ with a one-to-one mapping between (1, 2) and {i, j}. The co-integration tests are performed for six 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.

Panel B reports the results of the Johansen (1991) Trace test. The tests are again performed for the same six pairs as for the Engle Granger test for a significance level alpha of 5%. The table displays the eigenvalue, the trace statistic, the critical value and the *p*-value.

Panel A. Engle Granger Test

System 1: WTI & S&P500		System 2: WTI & MSCI		System 3: WTI & MSCI World excl. U.S.	
Left hand variable	ADF	Left hand variable	ADF	Left hand variable	ADF
y_{1t} (WTI)	-0.3023	y_{1t}(WTI)	-0.5764	y_{1t} (WTI)	-1.1112
y_{2t} (S&P500)	-1.6606	y_{2t}(MSCI)	-1.8315	y_{2t} (MSCI World excl. US)	-2.2493
System 4: Bonds & S&P500		**System 5: Bonds & MSCI**		**System 6: Bonds & MSCI World excl. U.S.**	
Left hand variable	ADF	Left hand variable	ADF	Left hand variable	ADF
y_{1t} (Bonds)	-0.6122	y_{1t} (Bonds)	-0.6242	y_{1t} (Bonds)	-0.6541
y_{2t} (S&P500)	-2.0444	y_{2t} (MSCI)	-1.7436	y_{2t} (MSCI World excl. US)	-1.5228

Panel B. Johansen Test Trace Test

	Number of cointegrating vectors	Eigenvalue	Trace statistic	0.05 Critical value	*p*-value
System 1: WTI & S&P500	None	0.0008	4.6388	15.4947	0.8459
	At most one	0.0000	0.0010	3.8415	0.9748
System 2: WTI & MSCI	None	0.0010	5.4420	15.4947	0.7602
	At most one	0.0000	0.1579	3.8415	0.6911
System 3: WTI & MSCI World excl. U.S.	None	0.0012	7.1116	15.4947	0.5647
	At most one	0.0001	0.7709	3.8415	0.3799
System 4: Bonds & S&P500	None	0.0023	7.6748	15.4947	0.5008
	At most one	0.0000	0.0307	3.8415	0.8608
System 5: Bonds & MSCI	None	0.0020	6.8071	15.4947	0.6002
	At most one	0.0000	0.0004	3.8415	0.9862
System 6: Bonds & MSCI World excl. U.S.	None	0.0018	6.0091	15.4947	0.6945
	At most one	0.0000	0.0145	3.8415	0.9039

Table IV

Cumulative Average Abnormal Returns

This table reports cumulative average abnormal returns (CAARs) in periods around the war/crisis trigger dates. 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. Findings for the World Gov. Bond Index CAARs are based on the sub-period from January 1995 to December 2007.

Panel A. Cumulative Average Abnormal Returns for the War Sample					
	WTI Crude Oil	World Gov. Bond Index	S&P 500	MSCI World	MSCI World excl. U.S.
CAAR(-50,50)	12.0848%***	*1.9495%***	-4.6700%**	-3.4670%**	-2.7791%*
	(3.6866)	*(2.0273)*	*(-2.2980)*	*(-2.3274)*	*(-1.7806)*
CAAR(-50,-1)	7.4314%***	*0.1526%*	-1.5979%	-1.0601%	-0.6869%
	(2.8547)	*(0.2192)*	*(-1.0083)*	*(-0.9084)*	*(-0.5598)*
CAAR(0,50)	4.6534%**	*1.7969%***	-3.0721%**	-2.4085%**	-2.0921%**
	(2.3287)	*(2.7643)*	*(-2.3989)*	*(-2.5905)*	*(-2.1630)*

Panel B. Cumulative Average Abnormal Returns for the International Crisis Sample					
	WTI Crude Oil	World Gov. Bond Index	S&P 500	MSCI World	MSCI World excl. U.S.
CAAR(-50,50)	8.4580%***	*3.0425%****	-3.3553%**	-2.9889%***	-2.9765%***
	(3.1623)	*(3.5171)*	*(-2.1064)*	*(-2.7892)*	*(-2.7382)*
CAAR(-50,-1)	5.7392%***	*1.0134%**	-1.7593%	-1.2056%	-0.9052%
	(2.7752)	*(1.7747)*	*(-1.4318)*	*(-1.4634)*	*(-1.0680)*
CAAR(0,50)	2.7188%	*2.0291%****	-1.5960%	-1.7833%**	-2.0713%***
	(1.6099)	*(3.1310)*	*(-1.5555)*	*(-2.5788)*	*(-3.0464)*

Table V

Modeling Oil Returns

This table presents estimation results for regressions where the daily return on crude oil is modeled 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 centered on a conflict trigger dates 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

	Proxy for market index used:		
	S&P 500	MSCI World	MSCI World (excl. US)
	(1)	(2)	(3)
C	0.0003 *(0.0003)*	0.0003 *(0.0003)*	0.0003 *(0.0003)*
r_{Stock}	-0.1197** *(0.0515)*	-0.0339 *(0.0659)*	0.0847 *(0.0601)*
$D_{Conflict} \times r_{Stock}$	-0.0101 *(0.0653)*	-0.1709** *(0.0849)*	-0.2337*** *(0.0774)*
R-square	0.2881%	0.2702%	0.2065%
F-stat regression	7.9100	7.4171	5.6642
p-value	0.0004	0.0006	0.0035
$(\beta_1 + \beta_2)$	-0.1298	-0.2048	-0.4674
Safe Haven *p*-value	0.9994	0.9999	0.9989

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

	Proxy for market index used:		
	S&P 500	MSCI	MSCI World (excl. US)
	(1)	(2)	(3)
C	0.0003 *(0.0003)*	0.0003 *(0.0003)*	0.0003 *(0.0003)*
r_{Stock}	-0.1138** *(0.0567)*	-0.0374 *(0.0722)*	0.0741 *(0.0673)*
$D_{Conflict} \times r_{Stock}$	-0.0177 *(0.0684)*	-0.1486* *(0.0884)*	-0.1909** *(0.0814)*
R-square	0.2889%	0.2480%	0.1404%
F-stat regression	7.9315	6.8058	3.8502
p-value	0.0004	0.0011	0.0213
$(\beta_1 + \beta_2)$	-0.1315	-0.1860	-0.1168
Safe Haven *p*-value	0.9997	0.9999	0.9946

Table VI

Pearson Correlations

Panel A reports Pearson correlations between asset classes during the (-50,50) event windows for 43 wars which occurred between January 1987 and December 2007, while Panel B presents the correlations during (-50,50) event windows for 64 intense international conflicts. Correlations coefficients corresponding to World Government Bond Index in Panel A and Panel B are measured for the same window length but for the 21 wars and 32 international conflicts occurring between January 1995 and December 2007. *p*-values for the correlation coefficients are given in parentheses.

Panel A. Pearson Correlations during the Instances of War	
	Pearson Correlation
WTI & S&P 500	-0.0574 *(0.0000)*
WTI & MSCI	-0.0678 *(0.0000)*
WTI & MSCI World excl. U.S.	-0.0543 *(0.0001)*
BOND & S&P 500	-0.1502 *(0.0000)*
BOND & MSCI	-0.2478 *(0.0000)*
BOND & MSCI World excl. U.S.	-0.2889 *(0.0000)*

Panel B. Pearson Correlations during Instances of International Crisis	
	Pearson Correlation
WTI & S&P 500	-0.0589 *(0.0000)*
WTI & MSCI	-0.0626 *(0.0000)*
WTI & MSCI World excl. U.S.	-0.0437 *(0.0012)*
BOND & S&P 500	-0.1322 (*0.0000*)
BOND & MSCI	-0.2348 (*0.0000*)
BOND & MSCI World excl. U.S.	-0.2764 (*0.0000*)

Table VII

Nonparametric Test

This table presents Kendall tau test results based on the residual returns from an ARMA(1,1) process for all the series under test for the whole sample, in times of war and international crises. The calculations were performed only for days falling into the (-50,50) event windows. The first column contains the names of the residual return series for which the test was performed, while the second column reports the respective values of the Kendall tau statistic with the corresponding *p*-value in parentheses.

Panel A. Kendall tau during the Instances of War	
	Kendall tau
WTI & S&P 500	-0.0117 *(0.3450)*
WTI & MSCI	-0.0035 *(0.7785)*
WTI & MSCI World excl. U.S.	0.0087 *(0.4863)*
BOND & S&P 500	-0.0646 *(0.0001)*
BOND & MSCI	-0.1185 *(0.0000)*
BOND & MSCI World excl. U.S.	-0.1602 *(0.0000)*
Panel B. Kendall tau during the Instances of International Crisis	
	Kendall tau
WTI & S&P 500	-0.0147 *(0.2030)*
WTI & MSCI	-0.0012 *(0.9187)*
WTI & MSCI World excl. U.S.	0.0144 *(0.2122)*
BOND & S&P 500	-0.0582 (*0.0001*)
BOND & MSCI	-0.1125 (*0.0000*)
BOND & MSCI World excl. U.S.	-0.1509 (*0.0000*)

Table VIII

Modeling Bond Returns

This table presents estimation results for regressions where the daily return on World Gov. Bond Index is modeled 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 centered on a conflict trigger dates 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 a *p*-value for the null hypothesis that bonds are 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

	Proxy for market index used:		
	S&P 500	MSCI World	MSCI World (excl. US)
	(1)	(2)	(3)
C	0.0003	0.0003	0.0003
	(0.0000)	*(0.0000)*	*(0.0000)*
r_{Stock}	-0.0461***	-0.1139***	-0.1345***
	(0.0091)	*(0.01153)*	*(0.0108)*
$D_{Conflict} \times r_{Stock}$	-0.0099	-0.0001	0.0110
	(0.0130)	*(0.0162)*	*(0.0150)*
R-square	1.7870%	5.5476%	8.0370%
F-stat regression	30.8228	99.4954	148.0445
p-value	0.0000	0.0000	0.0000
$(\beta_1 + \beta_2)$	-0.0560	-0.1140	-0.1235
Safe Haven *p*-value	1.0000	1.0000	1.0000

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

	Proxy for market index used:		
	S&P 500	MSCI World	MSCI World (excl. US)
	(1)	(2)	(3)
C	0.0003	0.0003	0.0003
	(0.0000)	*(0.0000)*	*(0.0000)*
r_{Stock}	-0.0518***	-0.1193***	-0.1473***
	(0.0010)	*(0.0127)*	*(0.0124)*
$D_{Conflict} \times r_{Stock}$	0.0015	0.0084	0.0290*
	(0.01312)	*(0.0165)*	*(0.0156)*
R-square	1.7706%	5.5548%	8.1167%
F-stat regression	30.5344	99.6319	149.6421
p-value	0.0000	0.0000	0.0000
$(\beta_1 + \beta_2)$	-0.0503	-0.1109	- 0.1183
Safe Haven *p*-value	1.0000	1.0000	1.0000

Table IX

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 minimizing the standard deviation of a portfolio subject to the constraint that the sum of all weights is equal to one. For all other portfolios we minimize 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, however since all portfolio weights are positive the short-selling restriction is not binding. The figures for portfolio mean and standard deviations were computed based on daily data

Portfolio	(1)[a]	(2)	(3)	(4)	(5)	(6)	(7)	(8)[b]	(9)	(10)
WTI Crude Oil	10.39%	11.3703%	12.3468%	13.3233%	14.2998%	15.2764%	16.2529%	**16.5310%**	17.2294%	0.1222%
MSCI World Index	74.36%	65.5815%	56.7993%	48.0172%	39.2351%	30.4529%	21.6707%	**19.1700%**	12.8885%	0.0000%
REITs World	15.24%	23.0482%	30.8539%	38.6594%	46.4651%	54.2707%	62.0764%	**64.2990%**	69.8820%	99.8778%
Portfolio Sharpe Ratio	1.1304%	1.2299%	1.3087%	1.3659%	1.4034%	1.4241%	1.4320%	**1.4323%**	1.4303%	1.2724%
Portfolio Mean	0.0083%	0.0091%	0.0099%	0.0107%	0.0115%	0.0123%	0.0131%	**0.0133%**	0.0139%	0.0155%
Portfolio Standard Deviation	0.7346%	0.7402%	0.7568%	0.7836%	0.8197%	0.8640%	0.9151%	**0.9308%**	0.9721%	1.2184%

[a] Minimum variance portfolio
[b] Optimal risky portfolio

Table X

Optimal Portfolio Weights

This table reports the optimal weights for mean-variance efficient portfolios invested in crude oil, world government bonds, world equities and world real estate investment trusts. The minimum variance portfolio is identified by minimizing the standard deviation of a portfolio subject to the constraint that the summed weights are equal to one. For all other portfolios we minimize 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. The figures for portfolio mean and standard deviations were computed based on daily data. The data series used for the optimization is shorter than those used in Table IX, due to the fact that the world government bond index starts in January 1995.

Portfolio	(1)[a]	(2)	(3)	(4)	(5)	(6)	(7)	(8)[b]	(9)	(10)
WTI Crude Oil	1.4768%	2.1978%	2.9189%	3.6399%	4.3610%	5.0820%	5.8031%	**6.1564%**	6.5241%	100.0000%
World Gov. Bonds Index	73.7695%	71.6714%	69.5733%	67.4752%	65.3772%	63.2791%	61.1811%	**60.1529%**	59.0830%	-0.0001%
MSCI World Index	21.8949%	20.4154%	18.9360%	17.4565%	15.9771%	14.4977%	13.0182%	**12.2932%**	11.5388%	0.0000%
REITs World	2.8589%	5.7153%	8.5718%	11.4283%	14.2847%	17.1412%	19.9977%	**21.3975%**	22.8541%	0.0001%
Portfolio Sharpe Ratio	3.2677%	3.4105%	3.5270%	3.6163%	3.6793%	3.7181%	3.7358%	**3.7378%**	3.7358%	1.5154%
Portfolio Mean	0.0105%	0.0110%	0.0115%	0.0120%	0.0125%	0.0130%	0.0135%	**0.0138%**	0.0140%	0.0352%
Portfolio Standard Deviation	0.3220%	0.3232%	0.3267%	0.3324%	0.3403%	0.3502%	0.3619%	**0.3683%**	0.3753%	2.3255%

[a] Minimum variance portfolio
[b] Optimal risky portfolio