Impact of Oil Price Fluctuations on Financial Markets Since 2014

1/24/2017

Ha Nguyen[1]
The World Bank
hanguyen@worldbank.org

Huong Nguyen
Tufts University
huong.nguyen@tufts.edu

Anh Pham
George Mason University
apham16@gmu.edu

Abstracts

This paper investigates the causal impact of oil price fluctuations on financial markets since January 2014. Following a heteroscedasticity-based event study approach, the paper instruments changes in oil prices by exogenous shocks in oil supply. It finds that oil price declines raise uncertainty and hurt risky assets (U.S. stocks and high-yield corporate bonds) while lifting safe assets (U.S. investment-grade bonds and long-term Treasury bonds). In addition, lower oil prices boost the U.S. dollar and reduce the prices of emerging market equities. Remarkably, the declines in oil prices hurt several sectors that supposedly benefit from lower oil prices, such as basic materials, industrials, and transportation.

JEL: G15; Q41

Keywords: Oil prices, financial markets

[1] We are grateful to Maya Eden, Roberto Fattal Jaef, Grace Li, Aart Kraay, Minh Thi Nguyen, Luis Serven and seminar participants at the World Bank and the IMF for comments and feedback..

Contents

I. Introduction

Recent developments in the oil market are nothing short of spectacular. The West Texas Intermediate (WTI) oil price has fallen from over $100 per barrel in mid-2014 to around $30 per barrel in February 2016. Since then, it has recovered to around $50 a barrel as of December 2016 (Figure 1). No one knows if we have seen the bottom of oil prices, or this recovery is only temporary.

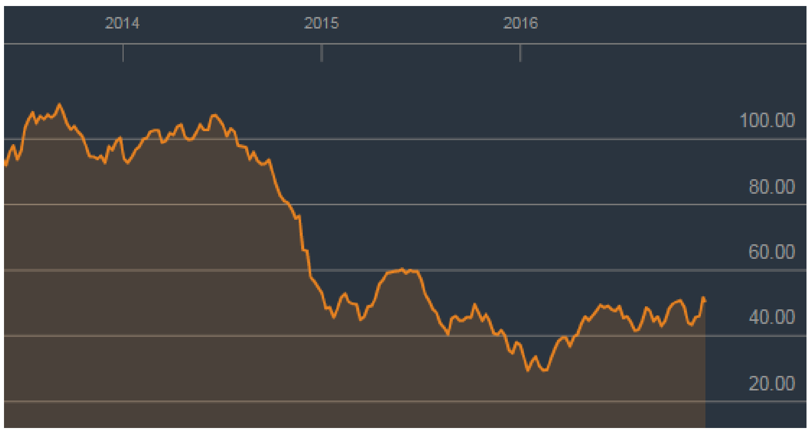


Figure 1.1: WTI oil price
Source: Bloomberg

A concerning observation in financial markets is that recently, stock prices and oil price tend to rise and fall together. Conventional wisdom suggests that a cheaper oil price benefits oil-importing economies, such as the U.S., because of lower production costs for industries and lower fuel costs for households. However, lower oil prices could hurt the oil and gas sector and transmit to financial markets, which could then propagate damages to the real economy via finance-macro linkages (Kiyotaki and Moore, 1997; Bernanke et al, 1999). Thus, it is possible for the negative effects of lower oil prices to outweigh their benefits. Indeed, many policy makers are concerned about potential systemic risk that the recent declines in oil prices may cause (for example, see IMF, 2015 and Bernanke, 2016).

In this paper, we investigate the causal impact of oil price fluctuations on U.S. and international financial markets from January 2014 until October 2016. Quantifying the causal impacts of oil prices on the financial markets is not straightforward. We do not know if oil prices affect stock prices, stock prices affect oil prices, or both are driven by a third factor such as the expectation about future economic growth. To overcome the issue of endogeneity, we use a heteroscedasticity-based event study approach, following Rigobon (2003) and Rigobon and Sack (2004). Specifically, we instrument for changes in oil prices with exogenous shocks that mainly affect oil supply. The window for our event study is one day. The detailed description of the events is discussed in section II.

There are three main findings. First, for the U.S. financial markets, we find that a lower WTI oil price hurts risky assets (stocks and high-yield bonds), lifts safe assets (investment grade bonds and long term Treasury bonds), and raises the market's future volatility (the VIX index). A 10% decline in the WTI oil price lowers the U.S. stock market index by about 1.2% and high-yield corporate bonds by 0.41%. The same decline raises investment-grade bonds by 0.31%, long-term Treasury bonds by 1.2%, and the VIX index by 9.1%. Second, a 10% decrease in oil price boosts the value of the U.S. dollar by 0.41% and hurts equity markets in emerging countries by 1.32%. Third, we examine the impact of oil price fluctuations on different sectors. As expected, lower oil prices adversely affect the energy sector. Remarkably, the declines in oil prices hurt basic materials, transport and industrials, sectors that supposedly benefit from lower oil prices.

Our paper complements the empirical literature on the impact of oil prices on financial markets and on oil-exporting countries. The existing literature finds either a *positive*[2] or a non-significant impact of oil price declines on advanced countries'

[2] Jones and Kaul, 1996; Sadorsky, 1999.

stock markets.[3] Additionally, some studies find that oil price declines hurt the oil and gas sector and oil exporting countries.[4] The vast majority of the empirical literature uses different VAR frameworks with various identification assumptions.

Our study's contribution is twofold. First, instead of using the traditional VAR approach, we use a heteroscedasticity-based event study approach, developed by Rigobon (2003). This event-study approach helps mitigate the concern about omitted variables and reverse causality. Second, we examine the recent episode of oil's steep decline (January 2014 to October 2016). We find that the declines in oil prices during this period have systemic negative impacts on financial markets, a finding not seen in the existing literature.

The rest of the paper is organized as follows: section II explains the identification strategy and oil-supply events. Section III describes data sources. Section IV presents the results for the U.S. financial market. Section V presents the results for emerging markets. Section VI discusses potential channels of the transmission. Section VII concludes.

---

[3] 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.

[4] 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.

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 the change in asset price, and z_t 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 directly 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 directly 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 of days, event (*E*) and non-event (*N*) days. We identify 28 days between 01/01/2014 to 10/15/2016 with important announcements and developments about oil supply as event days. A useful feature of the approach is that it does not require the complete absence of common shocks during 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 non-event days:

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

These assumptions imply that the "importance" of oil supply-side announcements increases on event days (E). Again, it is important to note that demand factors 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:

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

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

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

From (7), α can be estimated as

$$\hat{\alpha} = \frac{\Delta\Omega_{1,2}}{\Delta\Omega_{2,2}} \qquad (8)^5$$

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

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

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

[5] 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.

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:

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

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:

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

Simple algebra shows that the estimated value of α is *asymptotically* identical to the following:

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

The regression equation is therefore as follows:

$$\Delta s_t = \beta_0 + \beta_1 instr\Delta p_t + \sum_{i=1}^{3} \Delta s_{t-i} + \sum_{i=1}^{3} \Delta p_{t-i} + \epsilon_t$$

where Δs_t is the log change in asset prices (i.e. stock prices and bond prices); $instr\Delta p_t$ is the log change in the WTI oil price, instrumented by w; and Δs_{t-i} and

Δp_{t-i} are the log changes in lagged asset prices and oil prices (they are control variables).

We present regular 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

Identifying oil-supply events is challenging. There is not a fixed calendar for oil-supply events, so 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).[7] Seeking Alpha records all surprising events and announcements that arguably affect the oil supply. They range from surprising announcements by OPEC officials and OPEC member countries to unexpected developments in key oil exporters. From 1/1/2014 to 10/15/2016, we record 29 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 Table A1 in the Appendix, along with links to in-depth financial news discussing the events.

There could be concerns with this list. 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

[7] 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.

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 this possibility 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 29 event days. We removed 4/12/2015 as there were numerous Fed 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 ECB President. Thus, we have 28 event dates.

To increase our confidence that these 28 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" appear 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 1/1/2014. We check econometrically if the average article count for those 28 event days is higher or lower than that for the non-event days. Table 2.1 shows that the average count is marginally smaller on the event days than the non-event days, indicating that demand factors are marginally smaller in the events days.

Table 2.1: Demand news and event days

	Log (# News Article)
Event	-0.0983*
	(0.0505)
Constant	6.9286***
	(0.0096)
Observations	700
R-squared	0.0059

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 Kilian and Murphy (2014) and Hamilton (2009), 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 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 28 events, the reactions to the WTI oil price all indicate that the events are supply driven.

The third concern is that some of the geopolitical events (such as ISIS making advances in Iraq) could generate uncertainty, which is a demand factor. We argue that demand factors, if any, are weaker than the supply factors, by observing the price action. 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 the 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.

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.[8] Table 2.2 shows the results of several test statistics to confirm that the variance of the log change in the WTI oil price for the event days is larger than that for the non-event days.

Table 2.2: Tests of differences in variance of oil price changes[9]

Test	F-statistics	p-value
Levene	13.6400	0.0002
Brown-Forsythe trimmed mean	12.8885	0.0003
Brown-Forsythe median	13.5831	0.0002

[8] In a traditional Instrumental Variable method, it is the result of the first stage.

[9] 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.

III. Data

Our period of analysis spans 1/1/2014 to 10/15/2016. Overall, we have 700 trading days, and hence 699 observations. We obtain daily the WTI crude oil price from the U.S. Energy Information Administration. The WTI crude is chosen instead of Brent because WTI is the main benchmark for oil consumed in the United States. The WTI refers to oil extracted from wells in the U.S. and sent via pipelines to Cushing, Oklahoma[10].

We use the Dow Jones U.S. Market Index (DJUS), which represents about 95% of the U.S. market, to capture U.S. equity. We use the Bloomberg bond indices for bond prices. Daily 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.[11] These 10 indices together make up the Dow Jones U.S. Market Index. In addition, we also examine two important subsectors: transportation and airlines.[12] The S&P 500 and its sectoral indices serve as a robustness check.

The Bloomberg investment-grade corporate bonds are the aggregate index, Healthcare, Tech, Materials, Financials, Communication, Consumer Discretionary, Utilities, Industrials, Consumer Services and Energy.[13] Similarly, the Bloomberg high-yield corporate bond indices are the aggregate high-yield corporate bond

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

[11] 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).

[12] DJUSTS, and DJUSAR.

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

index, Healthcare, Technology, Materials, Financials, Communications, Consumer Discretionary, Utility, Industrials, and Consumer Staple.[14]

Table 3.1: Summary statistics

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	698	0.000205	0.00874	-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	0.000478	0.00827	-0.0276	0.0265
Δ Log (VIX)	699	0.000109	0.0802	-0.241	0.401

Event Days

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Δ Log Oil Price	28	0.0160	0.0441	-0.111	0.113
Δ Log Stocks	28	0.00329	0.00976	-0.0151	0.0242
Δ Log High-Yield Bonds	28	0.00154	0.00247	-0.00451	0.00732
Δ Log (Investment-Grade Bonds)	28	0.000378	0.00256	-0.00588	0.00510
Δ Log (TLT)	28	0.000317	0.00890	-0.0178	0.0179
Δ Log (VIX)	28	-0.0183	0.0775	-0.180	0.125

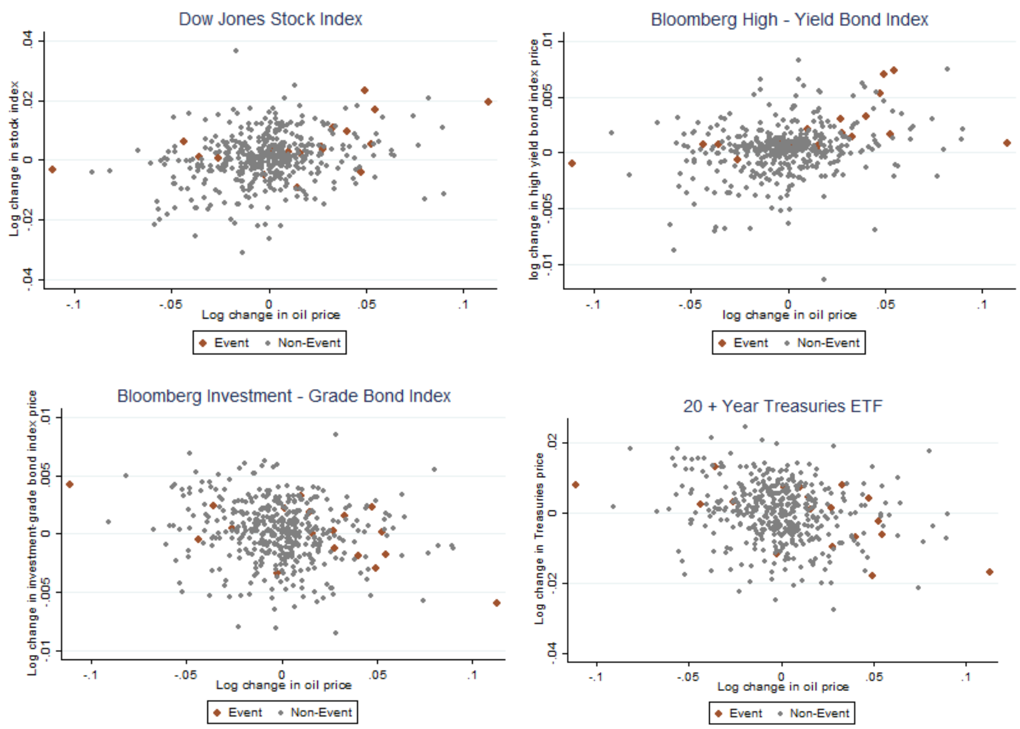
Non-Event Days

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Δ Log Oil Price	671	-0.00157	0.0255	-0.0905	0.102
Δ Log Stocks	670	7.59e-05	0.00868	-0.0402	0.0364
Δ Log High-Yield Bonds	671	0.000128	0.00232	-0.0114	0.00990
Δ Log (Investment-Grade Bonds)	671	0.000200	0.00248	-0.00847	0.00846
Δ Log (TLT)	671	0.000485	0.00825	-0.0276	0.0265
Δ Log (VIX)	671	0.000876	0.0803	-0.241	0.401

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

Figure 3.1

Changes in selected financial instruments and oil price



For emerging market indices, we use MSCI dollar-denominated indices: MSCI overall emerging market index, MSCI Gulf State Index, and MSCI individual country indices for key oil-exporter countries.

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.

Table 3.1 provides the summary statistics for changes in the WTI oil price and in different stock and bond indices. We present the summary statistics for the whole sample, for the event and non-event days. Overall, the price actions of oil in event days on average are larger than those in non-event days. For example, the standard deviation of the log change in WTI oil price in event days is 0.0441, about twice as much for that in non-event days (0.0255). We formally tested for this difference in Table 2.2.

IV. Results

Overall US market

This section presents the effects of oil price fluctuations in the US market. Note that in this setup, the impacts of oil 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. Table 4.1 shows that the decline in WTI oil price hurts U.S. risky assets, measured by 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 1.2% decrease in the Dow Jones U.S. market index. We find a similar result when using S&P 500 index as an alternative broad-based stock index. In addition, a 10% decrease in WTI oil price leads to a 0.41% decrease in the high-yield bond index. At the same time, investment-grade corporate bonds increase by 0.31%, and TLT increases by 1.19%.

Table 4.1: Impacts of WTI oil price on overall markets

VARIABLES	Δlog(Stock index)		Δlog (High-yield bond index)		Δlog (Investment-grade bond index)		Δlog (20+ Treasury bond)	
ΔLog (Oil Price)	**0.144***** (0.0538)	**0.120***** (0.0311)	**0.0446**** (0.0182)	**0.0408***** (0.0101)	**-0.0308**** (0.0137)	**-0.0308**** (0.0122)	**-0.112***** (0.0413)	**-0.119***** (0.0352)
$\Delta Log(Oil)_{t-1}$		0.0167 (0.0149)		0.0200*** (0.00369)		-0.00145 (0.00375)		-0.0326*** (0.0126)
$\Delta Log(Oil)_{t-2}$		0.0254* (0.0150)		0.00409 (0.00323)		-0.000114 (0.00367)		-0.0182 (0.0122)
$\Delta Log(Oil)_{t-3}$		-0.00853 (0.0146)		0.000797 (0.00306)		7.96e-05 (0.00371)		-0.0119 (0.0122)
$\Delta Log(Stock)_{t-1}$		-0.00740 (0.0544)						
$\Delta Log(Stock)_{t-2}$		-0.0682 (0.0524)						
$\Delta Log(Stock)_{t-3}$		-0.00722 (0.0501)						
$\Delta Log(HY)_{t-1}$				0.483*** (0.0664)				
$\Delta Log(HY)_{t-2}$				-0.0461 (0.0631)				
$\Delta Log(HY)_{t-3}$				0.00664 (0.0411)				
$\Delta Log(Bond)_{t-1}$						-0.0288 (0.0391)		
$\Delta Log(Bond)_{t-2}$						-0.0272 (0.0412)		
$\Delta Log(Bond)_{t-3}$						0.0420 (0.0375)		
$\Delta Log(TLT)_{t-1}$								-0.105*** (0.0394)
$\Delta Log(TLT)_{t-2}$								-0.0609 (0.0416)
$\Delta Log(TLT)_{t-3}$								0.0184 (0.0376)
Constant	0.000326 (0.00032)	0.000346 (0.00033)	0.00022** (8.81e-05)	0.00015** (7.46e-05)	0.000180* (9.36e-05)	0.000178* (9.64e-05)	0.000381 (0.00030)	0.000386 (0.00030)
Observations	698	695	699	696	699	696	699	696
R-squared	0.081	0.105	0.055	0.418	0.027	0.030	0.064	0.080

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 4.2 reports the persistence of the impact of the oil shocks. We consider the log change in the stock and bond indices one, two and three days after the event days. We find that oil price declines still affect high-yield bonds three days after the events. However, we find no evidence for the persistent impact of oil prices on stocks, investment-grade bonds, and Treasury bonds.

Table 4.2: Persistence of oil price shocks

Index	Without	With lags
Stock index (t+1)	0.0720	0.0429
Δ*Log (t+1; t)*	(0.0440)	(0.0270)
Stock index (t+2)	0.00715	0.0151
Δ*Log (t+2; t+1)*	(0.0586)	(0.0338)
Stock index (t+3)	-0.0774	-0.0487
Δ*Log (t+3; t+2)*	(0.0650)	(0.0366)
High-yield bond index (t+1)	0.0569***	0.0555***
	(0.0141)	(0.0107)
High-yield bond index (t+2)	0.0354***	0.0335**
	(0.0124)	(0.0137)
High-yield bond index (t+3)	0.0255**	0.0239**
	(0.0127)	(0.0121)
Investment grade bond index (t+1)	0.0175	0.0167
	(0.0129)	(0.0118)
Investment grade bond index (t+2)	-0.000559	0.00147
	(0.0152)	(0.0136)
Investment grade bond index (t+3)	0.0137	0.0104
	(0.0112)	(0.0113)
TLT (t+1)	0.0203	0.0158
	(0.0448)	(0.0433)
TLT (t+2)	-0.0279	-0.0213
	(0.0473)	(0.0450)
TLT (t+3)	0.0261	0.0133
	(0.0414)	(0.0393)

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 and 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 bootstrapped regressions are shown in Appendix B.

On volatility

This section examines the impacts of oil price fluctuations on uncertainty, proxied by the log of the VIX index. VIX is a popular measure of the market's expectation of stock volatility over the next 30-day period. Table 4.3 reveals that volatility hiked by 9.09% for every 10% decline in WTI oil price. This finding reinforces the argument that oil price declines, although driven by exogenous supply shocks, can create uncertainty, flight to safety, and a deterioration of the stock market.

Table 4.3: Oil price declines and the VIX index

VARIABLES	Δlog(VIX)	Δlog(VIX)
ΔLog (Oil Price)	-1.005***	-0.909***
	(0.297)	(0.290)
Lags	No	Yes
Constant	-0.000804	-0.000757
	(0.00297)	(0.00300)
Observations	699	696
R-squared	0.054	0.068

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

The US Market: Breakdown by sector and asset class

Table 4.4 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.

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 oil price decreases. Focusing on column 4 (regressions with lags), a 10% decline in the WTI oil price causes the Energy stock index to drop by 5.04%. 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 WTI oil price decreases by 10%, the stock index of Basic Materials decreases by 2.91%. Technology, consumer services, consumer goods, telecommunication, healthcare and utilities 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 oil price goes down. This suggests that other channels, such as uncertainty-driven 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 oil price, the magnitude of 1.75% is not relatively large compared to other sectors.

Table 4.4: Breakdown by sector and asset class

	Index	Without lags	With lags
Stocks	Energy	0.532*** (0.101)	0.504*** (0.0888)
	Basic Materials	0.312*** (0.0479)	0.291*** (0.0410)
	Transport Services	0.216** (0.109)	0.196* (0.109)
	Financials	0.190** (0.0779)	0.175** (0.0744)
	Industrials	0.169*** (0.0453)	0.158*** (0.0422)
	Aggregate Index	0.144*** (0.0531)	0.130*** (0.0481)
	Tech	0.121* (0.0702)	0.102* (0.0616)
	Consumer Services	0.0791 (0.0792)	0.0645 (0.0730)
	Consumer Goods	0.0642 (0.0621)	0.0519 (0.0565)
	Telecom	0.0403 (0.0662)	-0.0385 (0.0420)
	Healthcare	0.0359 (0.0730)	0.0317 (0.0603)
	Utilities	-0.0260 (0.0462)	0.0294 (0.0662)
	Airlines	-0.127 (0.194)	-0.138 (0.186)
High-yield Bonds	Energy	0.0973** (0.0449)	0.0899*** (0.0176)
	Materials	0.0545** (0.0234)	0.0510*** (0.0154)
	Communications	0.0538*** (0.0229)	0.0421*** (0.0150)
	Aggregate Index	0.0446** (0.0186)	0.0408*** (0.0101)
	Consumer Services	0.0355** (0.0142)	0.0332*** (0.00951)
	Financials	0.0244* (0.0130)	0.0254* (0.0140)

	Healthcare	0.0202** (0.00954)	0.0253*** (0.00919)
	Consumer Discretionary	0.0237** (0.0119)	0.0204*** (0.00726)
	Industrials	0.0237 (0.0164)	0.0181** (0.00785)
Investment-Grade Bonds	Energy	-0.00972 (0.0177)	-0.00445 (0.0155)
	Materials	-0.00716 (0.0159)	-0.00753 (0.0154)
	Financials	-0.0261** (0.0110)	-0.0263*** (0.00970)
	Aggregate Index	-0.0308** (0.0137)	-0.0308** (0.0122)
	Communications	-0.0343* (0.0195)	-0.0322* (0.0180)
	Healthcare	-0.0433*** (0.0145)	-0.0440*** (0.0130)
	Industrials	-0.0458*** (0.0159)	-0.0467*** (0.0141)
	Utilities	-0.0547*** (0.0172)	-0.0555*** (0.0156)

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 WTI oil price causes the Energy high-yield bond index to drop by 0.90%. Interestingly, high-yield bonds of most other sectors also suffer, ranging from Materials (0.51%) to Industrials (0.18%).

Cheap oil improves investment-grade corporate bonds, except those in 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 Communications. For a 10% decline in the WTI oil price, the indices for these sectors' investment-grade bond indices increase from 0.32% to 0.56%.

V. Impact on Emerging Markets

This section considers the impact of oil price declines to emerging markets. Table 5.1 shows that oil price declines hurt the dollar-denominated MSCI Emerging market index. For every 10% decline in WTI oil price, the dollar value of MSCI Emerging Market index drops by 1.32%. The MSCI Emerging Markets Index consists of 21 emerging countries,[15] most of them are not oil exporters. Nevertheless, we still see the declines in these markets. This reinforces the concern that this time, lower oil price could carry global systemic risk.

Table 5.1 MSCI Emerging Market index

VARIABLES	Δlog (MSCI Emerging)	Δlog (MSCI Emerging)
ΔLog(Oil Price)	0.142**	0.132**
	(0.0709)	(0.0534)
Lags	No	Yes
Constant	9.41e-05	0.000181
	(0.000358)	(0.000339)
Observations	699	696
R-squared	0.068	0.168

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

15 Brazil; Chile; China; Colombia; Czech Republic; Arab Republic of Egypt; Hungary; India; Indonesia; Republic of Korea; Malaysia; Mexico; Morocco; Peru; Philippines; Poland; Russian Federation; South Africa; Taiwan, China; Thailand; and Turkey.

The effect can be broken to two components: the decline in the stock markets of emerging markets, and the appreciation of the U.S. dollar. Indeed, as the WTI oil price declines, the dollar index appreciates in value (Table 5.2). A 10% decline in the WTI oil price leads to 0.41% increase in the U.S. dollar. We use the trade-weighted dollar index that the U.S. has against its major trade partners.[16] The appreciation of the U.S. dollar is usually a worrying sign to emerging markets (Shin, 2016).

Table 5.2 Dollar index (broad)

VARIABLES	Δlog (Index)	Δlog (Index)
ΔLog(Oil Price)	-0.0406**	-0.0414**
	(0.0200)	(0.0176)
Lags	No	Yes
Constant	0.000236**	0.000258**
	(0.000111)	(0.000115)
Observations	689	674
R-squared	0.133	0.148

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

Focusing the impact of oil price fluctuations on oil exporters, Table 5.3 examines the impacts of oil price fluctuations on the dollar-denominated MSCI Gulf States Index**.** The impact here reflects the reactions of oil-exporters' stock markets to changes in oil prices. Quite surprisingly, a lower WTI oil price hurts the dollar value of the Gulf States' stock markets but the impact is statistically insignificant: every 10% decline in WTI oil price, MSCI Gulf State index drops by 0.55%. The magnitude is relatively small and not statistically different to zero. Conventional

[16] Euro Area; Canada; Japan; Mexico; China; United Kingdom; Taiwan, China; Republic of Korea; Singapore; Hong Kong SAR, China' Malaysia; Brazil; Switzerland; Thailand; Philippines; Australia; Indonesia; India; Israel; Saudi Arabia; Russian Federation; Sweden; Argentina; República Bolivariana de Venezuela; Chile; and Colombia. Data are from the Federal Reserve.

wisdom suggests that lower oil prices should affect the Gulf States more severely than the overall emerging markets. The finding that Gulf States' index is less affected than the overall emerging market index suggests that other channels, above and beyond the lower oil revenue channel, might be at play.

Table 5.3 MSCI Gulf States Index

VARIABLES	Δlog (Index)	Δlog (Index)
Δ*Log(Oil Price)*	0.0714	0.0554
	(0.0773)	(0.0617)
Lags	No	Yes
Constant	-0.000235	-8.04e-05
	(0.000444)	(0.000401)
Observations	699	696
R-square	0.018	0.121

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

To investigate the possibility further, we examine the impacts of lower oil prices on individual important oil-exporting emerging markets. Key emerging oil exporters - Brazil, Colombia, Mexico and the Russian Federation - show tremendous sensitivity to the declines in oil prices. The coefficients are much larger than the overall MSCI Emerging Market Index, and the Dow Jones U.S. Market Index. In particular, a 10% decline in the WTI oil price reduces the stock index of Brazil by 3.01%, Colombia by 4.13%, Mexico by 2.21% and Russia by 4.57%. The declines here suggest heavy capital flight of investors from these markets when they see oil prices drop. Since these countries are large and likely systemically important, the magnitude of the impacts is concerning. The indices of many smaller Gulf States, however, are not significantly affected by lower oil prices. This finding is consistent with the results in table 5.4 and reinforces the possibility that other channels beyond the oil revenue channel could affect emerging markets.

Table 5.4 MSCI country indices

Index	Value (with lags)
Russia	0.457*** (0.0827)
Colombia	0.413*** (0.0750)
Brazil	0.301*** (0.0988)
Mexico	0.221*** (0.0712)
Qatar	0.144** (0.0654)
Kuwait	0.103*** (0.0380)
Kazakhstan	0.156 (0.107)
United Arab Emirates	0.141 (0.106)
Nigeria	0.0605 (0.0620)
Oman	0.0423 (0.0458)
Saudi Arabia	0.0280 (0.0782)

VI. Discussion on potential channels

At least three 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 from 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, who 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.

The third channel that could transmit the negative impacts of lower oil prices to the rest of the economy is uncertainty. Relentless declines in oil prices raise uncertainty,[17] which we confirm via the corresponding increase in the VIX index in table 4.2. When economic agents are uncertain about the economic prospect and direction of financial markets, they tend to move their investment to safer and less cyclical assets. This is precisely what we observe in the data: investment-grade and long-term Treasury bonds appreciate at the cost of equity and high-yield bonds.

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, swift and dramatic recent declines in oil prices and the accompanying movements in financial markets are concerning. Do lower oil prices carry systemic risk this time? This paper tries to shed light on the issue by examining the causal impacts of oil price

[17] This direction is different to the view postulated in Rey (2015) and Miranda-Agrippino and Rey (2015). These papers show that the VIX acts like a common factor behind the prices of risky assets as well as commodity prices around the world. The positive co-movement between oil prices and risky asset prices is driven by the VIX, which itself is driven by underlying fundamentals such as U.S. monetary policy. In our paper, we show that there is a direct causal link from lower oil prices to higher VIX.

declines on financial markets. The findings suggest that they do. A lower WTI oil price negatively affects risky assets (stocks and high-yield bonds) in many sectors in the U.S. financial market. Quite strikingly, sectors that supposedly benefit from lower prices, such as Basic Materials, Industrials and Transport Services, also suffer. Similarly, equities in emerging countries deteriorate, more so for large oil-exporting countries and, interestingly, less so for smaller oil-exporting Gulf States. 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 are typically observed during bad times.

An interesting direction of future research would be to examine in detail the channels via which the transmission from lower oil prices to the real economy could operate: does the impact work through the demand channel, the financial channel, or the conventional oil input channel? Using firm-level data, one could investigate to what extent stock prices of firms in demand-sensitive sectors, credit-sensitive sectors, or oil-intensive sectors reacted to oil price fluctuations in the last two years.

APPENDIX

Table A1: 29 Event dates

Date	Description ***** Removed because of a significant macro event**	Expected Effect	Actual Effect
10/10/16	Crude oil rallies as Putin says Russia is ready to join production deal http://www.bloomberg.com/news/articles/2016-10-10/putin-says-russia-ready-to-freeze-or-even-cut-output-with-opec	+	2.48% [18]
10/4/16	Oil prices peel back after reports on Libya and Iran production http://www.cnbc.com/2016/10/04/reuters-america-update-4-oil-eases-as-iran-libya-output-rises-hit-opec-deal-momentum.html	-	-0.27%
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%
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%

[18] 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.

6/2/16	OPEC fails to agree on production caps http://www.bloomberg.com/news/articles/2016-06-02/opec-said-to-keep-status-quo-after-failing-to-agree-output-limit	-	0.14%
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.	+	11.29%

	http://www.wsj.com/articles/oil-rebounds-from-12-year-low-1455251366		
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%
12/4/15 ***	OPEC decided to roll over its policy of maintain crude production in order to retain market share.*** http://www.cnbc.com/2015/12/04/opec-president-well-wait-and-watch-the-market.html	-	-2.66%
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%

1/13/15	Brent crude and WTI hits record six-year lows, as an oil minister from OPEC reiterated that the group would not change its production strategy+. http://www.cnbc.com/2015/01/13/oil-falls-below-45-as-opec-plays-hardball.html	-	-0.30%
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%
12/4/14	Oil prices turn lower after Saudi Arabia cut the price of its oil in the U.S., reinforcing concerns that the kingdom is prioritizing market share rather than raise prices. http://www.wsj.com/articles/saudi-arabia-cuts-all-january-crude-oil-prices-to-u-s-asia-1417700645	-	-0.85%
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%
6/24/14	Brent crude fell below $114/bbl, its lowest levels in a week, amid speculation that Iraqi oil production won't be disrupted by violence http://money.cnn.com/2014/06/12/news/oil-prices-iraq/	-	-0.17%
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 (28 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

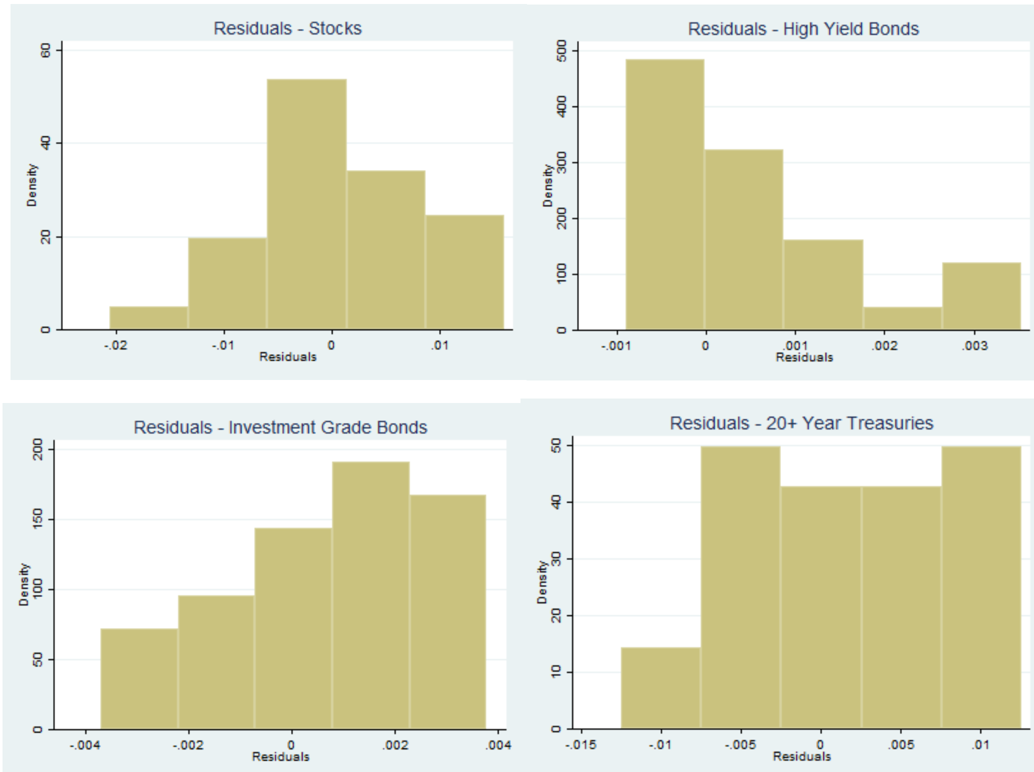
In this section, we test for whether different indices are normally distributed. We have 28 event days, which might raise some concerns about the small sample problem. However, we can still use the t-distribution for hypothesis tests, even when our sample is small, as long as the data are normally distributed.

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	28	0.97576	0.732	-0.642	0.73971
High-Yield Bonds	28	0.88287	3.537	2.601	0.00465
Investment-Grade Bonds	28	0.95911	1.235	0.434	0.33200
TLT	28	0.95579	1.335	0.595	0.27594

Figure B.1: Distribution of residuals



b) Bootstrapping

Following Hébert and Schreger (2016), 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 28 event days and 671 non-event days, except stock (with 670 non-event days). In each bootstrap sample, we compute $\widehat{t_k} = \frac{\widehat{\alpha_k} - \hat{\alpha}}{s_k}$, 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 28 events

	Stocks		**HY Bonds**	
	Without lags	With lags	Without lags	With lags
Δ*Log (Oil Price)*	0.144**	0.106**	0.052*	0.043**
95% Confidence Interval	[0.004, 0.242]	[0.024, 0.172]	[-0.014, 0.109]	[0.016, 0.069]
Observations	698	695	699	696

	Investment-Grade Bonds		**TLT**	
	Without lags	With lags	Without lags	With lags
Δ*Log (Oil Price)*	-0.0287**	-0.031***	-0.118**	-0.119***
95% Confidence Interval	[-0.055, -0.007]	[-0.054, -0.008]	[-0.179, -0.047]	[-0.186, -0.045]
Observations	699	696	699	696

References

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

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/]

Bernanke, Ben, Mark Gertler and Simon Gilchrist (1999), “The Financial accelerator in a quantitative business cycle framework” *Handbook of Macroeconomics*, Volume 1

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

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.

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

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 (2016) The costs of sovereign default: evidence from Argentina, *NBER Working Paper No 22270*

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

Huang, Roger, Ronald Masulis and Hans Stoll (1996), “Energy shocks and financial markets” *Journal of Futures Markets*, Vol. 16, pp 1-27

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

Kiyotaki, Nobuhiro and John Moore (1997) Credit Cycles, *Journal of Political Economy* Vol. 105, No. 2 (April 1997), pp. 211-248

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

Miranda-Agrippino Silvia & Hélène Rey (2015) "World Asset Markets and the Global Financial Cycle," *NBER Working Papers 21722*

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

Rey Hélène (2015) "Dilemma not Trilemma: The global Financial Cycle and Monetary Policy Independence," NBER Working Papers 21162

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.

Shin, Hyun Song (2016) "Global liquidity and procyclicality", speech at the World Bank conference "The state of economics, the state of the world"