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Oil Prices and the U.S. Economy: Evidence from the Stock Market (Revised)

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Abstract

Using three identification strategies, this paper finds that supply-driven oil price increases lowered U.S. stock returns in many sectors before the shale oil revolution but not after. It also reports that oil prices are a priced factor in a multi-factor asset pricing model both before and after the shale revolution. While oil prices mattered in both periods, the beneficial effects of oil price increases on the U.S. stock market have risen and the harmful effects have fallen since U.S. oil production soared after 2010.

Keywords: Q43, G14

JEL classification: Crude oil prices, Stock returns

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1. Introduction

U.S. oil production fell steadily from 1990 until the 2008-2009 Global Financial Crisis (GFC). Beginning in 2010, as shale oil output came online, U.S. production soared (see Figure 1). This paper investigates whether the impact of oil prices on the U.S. stock market differed before and after the shale revolution (SR).

Many predict that an increase in oil prices will lower stock prices and reduce growth for oil-importing nations such as the U.S. For instance, the IMF (2014), using its G20 economic model, reported that oil price increases after the GFC disrupt the macroeconomies of oil-importing countries. It forecasted that a 20 percent increase in oil prices would raise inflation in advanced economies by between 0.5 and 0.8 percentage points, lower GDP by between 0.4 and 1.9 percent, and decrease aggregate equity prices by between 3 and 8 percent.

Contrary to these predictions, Bernanke (2016) found that oil prices during the SR were positively correlated with U.S. aggregate stock returns. Using daily data over the June 2011 to December 2015 period, he reported that the log difference of the price of West Texas Intermediate (WTI) crude oil was positively correlated with the log difference of the Standard & Poor's 500 (S&P 500) stock price index. To control for the fact that increases in aggregate demand may raise both oil prices and stock prices, he used Hamilton's (2014) method to decompose oil price changes into changes driven by aggregate demand and residual changes driven by oil supply and other factors. Hamilton used the first differences of the log of copper prices, the ten-year Treasury constant maturity interest rate, and the log of the trade-weighted dollar exchange rate to capture the effect of aggregate demand on oil prices.

Bernanke (2016) noted that if investors retreat from both commodities and stocks during periods of high uncertainty, then shocks to volatility may cause oil prices and stocks to covary positively. To control for this, he regressed the daily change in the log of oil prices on the daily change in the log of the Chicago Board Options Exchange volatility index (VIX) together with the variables Hamilton (2014) employed to capture the impact of aggregate demand. Bernanke reported a correlation of 0.68 between S&P price changes and changes in the component of WTI prices explained by the VIX and demand factors. He found a correlation of 0.05 between changes in the S&P and residual changes in WTI prices. He questioned why there was a positive correlation between stock prices and oil price increases driven by supply factors, given the presumption that negative oil supply shocks that increase oil prices would decrease output and raise inflation in the U.S.

Bernanke (2016) stated that one explanation for why supply-driven oil price decreases did not benefit the S&P is that they damage the creditworthiness of oil-producing companies and worsen financial conditions. Obstfeld, Milesi-Ferretti, and Arezki (2016) similarly noted that low oil prices could lead to corporate defaults that roil the financial sector. They also observed that low oil prices make oil exploration and extraction activities less profitable and lead to large declines in energy-related investment.[1]

In previous work Chen, Roll, and Ross (1986) investigated whether crude oil prices are a priced factor in a multi-factor asset pricing framework. Using monthly data over five-year periods they regressed a sample of assets on news of potential economic state variables. They then used the assets' betas to the state variables as independent variables in cross-sectional regressions for each of the next 12 months, with the dependent variable being monthly asset returns. The coefficients from the cross-sectional regressions provide estimates of the risk premia associated with the state variables. They repeated this procedure for every year over the 1958-

[1] Lamont (1997) reported that a fall in oil prices significantly reduces cash flow and investment by oil company subsidiaries.

1984 sample period. Over the entire sample period and over several sub-sample periods, they found no evidence that there was a risk premium associated with oil prices.

Kilian and Park (2009) distinguished between demand and supply shocks in the oil market. They employed a monthly vector autoregression over the January 1975 to September 2005 period including global crude oil production, an index of real economic activity to capture global commodity demand, and crude oil prices. They reported that higher oil prices arising from oil-market specific demand shocks lowered stock returns. They also found that unexpected increases in the global aggregate demand for industrial commodities raised oil prices and stock prices. Increases in global oil production, on the other hand, had a much smaller impact on stock returns.

Ready (2018), citing articles by Chen, Roll, and Ross (1986), Kilian and Park (2009), Huang, Masulis, and Stoll (1996), and others noted that authors sometimes found relations between oil prices and stock returns at various leads and lags but found only weak evidence of contemporaneous impacts. He asked where the oil price beta is. Ready identified demand shocks as returns to an index of oil producing firms that are orthogonal to innovations in the VIX index and supply shocks as oil price changes that are orthogonal to demand shocks and to changes in the VIX. Using monthly regressions over the 1986 to 2011 period, he found that oil price increases driven by supply shocks decrease aggregate returns and oil price increases driven by demand shocks increase aggregate returns. He also reported almost all stocks but especially consumer stocks are negatively impacted by oil supply shocks. He interpreted these results as implying that oil supply shocks work primarily by influencing consumer spending.

This study focuses on the contemporaneous response of stock returns to oil price changes and examines whether the response has changed before and after U.S. oil production surged in

2010. To do this it first uses Bernanke (2016) and Hamilton's (2014) approaches and daily data to distinguish between oil price changes due to demand and supply factors. The results indicate that after 2010 oil price increases driven by both demand and supply factors increase aggregate stock prices in the U.S. Before the SR, price increases driven by demand reduced aggregate stock prices while increases driven by supply factors had no effect. To shed light on why these responses differed before and after the SR the paper investigates how oil shocks affected industry stock returns. The coefficient on supply-driven oil price increases went from negative to positive for industrial machinery, industrial engineering, chemicals, commercial vehicles, and other sectors.

This paper then uses Kilian and Park's approach (2009) and monthly data to distinguish between oil price changes due to demand and supply factors. As Kilian and Park also found, the results indicate that orthogonalized oil price increases lowered stock returns before the SR. After 2010, however, they did not. Many of the sectors whose coefficients on supply-driven oil price increases changed from being negative to positive also had coefficients on orthogonalized shocks to oil prices that went from being negative to positive. These include industrial machinery, industrial engineering, chemicals, and commercial vehicles. Over the 1990-2007 sample period 30 industries were harmed by higher oil prices and six benefited while over the 2010-2018 period only seven were harmed and 11 benefited.

The paper next uses Ready's (2018) approach and daily data to calculate demand-driven and supply-driven oil price changes. When oil production was falling the coefficients on oil shocks driven by both supply and demand side factors were negative and insignificant for the aggregate stock market. After shale oil production soared these coefficients were both positive and were statistically significant for demand shocks. Examining supply-driven oil price shocks, over the 1990-2007 period 26 sectors were harmed by oil price increases and eight sectors benefited. Over the 2010-2018 period six were harmed and six benefited. This follows the pattern using Kilian and Park's (2009) approach that indicated that supply-driven increases in oil prices were negative for many stocks before the SR but not after. Among the industries that were harmed before the increase in oil production but not after are industrial machinery, industrial engineering, commercial vehicles, and many consumer-oriented stocks.

Finally this investigation revisits the question that Chen, Roll, and Ross (1986) studied of whether crude oil prices are a priced factor in a multi-factor asset pricing framework. To do this it employs iterated nonlinear seemingly unrelated regression techniques to estimate whether there is an economy-wide risk premium associated with oil prices. The results indicate that the risk price associated with the price of crude oil is negative and statistically significant both before and after the shale revolution. This implies that oil prices are a state variable that influences the macroeconomy.

This study builds on the ones discussed above by examining whether the response of U.S. stock prices to oil prices differed before and after the shale revolution. Using several identification strategies, the findings indicate that oil price increases reduced financial wealth by lowering aggregate stock prices over the 1990-2007 period but did not have this effect after U.S. oil production accelerated in 2010.

The next section builds on Bernanke's (2016) and Hamilton's (2014) approaches and uses daily data to investigate how oil prices affect stock returns. Section 3 modifies Kilian and Park's (2009) approach and uses a monthly vector autoregression to examine oil market shocks and returns. Section 4 employs Ready's (2018) approach to examine these issues. Section 5 tests whether oil prices are a systematic factor in a multi-factor pricing model. Section 6 concludes.

2. Oil Prices and Stock Returns: Evidence from Hamilton and Bernanke's Approach

2.1 Data and Methodology

Bernanke (2016), Hamilton (2014) and others have highlighted a fundamental identification problem when investigating how oil prices affect the economy. Not only can oil prices affect the economy but weakness in the global economy can depress oil prices. Thus oil prices are endogenous. Hamilton noted that other financial variables are sensitive indicators of changes in global growth. For instance, during a slowdown, copper prices tend to fall. Hamilton employed the first differences of the log of copper prices, the ten-year Treasury constant maturity interest rate, and the log of the trade-weighted dollar exchange rate to measure the effects of demand on oil prices. He noted that high frequency changes in these variables are correlated with changes in the global demand for oil but uncorrelated with changes in the global supply of oil.

Daily changes in the log of the U.S. dollar price of West Texas Intermediate (WTI) crude oil are thus regressed on these variables to capture the change in oil prices driven by demand factors. WTI prices are a benchmark for oil prices in the United States. The residual from the regression then represents the change in oil prices driven by supply and other factors.

These demand and supply components of changes in oil prices are included as explanatory variables to explain industry stock returns. To control for other factors, the return on the world stock market index, the return on the aggregate U.S. stock market index, the change in the log of the Federal Reserve Board nominal effective exchange rate against major currencies, the change in the log of the VIX Index, and a variable measuring expansionary monetary and financial policy measures enacted in response to the GFC are also included. This last variable is a dummy variable equaling 1 on the dates that Roache and Rousset (2013) highlighted as the standard event dates for unconventional monetary policy and 0 otherwise. The estimated equation takes the form:

$$\Delta R_{i,t} = \alpha_0 + \alpha_1 \Delta WTI_{DD,t} + \alpha_2 \Delta WTI_{SS,t} + \alpha_3 \Delta R_{World,t} + \alpha_4 \Delta R_{US,t} + \alpha_5 \Delta NEER_{US,t} + \alpha_6 \Delta VIX_{US,t} + \alpha_7 UMP_t \quad (1)$$

where $\Delta R_{i,t}$ is the change in the log of the stock price index for industry i, $\Delta WTI_{DD,t}$ is the component of the change in the log of the spot price of WTI crude oil explained by demand factors, $\Delta WTI_{SS,t}$ is the component of the change in the log of the spot price of WTI crude oil explained by supply factors, $\Delta R_{World,t}$ is the change in the log of the price index for the aggregate world stock market, $\Delta R_{US,t}$ is the change in the log of the price for the aggregate U.S. stock market index, $\Delta NEER_{j,t}$ is the change in the log of the Federal Reserve Board nominal effective exchange rate against major currencies, $\Delta VIX_{US,t}$ is the change in the log of the Chicago Board Options Exchange volatility index, and UMP_t is news about unconventional monetary policy. The focus in this paper is on α_1 and α_2, the effects of demand-driven and supply-driven oil price changes on industry stock returns. Positive coefficients on α_1 and α_2 imply that oil price increases driven by demand factors and supply factors, respectively, will increase returns on industry i.

Data on the nominal effective exchange rate come from the Federal Reserve Bank of St. Louis FRED database and data on the other variables come from the Datastream database and from Roache and Rousset (2013). Daily data are available from January 1990 to September 2018. The sample is split into two subsamples, one before the SR began and one after. The pre-

SR subsample period extends from January 3, 1990 to June 1, 2007. The post-SR sample period extends from June 1, 2010 to September 28, 2018. As Figure 1 shows, U.S. oil production fell persistently during the first sample period and soared during the second sample period. The period of the GFC is excluded because it contained wild swings in both oil prices and stock returns that might interfere with inference.

2.2 Results

The first row of results in Table 1 presents the findings from estimating equation (1) with the return on the U.S. aggregate stock market index as the left-hand side variable. Columns (2) through (5) present results after the SR began and columns (6) though (9) for the pre-SR period. Before the SR, column (8) shows that demand-driven increases in oil prices lowered aggregate stock returns. After the SR began, column (4) shows that demand-driven increases raised returns. Before the SR, column (6) shows that supply-driven increases in oil prices did not have a statistically significant effect on aggregate returns. The coefficient is negative though. After the SR, column (2) shows that supply-driven increases raised returns. Standard hypothesis tests indicate that the post-SR demand-driven coefficient is statistically different from the pre-SR coefficient at the 1% level and the post-SR supply-driven coefficient is different from the pre-SR coefficient at the 5% level.

The negative coefficients on oil prices before the SR correspond to the conventional wisdom that oil price increases would disrupt the macroeconomies of oil-importing countries and lower aggregate equity returns (see IMF, 2014). From this perspective the positive coefficients after 2010 are puzzling, especially for supply-driven oil price increases.

Table 1 also presents findings for disaggregated equity returns from estimating equation (1). The results indicate that stocks in the energy sector benefit from demand- and supply-driven oil prices increases in both periods. These include oil and gas production and oil equipment, services, and distribution. Coal, a substitute for oil in the energy mix, also benefits from higher oil prices. Gold mining companies benefit from higher oil prices. Gold mining stocks are a hedge against inflation, and gain because higher oil prices raise inflation. [2]

Stocks in industries catering to consumers and those using oil intensively as an input are harmed by oil price increases before and after the shale revolution. These include airlines, hotels, restaurants & bars, and the retail sector.

To understand why the coefficients on oil prices for aggregate stock returns are positive and significant after the SR and negative before, it is helpful to examine the industries whose oil price betas exhibited statistically significant increases during the post-SR period relative to the pre-SR period. Examining first supply-driven oil price shocks, the coefficients on oil and gas production stocks became larger after the SR. The increase in U.S. crude oil production with the advent of light, tight oil caused the oil industry to benefit more from higher oil prices in recent years. The coefficients on industrial machinery and industrial engineering also changed from negative before the SR to positive and significant after. As domestic oil production has increased, spending by oil producers and other firms on industrial machinery and other capital goods has increased. Melek (2018) found that after the shale boom but not before, increased capital expenditures by oil producers triggered increased capital expenditures by non-oil producers. The coefficient on marine transportation remained positive after the SR but became

[2] Obstfeld, Milesi-Ferretti, and Arezki (2016) reported that oil prices are closely related to 5-year expected inflation. Frankel (2008) found that increases in expected inflation raise the prices of gold, silver and other sensitive commodities.

larger statistically, reflecting the beneficial effects of higher oil prices on companies transporting oil. The coefficient on the chemical industry changed from negative and significant to positive and significant, reflecting the growing importance of the petrochemical industry within the chemical sector and of chemicals as an input to shale oil production. Finally, the coefficient on commercial vehicles changed from negative and significant to positive and significant, reflecting increased demand for buses and other energy saving vehicles following oil price increases in recent years.

Turning to oil price shocks driven by demand, comparing columns (4) and (8) indicates that consumer-oriented stocks such as personal goods, household goods, and food and beverage are much less harmed (helped) by demand-driven increases (decreases) in price after the SR than before the SR. The difference between the pre-SR and post-SR coefficients for these sectors is statistically significant. This may indicate that consumers' marginal propensity to spend windfall gains from lower oil prices has dropped in recent years. In addition, the coefficient on the financial sector was negative and large in absolute value before the SR and positive and large after the SR. This reflects the observations of Obstfeld, Milesi-Ferretti, and Arezki (2016) and Bernanke (2016) that oil price falls after the shale revolution can damage the creditworthiness of oil-producing companies and harm the financial sector.

3. Oil Prices and Stock Returns: Vector Autoregression Evidence

3.1 Data and Methodology

Kilian and Park (2009) sought to disentangle supply and demand effects on oil prices using a VAR including global crude oil production, an index of real economic activity to capture global commodity demand, and crude oil prices. Their data on crude oil production came from the U.S. Energy Information Agency.[3] For the index of global economic activity in industrial commodity markets, they used data on dry cargo bulk freight rates. They observed that freight rates are a good indicator of global demand for commodities.[4]

Kilian and Park (2009) posited that crude oil supply will not respond within the same month to shocks to demand. They also argued that oil price shocks will not affect the global demand for commodities within the same month. In this paper it is also assumed that the return on the world stock market is influenced by so many factors that it can be placed before the oil market in a recursive ordering. In addition, Kang and Rutti (2013) and others reported no feedback within a month from U.S. macroeconomic variables to the price of oil. Thus it is assumed that the change in the log of the VIX index, the return on the aggregate U.S. stock market, and the nominal effective exchange rate can be placed after the oil market variables in the causal ordering. Finally, it is assumed that individual industry stock returns can be placed last. These assumptions imply that a monthly VAR can be estimated using the Cholesky decomposition with the variables ordered as follows: return on the world stock market, log change in oil supply, dry cargo bulk freight rates, log change in crude oil price, log change in the VIX index, return on the domestic stock market, log change in the effective exchange rate, and return on the individual industry.

Shocks to the price of oil in this specification reflect any factors not captured by the same month's change in the world stock market, the production of oil, or the aggregate demand for commodities. It thus reflects factors such an increase in precautionary purchases of oil due to

[3] The website is https://www.eia.gov/ .
[4] Kilian and Park (2009) provide details concerning the construction of the series. The data are available at: http://www-personal.umich.edu/~lkilian/paperlinks.html .

fears of future supply disruptions. It resembles the shocks to oil supply reported in the previous section.

A VAR is a regression of a vector of endogenous variables, y_t, on lagged values of itself:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + \varepsilon_t, \ E(\varepsilon_t \varepsilon_t') = \Sigma. \quad (2)$$

Equation (2) can be inverted and represented as an infinite-vector moving average process:

$$y_t = \varepsilon_t + C_1 \varepsilon_{t-1} + C_2 \varepsilon_{t-2} + C_3 \varepsilon_{t-3} + ... \quad (3)$$

Since the individual error terms in ε_t may be contemporaneously correlated, the Cholesky factorization can produce orthogonalized innovations. This method involves finding a lower triangular matrix P such that $\Sigma = PP'$, where Σ is the variance-covariance matrix of ε_t. Equation (3) can be rewritten as:

$$y_t = PP^{-1}\varepsilon_t + C_1 PP^{-1}\varepsilon_{t-1} + C_2 PP^{-1}\varepsilon_{t-2} + ... = \Gamma_0 \upsilon_t + \Gamma_1 \upsilon_{t-1} + \Gamma_2 \upsilon_{t-2} + ... \quad (4)$$

where $\Gamma_i = C_i P$, $\upsilon_t = P^{-1}\varepsilon_t$ and $E[\upsilon_t \upsilon_t'] = I$. Equation (4) represents the endogenous variables as functions of the orthogonalized residuals. Here the responses of industry stock returns (the last component of y_t) to shocks to oil production, bulk freight rates, and oil prices (the second, third, and fourth components of υ_t) are examined. Since investors will quickly capitalize the implications of oil market shocks for future cash flows and discount factors, the focus is on the initial period response of stock returns to the oil market shocks.

The VAR is estimated over the pre-SR period (January 1990 - June 2007) and the period after the SR began (June 2010 – June 2018). The number of lags is determined by the Schwarz information criterion.

3.2 Results

The first row of Table 2 presents the responses of the aggregate market in the initial period to orthogonalized shocks to oil production, bulk freight rates, and oil prices. Columns (2) through (4) present the responses after the SR and columns (5) through (7) report the responses before the SR. Comparing columns (2) and (5) indicates that the response of the market to shocks to oil production are of similar magnitude before and after the surge in oil production, although the response is statistically significant after. Comparing columns (3) and (6) indicates that the response of the market to bulk freight rates is close to zero in both periods. Comparing columns (4) and (7) indicates that orthogonalized innovations in oil prices decreased aggregate stock returns before the SR but did not affect them after.

To understand the response of aggregate stock returns to oil price innovations in columns (4) and (7), it is again helpful to look at results disaggregated by industry. Over both periods stocks in the oil sector benefit from higher oil prices and stocks in industries using oil intensively or catering to consumers (e.g., airlines and retail) are harmed. It is worth noting, though, that before the SR 30 industries were harmed by higher oil prices and six benefited while after only six were harmed and 11 benefited.

Many of the sectors whose coefficients on supply-driven oil price increases in Table 1 changed from being negative to positive also had coefficients on orthogonalized shocks to oil prices in Table 2 that went from being negative to positive. These include industrial machinery, industrial engineering, chemicals, commercial vehicles and marine transportation. In addition, many consumer-oriented stocks such as leisure goods, hotels, and food & beverage, and travel & tourism are much less exposed to orthogonalized oil price increases after the SR than before.

4. Oil Prices and Stock Returns: Evidence from Ready's Approach

4.1 Data and Methodology

Ready (2018) developed an innovative method to decompose oil price changes into those due to demand factors and those due to supply factors. He reasoned that oil producers would benefit from price increases due to oil demand, but have a natural hedge against supply difficulties. If oil becomes more difficult to produce, producers will sell less, but at higher prices. These two effects will tend to offset each other.

Following Ready's (2018) identification strategy, demand shocks are the portion of returns on an index of oil producing firms that are orthogonal to unexpected changes in the VIX index. He included innovations in the VIX index to control for aggregate changes in discount rates. Supply shocks are the portion of the change in oil prices that are orthogonal to unexpected changes in the VIX and to demand shocks.

Unexpected changes in the VIX are calculated using an autoregressive moving average (1,1) (ARMA(1,1)) model (see Ready, 2018). The return on an index of oil producing firms is captured using the World Integrated Oil and Gas Producer Index from the Datastream database. This index includes large publicly traded oil producing companies but not nationalized oil producers. This measure should thus be a sensitive indicator of the factors affecting oil producers. The change in the log of WTI crude oil prices is used when calculating supply shocks.

Ready's (2018) measures of demand shocks, supply shocks, and innovations in the VIX are then included in a regression similar to the one employed in Section 2:

$$\Delta R_{i,t} = \alpha_0 + \alpha_1 \Delta DD_t + \alpha_2 \Delta SS_t + \alpha_3 \Delta R_{World,t} + \alpha_4 \Delta R_{US,t} + \alpha_5 \Delta NEER_{US,t} + \alpha_6 UVIX_{US,t} + \alpha_7 UMP_t , \quad (5)$$

where $\Delta R_{i,t}$ is the change in the log of the stock price index for industry i, ΔDD_t is the demand shock, ΔSS_t is the supply shock, $\Delta R_{World,t}$ is the change in the log of the price index for the aggregate world stock market, $\Delta R_{US,t}$ is the change in the log of the price for the aggregate U.S. stock market index, $\Delta NEER_{j,t}$ is the change in the log of the Federal Reserve Board nominal effective exchange rate against major currencies, UVIX is the innovation in the VIX index calculated from an ARMA(1,1) model, and UMP is news about unconventional monetary policy. The focus is again on α_1 and α_2, the effects of demand and supply shocks to industry stock returns.[5] A positive coefficient on α_1 indicates that an increase in the demand for oil will raise the return on industry i and a positive coefficient on α_2 implies that an increase in the price of WTI driven by supply factors will raise the return on industry i.

Daily data are employed. The sample is again split into a pre-SR sample (3 January 1990 to 1 June 2007) and a post-SR sample (1 June 2010 to 28 September 2018).

4.2 Results

The first row of Table 3 presents the results from estimating equation (5) with the return on the aggregate market index as the left-hand side variable. Columns (2) through (5) present results for the period after the SR began and columns (6) though (9) for the pre-SR period. Columns (6) and (8) indicate that before the SR the coefficients on oil shocks driven by both supply and demand side factors are negative and insignificant for the aggregate stock market.

[5] The values of α_1 and α_2 are similar whether the change in the log of the VIX index is used, as in Section (2), or the unexpected change in the VIX from an ARMA (1,1) model is used.

Columns (2) and (4) indicate that after the SR these coefficients are both positive and are statistically significant for demand shocks.

Examining supply-driven oil price shocks, column (6) shows that before the SR 26 sectors were harmed by oil price increases and eight sectors benefited. After the SR column (2) shows that six were harmed and six benefited. This follows the pattern from the previous two sections indicating that supply-driven increases in oil prices were negative for many sectors before the SR but not after. Among the industries that were harmed before the SR but not after are industrial machinery, industrial engineering, commercial vehicles, and many consumer-oriented stocks such as retailers, food & beverage, and restaurants & bars. For all of these sectors, statistical tests indicate that the coefficients are greater after the SR than before.

The results for demand shocks in columns (4) and (8) indicate that stocks in the energy and mining sectors benefit from positive shocks both before and after the SR and airlines and consumer-oriented stocks are harmed. Before the SR 33 of the 46 stocks exhibited statistically significant responses to demand-driven oil shocks and after the SR 37 of the 46 did.

5. Oil Prices and Ex-Ante Returns

5.1 Data and Methodology

The evidence that the price of oil matters for so many stocks suggests that it might be a priced factor in a multi-factor asset pricing model. Chen, Roll, and Ross (1986) investigated this question over the 1958-1984 period and reported that it was not. This section investigates this question for the 1990-2016 period.

In a multi-factor framework an asset's *ex-ante* expected return equals the risk-free rate plus the inner product of a vector of betas with a vector of risk premia:

$$E_i = \lambda_0 + \sum_{j=1}^{K} \beta_{ij} \lambda_j \tag{6}$$

where E_i is the *ex-ante* return on asset i, λ_0 is the risk-free rate, β_{ij} is the factor loading of asset i to factor j, and λ_j is the risk premium associated with factor j. The *ex-post* return then equals the sum of the *ex-ante* return, a beta-weighted vector of innovations in the macroeconomic variables, and an error term measuring idiosyncratic risks:

$$R_i = \lambda_0 + \sum_{j=1}^{K} \beta_{ij} \lambda_j + \sum_{j=1}^{K} \beta_{ij} f_j + \varepsilon_i \tag{7}$$

where f_j represents news about state variable j and ε_i is a mean-zero error term.

McElroy and Burmeister (1988) employed Gallant's (1975) iterated nonlinear seemingly unrelated regression technique to estimate the risk premia and the factor loadings. They stacked equation (7) for all N assets and estimated the model as a system. This method allowed them to estimate simultaneously the λ's and the β's and to impose the nonlinear cross-equation restrictions that the intercept terms depend on the λ's. This technique delivers consistent estimates of the risk premia and the betas.

The left-hand side variables are excess returns on 60 assets. In order to increase the cross sectional variation of the beta coefficients, returns on commodities such as gold and silver are employed together with returns on stock market indices for various industries. The returns on one-month Treasury bills, obtained from Duff and Phelps (2017), are subtracted from asset returns to obtain excess returns.

The data on the systematic factors follow Chen, Roll, and Ross (1986). They employed the Treasury bond/Treasury bill spread (the horizon premium), the corporate bond/Treasury bond spread (the default premium), the monthly growth rate in industrial production, unexpected inflation, and the change in expected inflation. Following Boudoukh, Richardson, and Whitelaw (1994), unexpected inflation is calculated as the residuals of a regression of inflation on lagged inflation and current and lagged Treasury bill returns. The change in expected inflation is calculated as the first difference of the expected inflation series. They also included the change in the log of oil prices in some specifications. Chen, Roll, and Ross argued that each of the macroeconomic factors that they used, being either the difference between asset returns or very noisy, can be treated as innovations. The data to calculate the systematic factors come from Duff and Phelps (2017).

In preliminary analysis, there was no evidence that the change in expected inflation is a priced factor. This was thus replaced by the change in the log of the price of WTI crude oil. The estimation was performed over the pre-SR period (January 1990 – June 2007) the post-SR period (June 2010 – December 2016), and the entire January 1990 to December 2016 period. The sample period was truncated at December 2016 because data on the systematic macro variables from Duff and Phelps (2017) were available until this date.

5.2 Results

Table 4 presents estimates of the risk premia. The risk price associated with the price of crude oil is negative and statistically significant over all three periods. The negative coefficients imply that an asset that does well when oil prices increase can pay a discount to its *ex-ante* expected return. An asset whose return increases by 0.2 percent in response to a 1 percent increase in oil prices, for example, could pay a discount on its monthly return of 0.77 percent over the 1990-2007 period (equals 0.2 times -0.0386) and a discount of 1.2 percent over the 2010-2016 period (equals 0.2 times -0.0603). On the other hand, an asset whose return falls by 0.2 percent in response to a 1 percent increase in oil prices would have to pay an additional return of 0.77 percent over the 1990-2007 period and an additional return of 1.2 percent over the 2010-2016 period.

The results in Sections 2 through 4 indicate that many assets became less exposed to oil price increases after the SR. Thus fewer assets after 2010 have to pay positive increments to their expected returns to compensate for their exposure to oil price increases. The mechanism that causes *ex-ante* expected returns to fall is for stock prices to rise. Thus the fact that the risk price associated with oil is negative and that many assets are less exposed to oil price increases after the SR implies that stock prices can be higher for these assets.

The important implication of the results in this section is that oil prices are a systematic variable that affects asset returns. This implies that oil prices do not just matter for a few sectors such as energy or consumer goods but that they are a state variable that influences the overall macroeconomy.

6. Conclusion

Oil supply disruptions in oil-importing countries may decrease aggregate supply and act as a tax on consumers and firms. Because of this, the IMF's (2014) G20 economic model reported that a 20 percent increase in oil prices after the shale revolution would raise inflation in advanced economies by between 0.5 and 0.8 percentage points, lower GDP by between 0.4 and 1.9 percent, and decrease aggregate equity prices by between 3 and 8 percent.

This paper investigated how oil price increases driven by supply and demand factors affect U.S. stock returns. Results from several identification strategies indicate that supply-driven increases in oil prices harmed stock returns over the 1990-2007 period, but that these effects were attenuated or even reversed over the 2010-2018 period. Industries that provide inputs or services to the energy sector such as industrial machinery and marine transport, industries in the oil supply chain such as petrochemicals, and industries producing energy-saving devices such as buses gain from higher oil prices after the shale revolution. In addition, in many specifications consumer-oriented stocks are harmed less by oil price increases after the SR than they were before.

How can we interpret these findings? They indicate that the conventional view that oil price increases harm the overall U.S. stock market no longer holds. This is because, as U.S.-based shale oil production has soared, the structure of the economy has changed. Stocks in many sectors that were harmed by oil price increases before the shale revolution benefit from them now.

Black (1987, p. 113) observed that "The sector-by-sector behavior of stocks is useful in predicting sector-by-sector changes in output, profits, or investment. When stocks in a given sector go up, more often than not that sector will show a rise in sales, earnings, and outlays for plant and equipment." Future research should investigate how oil price changes affected sectoral output, profits, and investment before and after the shale revolution. It should also investigate whether consumers' marginal propensity to spend windfall gains from lower oil prices has decreased in recent years. Finally, it should investigate the relationship between increased investment by oil producing companies and investment by non-oil producing companies after the shale boom (see Melek, 2018).

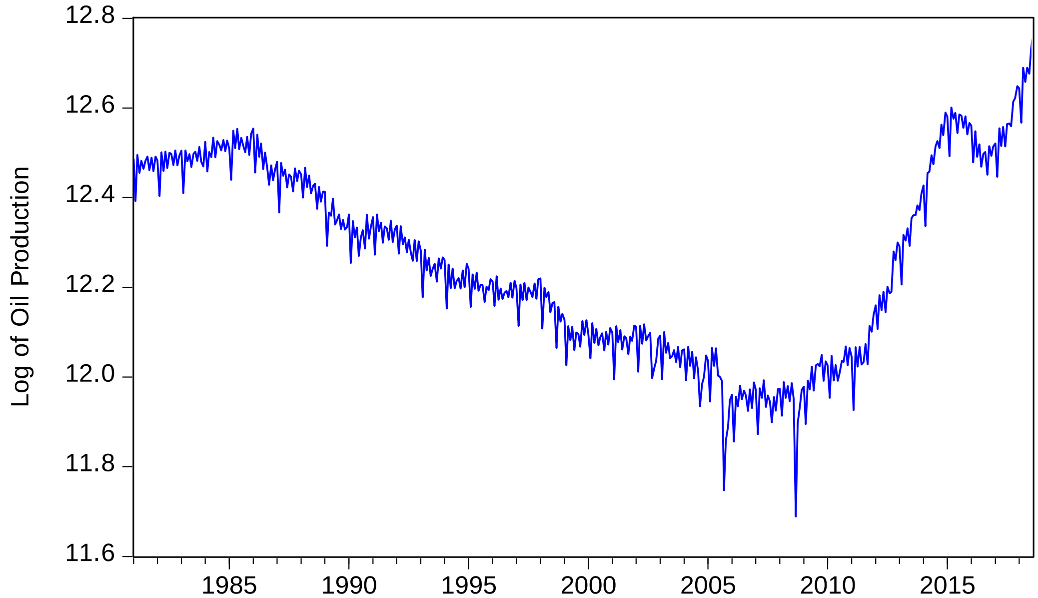

Fig.1. U.S. Crude Oil Production.
Source: U.S. Energy Information Agency.

Table 1
The effect of oil price shocks and other variables of U.S. aggregate and industry stock market returns before and after the shale revolution.

	June 2010 - September 2018				January 1990 – June 2007			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Portfolio	Beta to Supply-Driven Oil Price Increase	Probability Value	Beta to Demand-Driven Oil Price Increase	Probability Value	Beta to Supply-Driven Oil Price Increase	Probability Value	Beta to Demand-Driven Oil Price Increase	Probability Value
Aggregate Stock Market	0.0135**	0.016	0.0544***	0.001	-0.00330	0.387	-0.2610***	0
Airlines	-0.199***	0	-0.355***	0	-0.0885***	0	-0.0415	0.796
Auto & Parts	-0.0224*	0.0558	0.0953***	0.0029	-0.0167***	0.0075	0.281**	0.0161
Chemicals	0.0358***	0	0.146***	0	-0.0246***	0.0001	0.263***	0.0041
Coal	0.384***	0	0.661***	0	0.194***	0	1.24***	0.0022
Commercial Vehicles and Trucks	0.0379***	0.0001	0.285***	0	-0.0179**	0.0276	0.409***	0.0019
Construction & Materials	0.00734	0.374	0.0837**	0.0112	-0.00804	0.246	-0.068	0.585
Delivery Services	-0.0314	0.0004	0.0245	0.42	-0.0379***	0.0006	-0.172	0.251
Electricity	-0.00805	0.409	-0.323***	0	0.000329	0.954	-0.656***	0
Electronic & Electrical Equipment	-0.00368	0.557	0.112***	0	-0.00947*	0.0725	0.383***	0
Financials	-0.0270***	0	0.0937***	0	-0.0207***	0	-0.444***	0
Food & Beverage	-0.0106	0.124	-0.153***	0	-0.0362***	0	-0.523***	0
Forestry & Paper	0.00102	0.927	0.0522	0.167	-0.0114	0.112	0.360***	0.0032
Gambling	0.00795	0.678	0.0882	0.1318	-0.0315**	0.0258	0.0295	0.883
Gas Distributors	0.0628***	0	-0.127***	0	0.0643***	0	0.132	0.214
General Industrials	-0.00928	0.164	0.0567***	0.0021	-0.0128**	0.0501	0.277***	0.0009
General Retailers	-0.0339***	0	-0.0844***	0.0001	-0.0465***	0	-0.180*	0.0566
Gold Mining	0.147***	0	-0.0457	0.599	0.125***	0	1.39***	0
Health Care Equipment and Services	-0.0332***	0	-0.0628***	0.0018	-0.0161***	0.0037	-0.321***	0.0001
Hotels	-0.0360***	0.0012	0.0364	0.329	-0.0293***	0.0099	0.172	0.275
Household Goods, Home Construction	-0.0197***	0.0042	-0.123***	0	-0.0335***	0.0001	-0.571***	0
Industrial Engineering	0.0340***	0	0.234***	0	-0.00679	0.167	0.317***	0.0002
Industrial Goods and Services	-0.00910**	0.026	0.0767***	0	-0.0144***	0	0.151***	0.0011
Industrial Machinery	0.0306***	0.0002	0.180***	0	-0.00993*	0.1005	0.363***	0.0006
Industrial Metals & Mines	0.117***	0	0.705***	0	0.0213**	0.0206	1.59***	0

Industrial Transpor-tation	-0.0083	0.335	0.0605**	0.0127	-0.0290***	0	0.0131	0.887
Leisure Goods	-0.0282**	0.0116	-0.0295	0.438	-0.0261***	0	0.113868	0.158
Marine Transpor-tation	0.124***	0	0.207***	0.0016	0.0123	0.456	0.206	0.3
Media	-0.0179**	0.0145	0.0127	0.56	-0.00275	0.539	0.193***	0.0041
Mining	0.149***	0	0.133**	0.0489	0.136***	0	1.60***	0
Oil & Gas Production	0.234***	0	0.247***	0	0.155***	0	0.307**	0.012
Oil Equipment, Services, and Distribution	0.244***	0	0.187***	0	0.202***	0	0.669***	0
Personal Goods	-0.0116	0.162	-0.0505*	0.0521	-0.0368***	0	-0.585***	0
Pharmaceu-ticals & Biotech-nology	-0.0399***	0	-0.0855**	0.0133	-0.0239***	0.0009	-0.386***	0
Railroads	0.00535	0.715	0.0929**	0.018	-0.0122	0.11	0.0961	0.425
Real Estate	-0.0171*	0.0541	-0.290***	0	-0.0185***	0.0028	-0.390***	0
Recreational Services	-0.108***	0	0.0542	0.236	-0.0251***	0.0039	0.000854	0.995
Restaurants & Bars	-0.0298***	0.0001	-0.0747***	0.0033	-0.0287***	0.0013	-0.131	0.274
Retail	-0.0359***	0	-0.0819***	0	-0.0474***	0	-0.161*	0.0965
Software and Computer Services	-0.0231***	0.0005	-0.103***	0	0.00717	0.296	0.513***	0
Support Services	-0.0154***	0	0.0116	0.401	-0.0112*	0.066	0.0519	0.501
Technology Hardware and Equipment	-0.0146	0.111	-0.0262	0.364	0.00909	0.223	1.01***	0
Telecom-munication	-0.00813	0.398	-0.127***	0	-0.0132**	0.0465	-0.192**	0.0489
Transpor-tation Services	0.0269*	0.0623	0.0809**	0.0258	-0.0367***	0.0015	0.0953	0.531
Travel & Leisure	-0.0563	0	-0.0409*	0.0696	-0.0225***	0.0005	0.08	0.406
Travel and Tourism	-0.0223	0.118	0.0614	0.215	0.00327	0.834	0.472*	0.0578
Trucking	-0.0261**	0.026	0.0332	0.352	-0.0183***	0.0055	0.0326	0.75

Notes: The table reports the results from regressing the daily U.S. aggregate or industry stock returns on the log change in the price of West Texas Intermediate crude oil explained by demand and supply using the decomposition suggested by Hamilton (2014) and on the log change in the Chicago Board Options Exchange volatility index, the log change in the Federal Reserve Board nominal effective exchange rate, the return on the aggregate U.S. stock market, the return on the world stock market index, and a dummy variable equaling 1 on the dates that Roache and Rousset (2013) highlighted as the standard event dates for unconventional monetary policy and 0 otherwise. When the left-hand side variable is the return on the aggregate U.S. stock market, the return on the aggregate U.S. stock market is not included as a right-hand side variable. The sample period in columns (2) – (5) extends from 1/03/1990 to 6/01/2007 and the sample period in columns (6) through (9) extends from 6/01/2010 to 9/27/2018. Heteroskedasticity and serial correlation consistent standard errors are in parentheses.
*** (**)[*] denotes significance at the 1% (5%)[10%] levels.

Table 2
The response of U.S. aggregate and industry stock market returns to orthogonalized shocks to world oil production, world commodity demand, and crude oil prices before and after the shale revolution.

	June 2010 – June 2018			January 1990 – June 2007		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Portfolio	Response to World Oil Production Shock	Response to World Commodity Demand Shock	Response to WTI Crude Oil Price Shock	Response to World Oil Production Shock	Response to World Commodity Demand Shock	Response to WTI Crude Oil Price Shock
Aggregate Stock Market	0.0029** (0.0013)	0.00091 (0.0013)	-0.00040 (0.0012)	0.0025 (0.0015)	-0.000020 (0.0015)	-0.0033** (0.0015)
Airlines	0.0077 (0.0076)	0.0040 (0.0076)	-0.022*** (0.0074)	0.0065 (0.0047)	0.0036 (0.0047)	-0.021*** (0.0045)
Auto & Parts	0.0034 (0.0042)	0.00062 (0.0042)	-0.0018 (0.0042)	0.00022 (0.0036)	-0.0021 (0.0036)	-0.0089** (0.0035)
Chemicals	0.0013 (0.0025)	-0.0012 (0.0025)	0.0044* (0.0025)	-0.00032 (0.0027)	0.00052 (0.0027)	-0.0096*** (0.0027)
Coal	0.0086 (0.0012)	0.013 (0.012)	0.032*** (0.012)	0.00012 (0.013)	-0.014 (0.013)	0.030** (0.013)
Commercial Vehicles and Trucks	0.0078** (0.0040)	0.00079 (0.0040)	0.013*** (0.0038)	0.0030 (0.0040)	-0.0014 (0.0040)	-0.0089** (0.0040)
Construct-ion & Materials	0.0049 (0.0036)	-0.0015 (0.0035)	0.0025 (0.0035)	-0.00083 (0.0034)	0.00014 (0.0034)	-0.0094*** (0.0034)
Delivery Services	0.0069* (0.0038)	0.0079** (0.0037)	-0.0041 (0.0037)	0.0060 (0.0054)	0.0075 (0.0054)	-0.012** (0.0054)
Electricity	0.0022 (0.0035)	0.00021 (0.0035)	-0.0087** (0.0034)	0.0020 (0.0029)	0.0030 (0.0029)	-0.0030 (0.0029)
Electronic & Electrical Equipment	0.0037 (0.0029)	-0.0012 (0.0029)	0.0025 (0.0029)	0.0020 (0.0028)	-0.0010 (0.0028)	-0.0021 (0.0028)
Financials	0.0068 (0.0022)	0.00069 (0.0021)	-0.00043 (0.0021)	0.0025 (0.0027)	0.0038 (0.0027)	-0.012*** (0.0026)
Food & Beverage	-0.00078 (0.0023)	0.0026 (0.0023)	-0.0042* (0.0023)	0.0032 (0.0027)	0.00033 (0.0027)	-0.011*** (0.0027)
Forestry & Paper	0.00062 (0.0038)	-0.001363 (0.0038)	0.00095 (0.0038)	0.0000064 (0.0039)	-0.0014 (0.0039)	-0.0091** (0.0038)
Gambling	0.014 (0.0062)	0.00094 (0.0061)	-0.0032 (0.0061)	-0.0034 (0.0063)	0.0037 (0.0063)	0.00051 (0.0063)
Gas Distributors	0.0023 (0.0029)	0.0023 (0.0029)	0.0065** (0.0029)	0.0017 (0.0038)	0.0015 (0.0038)	0.011*** (0.0038)
General Industrials	0.0015 (0.0029)	-0.0015 (0.0029)	-0.0021 (0.0029)	0.0023 (0.0027)	0.0011 (0.0027)	-0.0060** (0.0027)
Gold Mining	-0.029** (0.010)	-0.025** (0.0098)	0.022** (0.0095)	-0.011* (0.0068)	0.0049 (0.0068)	0.021*** (0.0067)

Health Care Equipment and Services	0.0012 (0.0026)	-0.0026 (0.0026)	-0.0039 (0.0026)	0.0032 (0.0027)	-0.0019 (0.0027)	-0.0055** (0.0026)
Hotels	0.0021 (0.0041)	0.00093 (0.0041)	-0.00084 (0.0041)	0.0021 (0.0044)	-0.0010 (0.0044)	-0.012*** (0.0044)
Household Goods, Home Construct-ion	0.0017 (0.0030)	0.00071 (0.0030)	-0.0046 (0.0029)	0.0036 (0.0032)	-0.0033 (0.0032)	-0.0087*** (0.0032)
Industrial Engineering	0.0056 (0.0034)	0.00079 (0.0034)	0.010*** (0.0033)	0.0032 (0.0030)	-0.0022 (0.0030)	-0.0059** (0.0030)
Industrial Goods and Services	0.0041** (0.0021)	0.0011 (0.0020)	0.00023 (0.0020)	0.0022 (0.0014)	-0.0013 (0.0014)	-0.0031** (0.0014)
Industrial Machinery	0.0033 (0.0034)	0.00084 (0.0034)	0.0069** (0.0034)	0.00036 (0.0036)	-0.00017 (0.0036)	-0.010*** (0.0036)
Industrial Metals & Mines	0.0066 (0.0060)	0.0075 (0.0060)	0.019*** (0.0058)	-0.0031 (0.0044)	0.00012 (0.0043)	0.0038 (0.0043)
Industrial Transpor-tation	0.0039 (0.0033)	0.0092*** (0.0033)	-0.00036 (0.0032)	0.0012 (0.0030)	0.0018 (0.0030)	-0.010*** (0.0029)
Leisure Goods	-0.0023 (0.0034)	0.0037 (0.0034)	-0.0018 (0.0034)	0.0027 (0.0031)	0.00097 (0.0031)	-0.016*** (0.0030)
Marine Transpor-tation	-0.0048 (0.0066)	0.0052 (0.0066)	0.030*** (0.0062)	-0.012** (0.0056)	0.0013 (0.0055)	-0.0099* (0.0055)
Media	0.0013 (0.0028)	0.00055 (0.0028)	-0.0016 (0.0028)	-0.0019 (0.0025)	0.000049 (0.0025)	-0.0044* (0.0025)
Mining	-0.017* (0.0086)	-0.017** (0.0084)	0.024*** (0.0081)	-0.011* (0.0064)	0.0013 (0.0063)	0.021*** (0.0063)
Oil & Gas Production	0.0017 (0.0039)	0.00099 (0.0039)	0.022*** (0.0035)	0.000051 (0.0028)	0.0028 (0.0028)	0.017*** (0.0027)
Oil Equipment, Services, and Distribution	0.00022 (0.0042)	0.0045 (0.0041)	0.021*** (0.0038)	0.0015 (0.0044)	-0.00040 (0.0043)	0.023*** (0.0042)
Personal Goods	0.0056* (0.0029)	-0.00073 (0.0028)	-0.0033 (0.0028)	0.0035 (0.0031)	-0.0030 (0.0031)	-0.0074** (0.0031)
Pharma-ceuticals & Biotech-nology	0.0023 (0.0030)	0.0039 (0.0030)	-0.0076** (0.0029)	0.0053* (0.0031)	-0.0010 (0.0031)	-0.0076** (0.0031)
Railroads	0.00041 (0.0043)	0.011*** (0.0042)	0.0015 (0.0041)	-0.0035 (0.0037)	0.0018 (0.0037)	-0.0092** (0.0036)
Real Estate	0.0028 (0.0032)	-0.0041 (0.0031)	-0.0095*** (0.0030)	0.00034 (0.0032)	0.0016 (0.0032)	-0.011*** (0.0031)

Recrea-tional Services	0.013** (0.0053)	0.0079 (0.0052)	-0.016*** (0.0051)	0.0084** (0.003)	0.0018 (0.0038)	-0.014*** (0.0037)
Restaurants & Bars	0.0021 (0.0028)	0.0031 (0.0028)	-0.0038 (0.0028)	0.0030 (0.0034)	0.0035 (0.0034)	-0.0077** (0.0034)
Retail	0.0045* (0.0027)	0.0041 (0.0027)	-0.0059** (0.0026)	-0.0013 (0.0033)	-0.0020 (0.0033)	-0.015*** (0.0032)
Software and Computer Services	0.0013 (0.0025)	-0.00062 (0.0025)	-0.0040 (0.0025)	0.00045 (0.0041)	-0.0042 (0.0041)	-0.00039 (0.004)
Support Services	0.0035 (0.0018)	0.0016 (0.0018)	-0.0013 (0.0018)	-0.0061** (0.0025)	-0.0016 (0.0025)	-0.0075*** (0.0024)
Technology Hardware and Equipment	0.00033 (0.0037)	-0.0028 (0.0037)	-0.0017 (0.0037)	0.011** (0.0043)	-0.0036 (0.0043)	0.0024 (0.0043)
Telecomm-unication	-0.0063* (0.0035)	0.0039 (0.0035)	0.00096 (0.0035)	0.0074** (0.0033)	0.0053 (0.0033)	-0.0037 (0.0033)
Transpor-tation Services	0.0088* (0.0050)	0.013*** (0.0049)	0.0083* (0.0048)	-0.00093 (0.0050)	-0.0015 (0.0050)	-0.013** (0.0049)
Travel and Tourism	0.0032 (0.0058)	-0.0012 (0.0058)	0.0044 (0.0058)	-0.0060 (0.0067)	-0.0030 (0.0067)	-0.013* (0.0067)
Travel and Tourism	0.0032 (0.0058)	-0.0012 (0.0058)	0.0044 (0.0058)	-0.0060 (0.0067)	-0.0030 (0.0067)	-0.013* (0.0067)
Trucking	0.0072* (0.0043)	0.0013 (0.0043)	-0.0068 (0.0042)	-0.00090 (0.0033)	0.0013 (0.0033)	-0.0074** (0.0032)

Notes: Columns (2) through (4) and (5) through (7) report the response of stock returns in the initial period to one-standard deviation orthogonalized innovations to oil production, bulk freight rates, and oil prices. These responses come from an orthogonalized vector moving average process with the elements of the vector ordered as follows: return on the world stock market, world oil supply, dry cargo bulk freight rates, West Texas Intermediate (WTI) crude oil price, real effective exchange rate, return on the domestic stock market, and return on the individual sector. Analytic (asymptotic) standard errors are in parentheses.

*** (**) [*] denotes significance at the 1% (5%) [10%] levels.

Table 3
The effect of oil price shocks and other variables of U.S. aggregate and industry stock market returns before and after the shale revolution.

	June 2010 - September 2018				January 1990 – June 2007			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Portfolio	Beta to Supply-Driven Oil Price Increase	Probability Value	Beta to Demand-Driven Oil Price Increase	Probability Value	Beta to Supply-Driven Oil Price Increase	Probability Value	Beta to Demand-Driven Oil Price Increase	Probability Value
Aggregate Stock Market	0.00387	0.608	0.0796***	0	-0.00413	0.334	-0.0122	0.458
Airlines	-0.141***	0	-0.556***	0	-0.0743***	0	-0.212***	0
Auto & Parts	-0.0118	0.311	-0.0345	0.265	-0.0185***	0.0066	0.0222	0.453
Chemicals	-0.00202	0.815	0.237	0	-0.0462***	0	0.226***	0
Coal	0.0956***	0.0083	1.78***	0	0.0960***	0.0006	0.938***	0
Commercial Vehicles and Trucks	0.00610	0.608	0.262***	0	-0.0401***	0	0.244***	0
Construction & Materials	-0.00446	0.629	0.0825***	0.0008	-0.0313***	0	0.237***	0
Delivery Services	-0.0166	0.134	-0.0844***	0.0041	-0.0377***	0.0017	-0.0363	0.29
Electricity	-0.0239**	0.0315	-0.0553*	0.0605	-0.0237***	0.0001	0.220***	0
Electronic & Electrical Equipment	0.00817	0.253	-0.0143	0.451	0.0033	0.552	-0.121***	0
Financials	-0.0112*	0.0762	-0.0607***	0.0003	-0.0216***	0	-0.0271	0.158
Food & Beverage	0.00314	0.664	-0.117***	0	-0.0513***	0	0.108***	0.0004
Forestry & Paper	-0.00931	0.528	0.0593	0.121	-0.0304***	0.0001	0.212***	0
Gambling	-0.0145	0.504	0.126**	0.0286	-0.0241	0.102	-0.0976**	0.0407
Gas Distributors	-0.0149	0.155	0.321***	0	0.0180**	0.016	0.540***	0
General Industrials	-0.00977	0.186	0.0109	0.578	-0.0112	0.114	-0.0109	0.702
General Retailers	0.00368	0.619	-0.213***	0	-0.0390***	0	-0.120***	0.0001
Gold Mining	0.0318	0.302	0.595***	0	0.0710***	0.0007	0.729***	0
Health Care Equipment and Services	-0.00324	0.662	-0.175***	0	-0.0228***	0.0002	0.043	0.154
Hotels	0.00509	0.702	-0.191***	0	-0.0235*	0.0554	-0.0726*	0.0802
Household Goods, Home Construction	-0.00165	0.844	-0.131***	0	-0.0427***	0	0.0444	0.473
Industrial Engineering	0.0141	0.132	0.193***	0	-0.0250***	0	0.204***	0
Industrial Goods and Services	-0.00142	0.763	-0.0149	0.231	-0.0132***	0.0003	-0.0143	0.2958
Industrial Metals & Mines	0.0336*	0.061	0.692***	0	-0.0124	0.184	0.451***	0
Industrial Machinery	0.0233**	0.0102	0.121***	0	-0.0275***	0	0.197***	0

Industrial Transpor-tation	-0.0217**	0.0226	0.0649**	0.0103	-0.0359***	0	0.0535**	0.0421
Leisure Goods	0.00953	0.433	-0.190***	0	-0.0329***	0	0.0604**	0.0393
Marine Transpor-tation	0.0247	0.254	0.594***	0	-0.000825	0.962	0.156***	0.0002
Media	-0.0109	0.198	-0.0430*	0.0559	0.00351	0.469	-0.0578***	0.0029
Mining	0.00864	0.724	0.760***	0	0.0765***	0.0002	0.797***	0
Oil & Gas Production	0.0239***	0.0001	1.17***	0	0.0472***	0	1.26***	0
Oil Equipment, Services, and Distribution	0.0123	0.165	1.24***	0	0.0954***	0	1.29***	0
Personal Goods	0.0248***	0.0066	-0.175***	0	-0.0470***	0	0.0519	0.323
Pharmaceu-ticals & Biotech-nology	-0.0085	0.346	-0.194***	0	-0.0259***	0.0008	-0.014	0.681
Railroads	-0.0283**	0.0422	0.172***	0	-0.0326***	0	0.212***	0
Real Estate	-0.00723	0.484	-0.157***	0	-0.0291***	0	0.0798***	0.0005
Recreational Services	-0.0409***	0.0082	-0.364***	0	-0.0127	0.183	-0.148***	0.0001
Restaurants & Bars	0.00310	0.747	-0.188***	0	-0.0303***	0.0015	-0.0108	0.749
Retail	0.00039	0.9552	-0.209***	0	-0.0390***	0	-0.128***	0
Software and Computer Services	0.0173**	0.0317	-0.220***	0	0.0426***	0	-0.343***	0
Support Services	0.00910*	0.0820	-0.110***	0	-0.00913	0.15	-0.0263	0.247
Technology Hardware and Equipment	0.0208**	0.0395	-0.165***	0	0.0517***	0	-0.390***	0
Telecom-munication	-0.0107	0.317	-0.0414	0.146	-0.00844	0.2293	-0.0687**	0.0102
Transpor-tation Services	-0.0043	0.784	0.179***	0	-0.0465***	0.0002	0.0836*	0.0775
Travel & Leisure	-0.0179**	0.0215	-0.216***	0	-0.006	0.39	-0.185***	0
Travel and Tourism	0.0265	0.166	-0.198***	0.0001	0.0177	0.3095	-0.126**	0.0308
Trucking	-0.0233*	0.0847	-0.0264	0.462	-0.0300***	0	0.113***	0.0002

Notes: The table reports the results from regressing daily U.S. aggregate or industry stock returns on the log change in the price of West Texas Intermediate crude oil explained by demand and supply using the decomposition suggested by Ready (2018) and on the innovation in the Chicago Board Options Exchange volatility index calculated from an ARMA(1,1) model, the log change in the Federal Reserve Board nominal effective exchange rate, the return on the aggregate U.S. stock market, the return on the world stock market index, and a dummy variable equaling 1 on the dates that Roache and Rousset (2013) highlighted as the standard event dates for unconventional monetary policy and 0 otherwise. When the left-hand side variable is the return on the aggregate U.S. stock market, the return on the aggregate U.S. stock market is not included as a right-hand side variable. The sample period in columns (2) – (5) extends from 1/03/1990 to 6/01/2007 and the sample period in columns (6) through (9) extends from 6/01/2010 to 9/27/2018. Heteroskedasticity and serial correlation consistent standard errors are in parentheses.
*** (**)[*] denotes significance at the 1% (5%)[10%] levels.

Table 4

Iterated nonlinear seemingly unrelated regression estimates of the risk premiums associated with macroeconomic factors

(1)	(2)	(3)	(4)
	Sample Period		
Macroeconomic Factor	January 1990 – June 2007	June 2010 – December 2016	January 1990 – December 2016
Crude Oil Price	-0.0386** (0.0153)	-0.0603*** (0.0151)	-0.0146** (0.00722)
Unexpected Inflation	-0.000529 (0.000575)	-0.00665*** (0.00115)	-0.00168*** (0.000490)
Default Premium	-0.00161** (0.00146)	0.0198*** (0.00457)	0.00245* (0.00147)
Horizon Premium	0.00201 (0.00399)	-0.0208*** (0.00400)	-0.00774** (0.00270)
Industrial Production Growth	-0.0127*** (0.00279)	-0.00217*** (0.000710)	-0.00542*** (0.00110)

Notes: The table presents iterated nonlinear seemingly unrelated regression estimates of risk premia from a multi-factor model including returns on 60 assets on the left-hand side and the change in the log of West Texas Intermediate crude oil prices, unexpected inflation, the corporate bond/Treasury bond spread (the default premium), the Treasury bond/Treasury bill spread (the horizon premium), and the monthly growth rate in industrial production. Unexpected inflation is calculated using the method of Boudoukh *et al.* (1994). They calculated it as the residuals from a regression of inflation on lagged inflation and current and lagged Treasury bill returns.

*** (**) [*] denotes significance at the 1% (5%) [10%] levels.

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