Oil Price Declines Could Hurt Financial Markets

and A Possible Explanation

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Abstracts

This paper investigates the causal effects of oil price fluctuations on financial markets using daily oil price and financial market data from 2011 to 2016. To address endogeneity, we follow the heteroscedasticity-based event study approach in Rigobon (2003) and instrument for changes in oil prices with exogenous shocks that mainly affect oil supply. We find that a decline in oil prices negatively affects financial markets after 2014 when oil prices reach the break-even price of shale oil extractions, but not before 2014. The damage of a decline is more severe when oil prices are low than when they are high. These novel findings suggest oil price level could affect the relationship between oil prices and financial markets, which may also happen in other oil episodes.

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I. Introduction

In 2014, oil prices dropped sharply to the lowest level since the Great Recession (Figure 1.1). Stock prices also declined in this period. This positive correlation between stock prices and oil prices since 2014 contradicts the conventional expectation that cheaper oil prices benefit oil-importing economies, such as the U.S. Theoretically, a decrease in oil prices lowers production costs for industries and fuel costs for households, thus boosting the economy. Empirically, studies that examine past fluctuations of oil prices find negative or insignificant relationships between oil prices and stock prices.[2] The puzzling positive correlation since 2014 leads many economists to believe that a weak global demand drives both declines in oil prices and the stock market (Hamilton, 2014; IMF, 2015; Bernanke, 2016; Baumeister and Kilian, 2016).

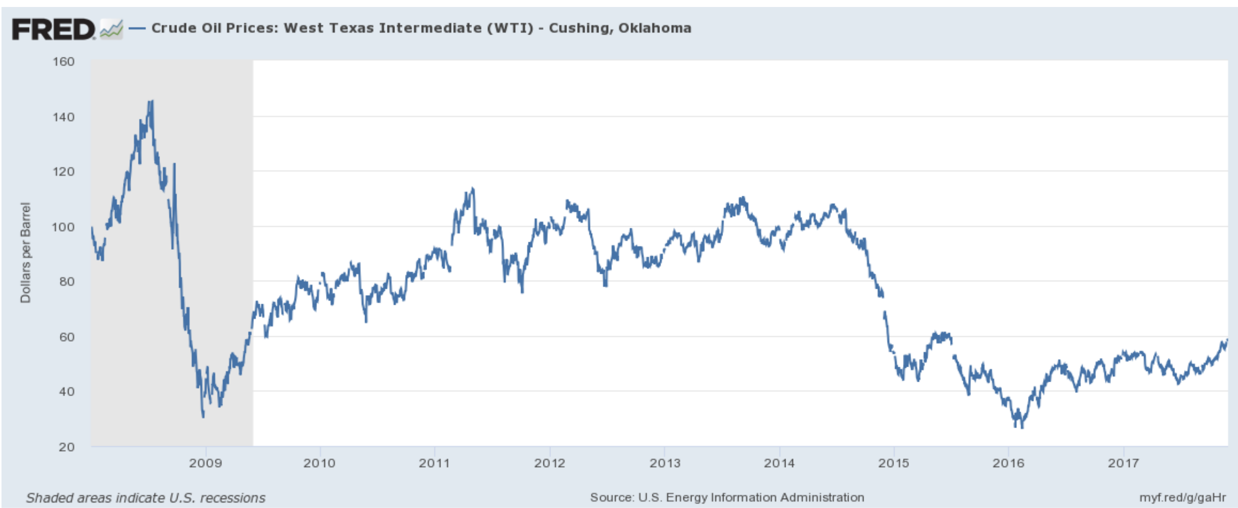

Figure 1.1. WTI oil price
Source: Federal Reserve Bank of Saint Louis

This paper investigates if oil price declines after 2014 negatively affect financial markets, after the effects from demand factors are taken out. With daily data of oil, stock and bond indices from 2011 to 2016, we obtain two novel findings. First, a decline in oil prices *negatively* affects financial markets since 2014, but not before 2014. Specifically, oil price declines cause capital flight to safety, hurt risky assets (equities and high-yield bonds) and lift safe assets (investment-

[2] Jones and Kaul (1996); Sadorsky (1999); Hammoudeh et al. (2004), Driesprong et al.(2008), Apergis and Miller (2009), Kilian and Park (2009), Filis et al.(2011), Anzuini et al (2015), and Ready (forthcoming)

grade bonds and long-term treasury bonds). Second, the damage of an oil price decline is more severe when oil prices are low than when they are high. This is consistent with the notion that lower oil prices are more likely to hurt the energy sector, which would have negative spillovers to other sectors.

To establish a causal effect of a change in oil prices on stock prices, we instrument for changes in oil prices with exogenous shocks that mainly affect oil supply. Specifically, we use a heteroscedasticity-based event study approach, following Rigobon (2003). This method has been widely used in different contexts (see for example, Rigobon and Sack (2004), Anderson et al (2007), Ehrmann et al (2011), Chaboud et al (2014), and Hébert and Schreger (forthcoming)). The method entails finding days where oil prices are moved by oil-supply shocks (these days are referred to as event days). We use Seeking Alpha to screen daily news about exogenous oil-supply shocks from January 2011, when oil daily news was first covered by Seeking Alpha, to October 2016.

The identifying assumption underlying our identification strategy is that global demand shocks in event days are the same as those in non-event days. We perform four additional checks to ensure the validity of this assumption. First, we drop the days that have important demand announcements recorded by Seeking Alpha. Second, we disregard announcements about U.S. oil inventories because those could reflect both supply and demand factors. Third, we cross check with independent economic calendars to ensure no important demand announcements were made in our event days. Fourth, we check demand news coverage in media. The average number of news articles containing "economy" or "economic growth" in U.S. national news outlets in the event days is not higher than that in non-event days, suggesting that global demand shocks are not more pronounced in event days than in non-event days.

In this paper, we assume that an oil price change affect stock prices symmetrically. There is an ongoing debate about whether an oil price increase affects the US economy differently from an oil price decrease. However, we cannot test for an asymmetric effect of oil prices on financial markets because we only have five events days with oil price decreases after 2014. Therefore, even though we interpret the coefficients as effects of oil price declines on stock prices, motivated by dramatic drops in oil prices in 2014, one can also interpret them as effects from an increase in oil prices.

From 2014 to 2016, after taking out demand shocks, a decline in oil price due to oil-supply shocks depresses risky assets (equities and high-yield bonds) and lifts safe assets (investment-grade bonds and long-term treasury bonds). Specifically, a 10% decline in the WTI oil prices lowers the U.S. stock index by about 1.4% and high-yield corporate bonds by 0.4%. The same decline raises investment-grade bonds by 0.3% and long-term Treasury bonds by 1.1%.

These findings contradict the literature, which tends to observe that a decrease in oil prices either increases or does not significantly affect stock prices. There are three possible reasons for such difference: (1) we examine the period after 2014 whereas the literature studies the period before 2014, (2) our method is different from VAR, a widely-used framework in the literature,[3] and (3) we use daily data instead of monthly, quarterly, or annual data. To distinguish between (1) from (2) and (3), we repeat our exercises and apply our Instrumental Variable (IV) approach to the daily data from January 2011, the beginning of our data, to the end of 2013. Our IV estimates on the effects of oil prices on stock prices from 2011 to 2013 are negative and statistically insignificant, consistent with the findings in the literature. This suggests that the distinct results with data since 2014 are not due to different methods or different data frequency. Thus, how oil price fluctuations affect financial markets after 2014 differs from how they did before 2014.

What makes post-2014 different? We explore a possible explanation that when oil prices are low, its effect on financial markets differ from when they are high, possibly due to concerns about the energy sector and its spillover to the rest of the economy. In fact, the average daily oil price from 2014 to 2016 is $63/barrel, around the break-even price for shale oil extraction. We interact log change in oil prices with the lag of log oil prices and find that this interaction term is negative and significant from 2014 to 2016, implying that the adverse effect of oil price declines on financial markets were stronger when oil prices were lower. From 2011 to 2013, the interaction term is not statistically significant. This suggests that the level of oil prices might not matter much for the relationship between oil prices and stock prices in this period when the average daily oil prices in this period were high, around $95/barrel. Although the interaction result is only suggestive (as oil prices could be correlated with other factors), it is consistent with an explanation

[3] The vast majority of the empirical literature uses different VAR frameworks with various identification assumptions. There are a few exceptions. Cavallo and Wu (2011) adopt a narrative approach, but they do not address the possibility that demand news could be present in oil-supply event days. Ready (forthcoming) develops a new method that uses the stock returns of oil producing firms as control variables to identify the demand and supply shocks of oil prices.

that at very low level of oil prices, the concern about oil companies going out of business is magnified, which could have spillover effects to other sectors.

To the best of our knowledge, this is the first paper to examine the causal effects of oil prices on financial markets after 2014. This episode of oil price fluctuation after 2014 is particularly interesting because the relationship contradicts what we observed in the past. We find that a decline in oil prices decreases stock prices. Thus, the weak global demand is not the only factor responsible for the recent co-movement between oil prices and stock prices. It is possible that a decline in energy sector and its potential subsequent spillovers could offset or even outweigh the benefits brought about by cheaper oil prices, as pointed out in Baumeister and Kilian (2016). In section VI, we will discuss other potential transmission mechanisms in more detail.

This paper extends a broad empirical literature on the impact of oil prices on financial markets with two novel results. First, we find that a decline in oil prices caused by exogenous oil-supply shocks could decrease stock prices, which has not been found in the literature. The existing literature finds that oil price declines is either associated with an increase[4] or insignificant change in advanced countries' stock markets.[5] The only sector and group of countries that were hurt by oil price declines are the oil and gas sector and oil-exporting countries.[6] Second, we find that when oil prices are low, the level of oil prices could affect how oil prices impact stock prices.

This paper also relates to the literature on oil prices and the US economy. The literature generally finds that an increase in oil prices adversely affects the economy, especially during the oil strikes in the 1970s. Many papers in this literature examine whether and why the effects of oil

[4] Jones and Kaul (1996); Sadorsky (1999); Driesprong et al.(2008), Filis et al.(2011), and Anzuini et al (2015), Ready(forthcoming)

[5] Hammoudeh et al. (2004) find none of the daily oil industry stock indices can explain the daily future movements of the New York Mercantile Exchange (NYMEX) futures prices. Kilian and Park (2009) find that oil supply shocks have no significant effect on the U.S. stock market. Apergis and Miller (2009) find that international stock market returns do not respond significantly to oil price shocks. Kilian (2009) decomposes shocks to oil prices to oil supply shocks, global demand shocks and crude oil specific demand shocks. He finds that the surge in oil prices between 2003-2007 was caused by global demand shocks and hence did not cause a major recession in the U.S.

[6] Park and Ratti (2008) find that while oil price increases have a negative impact on stock returns in the US and in 12 European countries, they have positive impacts on the stock market in Norway, an oil-exporting country. Boyer and Filion (2007) show that increases in the price of oil affect the stock returns of Canadian oil and gas companies positively. El-Sharif et al. (2005) reach a similar conclusion for oil and gas returns in the UK.

shocks on the economy is more muted from the mid-1980s compared to before. This discussion relates to the debate on whether oil shocks asymmetrically affect the economy, i.e. whether an increase in oil prices would affect the economy differently from a decrease in oil prices.[7] To the extent that stock prices represent a forward-looking view about the US economy, our results suggest that a decrease in oil prices induced by exogenous oil supply shocks could adversely affect the US economy when oil prices are low enough.

The rest of the paper is organized as follows. Section II explains in more details the methodology. Section III discusses data sources. Sections IV and V present the effects of oil prices after and before 2014 respectively. Section VI examines why the effect after 2014 differs from that before 2014 and argues for a role of oil price level. We conclude in section VII.

II. Methodology

We identify the effect of changes in oil prices on prices of various asset classes through a heteroscedasticity-based identification strategy, following Rigobon (2003) as well as Rigobon and Sack (2004). Consider the following system of equations:

$$\Delta p_t = \gamma \Delta s_t + \beta z_t + \varepsilon_t \qquad (1)$$
$$\Delta s_t = \alpha \Delta p_t + \delta z_t + \mu_t \qquad (2)$$

where Δp_t is the change in oil prices, Δs_t is the change in asset price, and z_t is a set of common factors that could affect both oil prices and stock prices (such as interest rates, news about global growth, or other demand-side factors). ε_t represents oil shocks that only affect oil prices. ε_t captures events that affect oil supply, such as a North Sea storm that forces oil firms to evacuate platforms. Similarly, μ_t are the idiosyncratic shocks that only affect stock prices. Our goal is to estimate the value of α: the causal impacts of changes in oil prices on changes in stock prices. Note that in this framework, the effects of oil price increases or decreases are symmetric.

We divide the days in our sample into two types: event (*E*) and non-event (*N*) days. Event days are days with important announcements and developments about the oil supply. A useful feature of the approach is that it does not require the complete absence of common shocks during

[7] Hooker (1996), Hamilton (2003), Blanchard and Gali (2007), Kilian and Vigfusson (2011), Hamilton (2011), Ramey and Vine (2011), Baumeister and Hamilton (2015)

event days. This strategy instead relies on the identifying assumption that the variances of the common shocks z_t and financial shocks μ_t are the same on non-event days and event days, whereas the variance of oil supply shocks ε_t is higher on event days than on non-event days:

$$\sigma^2_{z,E} = \sigma^2_{z,N} \quad (3)$$
$$\sigma^2_{\mu,E} = \sigma^2_{\mu,N} \quad (4)$$
$$\sigma^2_{\varepsilon,E} > \sigma^2_{\varepsilon,N} \quad (5)$$

These assumptions imply the "importance" of oil supply-side announcements increases on event days (E). Again, it is important to note that demand – side news can take place on event days, as long as the influence of demand factors is similar to that on non-event days. As argued by Rigobon and Sack (2004), these assumptions are much weaker than those required in traditional event-study approach.

Under such assumptions, we can identify parameter α by comparing the covariance matrices of stock price and oil price changes on event days and non-event days. In particular, for each of the two types of days $j \in \{E, N\}$, we can estimate the covariance matrix of $[\Delta s_t, \Delta p_t]$, denoted Ω_j:

$$\Omega_{j=} \begin{bmatrix} var(\Delta s_t) & cov(\Delta s_t, \Delta p_t) \\ cov(\Delta s_t, \Delta p_t) & var(\Delta p_t) \end{bmatrix} \quad (6)$$

Rigobon and Sack (2004) show that the difference in the covariance matrices on event and non-event days as $\Delta\Omega = \Omega_E - \Omega_N$:

$$\Delta\Omega = \frac{\sigma^2_{\varepsilon,E} - \sigma^2_{\varepsilon,N}}{(1-\alpha\gamma)^2} \begin{bmatrix} \alpha^2 & \alpha \\ \alpha & 1 \end{bmatrix} \quad (7)$$

From (7), α can be estimated as

$$\hat{\alpha} = \frac{\Delta\Omega_{1,2}}{\Delta\Omega_{2,2}} \quad (8)$$ [8]

which from (6), (8) can be written as:

$$\hat{\alpha} = \frac{cov_E(\Delta s, \Delta p) - cov_N(\Delta s, \Delta p)}{var_E(\Delta p) - var_N(\Delta p)} \quad (9)$$

[8] We choose $\hat{\alpha} = \frac{\Delta\Omega_{1,2}}{\Delta\Omega_{2,2}}$ instead of $\hat{\alpha} = \frac{\Delta\Omega_{1,1}}{\Delta\Omega_{1,2}}$ because the latter estimate is problematic. Under the null hypothesis of $\alpha = 0$, both the numerator $\Delta\Omega_{1,1}$ and the denominator $\Delta\Omega_{1,2}$ are zero. In other words, under the null hypothesis, the ratio $\frac{\Delta\Omega_{1,1}}{\Delta\Omega_{1,2}}$ is undetermined.

The numerator captures the difference between the covariance of oil prices and stock prices for event days and non-event days. If the covariance for event days is the same as that for non-event days, the relationship between oil prices and stock prices is driven only by common shocks, z_t. Hence, the causal impact of oil price on stock price, $\hat{\alpha}$, would be zero.

Empirically, the approach can be implemented through an instrumental variable estimation technique. As such, we define vectors Δs_E and Δp_E with size $T_E \times 1$ to contain the log changes in asset prices and oil prices on the event days, and vectors Δs_N and Δp_N with size $T_N \times 1$ to contain the log changes in asset prices and oil prices on the non-event days. We then combine the two subsamples into two $(T_E + T_N) \times 1$ vectors that contain the log changes in asset prices and oil prices in our sample, $\Delta s = [\Delta s_E' \quad \Delta s_N']'$ and $\Delta p = [\Delta p_E' \quad \Delta p_N']'$.

Consider the following instrument:

$$w = \left[\frac{\Delta p_E'}{T_E - L} \qquad -\frac{\Delta p_N'}{T_N - L}\right]' \qquad (10)$$

where L is the number of explanatory variables. α can be estimated by regressing the log change in asset prices Δs on the log change in oil prices over the sample period using the standard instrumental variable approach, with the instrument w:

$$\hat{\alpha} = (w'\Delta p)^{-1}(w'\Delta s) \qquad (11)$$

Simple algebra shows that the estimated value of α is *asymptotically* identical to (9).

The regression equation is therefore as follows:

$$\Delta s_t = \beta_0 + \beta_1 \widehat{\Delta p_t} + \Delta s_{t-1} + \Delta p_{t-1} + \epsilon_t \qquad (12)$$

where Δs_t is the change in log of asset prices (i.e. stock prices and bond prices), defined as log of asset in period t minus log of asset in period t-1. Similarly, $\widehat{\Delta p_t}$ is the change in log of WTI oil price, instrumented by *w*; and Δs_{t-1} and Δp_{t-1} are the changes in log of lagged asset prices and oil prices (they are control variables).

We present robust standard errors in our main results section, and bootstrap standard errors as robustness checks in Appendix. The two methods yield similar results.

Identifying oil-supply events

Our period of analysis in this section spans from January 1, 2011 to October 11, 2016. Ideally, we would like to go as far back as possible. However, as will be clear below, data on event days only goes back to 2011. In this section and for the rest of the paper, we will mostly examine the periods before and after 2014 separately because we would like to illustrate the differences between the two periods.

Identifying oil-supply related events is challenging. There is no fixed calendar for oil-supply events. One has to screen these days from financial news. Since there are multiple events that could happen in those days, it is not certain that oil supply news drives oil prices.

We employ several rounds of screening to identify oil-supply events. In the first round, we use the Seeking Alpha news portal (www.seekingalpha.com).[10] Seeking Alpha records all surprising events and announcements that arguably affect the oil supply. These range from surprising announcements by OPEC officials and OPEC member countries to unexpected developments in key oil exporters. From 1/1/2011, when oil-related announcements of Seeking Alpha are first available, to 12/31/2013, we identify 25 event days. From 1/1/2014 to 10/11/2016, we identify 24 events. The window for our event study is one day. For announcements that happen after trading hours, we examine the change in financial markets on the following trading day. These dates are shown in Tables A1 and A2 in the Appendix, along with links to in-depth financial news discussing the events.

There could be three potential concerns with this list. We state and address each of these concerns in turn. The first potential problem is that recorded events could reflect ad-hoc ex-post explanations of the analysts. For example, an analyst could see oil prices drop during the day and look for news about oil supply that could explain that event. This would be a problem if oil prices drop because of demand factors but the analysts interpret this as supply driven. We minimize the ad-hoc ex-post problem by *not* considering the days that have important demand announcements recorded by Seeking Alpha analysts. We also do not consider announcements about U.S. oil inventories because oil inventories could reflect both supply and demand factors. Furthermore, we also cross check with independent economic calendars to see if there are important surprising demand announcements in the event days. We removed 4/12/2015 as there were numerous Fed

[10] Seeking Alpha is a community-based platform for investment research, with broad coverage of stocks, asset classes, ETFs and investment strategy. In contrast to other equity research platforms, insight is provided by investors and industry experts rather than sell-side analysts. Seeking Alpha has 4M registered users (48% YOY growth). Over 18.5% of the audience are financial professionals.

speeches (Harker, Dudley, Bullard, Kocherlakota spoke at the "The New Normal for the U.S. Economy" forum hosted by the Philadelphia Fed), as well as the one by the ECB President. Thus, we have 23 event dates after 1/1/2014.

To increase our confidence that these events days are primarily supply events, we also use U.S. news coverage to provide a check. We use www.newslibrary.com to count how many articles with the words "economy" or "economic growth" appeared in 526 U.S. national news outlets. The number of the articles represents how intensively news about the economy, or "demand news", is covered. The assumption is that the higher the count for a day, the more significant demand news is for that day. We collect article counts for all the days since 01/01/2011. We check econometrically if the average article count for the event days is higher than that for the non-event days. Table 2.1 shows that the counts, in both the log form and the ratio form (i.e. number of articles with demand news divided by the total number of articles for that day), in event days are not significantly different from non-event days from 2011-2013. Table 2.1 also shows that from 2014 to 2016, demand news of event days and non-event days are not statistically different at a 5% significance level. If anything, there may even be fewer demand news in event days than in non-event days, which implies our estimates would underestimate the causal effect of oil price fluctuations on stock prices for the 2014-2016 period.

Table 2.1: Demand news and event days (2011-2016)

	2011-2013		2014-2016	
	Log(articles with demand news)	Ratio of articles with demand news	Log(articles with demand news)	Ratio of articles with demand news
Event days	-0.027	-0.002	-0.112*	-0.004*
	(0.037)	(0.002)	(0.059)	(0.002)
Observations	756	756	700	700
R-squared	0.000	0.001	0.007	0.007

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The second potential problem is that OPEC announcements could reflect worries about oil demand by OPEC. For example, an announcement that OPEC countries will be meeting to cut production could reflect their worry that demand for oil is low. Should we treat this announcement as an event about oil supply cut or oil demand decline? The reaction of oil prices in the market could help us answer this question. An oil demand decline shifts the demand curve for oil to the left, reducing its price. A cut in oil production shifts the supply curve for oil to the left, raising its price. The equilibrium price depends on how much the demand and supply curves shift and the relative magnitude of price elasticity of demand and supply. According to Hamilton (2009) and Kilian and Murphy (2014), the price elasticity of oil demand in the short run ranges from -0.26 to 0, and the price elasticity of oil supply in the short run is nearly 0. Thus, the magnitude of the short-run price elasticity of supply is not greater than that of the demand for oil. This implies that a rise in oil prices following an event OPEC announcement to cut production should reflect a supply shock. Let us take an extreme example where the supply curve for oil is almost vertical and the demand curve for oil is almost horizontal. In this case, if we see an increase in oil prices, the supply curve must shift to the left much more than the demand curve, indicating that people perceive the news about the production cut by OPEC as a supply event. In our 48 events, the reactions to the WTI oil price all indicate that the events are supply driven.

The third concern is that some of these geopolitical events (such as ISIS making advances in Iraq) could generate uncertainty, which depresses demand. We argue that demand factors, if there are any, are weaker than the supply factors, by observing price actions. Take the example of ISIS making advances in Iraq: uncertainty would cause oil prices to go down, while the negative supply shock associated with the ISIS disruptions would cause oil prices to go up. In equilibrium, we observe an increase in oil prices. Following the same logic about the shifts in demand and supply and the price elasticity of demand and supply for oils in the short run, we argue that oil supply shocks dominate demand shocks in these types of events.

III. Data

We obtain daily WTI crude oil price data from the U.S. Energy Information Administration. The WTI crude oil price is chosen instead of the Brent crude oil price because the WTI crude oil price is the main benchmark for oil consumed in the United States. The WTI crude oil price refers to oil extracted from wells in the U.S. and sent via pipelines to Cushing, Oklahoma[11].

We use the Dow Jones U.S. Market Index (DJUS), which represents about 95% of the U.S. market, to capture the U.S. equity. We use the Bloomberg bond indices for bond prices. Daily

[11] For 10/10/2016, we opted for future price (March strike date) to account for Columbus's Day.

historical Dow Jones U.S. Market indices, Bloomberg High-Yield Bond Indices and Bloomberg U.S. Corporate Bond Indices (investment grade) are obtained from Bloomberg. The 10 sectoral stock indices from Dow Jones are Basic Materials, Consumer Goods, Consumer Services, Financials, Healthcare, Industrials, Energy, Tech, Telecom, and Utilities.[12] These 10 indices together make up the Dow Jones U.S. Market Index. In addition, we also examine two important subsectors: transportation and airlines.[13] The S&P 500 and its sectoral indices serve as a robustness check.

The Bloomberg investment-grade corporate bonds are the aggregate index and the sectoral indices of Healthcare, Tech, Materials, Financials, Communication, Consumer Discretionary, Utilities, Industrials, Consumer Services and Energy.[14] Similarly, the Bloomberg high-yield corporate bond indices are the aggregate high-yield corporate bond index and the sectoral indices of Healthcare, Technology, Materials, Financials, Communications, Consumer Discretionary, Utility, Industrials, and Consumer Staple.[15]

We choose TLT as a proxy for long-term Treasury bonds. TLT is the iShares 20+ Year Treasury Bond ETF (Exchange Traded Fund) managed by BlackRock. It has 99.08% its market value in 20+ Year Treasuries, 0.60% in 15-20 Years Treasuries and the rest in cash and derivatives. It is the largest and most liquid ETF for long-term Treasury bonds.

Tables 3.1 and 3.2 provide the summary statistics for changes in the WTI crude oil price and in different stock and bond indices for 2011-2013 and 2014-2016. Overall, the price actions of oil in event days on average are larger than those in non-event days. For example, after 2014, the standard deviation of the log change in WTI oil price in event days is 0.0478, about two times larger than that for non-event days (0.0254).

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[12] Their tickers are, respectively, DJUSBM, DJUSNC, DJUSCY, DJUSFN, DJUSHC, DJUSIN, DJUSEN, DJUSTC, DJUSTL, DJUSUT. These 10 indices together make up the Dow Jones U.S. Market Index (DJUS).

[13] DJUSTS, and DJUSAR.

[14] Their tickers are, respectively, BUSC, BUSCHC, BUSCTE, BUSCMA, BUSCFI, BUSCCO, BUSCCD, BUSCUT, BUSCIN, BUSCCS and BUSCEN.

[15] Their tickers are BUHY, BUHYHC, BUHYTE, BUHYMA, BUHYFI, BUHYCO, BUHYCD, BUHYUT, BUHYIN and BUHYCS, respectively.

Table 3.1: Summary statistics (2011-2013)

Full Sample

Variable	Obs[16]	Mean	Std. Dev.	Min	Max
Δ Log Oil Price	755	0.0001	0.017	-0.085	0.090
Δ Log Stocks	751	0.0005	0.011	-0.072	0.049
Δ Log High-Yield Bonds	754	0.0003	0.002	-0.014	0.008
Δ Log (Investment-Grade Bonds)	754	0.0002	0.003	-0.016	0.011
Δ Log (TLT)	751	0.0001	0.010	-0.052	0.039
Δ Log (VIX)	751	-0.0004	0.072	-0.314	0.405

Event Days

Variable	Obs	Mean	Std. Dev.	Min	Max
Δ Log Oil Price	25	0.014	0.026	-0.041	0.086
Δ Log Stocks	25	-0.001	0.011	-0.0212	0.022
Δ Log High-Yield Bonds	25	0.0004	0.001	-0.004	0.002
Δ Log (Investment-Grade Bonds)	25	0.0003	0.003	-0.012	0.005
Δ Log (TLT)	25	0.0003	0.010	-0.035	0.015
Δ Log (VIX)	25	0.011	0.094	-0.173	0.236

Non-Event Days

Variable	Obs	Mean	Std. Dev.	Min	Max
Δ Log Oil Price	730	-0.0004	0.017	-0.085	0.090
Δ Log Stocks	726	0.0006	0.011	-0.072	0.049
Δ Log High-Yield Bonds	729	0.0003	0.002	-0.014	0.008
Δ Log (Investment-Grade Bonds)	729	0.0002	0.003	-0.016	0.011
Δ Log (TLT)	726	0.0001	0.010	-0.052	0.039
Δ Log (VIX)	726	-0.0008	0.071	-0.314	0.405

[16] Note: We have fewer observations for log changes in stock indices than in oil price since all stock indices for 1/3/2011 are unavailable and U.S. stock market was closed on 10/29/2012 and 10/30/2012 because of Hurricane Sandy.

Table 3.2: Summary statistics (2014-2016)

Full Sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Δ Log Oil Price	699	-0.000864	0.0266	-0.111	0.113
Δ Log Stocks	699	0.000205	0.00873	-0.0402	0.0364
Δ Log High-Yield Bonds	699	0.000185	0.00234	-0.0114	0.00990
Δ Log (Investment-Grade Bonds)	699	0.000207	0.00248	-0.00847	0.00846
Δ Log (TLT)	699	0.000375	0.00829	-0.0276	0.0265
Δ Log (VIX)	699	0.000109	0.0805	-0.241	0.401

Event Days

Variable	Obs	Mean	Std. Dev.	Min	Max
Δ Log Oil Price	23	0.0201	0.0478	-0.111	0.113
Δ Log Stocks	23	0.00451	0.0103	-0.0151	0.0242
Δ Log High-Yield Bonds	23	0.00182	0.00264	-0.00451	0.00732
Δ Log (Investment-Grade Bonds)	23	0.000275	0.00261	-0.00588	0.00510
Δ Log (TLT)	23	-0.000388	0.00915	-0.0197	0.0179
Δ Log (VIX)	23	-0.0266	0.0801	-0.180	0.125

Non-Event Days

Variable	Obs	Mean	Std. Dev.	Min	Max
Δ Log Oil Price	676	-0.00158	0.0254	-0.0905	0.102
Δ Log Stocks	676	5.82e-05	0.00864	-0.0402	0.0364
Δ Log High-Yield Bonds	676	0.000129	0.00232	-0.0114	0.00990
Δ Log (Investment-Grade Bonds)	676	0.000205	0.00248	-0.00847	0.00846
Δ Log (TLT)	676	0.000401	0.00827	-0.0276	0.0265
Δ Log (VIX)	676	0.00102	0.0804	-0.241	0.401

IV. Effects of oil price fluctuations on financial markets after 2014

A. Relevance of the instrument

For the heteroskedastic-based strategy to work, the changes in oil price on event days have to be larger than the changes on non-event days.[17] Table 4.1 shows the results of several test statistics to confirm that the variance of the change in log of the WTI crude oil price for the event days is larger than that for the non-event days after 2014. Similarly, Table 4.2 shows that the first stage F test is greater than 10, indicating that we have a relevant instrument.

Table 4.1: Tests of differences in variance of oil price changes[18]

Test	F-statistics	p-value
Levene	14.150	0.0002
Brown-Forsythe trimmed mean	11.413	0.0008
Brown-Forsythe median	13.536	0.0003

Table 4.2 F-Statistics for the 1st stage regressions

	Stock	High-Yield	Bond	TLT
F-Statistics without lags	81.618	81.618	81.618	81.618
F-Statistics with lags	38.447	37.529	38.407	38.527

B. OLS and Second Stage Regression Results

Table 4.3 shows the simple OLS result between changes in log of stock price and changes in log of stock and bond indices. They are highly correlated. Equity and high-yield bond indices move in tandem with oil prices; whereas investment-grade and TLT go in the opposite direction. These associations are the ones that capture the attention of economists and policy makers.

[17] In a traditional Instrumental Variable method, it is the result of the first stage.
[18] Notes: "Test" describe the F-statistic being computed. The Levene test for unequal variances is described in Levene (1960). The Brown-Forsythe tests are described in Brown and Forsythe (1974). These tests all formally test the hypothesis that the variances of the changes in oil prices are equal on event days and non-event days.

Table 4.3 OLS results

VARIABLES	Δlog(Stock index)		Δlog (High-yield bond index)		Δlog (Investment -grade bond index)		Δlog (20+ Treasury bond index)	
ΔLog (Oil)	0.102***	0.103***	0.027***	0.029***	-0.019***	-0.019***	-0.082***	-0.084***
	(0.014)	(0.014)	(0.004)	(0.003)	(0.004)	(0.004)	(0.013)	(0.012)
$\Delta Log(Oil)_{t-1}$		0.014		0.019***		-0.000		-0.027**
		(0.014)		(0.003)		(0.004)		(0.012)
$\Delta Log(Stock)_{t-1}$		-0.006						
		(0.054)						
$\Delta Log(HY)_{t-1}$				0.481***				
				(0.053)				
$\Delta Log(Bond)_{t-1}$						-0.028		
						(0.039)		
$\Delta Log(TLT)_{t-1}$								-0.089**
								(0.039)
Observations	699	698	699	698	699	698	699	698
R-squared	0.098	0.099	0.094	0.434	0.042	0.043	0.070	0.082

Stock: Dow Jones U.S. Market Index. High-yield bond: Bloomberg U.S. high-yield corporate bond index, BUHY. US corporate bond index: Bloomberg U.S. corporate bond index, BUSC. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.4: Impacts of WTI oil price on overall markets: the Instrumental Variable Method

VARIABLES	Δlog(Stock index)		Δlog (High-yield bond index)		Δlog (Investment -grade bond index)		Δlog (20+ Treasury bond index)	
ΔLog (Oil)	0.140***	0.140***	0.044***	0.042***	-0.030**	-0.030**	-0.107***	-0.111***
	(0.050)	(0.049)	(0.017)	(0.010)	(0.013)	(0.012)	(0.039)	(0.036)
$\Delta Log(Oil)_{t-1}$		0.016		0.020***		-0.001		-0.030**
		(0.015)		(0.003)		(0.004)		(0.013)
$\Delta Log(Stock)_{t-1}$		-0.006						
		(0.053)						
$\Delta Log(HY)_{t-1}$				0.478***				
				(0.051)				
$\Delta Log(Bond)_{t-1}$						-0.029		
						(0.039)		
$\Delta Log(TLT)_{t-1}$								-0.090**
								(0.039)
Observations	699	698	699	698	699	698	699	698
R-squared	0.085	0.087	0.059	0.413	0.028	0.029	0.064	0.074

Stock: Dow Jones U.S. Market Index. High-yield bond: Bloomberg U.S. high-yield corporate bond index, BUHY. US corporate bond index: Bloomberg U.S. corporate bond index, BUSC. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.4 presents the Instrumental Variable (IV) regression results. A decline in WTI crude oil price hurts U.S. risky assets, measured by the overall stock and the high-yield bond indices, while benefiting safe assets, specifically, investment-grade bond and long-term 20+ year Treasury bonds (TLT). A 10% decrease in oil price leads to a 1.4% decrease in the Dow Jones U.S. market index. We find a similar result using S&P 500 index as an alternative broad-based stock index. In addition, a 10% decrease in the WTI crude oil price leads to a 0.42% decrease in the high-yield bond index. At the same time, investment-grade corporate bond index increases by 0.3%, and TLT increases by 1.11%. Note that in this setup, the impacts of oil price increases or decreases on financial markets are symmetric. Hence, we could interpret the coefficients as the impacts of either an oil price increase or decline. Here, for brevity, we choose to interpret the coefficients as the impacts of oil price declines.

As Tables 4.4 and 4.3 show, the IV coefficients are stronger than the OLS coefficients. This is plausible. Recall equation (9) for the IV estimate: $\hat{\alpha} = \frac{cov_E(\Delta s, \Delta p) - cov_N(\Delta s, \Delta p)}{var_E(\Delta p) - var_N(\Delta p)}$. Since most of the sample consists of non-event days, approximately, the OLS estimate between change of log oil price and change of log stock price is $\widehat{\alpha_{OLS}} = \frac{cov_N(\Delta s, \Delta p)}{var_N(\Delta p)}$. From these two equations, we can see that the IV estimates $\hat{\alpha}$ could be larger or smaller than the OLS estimate, depending on the relative value of the two $\frac{cov_N(\Delta s, \Delta p)}{var_N(\Delta p)}$ and $\frac{cov_E(\Delta s, \Delta p)}{var_E(\Delta p)}$ ratios.

To address the potential concern about the small sample of event days, we do two things. First, we test for the normality of the regression residuals. Second, we apply bootstrapping to the baseline regressions. We find that the results remain unchanged: lower oil prices hurt stock and high-yield bond indices, and help investment-grade and long-term Treasury bonds. The details of the normality test and bootstrapped regressions are presented in Appendix B.

C. Breakdown by sector and asset class

Table 4.6 presents the impact of oil price fluctuations on different asset classes (stocks, high-yield bonds, and investment-grade bonds) of different sectors. In each asset class, the sectors are sorted by the magnitude of the impacts.

Table 4.6: Breakdown by sector and asset class

	Index	Without lags	With lags
Stocks	Energy	0.514***	0.519***
		(0.092)	(0.089)
	Basic Materials	0.303***	0.298***
		(0.044)	(0.041)
	Transport Services	0.207**	0.208**
		(0.102)	(0.106)
	Financials	0.183**	0.184**
		(0.073)	(0.073)
	Industrials	0.164***	0.165***
		(0.042)	(0.042)
	Aggregate Index	0.140***	0.140***
		(0.050)	(0.049)
	Tech	0.116*	0.114*
		(0.066)	(0.063)
	Consumer Services	0.077	0.075
		(0.075)	(0.073)
	Consumer Goods	0.064	0.065
		(0.059)	(0.058)
	Telecom	0.039	0.041
		(0.062)	(0.061)
	Healthcare	0.034	0.035
		(0.069)	(0.068)
	Utilities	-0.028	-0.028
		(0.043)	(0.044)
	Airlines	-0.131	-0.128
		(0.182)	(0.180)
High-yield Bonds	Energy	0.096**	0.089***
		(0.042)	(0.017)
	Materials	0.052**	0.050***
		(0.021)	(0.014)
	Communications	0.052***	0.047***
		(0.019)	(0.016)
	Aggregate Index	0.044***	0.042***
		(0.017)	(0.010)
	Consumer Staples	0.034***	0.036***
		(0.013)	(0.010)
	Financials	0.024**	0.027***
		(0.012)	(0.009)
	Consumer Discretionary	0.023**	0.022***
		(0.011)	(0.007)
	Industrials	0.023	0.018**
		(0.015)	(0.008)

	Healthcare	0.021** (0.009)	0.024* (0.012)
	Tech	0.019 (0.013)	0.021** (0.009)
	Utilities	0.015 (0.020)	0.012* (0.007)
	Industrials	0.023 (0.015)	0.018** (0.008)
Investment-Grade Bonds	Materials	-0.007 (0.015)	-0.007 (0.015)
	Energy	-0.009 (0.017)	-0.006 (0.016)
	Financials	-0.026** (0.010)	-0.026*** (0.010)
	Aggregate Index	-0.030** (0.013)	-0.030** (0.012)
	Tech	-0.031** (0.013)	-0.031** (0.013)
	Consumer Discretionary	-0.033*** (0.010)	-0.033*** (0.010)
	Communications	-0.034* (0.018)	-0.033* (0.018)
	Consumer Services	-0.035*** (0.013)	-0.036*** (0.012)
	Healthcare	-0.042*** (0.014)	-0.043*** (0.013)
	Industrials	-0.045*** (0.015)	-0.045*** (0.014)
	Utilities	-0.054*** (0.016)	-0.054*** (0.015)

About half of the sectoral stock indices are negatively affected by oil price declines. As expected, the energy sector is hit the hardest as the WTI crude oil price decreases. Focusing on column 4 (regressions with first lags), a 10% decline in the WTI crude oil price causes the Energy stock index to drop by 5.2%. The decline in the energy sector is expected because lower oil prices squeeze energy companies' profit and put pressure on their credit-worthiness. The Basic Materials sector is also very sensitive to oil price fluctuations: when the WTI crude oil price decreases by 10%, the stock index of Basic Materials decreases by 2.98%. Consumer services, Consumer Goods, Telecommunication, Healthcare, Utilities and Airlines do not seem affected by oil price declines.

Interestingly, some sectoral stock indices that are expected to benefit from oil price declines—Industrials, Basic Materials, and Transport Services – also witness the value of their indices drop with oil price. In addition, the valuation of Airlines, another sector that supposedly benefits from oil price declines, remains unchanged when the WTI crude oil price goes down. This suggests that other channels, such as worries about demand reduction for industrial products or transport services and air travel, might be at play.

The Financial sector is widely expected to be affected by the spillovers from the Energy sector. Economists and policy makers are concerned that distressed energy companies, driven by lower oil prices, could default on their loans to banks, adversely impacting banks' balance sheets. We find that while the stock index of Financial sector is negatively affected by a lower WTI crude oil price, the magnitude of 1.84% is not large compared to other sectors.

We see similar trends among the high-yield bond indices. Focusing on column 4 (regressions with lags), we find that the Bloomberg Energy high-yield bond index stands out as the most affected high-yield sector. A 10% decline in the WTI crude oil price causes the Energy high-yield bond index to drop by 0.89%. Interestingly, high-yield bonds of most other sectors also suffer, ranging from Materials (0.5%) to Industrials (0.18%).

Cheap oil improves investment-grade corporate bonds, except those in the Energy and Materials sectors. The signs for almost all sectors are negative, implying a negative relationship between oil prices and the investment-grade corporate bonds' indices: when oil prices are lower, the corporate bond indices are higher. However, we do not find evidence for a negative relationship between cheap oil and prices of investment grade bonds in the Energy or Basic Materials sectors. This suggests that investors are reluctant to invest in the Energy and Basic Materials' corporate bonds, even when they are of higher ratings. The sectors whose investment grade bonds benefit the most are relatively less cyclical: Utilities, Industrials, Healthcare and Consumer Services. For a 10% decline in the WTI oil price, the indices for these sectors' investment-grade bond indices increase from 0.32% to 0.54%.

V. Effects of oil price fluctuations on financial markets before 2014

This section considers the effects of oil price fluctuations on financial markets from 1/1/2011 to 12/31/2013. Overall, we find that the effects of oil price fluctuations on financial market during this period are very different to those after 2014. Oil price fluctuations have statistically insignificant impact on all financial market, although the OLS results indicate very strong correlations between oil price fluctuations and financial market indices.

A. Relevance of the instrument

Table 5.1 presents the tests for different variance of change in oil price pass. The variance of change in log oil price in event days is larger than that in non-event days. F-statistics of the first stage regressions are also greater than 10, suggesting that we do not face the weak-instrument problem.

Table 5.1: Tests of differences in variance of oil price changes (2011-2013)

Test	F-statistics	p-value
Levene	5.580	0.018
Brown-Forsythe trimmed mean	5.331	0.021
Brown-Forsythe median	5.845	0.016

Table 5.2 F-Statistics for the 1st stage regressions

	Stock	High-Yield	Bond	TLT
F-Statistics without lags	30.606	30.934	30.934	30.606
F-Statistics with lags	14.445	13.841	13.606	13.601

B. OLS and IV Results

Table 5.3 presents simple OLS results between change in log of oil price and the financial market indices. While equity and the high-yield bond index are clearly positively correlated with log change in oil prices, less-risky indices such as investment-grade bond index and TLT are negatively correlated with log change in oil prices.

Table 5.4 reveals that the causal effects of oil price fluctuations on financial markets during 2011-2013 are insignificantly different to zero. The IV results and the OLS results are sharply different. While the OLS results show highly significant correlation between oil price fluctuations and the financial market indices, it is no longer the case with the IV results.

The IV results for 2011-2013 are also sharply different to those since 2014. We do not see significant effects of oil price fluctuations on financial markets before 2014, a result consistent with previous findings in the literature.

Table 5.3: Impacts of WTI oil price (OLS), 2011-2013

VARIABLES	Δlog (Stock index)		Δlog (High-yield bond index)		Δlog (Investment -grade bond index)		Δlog (20+ Treasury bond index)	
$\Delta Log\ (Oil)$	0.288***	0.292***	0.023***	0.027***	-0.042***	-0.042***	-0.207***	-0.206***
	(0.038)	(0.037)	(0.006)	(0.005)	(0.007)	(0.007)	(0.027)	(0.027)
$\Delta Log(Oil)_{t-1}$		0.040		0.009***		0.006		-0.028
		(0.035)		(0.003)		(0.008)		(0.028)
$\Delta Log(Stock)_{t-1}$		-0.116						
		(0.073)						
$\Delta Log(HY)_{t-1}$				0.607***				
				(0.073)				
$\Delta Log(Bond)_{t-1}$						0.011		
						(0.050)		
$\Delta Log(TLT)_{t-1}$								-0.071
								(0.051)
Observations	751	749	754	753	754	753	751	749
R-squared	0.209	0.219	0.046	0.443	0.061	0.062	0.120	0.124

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 5.4: Impacts of WTI oil price on overall markets, 2011-2013, the Instrumental Variable Method

VARIABLES	Δlog (Stock index)		Δlog (High-yield bond index)		Δlog (Investment -grade bond index)		Δlog (20+ Treasury bond index)	
$\Delta Log\ (Oil)$	-0.147	-0.135	0.005	-0.002	0.032	0.029	0.072	0.068
	(0.123)	(0.118)	(0.009)	(0.008)	(0.026)	(0.026)	(0.092)	(0.087)
$\Delta Log(Oil)_{t-1}$		0.016		0.009**		0.008		-0.020
		(0.039)		(0.003)		(0.009)		(0.031)
$\Delta Log(Stock)_{t-1}$		-0.072						
		(0.075)						
$\Delta Log(HY)_{t-1}$				0.596***				
				(0.080)				
$\Delta Log(Bond)_{t-1}$						0.013		
						(0.055)		
$\Delta Log(TLT)_{t-1}$								-0.067
								(0.060)
Observations	751	749	754	753	754	753	751	749
R-squared	-0.267	-0.237	0.017	0.373	-0.130	-0.110	-0.098	-0.089

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

VI. Why does post-2014 differ from pre-2014?

To confirm that the results before 2014 were indeed statistically different from the results after 2014, we pool the data from 2011 to 2016 and run a difference in differences regression with a dummy for before and after 2014. Specifically, the regression specification is as follows:

$$\Delta s_t = \beta_0 + \beta_1 \widehat{\Delta p_t} + year_{2014} + \beta_2 \widehat{\Delta p_t} \times year_{2014} + \Delta s_{t-1} + \Delta p_{t-1} + \epsilon_t \quad (6.1)$$

where Δs_t is the change in log of asset prices (i.e. stock prices and bond prices); $\widehat{\Delta p_t}$ is the change in log of the WTI crude oil price, instrumented by *w*; and Δs_{t-1} and Δp_{t-1} are the changes in log of lagged asset prices and oil prices (these are control variables). $year_{2014} = 1$ if year is 2014 or later and 0 otherwise. The coefficient of interest in this regression is β_2, which is the coefficient of the interaction term between a change in log oil price and $year_{2014}$.

Table 6.1 shows that β_2 is generally statistically significant. These results are consistent with Tables 5.3 and 5.4, which show that oil price fluctuations have significant effects on financial markets after 2014 but not before that.

Table 6.1: Effects of oil price fluctuations on financial markets before and after 2014

	Δlog (Stock index)		Δlog (High-yield bond index)		Δlog (Investment -grade bond index)		Δlog (20+ Treasury bond index)	
ΔLog(Oil)	-0.145	-0.139	0.005	-0.002	0.032	0.031	0.071	0.074
	(0.122)	(0.119)	(0.009)	(0.008)	(0.026)	(0.026)	(0.092)	(0.087)
ΔLog(Oil)*2004	0.285**	0.282**	0.039**	0.043***	-0.062**	-0.061**	-0.177*	-0.185**
	(0.132)	(0.130)	(0.019)	(0.013)	(0.029)	(0.029)	(0.100)	(0.094)
2004 dummy	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta Log(Oil)_{t-1}$		0.017		0.016***		0.001		-0.026**
		(0.016)		(0.003)		(0.004)		(0.013)
$\Delta Log(Stock)_{t-1}$		-0.048						
		(0.048)						
$\Delta Log(HY)_{t-1}$				0.529***				
				(0.044)				
$\Delta Log(Bond)_{t-1}$						-0.007		
						(0.036)		
$\Delta Log(TLT)_{t-1}$								-0.077**
								(0.039)
Constant	0.001	0.001	0.000***	0.000**	0.000*	0.000*	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	1451	1449	1454	1453	1454	1453	1451	1449
R-squared	-0.130	-0.120	0.042	0.394	-0.065	-0.060	-0.035	-0.031

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

What makes the post-2014 period different? The oil price level after 2014 is much lower than before. The average daily oil prices from 2014 to 2016 is \$63/barrel, which is interestingly also around the break-even price for shale oil extraction. A possible explanation is that at very low levels of oil price, the concern about oil companies going out of business is magnified. This could have spillover effects on other sectors. At least two potential channels could explain the negative impact of lower oil prices on financial markets and the economy. The first one is the demand channel. Lower oil prices imply that many energy firms might have to scale down production. Since the sector buys many goods and services from other sectors (for example, electricity generation relies on a range of inputs such as construction and IT services), a decline in the sector reduces demand for the rest of the economy (usually referred to as the 'indirect effect'). In addition, laid-off workers from the energy sector also reduce consumption in local services and tradable goods (the 'induced effect'). The second channel works through the financial sector. As energy firms scale down their operation or become bankrupt, they would have difficulties repaying their debts. This would hit the financial sector, which in turn would have to scale down lending to the rest of the economy. The energy sector-led credit crunch could cause other sectors in the economy to reduce investment and production.

To explore the possible explanation that low levels of oil price may matter, we interact change in log of oil prices with lag of log of oil prices:

$$\Delta s_t = \beta_0 + \beta_1 \widehat{\Delta p_t} + \widehat{\Delta p_t} + \beta_2 \widehat{\Delta p_t} \times \widehat{p_{t-1}} + \Delta s_{t-1} + \Delta p_{t-1} + \epsilon_t \quad (6.2)$$

where $\widehat{p_{t-1}}$ is the lag of the WTI crude oil price, instrumented by *w*. From equation (6.2), the total effect of oil prices on stock would be:

$$\frac{\partial \Delta s_t}{\partial \Delta p} = \beta_1 + \beta_2 \widehat{p_{t-1}} \quad (6.3)$$

If the level of oil prices matters, we expect β_2 to be statistically different from 0.

Table 6.2 presents the effect of oil price level with the entire sample from 2011 to 2016. The interaction term between the lag of log of oil prices and the change in log of oil prices are negative and statistically significant when the dependent variables are the stock and high-yield bond indices, suggesting that a decline in oil prices decrease stocks and high-yield bonds more when oil prices are low. For investment-grade bonds and long-term treasury bonds, the effect of oil price level is not as clear, although the sign of the interaction is consistent.

Table 6.2: Could oil price level matter? 2011-2016

	Δlog (Stock index)		Δlog (High-yield bond index)		Δlog (Investment -grade bond index)		Δlog (20+ Treasury bond index)	
ΔLog(Oil)	1.101***	1.110***	0.158	0.221***	-0.160*	-0.157*	-0.560**	-0.596**
	(0.397)	(0.396)	(0.134)	(0.044)	(0.097)	(0.095)	(0.279)	(0.264)
*ΔLog(Oil)** $\text{Log}(Oil)_{t-1}$	-0.263**	-0.264**	-0.031	-0.048***	0.037	0.036	0.127*	0.135*
	(0.105)	(0.104)	(0.032)	(0.011)	(0.026)	(0.026)	(0.075)	(0.072)
$\text{Log}(Oil)_{t-1}$	0.000	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
$\Delta Log(Oil)_{t-1}$		0.014		0.015***		0.002		-0.024*
		(0.015)		(0.002)		(0.004)		(0.013)
$\Delta Log(Stock)_{t-1}$		-0.052						
		(0.048)						
$\Delta Log(HY)_{t-1}$				0.538***				
				(0.043)				
$\Delta Log(Bond)_{t-1}$						-0.008		
						(0.035)		
$\Delta Log(TLT)_{t-1}$								-0.077**
								(0.037)
Constant	-0.002	-0.002	-0.001	-0.000	-0.000	-0.000	0.001	0.001
	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
N	1451	1449	1454	1453	1454	1453	1451	1449
r2	-0.067	-0.061	0.072	0.419	-0.001	0.002	0.018	0.022

Robust Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We rerun the regressions for 2014-2016 and 2011-2013 separately. Interestingly, the effect of oil price level remains for 2014-2016 (Table 6.3[19]) but largely disappears for 2011-2013 (Table 6.4). Thus, the level of oil prices might not matter much for the effect of oil price on stock price from 2011 to 2013. This is probably because during 2011-2013 oil prices are at a high level. The average daily oil price in this period is $95/barrel. Even a sharp fall in oil prices would not affect oil firms' possibility of bankruptcy during this period.

For 2014-2016, column (2) of Table 6.3 shows that the coefficient of the change in log oil price, β_1, is 0.925 and the interaction term's coefficient, β_2, is -0.210. From equation (6.3), when oil prices are lower than $80/barrel, the effect of an increase in oil prices on stock prices would be

[19] Note that for brevity, for Tables 6.3 and 6.4, we only show the coefficients for Δ*Log(Oil)* and Δ*Log(Oil)** $\text{Log}(Oil)_{t-1}$

positive.[20] When oil prices are greater than $80/barrel, the negative interaction term starts to dominate, making the relationship between oil prices and stock prices negative.

Table 6.3: Could oil price level matter? 2014-2016

	Δlog (Stock index)		Δlog (High-yield bond index)		Δlog (Investment -grade bond index)		Δlog (20+ Treasury bond index)	
ΔLog(Oil)	0.921^{***}	0.925^{***}	0.099	0.206^{***}	-0.054	-0.056	-0.349^{*}	-0.376^{**}
	(0.289)	(0.278)	(0.181)	(0.057)	(0.092)	(0.091)	(0.184)	(0.176)
*ΔLog(Oil)** $\text{Log}(Oil)_{t-1}$	-0.209^{***}	-0.210^{***}	-0.015	-0.044^{***}	0.006	0.007	0.065	0.071
	(0.074)	(0.071)	(0.046)	(0.014)	(0.024)	(0.024)	(0.048)	(0.047)
Other controls	Y	Y	y	y	y	y	y	y
N	699	698	699	698	699	698	699	698
r2	0.078	0.079	0.074	0.438	0.031	0.032	0.072	0.083

Robust Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6.4: Could oil price level matter? 2011-2013

	Δlog (Stock index)		Δlog (High-yield bond index)		Δlog (Investment -grade bond index)		Δlog (20+ Treasury bond index)	
ΔLog(Oil)	-10.690^{*}	-10.192^{*}	-0.311	-0.484	2.467^{*}	2.403^{*}	8.352^{*}	7.748^{*}
	(6.418)	(6.072)	(0.628)	(0.576)	(1.411)	(1.333)	(4.986)	(4.686)
*ΔLog(Oil)** $\text{Log}(Oil)_{t-1}$	2.334	2.227^{*}	0.071	0.107	-0.538^{*}	-0.525^{*}	-1.833^{*}	-1.701
	(1.420)	(1.345)	(0.140)	(0.128)	(0.313)	(0.296)	(1.103)	(1.038)
Other controls	y	Y	Y	y	y	y	y	y
N	751	749	754	753	754	753	751	749
r2	-0.361	-0.321	0.024	0.354	-0.199	-0.175	-0.173	-0.152

Robust Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note that since oil price level could be correlated with other omitted factors, we do not claim causal relationships in this section. However, these correlations are consistent with the notion that lower oil prices are more likely to hurt the energy sector, which would have negative spillovers to other sectors.

[20] Oil prices after 2014 range from $26/barrel to $107/barrel, so we do a within sample prediction.

VII. Conclusion

Lower oil prices are traditionally thought to be good for oil-importing economies, such as the U.S. Indeed, the existing literature tends to find statistically insignificant to positive impacts of lower oil prices on U.S. stock markets. However, after 2014, swift and dramatic recent declines in oil prices and the accompanying movements in financial markets are concerning.

Do lower oil prices since 2014 carry systemic risk? This paper tries to shed light on this matter by examining the causal impacts of oil price declines on the financial markets post 2014. The findings from this paper suggest that there exist such risks. A lower WTI crude oil price negatively affects risky assets (stocks and high-yield bonds) in many sectors in the U.S. financial markets. Quite strikingly, sectors that supposedly benefit from lower prices, such as Basic Materials, Industrials and Transport Services, also suffer. Safer assets, such as investment-grade bonds, and particularly, long-term Treasury bonds, are boosted when oil prices drop. Overall, the findings suggest capital flight to safety when oil prices drop: capital moves out of stocks and high-yield bonds, and flocks to investment-grade corporate bonds and risk-free long-term T-bonds. These phenomena would usually be observed during downturns.

An interesting question is then why the impact of the of oil price movements differs for the period after 2014 compared to the one before that. A possible explanation could be that after 2014, oil prices are low and around the break-even point of shale oil extraction. At very low levels of oil price, the concern about oil companies going out of business and the implications to other sectors is magnified. Thus, the level of oil price may matter to the relationship between oil prices and stock prices, especially when it is low. This novel result indicates that in future studies, the level of oil prices could be an important factor that explains differential impacts of oil price movements on financial markets.

Appendix A

Table A1: 25 event days from 1/1/2011 to 12/31/2013

Date	Description	Expected Effect	Actual Effect
10/10/2013	A group of former rebels aligned with the Libya's interior ministry has seized Libyan Prime Minister Ali Zaidan and taken him to an unknown destination. https://www.bloomberg.com/news/articles/2013-10-10/libyan-pm-taken-from-hotel-by-revolutionary-group	+	1.42%
8/27/2013	Possible missile strikes on Syria aimed at sending message http://msnbcvvd.nbcnews.com/_news/2013/08/27/20209022-military-strikes-on-syria-as-early-as-thursday-us-officials-say	+	3.01%
7/5/2013	Supporters of ousted President Morsi continue to call his removal invalid and vow continued protests until he is reinstalled. http://online.wsj.com/article/SB10001424127887323899704578587131736732940.html?mod=wsj_share_tweet	+	1.14%
7/3/2013	Crowds in Cairo are alarming and partly responsible for WTI crude pushing past $100/bbl, but Liam Denning reminds that Egypt is a net oil importer, and Suez Canal oil transit totals just 0.1% of global demand. http://online.wsj.com/article/SB10001424127887324260204578583723667583486.html	+	2.25%
7/1/2013	Unrest in Egypt is helping add to anxiety in the oil markets (USO +1.4%), but it is not likely to significantly lift oil prices that already have been elevated for months due to Middle East turmoil, says the head of Middle East research for IHS CERA. http://www.cbsnews.com/8301-202_162-57591775/egypt-military-gives-president-morsi-48-hours-to-reach-agreement-with-opposition-or-face-political-transition/	+	1.63%
1/17/2013	Islamic militants taken Algerian gas pumping station As many as 20 hostages, including several Americans, reportedly have escaped their captors at an Algerian gas pumping station taken over by Islamic militants. http://www.nydailynews.com/news/world/hostages-daring-escape-islamic-militants-algerian-gas-plant-article-1.1241698	+	1.28%
11/9/2012	Tension between Iran and U.S. escalates News that Iranian warplanes fired on an unmanned U.S. drone in international airspace is a reminder of how quickly underlying tensions could turn into conflict. http://online.wsj.com/article/SB10001424127887324439804578107191429662874.html	+	1.18%
10/9/2012	West Texas crude pushes past $90/bbl. on rising tension between Turkey and Syria, as yesterday's pipeline blast raises concerns about supply disruptions. http://www.balkans.com/open-news.php?uniquenumber=159149	+	3.29%

7/19/2012	Tensions across the Middle East are as good an excuse as any, with Israeli authorities blaming Iran for the deadly bombing of a tour bus in Bulgaria. http://www.marketwatch.com/story/oil-rallies-to-end-at-best-since-mid-may-2012-07-19?siteid=bnbh	+	3.18%
7/9/2012	Statoil (STO) says it is preparing to shut down production on the Norwegian continental shelf at midnight after strike negotiations broke down Sunday. http://online.wsj.com/article/BT-CO-20120709-703493.html	+	1.83%
7/3/2012	Iran claims it successfully test-fired missiles capable of hitting Israel. http://www.reuters.com/article/2012/07/03/us-iran-nuclear-missiles-idUSBRE8620HF20120703	+	4.69%
6/11/2012	Crude slides another dollar near a weekly low (now -2.6% to $82) as Saudi Arabia's oil minister hints at higher production as he arrives for OPEC meetings. http://www.forexlive.com/blog/2012/06/11/oil-nears-one-week-low-as-saudis-hint-at-more-supply/	-	-1.80%
5/4/2012	The UAE completes and expects to have operational within 90 days a pipeline which will allow it to bypass the Strait of Hormuz for its oil exports. http://www.bi-me.com/main.php?id=57676&t=1&c=34&cg=4&mset=1011	-	-4.05%
3/20/2012	Apparently trying to do its part to keep oil prices in check, Saudi Arabia has hired 11 large tankers to send to U.S.-based refiners this month. http://im.media.ft.com/content/images/16220aa4-71f6-11e1-8497-00144feab49a.img	-	-2.25%
3/6/2012	Six world powers, including the U.S., are prepared to resume talks with Iran about its nuclear program in what could be a final attempt to reach a deal that will avoid military action by Israel or the U.S. http://www.ft.com/intl/cms/s/0/d1bc9f78-678c-11e1-b6a1-00144feabdc0.html	-	-1.88%
3/2/2012	Crude oil continues to retreat, down nearly $4/barrel from yesterday's spike following the (apparent) hoax of an attack and explosion at a Saudi pipeline. https://www.bloomberg.com/news/articles/2012-03-02/oil-trades-near-one-week-high-on-economic-recovery-middle-east-tension	-	-1.93%
3/1/2012	Already up on the day, crude oil flies higher on a report of an attack and explosion on a Saudi pipeline. http://www.thearabdigest.com/2012/03/saudi-arabias-eastern-revolution.html	+	1.56%
1/23/2012	Oil prices show mild gains off of a more specific proclamation from Iran that it will "definitely" close the Strait of Hormuz if the EU embargo disrupts exports. https://twitter.com/#!/BreakingNews/status/161417225444667392	+	1.34%

12/13/2011	Crude oil spikes $2 in minutes to $100.45/barrel on a report Iran has closed the Strait of Hormuz "until further notice," for a military exercise. http://www.tehrantimes.com/politics/93462-iran-to-hold-war-game-to-close-strait-of-hormuz-mp	+	2.49%
6/8/2011	Oil skies as OPEC talks break down with no agreement to increase production. Saudi Oil Minister Naimi says it's the worst OPEC meeting he's ever attended. http://blogs.wsj.com/marketbeat/2011/06/08/opec-keeps-oil-production-unchanged/	+	1.59%
3/27/2011	After seizing several key oil production towns, Libyan rebels would like to resume crude exports within a week. http://www.nytimes.com/2011/03/29/business/global/29oil.html?smid=tw-nytimesbusiness&seid=auto	-	-1.30%
3/22/2011	Steve Levine reports that Yemen, a minor producer of crude, may still influence the price because its porous northern border with Saudi Arabia could allow a flood of (armed) refugees into the Kingdom. http://oilandglory.foreignpolicy.com/posts/2011/03/21/back_to_saudis_fault_lines	+	2.10%
3/21/2011	Coalition forces launch a 2nd wave of air strikes, furthering weakening and isolating Gaddafi's forces near Benghazi. http://www.cnbc.com/id/42187153	+	1.28%
3/17/2011	Rising Middle East tension, talk of U.S. military intervention in Libya, and hope Japan is coming under control all contribute. http://www.guardian.co.uk/world/2011/mar/17/libya-air-strikes-urged-us-un	+	3.49%
2/22/2011	The Libyan unrest lights a fire under already happy oil and precious metals. https://seekingalpha.com/news/69184	+	8.58%

Table A2: 23 Event dates from 1/1/2014 – 10/15/2016

Date	Description	Expected Effect	Actual Effect
10/10/16	Crude oil rallies as Putin says Russia is ready to join production deal https://www.bloomberg.com/news/articles/2016-10-10/putin-says-russia-ready-to-freeze-or-even-cut-output-with-opec	+	2.48%[21]
9/28/16	OPEC reportedly agrees to first production cut in 8 years http://www.bloomberg.com/news/articles/2016-09-28/opec-said-to-agree-on-first-oil-output-cut-in-eight-years	+	5.27%

[21] Since WTI oil price is not available on 10/10/2016 (Columbus Day), we take the log change of March 2017 WTI oil future between 10/10/2016 (Monday) and 10/07/2016 (Friday) instead.

9/21/16	Norway oil workers go on strike, helping send crude prices higher http://www.reuters.com/article/norway-oil-strike-idUSL8N1BX09O	+	3.32%
9/5/16	Big move in Oil on Saudi-Russia cooperation http://www.cnbc.com/2016/09/05/saudi-arabia-russia-to-call-for-oil-market-cooperation-report.html	+	1.03%
8/23/16	Reuters: Iran signals more willingness for joint action to boost oil price http://www.reuters.com/article/us-opec-freeze-idUSKCN10Y1MM	+	1.57%
8/15/16	Crude oil continues three-day rally on potential OPEC action http://www.marketwatch.com/story/oil-futures-rally-on-fresh-hopes-for-a-production-freeze-2016-08-15	+	2.77%
5/9/16	Crude oil gives up Friday gains as Canadian fires slow their spread http://www.bloomberg.com/news/articles/2016-05-08/alberta-s-vicious-wildfires-spread-to-suncor-oil-sands-site	-	-2.56%
4/19/16	Oil prices rises as a result of an oil worker strike in Kuwait that has reduced output to 1.1M barrels per day from 2.8M. http://www.cnbc.com/2016/04/18/crude-prices-edge-up-on-kuwait-oil-worker-strike.html	+	2.83%
4/12/16	Oil pops higher on report of output freeze agreement. According to Interfax, Saudi Arabia and Russia have reached a consensus on an oil production freeze. http://www.bloomberg.com/news/articles/2016-04-12/russia-saudi-arabia-reach-oil-freeze-consensus-interfax-says	+	4.02%
4/1/16	"It looks like the freeze deal may be starting to fall apart," says Dominick Chirichella of the Energy Management Institute, suggesting the April 17 meeting between OPEC and non-OPEC producers to discuss a freeze deal could be postponed. http://www.wsj.com/articles/oil-prices-decline-ahead-of-u-s-data-1459503111	-	-4.37%
3/1/16	Crude oil tops $34 on talk of production agreement http://www.cnbc.com/2016/02/16/oil-prices-spike-on-reports-of-saudi-russia-output-cut-talks.html	+	4.91%
2/17/16	Oil pokes above $30 after bullish comments from Iran The country's oil minister says Iran would support any effort aimed at stabilizing oil prices - including a deal between OPEC and non-OPEC (Russia) producers. http://www.cnbc.com/2016/02/16/russia-saudi-arabia-output-freeze-helps-oil-price-higher-in-asia.html	+	5.46%
2/12/16	WTI crude oil climbs as much as 12%, supported by yesterday's comments by the UAE energy minister that OPEC may be willing to cooperate on possible production cuts. http://www.wsj.com/articles/oil-rebounds-from-12-year-low-1455251366	+	11.29%

1/28/16	Russia's energy minister said Thursday that Moscow was ready to take part in an OPEC meeting aimed at establishing possible "coordination" in the face of low oil prices due largely to a supply glut. https://www.yahoo.com/news/russia-ready-meet-opec-over-low-oil-prices-184309486.html?ref=gs	+	2.72%
12/31/15	North Sea storm forced oil firms to evacuate platforms and shut down production on Thursday http://www.reuters.com/article/us-weather-northsea-idUSKBN0UE0OR20151231	+	1.46%
10/6/15	Crude oil rallies following comments by OPEC chief Abdalla Salem el-Badri anticipating big cuts to oil investments that are expected to ease production and draw down global crude supplies. http://www.wsj.com/articles/opec-chief-sees-oil-price-rising-on-investment-cuts-1444123148	+	4.74%
8/27/15	According to the *WSJ*, the República Bolivariana de Venezuela is pushing for an emergency OPEC meeting to come up with a plan to combat the rout in oil prices. http://af.reuters.com/article/energyOilNews/idAFL4N1125I320150827	+	9.81%
3/25/15	Western-backed President Abed Rabbo Mansour Hadi has reportedly fled the Yemen port of Aden by boat as militants were closing in. http://www.cbsnews.com/news/yemen-president-abed-rabbo-mansour-hadi-flees-aden-palace-houthi-rebels/	+	3.59%
1/20/15	Bearish Iran comments: "Iran is strong enough to withstand a deeper slump in prices even if the country must sell at $25 a barrel," http://www.bloomberg.com/news/articles/2015-01-19/iran-sees-opec-sticking-by-oil-output-decision-amid-price-slump	-	-3.57%
1/6/15	Saudi Arabia's King Abdullah, in a speech, makes clear Saudi Arabia is giving no signs it will cut supply http://www.reuters.com/article/us-markets-oil-idUSKBN0KE06V20150106	-	-4.22%
11/27/14	Saudis block OPEC output cut, sending oil price plunging http://www.reuters.com/article/us-opec-meeting-idUSKCN0JA0O320141127	-	-11.1%
10/23/14	Crude oil prices sprint higher as Saudi Arabia is said to have cut supply last month, according to a source familiar with the country's oil policy. http://www.bloomberg.com/news/articles/2014-10-23/saudi-arabia-said-to-cut-crude-oil-supply-to-market-in-september	+	2.80%
6/12/14	Islamist militant made rapid gains across northern Iraq on Wednesday and Kurdish forces on Thursday took control some parts of Kirkuk http://www.wsj.com/articles/oil-prices-surge-after-militants-seize-iraqi-cities-1402572871	+	2.03%

Figure A1: Seeking Alpha news article – Sample

Crude oil tops $34 on talk of production agreement

Mar 1 2016, 15:57 ET | By: Carl Surran, SA News Editor

- WTI crude oil settled at its highest level in eight weeks, gaining 1.9% at $34.40/bbl, on the possibility of a production agreement among major oil producers.
- Russia's energy minister reportedly said that a "critical mass" of oil-producing countries had agreed to freeze production, and that a decision would be effective even without Iran.
- Additionally, the UAE energy minister said "everyone should move toward freezing production whether they like it or not," due to current low oil prices.
- Oil prices had been lower in earlier trading after the EIA said late Monday that U.S. production fell by 43K bbl/day to 9.3M bbl/day in December, a smaller decline than in the previous two months, when production fell by more than 70K bbl/day.
- ETFs: USO, OIL, UCO, UWTI, SCO, BNO, DWTI, DBO, DTO, USL, DNO, OLO, SZO, OLEM

Appendix B: Dealing with the small sample problem

To alleviate the concern that we have a small sample problem (23 events days), we (a) test for the normality of the error terms in event days, and (b) use bootstrap standard errors.

a) Test for the normality of the error terms

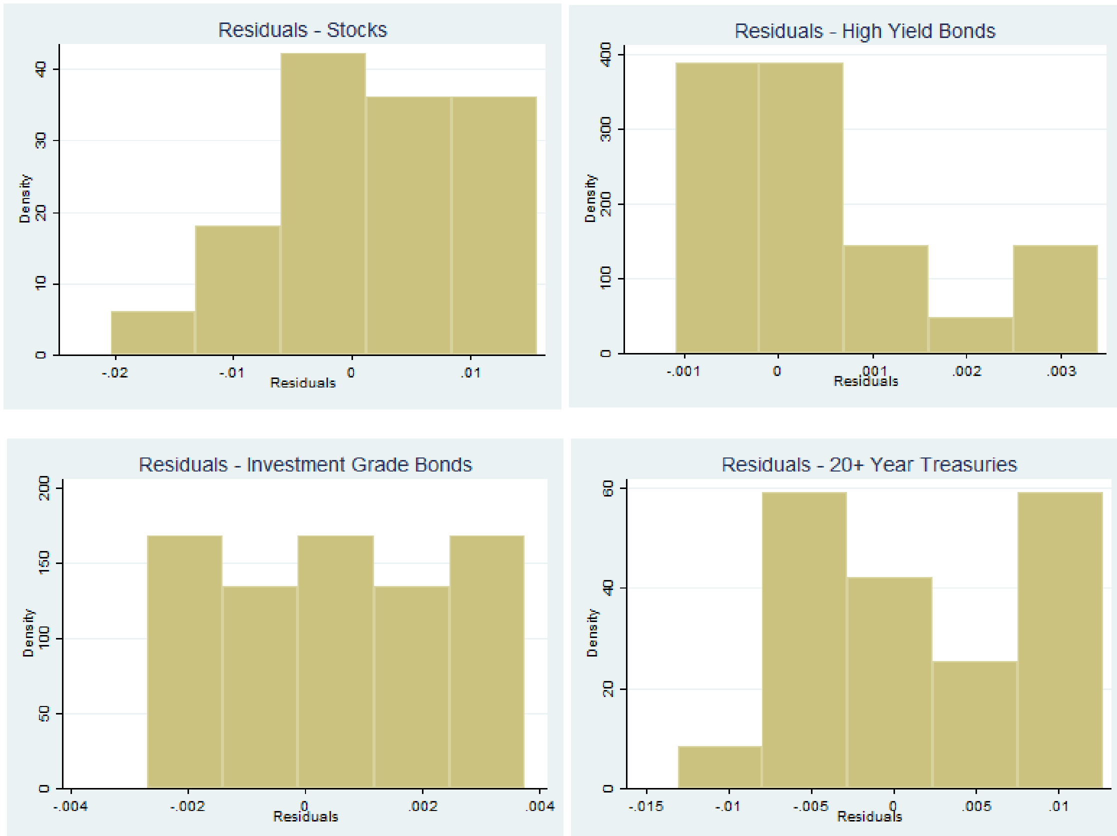
In this section, we test for whether different indices are normally distributed. We have 23 event days, which might raise some concerns about the small sample problem. However, we can still use the t-distribution for hypothesis tests, even when our sample is small, as long as the data are normally distributed.

Results of Shapiro-Wilk test for the normality of the baseline regressions' residuals in Table B.1 show that we fail to reject the null hypothesis that the error terms of the baseline regressions for stock prices, investment grade bonds and TLT are normally distributed. We reject the null hypothesis that the error terms of high-yield bonds are normally distributed. Thus, we are more confident when using the regular inference method for hypothesis tests of stocks, investment-grade bonds, and Treasury bonds. We are less confident using the regular inference method for high-yield bonds. As a result, we will present our bootstrap confidence intervals in part (b).

Table B.1: Shapiro-Wilk W Test

	Obs.	**W**	**V**	**Z**	**P-value**
Stocks	23	0.955	1.168	0.316	0.376
High-Yield Bonds	23	0.875	3.260	2.403	0.008
Investment-Grade Bonds	23	0.948	1.347	0.606	0.272
TLT	23	0.945	1.444	0.748	0.227

Figure B.1: Distribution of residuals



b) Bootstrapping

Following Hébert and Schreger (forthcoming), we implement the bootstrap procedure by Horowitz (2001) to calculate confidence intervals. This robustness check is especially important for the results of high-yield bonds because they are not normally distributed, as shown in part (a). In this section, we find that our confidence intervals for our coefficients are similar to confidence intervals constructed under normal approximations

From our original data, we resample 2000 bootstrap samples with replacements from event and non-event days, separately. Each bootstrap sample contains 23 event days and 676 non-event days, except stock (with 670 non-event days). In each bootstrap sample, we compute $\widehat{t_k} = \frac{\widehat{\alpha_k} - \widehat{\alpha}}{s_k}$, where $\hat{\alpha}$ is the point estimate from our original data, $\hat{\alpha}_k$is the point estimate in the k^{th} bootstrap sample, and s_k is the heteroskedasticity-robust standard error of the k^{th} bootstrap sample. We calculate the 2.5th percentile and 97.5th percentile of $\widehat{t_k}$ in the bootstrap replications, denoted $\widehat{t_{2.5}}$

and $\widehat{t_{97.5}}$, respectively. We then report 95% confidence interval for $\hat{\alpha}$: $[\widehat{t_{2.5}} \times s + \alpha, \widehat{t_{97.5} \times s} + \hat{\alpha}$], where s is the heteroskedasticity-robust standard error from our original data sample.

Table B.2: Bootstrapping for the 23 events

	Stocks		**HY Bonds**	
	Without lags	With lags	Without lags	With lags
∆Log (Oil Price)	0.140***	0.140***	0.044***	0.042***
95% Confidence Interval	[-.052, .331]	[-0.001, .280]	[-0.115, 0.202]	[0.013, 0.070]
Observations	699	698	699	698

	Investment-Grade Bonds		**TLT**	
	Without lags	With lags	Without lags	With lags
∆Log (Oil Price)	-0.030**	-0.030**	-0.107***	-0.111***
95% Confidence Interval	[-0.068, 0.007]	[-1.699, 1.638]	[-0.270, 0.057]	[-0.247, 0.024]
Observations	699	698	699	698

References

Andersen, Torben G., Tim Bollerslev, Francis X. Diebold, and Clara Vega, (2007) "Real-time price discovery in global stock, bond and foreign exchange markets." *Journal of International Economics* 73, no. 2,pp 251-277

Anzuini, Alessio, Patrizio Pagano and Pisani, Massimiliano (2015), “Macroeconomic Effects of Precautionary Demand for Oil” *Journal of Applied Econometrics*, 30, pp. 968–986

Apergis, Nicholas and Stephen Miller (2009), “Do structural oil-market shocks affect stock prices” *Energy Economics*, Volume 31, pp 569-575

Baumeister, Christiane and James D. Hamilton (2015), ‘Structural Interpretation of Vector Autoregressions with Incomplete Identification: Revisiting the Role of Oil Supply and Demand Shocks,’ working paper, UCSD.

Baumeister, Christiane and Lutz Kilian (2016) “Lower oil prices and the U.S. economy: is this time different?” *Brooking Papers on Economic Activity*, Fall 2016

Bernanke, Ben (2016) “The relationship between stocks and oil prices” *Brooking Institution blog* [https://www.brookings.edu/blog/ben-bernanke/2016/02/19/the-relationship-between-stocks-and-oil-prices/]

Blanchard, Olivier J., and Jordi Galí (2007), ‘The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so Different from the 1970s?’ in Jordi Galí and Mark Gertler (eds.), *International Dimensions of Monetary Policy*, pp. 373-428.

Boyer, M. Martin and Filion, Didier, (2007), “Common and fundamental factors in stock returns of Canadian oil and gas companies”, *Energy Economics*, **29**, issue 3, p. 428-453.

Brown, Morton B.; Forsythe, Alan B. (1974). "Robust tests for the equality of variances". *Journal of the American Statistical Association*. 69: 364–367

Cavallo, Michele, and Tao Wu (2011), ‘Measuring Oil-Price Shocks Using Market-Based Information,’ *IMF working paper WP/12/19*

Chaboud, Alain & Benjamin Chiquoine & Erik Hjalmarsson & Clara Vega, (2014) "Rise of the machines: algorithmic trading in the foreign exchange market," Journal of Finance (69) pages 2045-2084

Driesprong, Gerben; Jacobsen, Ben; and Matt, Benjamin, (2008) "Striking oil: Another puzzle?" *Journal of Financial Economics*. 89(2), 307-327

Ehrmann, M., Fratzscher, M. and Rigobon, R. (2011), Stocks, bonds, money markets and exchange rates: measuring international financial transmission. Journal of Applied Econometrics, 26: 948–974

El-Sharif, I., Brown, D., Burton, B., Nixon, B., Russell, A., (2005) "Evidence on the nature and extent of the relationship between oil prices and equity values in the UK" *Energy Economics* 27 (6), 819-830.

Filis, George; Degiannakis, Stavros; and Floros, Christos (2011) "Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries" *International Review of Financial Analysis* 20 (3), 152-164

Hamilton, James D. (2003), 'What Is an Oil Shock?', *Journal of Econometrics*, 113: 363-398.

Hamilton, James (2009), "Understanding Crude Oil Prices" *The Energy Journal* 30(2), 179-206

Hamilton, James (2011), 'Nonlinearities and the Macroeconomic Effects of Oil Prices', *Macroeconomic Dynamics*, 15, no. S3: 364-378.

Hamilton, James (2014), "Oil prices as an indicator of global economic conditions" *blog* [http://econbrowser.com/archives/2014/12/oil-prices-as-an-indicator-of-global-economic-conditions]

Hammoudeh, S., Dibooglu, S. & Aleisa, E. (2004), "Relationships among U.S. oil prices and oil industry equity indices" *International Review of Economics and Finance* 13(4), 427-453.

Hébert, Bengamin and Jesse Schreger (forthcoming) The costs of sovereign default: evidence from Argentina, *American Economic Review*.

Hooker, Mark A. (1996), 'What Happened to the Oil Price-Macroeconomy Relationship?', *Journal of Monetary Economics* 38: 195-213.

Horowitz, Joel (2001) "The Bootstrap", Chapter 52 in *Handbook of econometrics*, vol 5, pp 3159-3228

IMF (2015) "Global implications of lower oil prices" *IMF Staff Discussion Note*

Jones, Charles and Gautam Kaul (1996) "Oil and the stock market" *The Journal of Finance*, Vol. 51, No. 2, pp. 463-491

Kilian, Lutz (2009) "Not all price shocks are alike: disentangling demand and supply shocks in the crude oil market" *American Economic Review*, Vol 99, pp 1053-1069

Kilian, Lutz and Murphy, D. (2014), "The Role of Inventories and Speculative Trading in the Global Market for Crude Oil". *Journal of Applied Econometrics*, 29: 454-478

Kilian, Lutz and Park, C. (2009), "The impact of oil price shocks on the U.S. stock market". *International Economic Review*, 50: 1267–1287

Kilian, Lutz and Vigfusson, Robert J. (2011), 'Are the Responses of the U.S. Economy Asymmetric in Energy Price Increases and Decreases?', *Quantitative Economics* 2: 419-453.

Levene, H. (1960). Robust tests for equality of variances. In *Contributions to Probability and Statistics* (I. Olkin, ed.) 278–292. Stanford Univ. Press

Park, Jungwook and Ronald Ratti (2008), "Oil price shocks and stock markets in the U.S. and 13 European countries" *Energy Economics*, Vol 30, pp 2587-2608

Ramey, Valerie A. and Vine, Daniel J. (2011), 'Oil, Automobiles, and the U.S. Economy: How Much have Things Really Changed?', in Daron Acemoglu and Michael Woodford, eds., *NBER Macroeconomics Annual 2010*, pp. 333-368.

Ready, Robert (forthcoming) "Oil Prices and The Stock Market" *Review of Finance.*

Rigobon, Roberto (2003) "Identification Through Heteroskedasticity," *The Review of Economics and Statistics*, MIT Press, vol. 85(4), pages 777-792, November.

Rigobon, Roberto & Sack, Brian (2004), "The impact of monetary policy on asset prices," *Journal of Monetary Economics*, Elsevier, vol. 51(8), pages 1553-1575, November.

Sadorsky, Perry (1999). "Oil price shocks and stock market activity," *Energy Economics*, Elsevier, vol. 21(5), pages 449-469, October.