# The effects of oil price shocks on U.S. stock order flow imbalances and stock returns

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**Abstract**

This paper investigates for the first time the effects of oil price shocks on stock order flow imbalances leading to changes in stock returns. Through the estimation of a structural VAR model, positive demand-related oil price shocks are able to explain almost 36% of the observed variation in the daily average stock order flow imbalances measured by the buy/sell trades ratio; which consequently lead to a negative rather than positive stock returns reaction. In contrast, oil supply shocks exhibit a negative and marginally significant effect on stock order flow imbalances. Our aggregate analysis suggests that positive shocks on stock order flow imbalances are negatively related to stock returns. These effects are stronger for oil-related sectors when compared with the rest of the equities sectors.

Key words: Oil price shocks, stock order flow imbalances, structural VAR.

JEL Classification: G10, G12, G14, G15, G40.

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**Abstract**

This paper investigates for the first time the effects of oil price shocks on stock order flow imbalances leading to changes in stock returns. Through the estimation of a structural VAR model, positive demand-related oil price shocks are able to explain almost 36% of the observed variation in the daily average stock order flow imbalances measured by the buy/sell trades ratio; which consequently lead to a negative rather than positive stock returns reaction. In contrast, oil supply shocks exhibit a negative and marginally significant effect on stock order flow imbalances. Our aggregate analysis suggests that positive shocks on stock order flow imbalances are negatively related to stock returns. These effects are stronger for oil-related sectors when compared with the rest of the equities sectors.

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# 1 Introduction

The relationship between oil prices and stock markets is an important issue for academics and industry professionals for long.[1] Kling (1985) was among the first who examined the interaction beween the two and revealed that an increase in crude oil prices is associated with a decline in stock prices.[2] A number of studies have revealed that oil and stock markets seem to respond to the same economic forces (Sadorsky, 1999; Barsky & Kilian, 2002, 2004; Hamilton, 2003; Kilian, 2008a,b). Subsequent studies have revealed that the *origin* of oil price shocks is important in assessing their impact on stock markets (Hamilton, 2009; Kilian, 2009; Kilian & Park, 2009). Specifically, Kilian (2009) dissagregates oil price shocks into three components, namely the supply-side oil price shocks which are caused by changes in world oil production, the demand-side oil price shocks which are caused by aggregate demand and the precautionary demand shocks (oil-specific demand shocks).[3] The author provides evidence that oil price increases may have very different effects on the real price of oil, depending on the underlying cause of the price increase. For example, an increase in aggregate demand for all industrial commodities causes a somewhat delayed, but sustained, increase in the real price of oil that is also substantial. In a related study, Kilian & Park (2009) reveal that oil price shocks of different origin have different effects on U.S. stock returns.[4] Specifically, the authors show that the crude oil's global demand and supply

[1] Oil price shocks form an important indicator of physical economic activity (Lardic & Mignon, 2008) and petroleum-based commodities (mainly crude oil, gasoline, heating oil) are essential to our economies primarily from an industrial perspective. The importance of crude oil is documented by the 91.19 million barrels of global daily consumption in 2013 as reported by the U.S. Energy Information Administration, accessed on December 6, 2015. (http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=5&aid=2&cid=ww,&syid=2010&eyid=2014 &unit=TBPD). In addition, oil futures contracts exhibit the largest volume numbers of trading on New York Mercantile Exchance (NYMEX). For these reasons, oil is considered widely by industry professionals as the leading commodity linked with the capital markets.

[2] However, later studies by Chen *et al.* (1986); Huang *et al.* (1996) failed to establish robust relationships between oil spot and future prices and US stock returns.

[3] Hamilton (2009) also dissagregates oil price shocks into two components, namely the demand-side oil price shocks which are caused by aggregate demand and supply-side oil price shocks which are caused by changes in world oil production.

[4] Kilian & Park (2009) argue the positive relationship between stock returns and aggregate demand shocks

shocks account for 22% of the long-run variation in U.S. real stock returns. Kilian & Vega (2010) support this finding by showing that energy prices do not respond instantaneously to macroeconomic news. Apart from the US stock market returns, different oil price shocks have been shown to affect: stock sector returns for the US and European stock markets (El Hedi Arouri *et al.*, 2011), stock market volatility (Degiannakis *et al.*, 2014) and bond markets (Kang *et al.*, 2014). The aforementioned studies provide evidence that oil prices and stock returns respond to a common factor, namely the global aggregate demand proxied by a shipping freight rates index constructed in Kilian (2009). An important question arising from the above rationale is whether stock traders respond symmetrically to changes in oil prices as the latter may serve as indicators of underlying global demand and growth.

Despite the plethora of studies examining the effects of different oil price shocks on capital markets to date there is no empirical investigation regarding the transmission mechanisms through which oil price shocks affect stock returns. This paper fulfills this gap in the literature by investigating for the first time the effects of different oil price shocks on investors' trading behavior, i.e. on triggering more/less buyer-initiated trades in comparison to seller-initiated trades. In order to compare buyer/seller-initiated trades we rely on the the *buy/sell ratio* (b/s) as our measure for the stock order flow imbalance.[5] We define *net buy pressure* when b/s $> 1$ and *net sell pressure* when b/s $< 1$. In addition, to make our results comparable with the previous literature on the issue (Kilian, 2009; Kilian & Park, 2009) we investigate the effect of oil-driven order flow imbalance shocks on stock returns.

Order flow imbalances have been shown to form a more intuitive measure of stock trading activity when compared to the widely used trading volume (Chordia & Subrahmanyam, 2004). Specifically, trading volume or other liquidity measures, such as

has been driven primarily by the stimulating effects of strong global demand for industrial commodities during 1975–2006.

[5]This ratio equals the dollar denominated volume of buyer-initiated trades over seller-initiated trades.

the Amihud (2002) illiquidity ratio, are not appropriate for the research question of this study because the impact of oil-price shocks on illiquidity ratio or volume is symmetrical in positive and negative shocks, i.e. liquidity may increase due to increased investors' trading activity triggered by both positive and negative oil-price news. For example, an oil price shock may increase illiquidity Amihud ratio through increased buy- or sell-initiated trades.[6] In this way, this paper contributes to the literature by extending Kilian & Park (2009) and revealing that in addition of not all oil price shocks being the same, neither stock price changes are the same, i.e. different oil price shocks trigger relatively more/less buyer/seller-initiated trades which eventually result into stock price movements.

Aggregate results presented in Table 1 show that in the long run, 36% of the variation in aggregate stock ratio during 1993-2011 can be attributed to crude oil's market shocks, making oil market fundamentals an important determinant of trades in the equity market. Almost four-fifths of this contribution is driven by demand-related oil price shocks, i.e. the contributions of global aggregate demand and oil-specific demand combined, even if the latter is generally thought to indicate uncertainty over future oil supply (Kilian, 2009). Oil supply related shocks have a negative and only marginally significant effect on the stock order flow imbalances of the equity market. Last, positive shocks on the stock order flow imbalances are negatively related to stock returns.

Also important for investors and traders in the capital markets is the response of the industry-specific stock order flow imbalance to demand and supply shocks in the crude oil market. Therefore, we investigate whether our findings vary within different sectors of the economy and reveal that global aggregate demand shocks are shown to affect more heavily the stock order flow imbalance of oil-heavy dependent industries,

[6] As Chordia & Subrahmanyam (2004) points out, a high stock order imbalance can affect stock returns due to the market maker's struggle to re-adjust their inventory of assets. Furthermore, high order imbalances indicate investors excess interest in a stock, which if autocorrelated, can relate current order imbalances with future stock returns. Investors can increase their diversificiation opportunities if they take account of security order flow information (Chelley-Steeley *et al.*, 2015).

such as Manufacturing[7] (sector code 3), Energy (sector code 4) and Others[8] (sector code 10). This empirical exercise is motivated by the related literature which provides strong evidence on the leading role of industries in the equities markets in general (Hong *et al.*, 2007) and in the oil-equity nexus in particular (Kilian & Park, 2009; El Hedi Arouri *et al.*, 2011). For instance, Kilian & Park (2009) show that stock returns of firms in the precious metals industry will appreciate in response to a positive oil-market specific demand shock, whereas petroleum and natural gas shares will barely appreciate. In addition, El Hedi Arouri *et al.* (2011) use the estimation framework of Kilian & Park (2009) to reveal that oil price shocks raise U.S. stock volatilities substantially more for oil-dependent sectors, such as Automobile and Parts, Basic Materials, Industrials and Utilities rather than for non-oil-dependent sectors, such as Telecommunications. Furthemore, Driesprong *et al.* (2008); Narayan & Sharma (2011) document that oil price contains information regarding the future evolution of stock returns, but the degree of this relationship varies across industries.

The rest of this paper is organized as follows. Section 2 provides the theoretical background along with the research design of the paper; section 3 outlines the methodology; section 4 describes the dataset; section 5 presents the results and section 6 concludes the paper.

## 2 Theoretical background and research design

This study explores the transmission mechanism through which oil price shocks affects stock returns. Therefore, it is essential to distinguish the components of this transmission mechanism; first the impact of oil price shocks on stock market variables, such

[7]Sectors' classification follow the Fama-French equity sectors: Consumer non-durables (sector code 1), Consumer durables (sector code 2), Manufacturing (sector code 3), Energy (sector code 4), High technology business equipment (sector code 5), Telecommunications (sector code 6), Shops wholesale-retail (sector code 7), Healthcare (sector code 8), Utilities (sector code 9), Others (sector code 10).

[8]Sector classification "Others" includes includes the heavily oil-dependent transportation activities.

as trading and illiquidity variables, and second the impact of trading activity on stock returns. The impact of oil price shocks on stock trading activity, as measured by the buy/sell trades ratio or other liquidity measures, is fundamental. It is widely known that macro-economic shocks trigger investors' reaction, which is manifested through trading activity, and consequently lead to stock market movements. For this reason, we discuss below prior studies investigating the effects of oil price shocks on various stock market variables. Specifically, the fundamental mechanism of oil price shock on the buy/sell ratio variable is tested empirically in this study for the first time. We further discuss the second mechanism of liquidity measures, such as the Amihud illiquidity ratio, volume, and/or the buy/sell trades ratio, on stock market variables.

### 2.1 Oil price shocks and stock market variables

Hamilton (2008) suggests that the main channel through which energy price shocks affect aggregate economic activity is through consumer and business spending on other goods and services. This is also confirmed with evidence provided in Lee & Ni (2002) who show that oil price shocks primarily influence activity at the industry level through demand side effects. Several studies have confirmed the importance of identifying the source of the oil price change when examining the effect of oil prices on stock returns. As shown in Filis *et al.* (2011); Basher *et al.* (2012); Abhyankar *et al.* (2013) positive oil price shocks due to unexpected global aggregate demand factors increase stock returns, whereas positive oil price shocks due to unexpected oil-market specific demand factors decrease stock returns. Kilian & Park (2009) show that the effect of oil price shocks on the stock market depends on the origin of the oil price shock. Specifically, the widely held view that oil price shocks and stock returns are negatively correlated, i.e. higher oil prices hurt the stock market, is shown to be true only when the price of oil has risen due to an oil-market specific demand shock such as an increase in precautionary

demand driven by concerns about future crude oil supply shortfall. In contrast, higher oil prices due to an unexpected aggregate demand shock have persistent positive effects on cumulative stock returns, whereas when oil price increases are due to a crude oil supply shocks no significant effect is observed in stock returns.

Oil prices shocks may hurt the stock market as they directly affect large energy companies which are influential constituents of stock indices. For example, Exxon and Chevron are members of the 30-member Dow Jones industrial average. Another channel through which oil prices may affect the stock market is through the response of investors when oil price decreases. Specifically, investors may sell shares of companies that have exposure to the oil industry, such as certain banks. In this paper we examine empirically the aforementioned transmission channels for the first time in the literature. In particular, we examine if the origin of the oil price shock has an impact on the stock trading behavior observed in the US equity market. For example, an unexpected oil price increase due to a stronger global economic growth may trigger a higher number of buy trades relative to sell trades as the prospects of the global economy are booming. In contrast, an unexpected decrease of oil price due to higher oil supply may trigger more sell trades relative to buy trades in the stock market ceteris paribus; as investors sell oil-related stocks whose profit margins are severely affected by the drop in oil price. A decline in oil prices is typically perceived as good news for the economy, at least for net oil importers like U.S. and China. However, falling oil prices may be regarded as bad news for the creditworthiness of oil producing companies or countries. Evidence provided in Park & Ratti (2008); Wang *et al.* (2013) suggests that it also important to distinguish between oil importing and exporting countries when investigating the effect of oil price shocks on stock returns. The authors show that the effects of aggregate demand uncertainty on stock markets in oil-exporting countries are much stronger and more persistent than in oil-importing countries

### 2.2 Stock order flow imbalances and stock returns

A number of studies have been devoted on examining the relationship between stock order flow imbalance and stock returns. In particular, stock order flow projects new information in the stock market and for this reason it is believed to have a notable impact on stock returns, see for example, Evans & Lyons (2002); Underwood (2009). Developing a novel model, Kyle (1985) shows that order flow contains private information and in this way has a strong impact on stock prices. In related studies, Easley *et al.* (1996, 1997) also provide evidence supporting the positive correlation between private information and trading pressure. Another channel of information flow between order flow and stock prices is predicted from inventory models. For example, Stoll (1978); Ho & Stoll (1983) propose that order imbalances cause inventory adjustments that require dealers to adjust prices.

The stock order flow imbalance has been shown to have both a firm specific and a market wide component. Huberman & Halka (2001); Chordia *et al.* (2002) show that liquidity at the security level is correlated with both market and industry liquidity and in this way establish commonality in trading activity. In a related study, Hasbrouck & Seppi (2001) extract common components of order flow information by using a principal components model and reveal that while these components are correlated with market returns, firm level returns are primarily influenced by their own stock order flow imbalances. In another study, Chordia *et al.* (2001) show that security order imbalances are linked with changes in securities returns who are included in the S&P 500 index, while Chordia & Subrahmanyam (2004) show that daily security returns are also associated with security order imbalances and develop a theoretical framework to support this relationship. Finally, Harford & Kaul (2005) provide evidence that commonality of order flow is stronger for S&P 500 listed securities when compared to those securities trading outside the index.

## 3 Methodology

A structural VAR model is used to examine the effects of three oil price shocks on security order flow imbalances and cumulative stock returns. Specifically, oil shocks are disaggregated to world oil supply shocks *(production of oil - prod)*, global aggregate demand shocks for commodities worldwide *(real economic activity - rea)* and oil market-specific demand shocks *(real price of oil - rpo)*. The structural representation of the VAR model of order p is:

$$A_0 y_t = c_0 + \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t \tag{1}$$

where $y_t$ = ($\Delta prod_t$, $rea_t$, $rpo_t$, $bsr_t$, $ret_t$) is a 5x1 vector of endogenous variables, $A_0$ refers to the 5x5 contemporaneous coefficient matrix, $c_0$ represents a 5x1 vector of constant returns, $A_i$ denotes the 5x5 autoregressive coefficient matrices and $\varepsilon_t$ stands for the 5x1 vector of structural disturbances, assumed to have zero covariance and being serially uncorrelated. $\Delta prod_t$ is the percentage change in world oil production, $rea_t$ is the real global aggregate demand for all industrial commodities[9], $rpo_t$ are the real prices of oil, $bsr_t$ is the stock order flow imbalance (buy/sell ratio) and $ret_t$is the stock returns.

Following Kilian & Park (2009) we choose a long lag length of 24 months (p=24) which allows for potential delays between structural oil price shocks and their effect on the economy. In addition, such a long number of lags removes serial correlation effects. Previous literature on the issue, see for e.g. Hamilton & Herrera (2004), has shown that introducing long lags is important in structural models of the global oil market as they take into account the low frequency co-movement between the real price of oil

[9]The real global aggregate demand refers to the demand for all industrial commodities represented by the equally weighted growth rates of freight rates for individual voyages of bulk dry cargoes. These freight rates are deflated using the US consumer price index and linearly detrended to remove long-term trends in demand for sea transport and the effects of technological advances in ship building (for details see Kilian 2009).

and the global economic activity. In order to arrive to the reduced form VAR model we multiply both sides of Eq. (1) with $A_0^{-1}$ which follows a recursive structure for the reduced form errors $\mathrm{e_t}$ to be linear combinations of the structural errors $\varepsilon_\mathrm{t}$ as follows:

$$e_t = \begin{bmatrix} e_t^{\Delta\mathrm{prod}} \\ e_t^{rea} \\ e_t^{\mathrm{rpo}} \\ e_t^{\mathrm{bsr}} \\ e_t^{\mathrm{ret}} \end{bmatrix} = \begin{bmatrix} \alpha_{11} & 0 & 0 & 0 & 0 \\ \alpha_{21} & \alpha_{22} & 0 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & 0 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & 0 \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{\Delta\mathrm{prod}} \\ \varepsilon_t^{rea} \\ \varepsilon_t^{\mathrm{rpo}} \\ \varepsilon_t^{\mathrm{bsr}} \\ \varepsilon_t^{\mathrm{ret}} \end{bmatrix} \tag{2}$$

Where, $\varepsilon_t^{\Delta\mathrm{prod}}$stands for the oil supply side shock, $\varepsilon_t^{\mathrm{rea}}$ denotes the aggregate demand shock, $\varepsilon_t^{\mathrm{rpo}}$ captures the oil market-specific demand shock, $\varepsilon_t^{\mathrm{bsr}}$ is the buy/sell ratio shock and $\varepsilon_t^{\mathrm{ret}}$is the stock return shock.

The economic rationale for the identifying restrictions imposed in $A_0^{-1}$ are motivated by Kilian (2009). The oil production is assumed not to respond contemporaneously to an oil demand shock within a given month due to the high adjustment costs of oil production. In contrast, oil supply shocks can influence the global economic activity, the price of oil and the stock order flow imbalance within the same month. Next, the global economic activity is assumed not to be responding contemporaneously to shocks of the real price of oil within a given month because of the time that is required for the world economy to react. However, a global economic activity shock will have an immediate effect on oil prices and stock order flow imbalance, considering the low reaction time of commodities and financial markets. In turn, real oil price innovations are not assumed to respond contemporaneously to changes in the stock order flow imbalance, but both oil supply shocks and global economic activity shocks can influence oil prices contemporaneously. In highly liquid capital markets such as the US equities market the stock order flow imbalance is not assumed to react contemporaneously to

stock returns, but reacts contemporaneously to all the aforementioned oil price shocks.[10] Finally, stock returns are assumed to react contemporaneously to all the aforementioned shocks. We do not attempt to disentangle further stock the shocks driving stock returns, this is because in this paper we only examine the impact of structural oil price shocks on stock trading activity and stock returns.

Before estimating the reduced form of the VAR model in Eq. (1) it is necessary to establish the stationarity of the variables involved. The Augmented Dickey & Fuller (1981) (ADF) and Phillips & Perron (1988) (PP) unit root tests suggest that all variables are I(1).[11] The lag length of the VAR model is selected based on the minimization of the Schwarz (1978) Bayesian Information Criterion (SBIC).

## 4 Data description

In this study the Trade and Quote (TAQ) database is used to obtain tick-by-tick data for the NYSE/AMEX ordinary common stocks over the period January 1993 to December 2011. Stocks included in NASDAQ are excluded due to the difficulty in assigning trades as noted by Christie & Schultz (1999). The data extracted include quotes, transaction prices and trade quantities for each trade undertaken.

Based on all intra-day trades, we define the daily stock order flow imbalance (buy/sell ratio) as the aggregate number of buyer initiated trades over seller initiated trades at the security level. Then, the market buy/sell ratio represents the aggregate imbalance and is computed monthly as the cross-sectional time-series average of daily security stock order flow imbalances for all available firms within each month. When this ratio takes a value over unity at day t indicates that buyer initiated trades exceed seller ini-

[10] As a robustness test and to investigate the possibility that the stock order flow imbalance reacts contemporaneously to stock returns, we replace the zero restriction in line 4 and column 5 of the matrix presented in Eq. (2) with an estimated coefficient. All the results of this paper as presented in the next sections are qualitatively the same due to this change.

[11] The results for the ADF and PP tests are available from the authors upon request.

tiated trades giving rise to net buying pressure (buy/sell ratio $> 1$); while a net selling pressure arises when the ratio is below unity (buy/sell ratio $< 1$). Accordingly, positive shocks increase the ratio, while negative shocks reduce the ratio. Using the stock order flow imbalance as defined above indicates the relative magnitude of buyer-initiated trades in comparison with the seller-initiated ones.

In addition to the data above, monthly observations are utilized for world oil production (supply), a measure of global economic activity and oil prices as the U.S. refiner's acquisition cost of imported crude oil. Both world oil production and oil prices are from the US Department of Energy. The percent change in world oil production is measured by 100 x log difference in the world oil production in millions of barrels pumped per day averaged by month. The real price of oil is the nominal price of oil deflated by the U.S. consumer price index (CPI) from the Bureau of Labor Statistics. Prices are expressed in dollars and transformed in log-returns. Global aggregate demand is measured by the index of global real economic activity constructed by Kilian (2009).[12] This index is based on the equal weighted dry cargo freight rates and higher values of the index indicate higher demand of shipping transportation service which is an indicator of real economic activity. This index has the advantage that it incorporates activity in important emerging economies such as China and India, which are not included in conventional measures of global economic activity for OECD countries. The aggregate U.S. real stock return is computed by subtracting the Consumer Price Index (CPI) inflation rate from the log returns of the Center for Research in Security Prices (CRSP) value-weighted market portfolio.

## 5 Empirical results

The responses of the stock order flow imbalance to a structural shock on oil supply,

[12]The data are available at Kilian's webpage: http://www-personal.umich.edu/~lkilian/paperlinks.html

global aggregate demand and oil-specific demand shocks are reported in Figures 1a, 1b, 1c, respectively. In turn, Figure 1d refers to the response of the cumulative stock return to a structural shock on the stock order flow imbalance. The oil supply shock has been normalized to represent a negative one standard deviation shock, whereas the global aggregate demand and oil-market specific demand shock have been normalized to represent positive shocks. Thus, all shocks have been normalized such that an innovation will tend to raise the stock order flow imbalance. The bands of one-standard and two-standard errors are depicted by dotted and dashed lines, respectively. These intervals have been computed based on a recursive-design wild bootstrap with 10,000 replications (see, Goncalves & Kilian 2004). As observed, in Figure 1a an unexpected increase in world oil supply triggers an immediate decrease to stock order flow imbalance for the first 3 months, followed by a mild correction and then another decrease until month 11. This result supports our hypothesis that as oil prices decrease due to an unexpected increase of oil supply ceteris paribus, sell trades increase relatively to the buy trades as investors sell the influential in terms of market capitalization oil-related stocks and certain banks with exposure in the oil industry, since profit margins in the industry are severely affected by the drop in oil price. Next, Figure 1b shows that an unexpected positive shock in global demand for all industrial commodities causes a persistent increase in the stock order flow imbalance for the first 7 months, followed by a mild decline. This result confirms our research hypothesis that oil price increases due to an unexpected positive shock on global aggregate demand trigger a higher number of buy trades relative to sell trades as the prospects of the global economy are booming. In turn, Figure 1c shows that a shock in precautionary demand for oil causes a persistent increase in the stock order flow imbalance for 14 months, followed by a mild decline. This result is in contrast with the widely held view in the financial press that increases in oil price introduce uncertainty and in this way pave the path for higher expected

stock returns, rather it provides evidence that oil price increases trigger more buy trades relative to sell trades. This can be attributed to investors reaction on buying oil-related stocks with large market capitalization and certain banks with exposure in the oil industry, as the profit margins are increasing within the industry. Accordingly, Figure 1d reveals that an unexpected positive shock on the stock order flow imbalance causes a sustained decrease in U.S. stock returns that builds for 4 months and then drifts around the reached threshold.

The results depicted in Figures 1a, 1b, 1c and 1d have important implications regarding the effects of oil price shocks on the U.S. stock market. Specifically, demand-related oil price shocks trigger relatively more buyer-initiated rather than seller-initiated trades from the participants in the equity market (Figs. 1b and 1c), while supply-side oil price shocks have the opposite effect, i.e. trigger relatively more seller-initiated rather than buyer-initiated trades and thus lead to lower stock order flow imbalances (Fig. 1a). Figure 1d depicts a negative impulse response of cumulative stock returns on a positive unexpected increase (shock) of the stock order flow imbalance. Overall, the results presented here suggest that demand-related oil price shocks stimulate the interest of equity market participants on holding long positions in stocks. Thus, the stimulating effect of demand-related oil price shocks to the US stock market and economy documented in the literature (Kilian, 2009; Kilian & Park, 2009) is shown to be transmitted through the execution of relatively more buyer-initiated trades rather than seller-initiated trades in the stock market.

The impulse responses graphs depicted in Figure 1 indicate the timing and the magnitude of the stock order flow imbalance responses to one-time shocks in the supply and demand for oil. Albeit, historical oil price shocks may not be limited to one-time shocks as they may involve a set of shocks, often coming with different signs at different points in time. Thus, in order to understand the cumulative effect of these historical set

of shocks we perform a historical decomposition of these shocks on the stock order flow imbalance and depict the results in Figure 2. As observed, responses of the stock order flow imbalance have been mainly driven by liquidity shocks (Fig. 2d) rather than oil price shocks which exhibit smaller effects. Notably, after the year 2005 global aggregate demand shocks exhibit a strong negative and persistence effect on the stock order flow imbalance (Fig. 2b). This effect coincides with the period when the financialiation of oil markets became more pronounced, years 2003-2004, see for instance, Singleton (2013).

In order to test whether our results vary for different industries of the equity market we perform the same analysis as in the previous section of the paper but this time using industry-level stock order flow imbalance and their corresponding cumulative stock returns. Different results are expected for oil-related and non-oil-related sectors as it is easier for investors and traders to assess the effects of oil price shocks on listed companies in the oil-related sectors. Figures 3a, 3b, 3c, present the impulse responses of stock order flow imbalance to an unexpected shock on global aggregate demand for manufacturing (sector 3), energy (sector 4) and others-including transportation (sector 10), respectively. The full set of results in this section includes the effects of shocks on oil production ($\Delta prod$), real economic activity ($rea$) and real price of oil ($rpo$) on the stock order flow imbalance and eventually to cumulative stock returns for all the sectors of the economy, however in order to preserve space we only present the cases where the impulse responses obtained were statistically significant in Figures 3a, 3b, 3c. As observed in Figure 3a for the manufacturing sector, shocks on global aggregate demand cause an immediate and persistent increase in the stock order flow imbalance until month 6, which is further increased gradually over the next months for the manufacturing industry. Next, in Figure 3b for the energy sector the stock order flow imbalance is again sharply increased for the first 6 months, but then declines gradually. Finally, in Figure

3c the stock order flow imbalance for other sectors (including transportation) increases gradually over the first 3-4 months, but then increases sharply until month 6 to decline afterwards. These results reveal the existence of a large and positively assymetric response of equity traders (more buy trades than sell) to global aggregate demand shocks within the three oil-related sectors examined, i.e. manufacturing, energy and other (including transportation). In this way, these results extend the extant literature on the issue providing strong evidence on the leading role of industries in the equities markets in general (Hong *et al.*, 2007) and in the oil-equity nexus in particular (Kilian & Park, 2009; El Hedi Arouri *et al.*, 2011). For instance, El Hedi Arouri *et al.* (2011) use the estimation framework of Kilian & Park (2009) to reveal that oil price shocks raise U.S. stock volatilities substantially more for oil-dependent sectors, such as Automobile and Parts, Basic Materials, Industrials and Utilities rather than for non-oil-dependent sectors, such as Telecommunications.

## 6 Conclusion

This paper provides novel evidence that oil price shocks affect esoterically the stock order flow imbalance in the US equity market. The effect is large and statistically significant. In this way, a measure of stock trading activity is found to be a significant transmission mechanism of oil price shocks to stock prices. Specifically, positive demand-related oil price shocks are shown to have an imminent and persistent positive effect on the stock order flow imbalance, whereas positive supply-related oil price shocks have a negative and less significant effect. Furthermore, positive shocks of the stock order flow imbalance trigger a decrease of stock returns in the subsequent months. These effects are found to be more pronounced for oil-related sectors where the stock order flow imbalance exhibit higher and more persistent increases as responses to unexpected positive shocks on the global aggregate demand.

## References


Abhyankar, Abhay, Xu, Bing, & Wang, Jiayue. 2013. Oil Price Shocks and the Stock Market: Evidence from Japan. *The energy journal*, **34**(2), 199–222.

Amihud, Yakov. 2002. Illiquidity and stock returns: cross-section and time-series effects. *Journal of financial markets*, **5**(1), 31–56.

Barsky, Robert, & Kilian, Lutz. 2004. *Oil and the Macroeconomy Since the 1970s*. Working Paper 10855. National Bureau of Economic Research.

Barsky, Robert B., & Kilian, Lutz. 2002. Do we really know that oil caused the great stagflation? A monetary alternative. *Pages 137–198 of: NBER Macroeconomics Annual 2001, Volume 16*. MIT Press.

Basher, Syed Abul, Haug, Alfred A., & Sadorsky, Perry. 2012. Oil prices, exchange rates and emerging stock markets. *Energy economics*, **34**(1), 227–240.

Chelley-Steeley, Patricia, Lambertides, Neophytos, & Savva, Christos S. 2015. The effect of security and market order flow shocks on co-movement. *Journal of international financial markets, institutions and money*.

Chen, Nai-Fu, Roll, Richard, & Ross, Stephen A. 1986. Economic Forces and the Stock Market. *The journal of business*, **59**(3), 383–403.

Chordia, Tarun, & Subrahmanyam, Avanidhar. 2004. Order imbalance and individual stock returns: Theory and evidence. *Journal of financial economics*, **72**(3), 485–518.

Chordia, Tarun, Roll, Richard, & Subrahmanyam, Avanidhar. 2001. Market Liquidity and Trading Activity. *The journal of finance*, **56**(2), 501–530.

Chordia, Tarun, Roll, Richard, & Subrahmanyam, Avanidhar. 2002. Order imbalance, liquidity, and market returns. *Journal of financial economics*, **65**(1), 111–130.

Christie, William G., & Schultz, Paul H. 1999. The initiation and withdrawal of odd-eighth quotes among Nasdaq stocks: an empirical analysis. *Journal of financial economics*, **52**(3), 409–442.

Degiannakis, Stavros, Filis, George, & Kizys, Renatas. 2014. The Effects of Oil Price Shocks on Stock Market Volatility: Evidence from European Data. *The energy journal*, **35**(1).

Dickey, David A., & Fuller, Wayne A. 1981. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica: Journal of the econometric society*, **49**(4), 1057–1072.

Driesprong, Gerben, Jacobsen, Ben, & Maat, Benjamin. 2008. Striking oil: Another puzzle? *Journal of financial economics*, **89**(2), 307–327.

Easley, David, Kiefer, Nicholas M., O'hara, Maureen, & Paperman, Joseph B. 1996. Liquidity, Information, and Infrequently Traded Stocks. *The journal of finance*, **51**(4), 1405–1436.

Easley, David, Kiefer, Nicholas M., & O'Hara, Maureen. 1997. One Day in the Life of a Very Common Stock. *Review of financial studies*, **10**(3), 805–835.

El Hedi Arouri, Mohamed, Jouini, Jamel, & Nguyen, Duc Khuong. 2011. Volatility spillovers between oil prices and stock sector returns: Implications for portfolio management. *Journal of international money and finance*, **30**(7), 1387–1405.

Evans, Martin D. D., & Lyons, Richard K. 2002. Order Flow and Exchange Rate Dynamics. *Journal of political economy*, **110**(1), 170–180.

Filis, George, Degiannakis, Stavros, & Floros, Christos. 2011. Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries. *International review of financial analysis*, **20**(3), 152–164.

Goncalves, Silvia, & Kilian, Lutz. 2004. Bootstrapping autoregressions with conditional heteroskedasticity of unknown form. *Journal of econometrics*, **123**(1), 89–120.

Hamilton, J. D. 2008. *Oil and the macroeconomy. New Palgrave Dictionary of Economics, edited by Durlauf, S. and Blume, L.* Palgrave McMillan Ltd.

Hamilton, James D. 2003. What is an oil shock? *Journal of econometrics*, **113**(2), 363–398.

Hamilton, James Douglas, & Herrera, Ana Maria. 2004. Oil Shocks and Aggregate Macroeconomic Behavior: The Role of Monetary Policy: A Comment. *Journal of money, credit, and banking*, **36**(2), 265–286.

Hamilton, J.D. 2009. Understanding crude oil prices. *Energy journal*, **30**(2), 179–206.

Harford, Jarrad, & Kaul, Aditya. 2005. Correlated Order Flow: Pervasiveness, Sources, and Pricing Effects. *Journal of financial and quantitative analysis*, **40**(01), 29–55.

Hasbrouck, Joel, & Seppi, Duane J. 2001. Common factors in prices, order flows, and liquidity. *Journal of financial economics*, **59**(3), 383–411.

Ho, Thomas S. Y., & Stoll, Hans R. 1983. The Dynamics of Dealer Markets Under Competition. *The journal of finance*, **38**(4), 1053–1074.

Hong, Harrison, Torous, Walter, & Valkanov, Rossen. 2007. Do industries lead stock markets? *Journal of financial economics*, **83**(2), 367–396.

Huang, Roger D., Masulis, Ronald W., & Stoll, Hans R. 1996. Energy shocks and financial markets. *Journal of futures markets*, **16**(1), 1–27.

Huberman, Gur, & Halka, Dominika. 2001. Systematic Liquidity. *Journal of financial research*, **24**(2), 161–178.

Kang, Wensheng, Ratti, Ronald A., & Yoon, Kyung Hwan. 2014. The impact of oil price shocks on U.S. bond market returns. *Energy economics*, **44**(July), 248–258.

Kilian, Lutz. 2008a. A Comparison of the Effects of Exogenous Oil Supply Shocks on Output and Inflation in the G7 Countries. *Journal of the european economic association*, **6**(1), 78–121.

Kilian, Lutz. 2008b. Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy? *Review of economics and statistics*, **90**(2), 216–240.

Kilian, Lutz. 2009. Not all oil price shocks are alike: disentangling demand and supply shocks in the crude oil market. *American economic review*, **99**(3), 1053–1069.

Kilian, Lutz, & Park, Cheolbeom. 2009. The Impact of Oil Price Shocks on the U.s. Stock Market. *International economic review*, **50**(4), 1267–1287.

Kilian, Lutz, & Vega, Clara. 2010. Do Energy Prices Respond to U.S. Macroeconomic News? A Test of the Hypothesis of Predetermined Energy Prices. *Review of economics and statistics*, **93**(2), 660–671.

Kling, John L. 1985. Oil price shocks and stock market behavior. *The journal of portfolio management*, **12**(1), 34–39.

Kyle, Albert S. 1985. Continuous Auctions and Insider Trading. *Econometrica*, **53**(6), 1315–1335.

Lardic, Sandrine, & Mignon, Valerie. 2008. Oil prices and economic activity: An asymmetric cointegration approach. *Energy economics*, **30**(3), 847–855.

Lee, Kiseok, & Ni, Shawn. 2002. On the dynamic effects of oil price shocks: a study using industry level data. *Journal of monetary economics*, **49**(4), 823–852.

Narayan, Paresh Kumar, & Sharma, Susan Sunila. 2011. New evidence on oil price and firm returns. *Journal of banking & finance*, **35**(12), 3253–3262.

Park, Jungwook, & Ratti, Ronald A. 2008. Oil price shocks and stock markets in the U.S. and 13 European countries. *Energy economics*, **30**(5), 2587–2608.

Phillips, Peter C. B., & Perron, Pierre. 1988. Testing for a unit root in time series regression. *Biometrika*, **75**(2), 335–346.

Sadorsky, Perry. 1999. Oil price shocks and stock market activity. *Energy economics*, **21**(5), 449–469.

Schwarz, Gideon. 1978. Estimating the dimension of a model. *The annals of statistics*, **6**(2), 461–464.

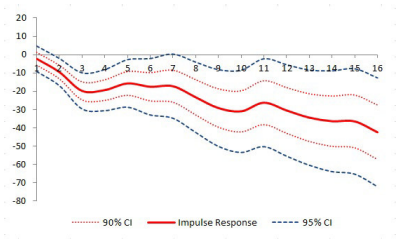
Singleton, Kenneth J. 2013. Investor Flows and the 2008 Boom/Bust in Oil Prices. *Management science*, **60**(2), 300–318.

Stoll, Hans R. 1978. The Supply of Dealer Services in Securities Markets. *The journal of finance*, **33**(4), 1133–1151.

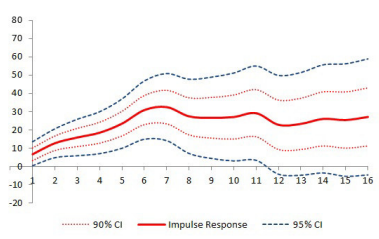
Underwood, Shane. 2009. The cross-market information content of stock and bond order flow. *Journal of financial markets*, **12**(2), 268–289.

Wang, Yudong, Wu, Chongfeng, & Yang, Li. 2013. Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries. *Journal of comparative economics*, **41**(4), 1220–1239.

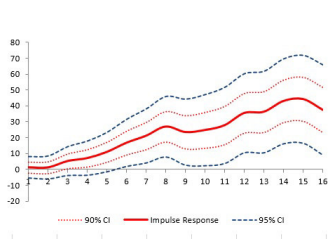
Figure 1: Oil shocks on stock order flow imbalance; and stock order flow imbalance on cumulative stock return. Y-axis in percentage, X-axis in months.



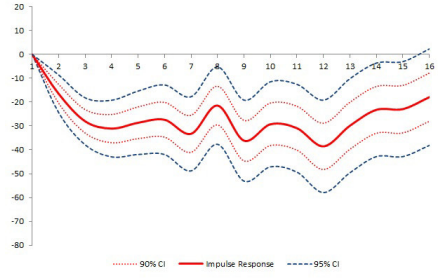

(a) Oil supply shock on stock order flow imbalance




(b) Aggregate demand shock on stock order flow imbalance




(c) Oil-specific demand shock on stock order flow imbalance



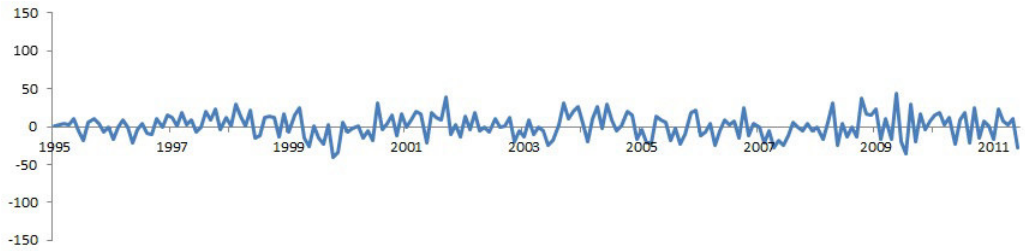

(d) Buy/sell ratio shock on cumulative stock return

Table 1: Percent contribution of demand and supply shocks in the crude oil market to the overall variability of buy/sell ratio and U.S. real stock returns

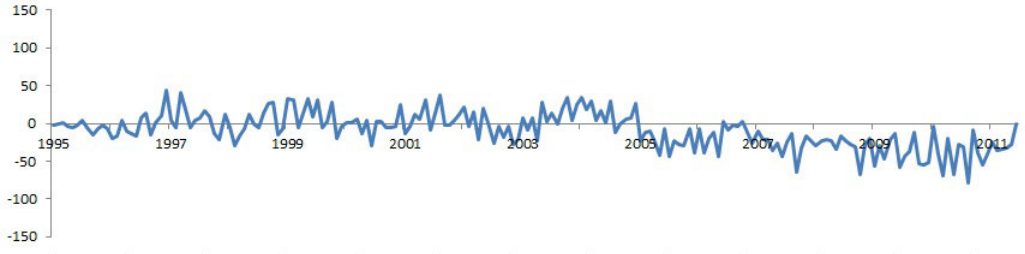
| Horizon | Oil Supply Shock | Aggregate Demand Shock | Oil-specific Demand Shock | Other Shocks |
|---|---|---|---|---|
| 1 | 0.14 | 1.29 | 1.33 | 97.24 |
| 2 | 3.40 | 9.34 | 9.39 | 77.88 |
| 3 | 6.85 | 11.17 | 11.64 | 70.34 |
| 12 | 5.07 | 12.86 | 14.67 | 67.41 |
| $\infty$ | 7.20 | 13.11 | 15.68 | 64.02 |

**Notes:** Based on variance decomposition of the SVAR model (1).

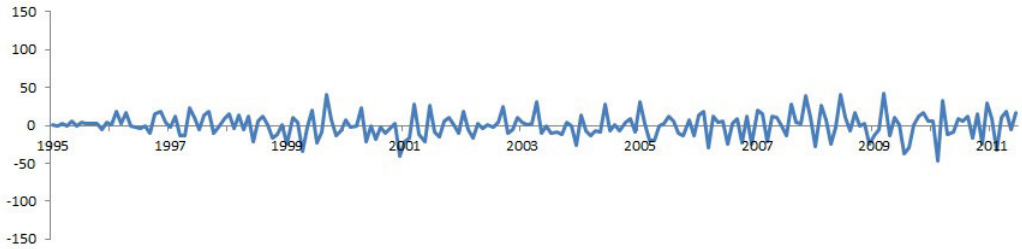
Figure 2: Historical decomposition of buy/sell ratio: 1995:2 - 2011:7



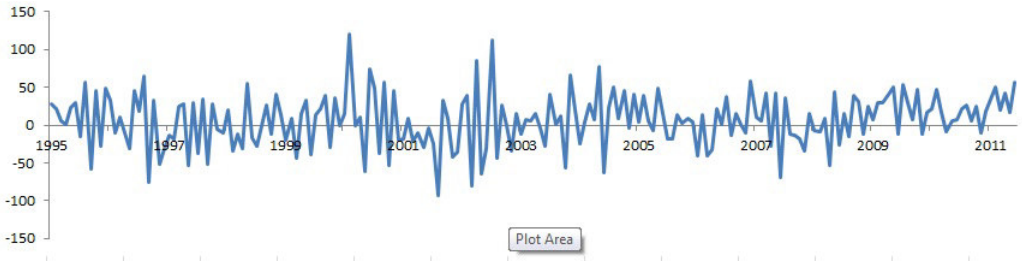

(a) Cumulative effect of oil supply shock on buy/sell ratio




(b) Cumulative effect of aggregate demand shock on buy/sell ratio

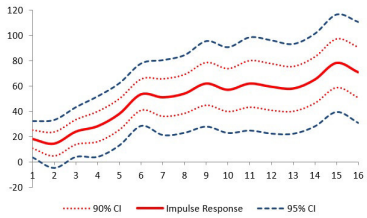



(c) Cumulative effect of oil-market specific demand shock on buy/sell ratio

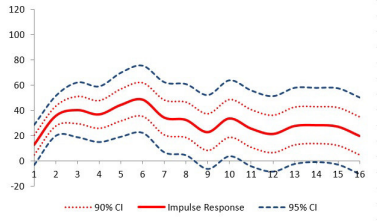



(d) Cumulative effect of liquidity shock on buy/sell ratio

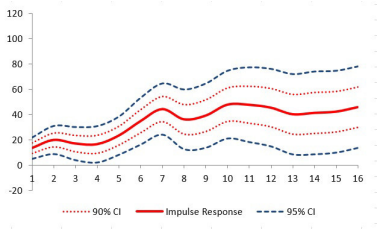
Figure 3: Oil shocks on stock order flow imbalance by industry and stock order flow imbalance shocks on cumulative stock return by industry. Y-axis in percentage, X-axis in months.




(a) Sector 3 Stock order flow imbalance response to a shock on Aggregate Demand




(b) Sector 4 Stock order flow imbalance response to a shock on Aggregate Demand




(c) Sector 10 Stock order flow imbalance response to a shock on Aggregate Demand