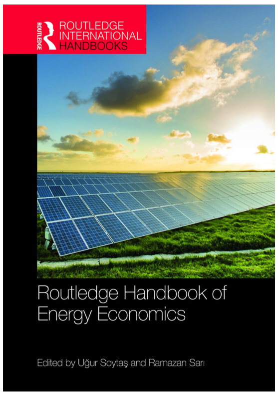

Routledge Handbook of Energy Economics

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Oil and stock prices

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Oil and stock prices

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1 Introduction

Between December 1973 and January 1974, US spot oil prices rose from $4.31 per barrel to $10.11 per barrel.[1] This 135% increase was the result of an Arab embargo on oil flowing to Western countries. The United States and many other Western countries were major importers of Middle East oil, and any oil supply disruption was immediately transmitted to the price of oil. Before the decade was out, the oil market received another shock in 1979 when the Shah of Iran was overthrown. Oil prices increased 149% between April 1979 and April 1980. The 1970s are often characterized as a decade of stagflation: a term used to describe slow economic growth and high inflation. This created a whole new research area as researchers began to study the impact of oil prices on the macroeconomy. Hamilton (1983) is one of the first and most influential papers on this topic. Motivated by the oil price shocks of the 1970s and using recently developed vector autoregression (VAR) techniques, Hamilton investigated the relationship between oil prices and several important macroeconomic and financial variables. The focus was mostly on which variables have a Granger causal impact on oil prices, but there is one regression that tests whether stock prices as measured by the Dow Jones Industrial Average impact oil prices (they don't). Hamilton's paper became the basis for many empirical papers further investigating the impact of oil prices on the macroeconomy (Barsky and Kilian, 2004). Following the publication of Hamilton's paper, a new area of research developed that specifically looked at the relationship between oil prices and stock prices. Seminal papers include Chen et al. (1986), Huang et al. (1996), Jones and Kaul (1996), and Sadorsky (1999). The empirical approach used in these papers was either a multi-factor model or VARs.

Before 2000 there was a small number of papers published on the relationship between oil prices and stock prices. The literature on the relationship between oil prices and stock prices has exploded over the past 15 years. There are now thousands of papers published on this topic. Figure 22.1 shows the index of Google Scholar hits per year for the search terms "oil" and "stock prices" for the years 1997 to 2017.[2] The base year of 1997 is set to 100. The base year value for 1997 is 657. Patents and citations are excluded from the search. There has been a sevenfold increase in these search terms over the past 20 years, which demonstrates the popularity of the topic.

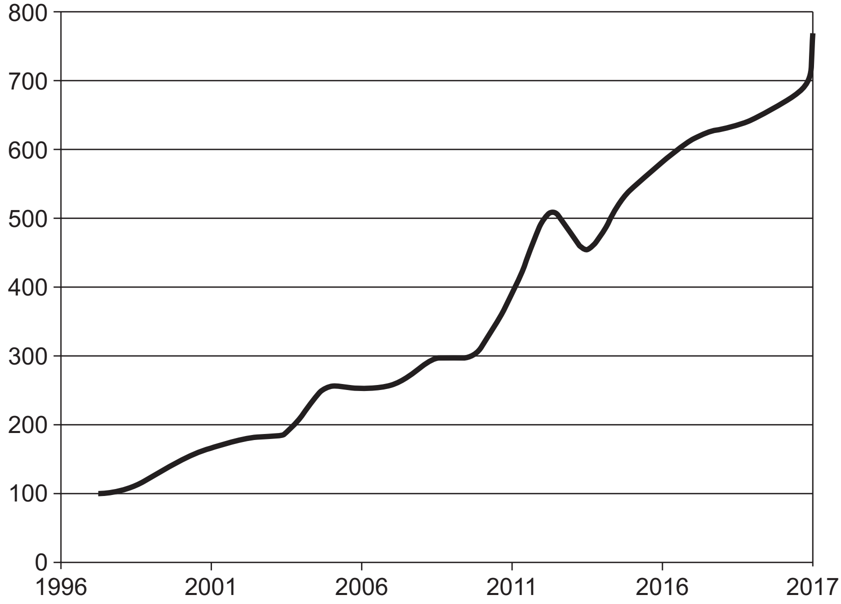

Figure 22.1 Index of Google Scholar hits per year for the search terms "oil" and "stock prices". The base year 1997 is set to 100. The base year value for 1997 is 657. Patents and citations are excluded from the search.

The purpose of this survey is to present the conceptual framework for how and why oil prices affect stock prices and stock markets and present examples of the main empirical approaches to the analysis. The survey is selective in the choice of papers discussed and not meant to be a comprehensive review of every paper published on this voluminous topic. Papers selected for inclusion were mostly based on their citations in Google Scholar keyword searches. This process of selecting papers tends to favor older papers with more citations. There is also a large literature looking at volatility spillovers between oil and equities, but this topic is covered in Chapter 23 in this handbook.

The chapter is organized as follows. The following section sets out the main conceptual framework and empirical approaches for measuring the relationship between stock prices and oil prices. These approaches include multi-factor models, VARs, SVARs, switching models, copulas, and wavelets. The chapter concludes with a summary and some important implications for researchers looking for new avenues of research.

2 Conceptual framework

Stock prices can be expressed as the expected present value of discounted future cash flows (Huang et al., 1996; Jones and Kaul, 1996). Oil prices can impact stock prices through the effect that oil prices have on cash flow and the discount rate. Energy along with capital, labor, and raw materials are the basic inputs into the production of most goods and services. Higher oil prices affect the costs of production because almost all consumer goods and services use oil or products refined from oil in the production, transportation, or distribution of goods. For non-oil producing companies higher oil prices, in the absence of complete substitution among the other factors of production, increase the costs of production and dampen cash flow. Higher oil prices can also impact the discount factor used in the present value calculation. Higher oil prices are often indicative of inflationary pressure and central banks respond to higher inflation by increasing interest rates. Higher interest rates increase the denominator in the stock price equation, pushing stock prices down. Interest rates affect the cost of financing, the cost of margin debt, and the risk return tradeoff between financial assets. Since stock prices are inversely correlated with interest rates, higher interest rates reduce stock prices. For oil producing companies, higher oil prices are expected to lead to higher stock prices because higher oil prices increase the cash flows of oil producers. At the stock market country level, higher oil prices reduce stock prices provided there are more oil consuming companies than oil producing companies.

In the early literature the changes in oil prices were often associated with an oil shock and many papers refer to changes in oil prices as oil shocks. This is not technically correct, because a change in oil prices need not be large enough in magnitude to be labeled a shock. More recently, however, Hamilton (2003, 1996) has offered some constructive insights on how to actually measure an oil shock. For example, one approach to measuring an oil price shock is to compare the current price to the maximum value over the past year. This approach is particularly useful when working with monthly or quarterly data sets. This distinction between changes in oil prices and oil shocks is now becoming more apparent in the literature.

3 The multi-factor model approach

Multi-factor models relate stock returns to the returns of other important factors that may influence stock returns (Chen et al., 1986). For example, a two-factor model relating stock returns to market returns and oil price returns can be written as follows (Faff and Brailsford, 1999):

$$r_t = \beta_0 + \beta_1 R_t + \beta_2 o_t + e_t \tag{22.1}$$

Where r_t is the return on an asset, R_t is the return on the market index, and o_t is the return on oil prices. A statistically significant estimated coefficient on the oil price return variable provides evidence for oil returns impacting stock returns. Notice that if there are no oil returns and stock returns are expressed as excess returns, then Equation (22.1) is the capital asset pricing model (CAPM). The multi-factor model is related to arbitrage pricing theory (APT) (Hamao, 1988) and in some specifications the market return may be omitted. The model in Equation (22.1) can be estimated for company stock returns, industry stock returns, or country stock returns using daily, weekly, or monthly data. Regression specification tests can be carried out to check the adequacy of the model fit. In some cases, it is desirable to include GARCH terms in the error term. Equation (22.1) can be extended to include asymmetric oil prices, time varying parameters, or quantile effects. The multi-factor model approach is widely used in studying the relationship between oil prices and stock returns. The remaining paragraphs of this section provide examples of using multi-factor models to investigate the impact of oil price changes on stock returns. Results are presented for analysis at the national level, industry level, and company level.

Chen et al. (1986), in a seminal paper, use US monthly data from 1953 to 1983 to estimate several multi-factor models for US stock returns. They find the oil factor is not statistically significant. Hamao (1988) following the approach of Chen et al. (1986) finds that oil returns are not a priced risk factor for Japanese equities. Kaneko and Lee (1995), however, use more recent data and find that oil price returns are a priced factor for Japanese equities. Jones and Kaul (1996) use quarterly data to test whether oil is a priced risk factor for equities in Canada, Japan, the United Kingdom, and the United States. Several different econometric specifications are estimated where real stock returns are related to current and lag values of oil price changes and future changes in industrial production. In simple specifications that relate stock returns to current and lagged oil price changes, they find that oil price changes have a negative impact on real stock returns in all four countries and the impact varies considerably across the countries. These simple specifications do not, however, control for other important market effects like future expected cash flows and a deeper analysis is conducted. Granger causality tests are used to determine whether stock markets are rational or they overreact to new information. Canadian and US stock markets are rational in their reaction to oil shocks because the impact of oil shocks on stock markets in these countries can be accounted for through the impact of current and expected future real cash flows. For Japan and the United Kingdom, however, the effect of oil prices on stock markets cannot be explained using changes in future cash flows or other financial variables. Basher and Sadorsky (2006) study the impact of oil prices on stock returns in 21 emerging market economies. They use a multi-factor model that incorporates conditional and unconditional risk factors. Additional risk factors like total risk, skewness, and kurtosis are also studied. In most countries an increase in oil price returns has a negative impact on stock returns. There is also some evidence of nonlinear effects. Nandha and Hammoudeh (2007) study the relationship between oil risk and stock returns in 15 Asia-Pacific countries. The Philippines and South Korea are the only countries with significant oil price risk when stock returns are measured in local currency. No countries exhibit significant oil price risk when stock returns are measured in US dollars. Asteriou and Bashmakova (2013) examine the impact of oil prices on the stock markets of ten Central and Eastern European countries. Using multi-factor models and daily data from 1999 to 2007, they find that oil beta is negative and statistically significant. There is some evidence of asymmetric oil price effects. Narayan and Gupta (2015) use predictive regressions to explore the relationship between stock prices and oil prices over the past 150 years and find that oil prices do help to predict stock prices in a statistically significant manner.

A number of papers have investigated the impact of oil prices on stock prices using industry sector data. Faff and Brailsford (1999) study the impact of oil prices on Australian equity industry sectors. They estimate a two-factor model (market returns, oil prices) over the period 1983 to 1996. They find a significant positive relationship between an oil factor and oil and gas industry stock returns. They find a significant negative relationship between an oil factor and stock returns in the paper and packaging and the transport industries. Sadorsky (2001) uses a multi-factor model to investigate the impact of oil prices, exchange rates, and interest rates on the stock prices of Canadian oil and gas companies over the period April 1983 to April 1999. He finds that increases in oil prices increase the stock returns of Canadian oil and natural gas stocks. Building on Sadorsky (2001) and Boyer and Filion (2007) add company specific factors to the multi-factor model and also find that oil price appreciation increases the stock returns of Canadian oil and gas stocks. El-Sharif et al. (2005) investigate the impact of oil price returns on UK equity returns. They find that oil price increases increase the return to UK oil and gas stocks. For other industries like banking, transportation, and computers, the relationship is weak. Nandha and Faff (2008) investigate the impact of oil price changes on the stock returns of 35 global industry indices over the period April 1983 to September 2005. They find that oil price increases have a negative impact on equity returns for all of the industries studied except mining and oil and gas. Arouri and Nguyen (2010) model the relationship between the stock returns of European industry sectors and oil prices using weekly data for the period January 1998 to November 2008. They find that European industry stock returns and oil prices are weakly correlated and the reaction of stock returns to oil prices varies considerably by industry. There is also some evidence of asymmetric interactions between oil changes and stock returns. Gogineni (2010) uses daily data spanning 1986 to 2007 to investigate the impact of oil price changes on

US stock returns using a multi-factor model. Using a large data set, he finds that oil price changes do impact daily stock returns (as measured by the value-weighted NYSE/Nasdaq/AMEX index) for the full sample and the first sub-sample (1986 to 1997) but not over the second sub-sample (1997 to 2007). Further investigation at the industry level reveals that oil intensive industries like petroleum and manufacturing and some other industries like financial services and insurance are impacted by oil price changes. Industry estimates of cost side and demand side dependence on oil are provided. Arouri (2011) uses GARCH models estimated on weekly data covering 1998 to 2010 to investigate the impact of oil price returns on stock returns for 12 European sectors. Results are presented showing the strength of the relationship varies across sectors and in addition there is evidence of asymmetries. Elyasiani et al. (2011) used daily data from December 1998 to December 2006 to analyze the impact of oil price changes on the stock returns of US sector stock returns. Empirical models are estimated using Fama-French factor models augmented with either oil price returns or oil price volatility. Nine of the 13 industry sectors studied are affected by either oil price changes or oil price volatility. The impact of oil prices on Gulf stock markets is investigated by Mohanty et al. (2011). They estimate multi-factor models for Bahrain, Kuwait, Qatar, Oman, Saudi Arabia, and the United Arab Emirates (UAE) using weekly data spanning June 2005 to December 2009. In addition to analysis at the country level, analysis is also conducted at the industry level. At the country level, oil price changes affect stock prices for all countries except Kuwait. At the industry level, oil price changes have a statistically significant impact on 12 of the 20 industries studied. Ramos and Veiga (2011) study the impact of oil price changes on oil and gas industry stock return in 34 countries. They find that oil is a priced risk factor and the impact is greatest in developed countries. Aloui et al. (2012) find that for a sample of 25 emerging economies, oil beta is significant and positive for moderately oil-dependent countries during bull markets and negative during bear markets. The largest net oil importing countries are not sensitive to oil beta regardless of the market phase. Broadstock et al. (2012) uses multi-factor models to explore the impact of oil prices on Chinese energy industry stock prices. Weekly data is used covering the period January 2000 to May 2011. A number of different multi-factor models are estimated over different sub-samples. They find the relationship between oil prices and stock prices is stronger after the 2008–2009 financial crises. They suggest that this result is because investors in the Chinese stock market are more sensitive to shocks in the world oil market. Ramos and Veiga (2013) find that oil price increases lead to increases in the stock markets of oil exporting countries. Asymmetric oil price effects are found for oil importing countries. Inchauspe et al. (2015) model renewable energy stock price returns using a multi-factor model. They allow for time variation in the estimated coefficients. The market return and technology stock prices exert a greater influence on renewable energy stock prices than do oil prices.

There are fewer studies that study the impact of oil prices on stock prices using company data. Al-Mudhaf and Goodwin (1993) use a two-factor model to investigate the impact of the oil risk factor on 29 NYSE oil companies. They find the oil price risk premium was very unstable. Sadorsky (2008) follows a large panel of US stocks over a 17-year period to study the impact that firm size has on the relationship between oil prices and stock prices. The relationship between oil prices and stock prices varies with firm size. The relationship is strongest for medium-sized firms. One possible explanation for this result is that medium-sized firms do not have the production efficiency and financial leverage of large firms, nor do medium-sized firms have the flexibility and responsiveness of small-sized firms. Demirer et al. (2015) use multi-factor models and firm level data from the Arab Gulf stock markets over the period March 2004 to March 2013 to test the significance of an oil price factor. The Fama-French size and book-to-market factors are included in the analysis. Stocks that are more sensitive to oil price changes yield higher returns.

Cross-sectional tests, however, do not reveal a significant oil price risk premium suggesting that other firm factors may adequately capture oil price effects. Gupta (2016) uses a large data set of company level data on oil and gas companies from 70 countries to investigate the impact of oil price shocks on these companies. He finds that oil price increases positively impact oil and gas stock returns. Firms located in oil producing countries are more sensitive to macroeconomic events and oil prices shocks. Firms in non-competitive industries are less affected by oil price shocks.

In summary, many of the existing studies that use a multi-factor model to study the impact of oil prices on stock prices find evidence supporting a statistically significant relationship between the two variables. For most countries or industries, higher oil prices dampen stock prices. Higher oil prices are beneficial for oil industry stock prices. Some research has investigated the asymmetric relationship between stock prices and oil prices, but so far the results are inconclusive. Recent developments in panel quantile regression techniques should be useful for further examining the relationship between stock prices and oil prices.

4 The VAR approach

Vector autoregressions (VARs) which date back to the 1970s are a natural extension of univariate autoregressive models. VARs are useful for modeling the dynamic interaction between variables. A VAR is a system of equations where each variable in the system is endogenous. Consider the following VAR.

$$y_t = c + A(L) y_{t-1} + \varepsilon_t, \tag{22.2}$$

In Equation (22.2), **y** is a vector with p variables, L is the maximum lag length and ε is a serially uncorrelated error term. VARs are useful for testing Granger causality, calculating impulse response functions and forecast error decomposition. The dynamic relationship between stock returns and oil price returns can be studied by using a VAR with these two variables. If omitted variables are a concern or a deeper analysis with other variables is needed than additional variables can be added. A good fitting VAR has serially uncorrelated errors and polynomial roots less than unity. A VAR model can be extended to a vector error correction model (VECM) when investigating specific cointegration relationships.

Most of the studies that use VAR to investigate the relationship between stock prices and oil prices use national stock market data. Sadorsky (1999) uses monthly data for the period 1947 to 1996 and VARs to determine the impact that oil prices have on real US stock returns. The basic model includes real stock returns and changes in industrial production, interest rates, and oil prices. There is evidence that oil prices and oil price volatility impact stock returns. There is also evidence that after 1986 oil prices movements explain a larger fraction of stock return forecast error variance than do interest rates. As US monetary policy has become more transparent and predictable, its impact on stock prices has diminished in relationship to sudden changes in oil prices. Papapetrou (2001) uses a VAR to investigate the dynamic relationship between stock prices, oil prices, interest rates, economic activity, and employment in Greece over the period 1989 to 1999. There is evidence that oil prices affect real economic activity, employment and stock prices. Hammoudeh and Li (2005) use vector-error correction models (VECMs) and multi-factor models to explore the dynamic relationship between oil prices and stock prices in Mexico, Norway, and US oil and transportation industries. They find that increases in oil price changes increase stock returns for the countries and industries studied. In other words, stock markets comprised of oil producing companies increase with increases in oil prices. Systematic risk has a larger impact on stock returns than does oil price risk. Hammoudeh and Choi (2006) estimate VECMs using weekly data to investigate the impact of oil prices, US interest rates, and the S&P 500 on Gulf Cooperation Council (GCC) member stock returns. US oil prices and stock prices have no direct impact on GCC stock prices. Impulse response functions do reveal that oil prices impact GCC stock prices. Maghyereh and Al-Kandari (2007) use nonlinear cointegration techniques to test the relationship between oil prices and stock prices in Gulf stock markets. There is evidence of non-linear cointegration between stock prices and oil prices in Gulf countries. Park and Ratti (2008) investigate the impact of oil prices on stock prices in the United States and Europe over the period 1986 to 2005. They find that oil prices have a statistically significant impact on stock returns either contemporaneously or within the following month. For oil exporter Norway, an increase in oil prices leads to an increase in stock returns. For European countries, increases in oil price volatility have a negative impact on stock returns. Cong et al. (2008) study the impact of oil prices on stock returns in China. They find that oil prices do have statistically significant impacts on stock returns in manufacturing and oil companies but do not have a statistically significant impact on stock returns in other industries. Oil price shocks have a larger impact on manufacturing stock returns than interest rates. Miller and Ratti (2009) study the long-run relationship between the world oil price and OECD stock markets over the period January 1971 to March 2008. Using VECMs that allow for structural breaks, they find evidence of a cointegrating relationship between oil prices and stock markets. Evidence of a negative relationship between oil prices and stock markets is found in the early part of the data set but after 1999 this relationship weakens considerably. Filis (2010) studies the dynamic relationship between consumer prices, industrial production, stock prices, and oil prices in Greece using VECMs to study the data in levels and VARS to study the cyclical components. Cyclical components are extracted using the Hodrick-Prescott filter. The cyclical analysis shows that oil prices have a significant negative impact on stock prices. Arouri et al. (2011) use VAR-GARCH models to study the relationship between oil prices and the stock prices of Gulf Cooperation Council countries over the period 2005 to 2010. They find that oil price returns have a strong positive impact on the stock returns of Bahrain, Oman, and Qatar. The impact of oil prices and oil price volatility on stock prices in South Korea are studied by Masih et al. (2011). They use a VECM with real stock returns, real oil prices, oil price volatility, interest rates, and economic activity (measured using industrial production). They find that oil prices and oil price volatility both have an impact on stock returns with oil price volatility having the largest impact. A linear VECM is preferred over a two state Markov-switching model. Arouri and Rault (2012) study the impact of oil prices on Gulf stock markets using bootstrap cointegration techniques and seemingly unrelated regression (SUR). There is evidence of cointegration between stock prices and oil prices. The results from SUR indicate that oil price increases have a positive impact on stock prices for all countries except Saudi Arabia. Using VARs, Lee et al. (2012) do not find much evidence that oil prices impact composite stock indexes in the G7 countries. At the sectoral level, however, there is evidence that oil prices impact stock prices in the information and technology, consumer staples, financials, utilities and transportation sectors. Cunado and Perez de Gracia (2014) analyze the impact of oil shocks on 12 European stock markets. Several different specifications for oil shocks are used. Evidence shows that oil shocks impact stock prices and this result is robust to different measures of oil price shocks.

There are several studies that use VARs to analyze the stock price–oil price relationship at the sector level. Huang et al. (1996) use VARs to investigate the dynamic relationship between oil futures prices and US stock prices. They find that oil futures prices do lead petroleum stock prices, but there is little evidence to support the hypothesis that oil prices lead stock prices in other industries. Ciner (2001) revisits the Huang et al. (1996) paper and suggests that their failure to find a strong relationship between oil price changes and stock returns is because they only considered linear tests for causality. Using daily data he finds evidence of nonlinear causality between oil prices and the S&P 500. The relationship is strongest in the 1990s. Henriques and Sadorsky (2008) explore the relationship between the stock prices of alternative energy companies, technology companies, and oil prices. Alternative energy companies are those that are mostly focused on renewable energy generation. They find that technology stock prices have a greater impact on alternative energy stock prices than do oil prices. This result is plausible because the success of alternative energy companies is often closely aligned with the success of technology to reduce the cost of producing alternative energy. Kumar et al. (2012) uses VARs to study the relationship between the stock prices of clean energy companies, technology stock prices, oil prices, and carbon dioxide prices. They find that oil prices and technology stock prices impact the stock prices of clean energy companies. They do not, however, find much support for carbon dioxide prices impacting clean energy stock prices.

Most of the literature that uses VARs to study the dynamic relationship between oil prices and stock prices finds evidence that oil prices impact stock prices. The standard VAR model can be extended in many ways including a structural interpretation (the topic of the next section), time varying parameters, and a Bayesian approach. Some of these newer approaches to modeling the oil price–stock price relationship are now just entering the literature.

5 The structural VAR (SVAR) approach

Structural VARs (SVARs) build on the VAR framework by incorporating structural relationships between the variables. $\mathbf{A}_0$ is the contemporaneous matrix, $\mathbf{A}$(L) is the sequence of autoregressive coefficient matrices and $\boldsymbol{\varepsilon}$ is the uncorrelated structural error term.

$$A_0 y_t = \alpha + A(L) y_{t-1} + \varepsilon_t \tag{22.3}$$

The reduced form of the structural model can be obtained by pre-multiplying Equation (22.3) through by A_0^{-1}.

$$y_t = \beta + B(L) y_{t-1} + e_t \tag{22.4}$$

For example, $e_t = A_0^{-1}\varepsilon_t$. The structural disturbances $\boldsymbol{\varepsilon}_t$ can be obtained by imposing identifying restrictions on $\mathbf{A}_0$.

The SVAR approach to modeling the impact of oil shocks on stock prices is mostly derived from the work of Kilian (2009) who models oil shocks as originating from oil supply, global economic demand, or oil specific. In this framework oil shocks can have different impacts on economic activity depending upon their origin. This approach is a considerable improvement over previous literature that uses changes in oil prices to measure oil price shocks. Using this approach, Kilian and Park (2009) investigate the impact of oil shocks on US stock returns. They find that the impact of oil shocks on stock returns depends upon whether the shocks are demand or supply shocks. Demand and supply shocks account for 22% of the long run variation in US real stock returns. Impulse responses show that oil specific demand shocks have a negative and statistically significant impact on US stock returns. The Kilian and Park (2009) approach is very unique, innovative, and useful in that it allows for oil shocks to be characterized as originating from either the demand side or supply side. This facilitates a much more detailed analysis of the impact of oil shocks on stock returns than what would be obtained by only looking at oil prices.

Apergis and Miller (2009) uses the Kilian (2009) and Kilian and Park (2009) approach to identifying oil shocks to explore the impact of oil shocks on stock returns in eight countries (Australia, Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States). The analysis uses a two-step procedure. In the first step, the structural oil shocks are estimated from a three-variable SVAR. In the second stage, the structural oil shocks are combined with stock returns to investigate the impact of oil shocks on stock returns using a VAR. They find that structural oil shocks do have a significant impact on stock returns but the magnitude is small.

Bjornland (2009) analyzes the impact of oil price shocks on stock returns in Norway using a SVAR model. A 10% increase in oil prices increases stock returns by 2.5%. The results are robust to different specifications of the oil price shock (linear or non-linear). For Norway, higher oil prices increase demand and wealth. Basher et al. (2012) use a SVAR to examine the dynamic relationship between the oil market, exchange rates, and emerging economy stock returns over the period 1988 to 2008. Impulse response functions are calculated using standard methods as well as orthogonal projections. They find that oil price shocks dampen emerging market stock prices and US dollar exchange rates in the short run. In addition, evidence is presented showing that an increase in emerging market stock prices increase oil prices. Wang et al. (2013) use SVAR to explore the impact of oil price shocks on oil importing countries (China, France, Germany, India, Italy, Japan, Korea, the United Kingdom, and the United States) and oil exporting countries (Canada, Saudi Arabia, Kuwait, Mexico, Norway, Russia, and Venezuela). The stock market response to oil shocks depends upon whether the country is an oil importer or oil exporter. The impact of oil shocks on stock markets also depends upon whether the shock is a demand or supply shock. Oil price shocks explain approximately 20% to 30% of stock returns. Positive demand and precautionary demand shocks have a higher degree of co-movement among the stock markets in oil exporting countries. Kang et al. (2015) use a time-varying parameter VAR to study the impact of structural oil price shocks on US stock market returns. Structural oil shocks account for 25.7% of the long-run variation in stock returns. The contribution of oil supply shocks has decreased across time while oil market shocks increased across time. Global economic activity shocks have increased across time.

SVARs add structure to VARs by imposing zero restrictions on the contemporaneous relationship between the variables of interest. The Kilian and Park (2009) approach is useful for analyzing the impact of oil supply, global economic demand, and oil specific shocks on stock prices. Another approach to imposing structure on VARs is to use sign restrictions. Gupta and Modise (2013) use this approach to analyze the impact of oil shocks on stock returns in South Africa. They find that oil supply shocks contribute more to real stock return variability than oil demand shocks.

6 Switching approaches

The relationship between oil prices and stock prices may be characterized by distinct periods of high or low returns or high or low volatility. Stock markets, for example, are often characterized by bull and bear regimes. Threshold autoregression, smooth transition, and Markov-switching models are popular ways of modeling regime switching in economics and finance.

Huang et al. (2005) use multivariate threshold models to study the impact of oil price changes and oil price volatility on real stock returns for Canada, Japan, and the United States. Many studies characterize asymmetric oil price changes as either non-negative or negative. This is rather arbitrary and does not allow for deeper nonlinear relationships or threshold values that vary by country. This paper finds oil price change threshold values between 2.58% and 2.70%. Oil price changes have greater explanatory power on stock returns than oil price volatility.

Aloui and Jammazi (2009) use a Markov-switching EGARCH model to investigate the relationship between equity returns in France, Japan, and the United Kingdom and oil shocks. They find that oil price shocks affect the volatility of stock returns and the probability of transition between regimes. Chen (2010) uses a Markov-switching model to determine the impact that oil price shocks have on the probability of being in a bear stock market. Oil price shocks are measured in several different ways including: changes in oil prices, oil price increases, net oil price increases, and scaled oil price increases. Evidence is presented showing that higher oil prices increase the probability of switching from a bull market to a bear market. Narayan and Sharma (2011) investigate the impact of oil price changes on the stock returns of 560 US companies. They find the impact of oil price changes varies across industries. There is also evidence that oil prices impact stock returns with a lag effect. Further analysis using a threshold model shows that oil price effects vary by regime for 5 of the 14 industries studied. Similar to Sadorsky (2008) evidence is presented showing that the impact of oil prices on stock prices varies with firm size. Zhu et al. (2011) use a panel threshold cointegration approach to examine the relationship between oil shocks and stock markets for OECD and non-OECD panels over the period January 1995 to December 2009. Evidence of threshold cointegration is found and threshold error correction models are used to understand the asymmetric dynamic adjustment. Granger causality tests find evidence of bidirectional long-run causality between oil prices and stock prices. Naifar and Al Dohaiman (2013) use Markov switching techniques to investigate the nonlinear relationship between GCC stock returns oil volatility. Evidence is presented showing that for most countries the relationship between GCC stock market returns and OPEC oil market volatility is regime dependent. Mensi et al. (2014) use quantile regression techniques to study the impact of global macroeconomic factors on BRICS stock returns for the period September 1997 to September 2013. Evidence from quantile regressions is presented showing that US stock prices, oil prices and gold prices do have an impact on BRICS stock returns. Angelidis et al. (2015) use Markov-switching models to investigate the impact of oil shocks on US stock market returns and stock market volatility. Oil shocks are modeled as in Kilian (2009) using a SVAR. Probit models are used to relate the probability of being in the low volatility state in relationship to a set of explanatory variables that include oil shocks (supply, demand, and oil price), interest rates, dividend yields, unemployment, inflation rates, and default spreads. There is some evidence that oil shocks affect the transition from a low volatility state to a high volatility state.

Balcilar et al. (2015) use a Markov-switching vector error correction model and monthly data from 1859 to 2013 to investigate the impact of oil prices on stock prices. They find that the high volatility regime was more frequent before the Great Depression and after the 1973 oil price shock. The high volatility regime tends to occur more frequently when the economy is in a recession.

Switching approaches are useful ways to model the regime dependent relationship between stock prices and oil prices because stock prices are often characterized by bull market and bear market regimes. Most of this literature finds evidence for a regime dependent relationship between stock prices and oil prices.

7 Copula approaches

Copulas are used to model the dependence structure between random variables by coupling univariate marginal distributions into a joint multivariate distribution. More precisely, copulas separate the modeling of the dependence between assets from the modeling of their univariate marginal distributions. The main advantage of using copulas is that copulas can model many different types of correlations while standard measures of linear correlation like the widely used

Pearson correlation coefficient cannot. Copulas are useful in finance for modeling tail risk. Some examples of using copulas to model dependence between oil prices and stock prices are included below.

Nguyen and Bhatti (2012) use copulas to study the dynamic relationship between oil prices and stock prices in China and Vietnam. They find evidence of left tail dependence between oil prices and stock prices in Vietnam and evidence of right tail dependence between oil prices and stock prices in China. Aloui et al. (2013) use time-varying copulas to investigate the dynamic relationship between oil prices and stock prices in six Central and Eastern European countries (Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovenia). The daily data covers the period 1 December 2005 to 20 August 2012. There is evidence of dependence between oil and these stock markets implying a lack of diversification between these assets. The survival Gumbel copula is the best. There is strong lower tail dependence during financial crises. Zhu et al. (2014) use copulas to study the relationship between oil prices and stock prices for Asia-Pacific countries over the period 4 January 2000 to 30 March 2012. Overall, they find the dependence between oil prices and stock prices is weak but has increased after the 2008–2009 financial crisis. In the post-crisis period, the lower tail dependence is larger than the upper tail dependence except in Japan and Singapore. Sukcharoen et al. (2014) use copulas to study the dynamic relationship between oil prices and stock prices for a large number of countries. They create country specific stock market indices by removing the oil and gas sector. They find a weak dependence between oil prices and stock markets. In the case of Canada and the United States the dependence is larger. The dependence structure between oil prices and stock prices changed considerably after the introduction of the euro in 1999.

Most of the papers that use copulas to model the oil price–stock price relationship find evidence of tail risk. This is in itself not surprising because copulas are more sophisticated ways of conducting correlation analysis. There is a need to move beyond the establishment of tail risk to incorporate more practical implications of these results.

8 Wavelet approaches

Wavelet analysis is a frequency and time domain approach which traces its origins from Fourier analysis and spectral density analysis. Fourier analysis and spectral filtering methods impose strong restrictions on the data structure and in doing so lose information about the time dimension. By comparison, wavelets combine information from the time dimension and frequency dimension. Wavelet analysis facilitates studying data relationships at different time scales (typically categorized as short run to long run). Wavelets do not make strong assumptions about the data generating process. The wavelet approach has been used to investigate the relationship between oil prices and stock prices. Here are some examples of using wavelets to explore the relationship between oil prices and stock prices.

Jammazi and Aloui (2010) use wavelets to decompose stock prices and oil prices. Markov-switching models are then estimated using the decomposed data. Changes in crude oil prices have temporary impacts on the stock market volatility of France and the UK. The effects are stronger for Japan. Akoum et al. (2012) use wavelet coherence to study the relationship between oil prices and the stock prices of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, the UAE, Egypt, and Jordan over the period 2002–2011. Weekly data is used in the analysis. There is a lack of dependence between oil price changes and stock price returns in the short term. In the long term there is evidence of co-movement between oil price returns and stock returns. Market dependencies increased after 2007. Reboredo and Rivera-Castro (2014) use wavelet analysis to examine the relationship between oil prices and stock prices in Europe and the United States.

Results for the period 2000 to July 2008 indicate the oil price changes had no impact on stock returns. After July 2008, however, there is evidence of contagion and co-movement between oil prices and stock prices. Boubaker and Raza (2017) use wavelets to decompose the relationship between oil prices and stock prices for the BRICS countries. They find the co-movement between oil and stock prices increases with time scales. Over a time scale of less than two weeks the co-movement is weak. The strongest co-movement if found for longer time scales of 16 to 32 days. At these longer time scales, Brazil and South Africa show the greatest co-movement. Reboredo et al. (2017) use wavelets to study the relationship between oil prices and six different renewable energy stock indices. They find that the relationship is strongest in the long run. Non-linear causality was present at the higher frequencies while linear causality was present at the lower frequencies. Non-linear causality tests show causality running from renewable energy stock prices to oil prices.

Wavelet analysis shows that the relationship between oil prices and stock prices can depend upon the frequency. Wavelet techniques like copulas are incorporated into popular software like MATLAB and R and this has resulted in a proliferation of papers using these techniques to analyze the relationship between stock prices and oil prices. The next step is to use the results from these techniques to provide practical implications. For example, Khalfaoui et al. (2015) combine wavelets with GARCH models to estimate hedge ratios between oil prices and stock prices in the G7 countries.

9 Summary

This chapter provides a selective survey of the oil price and stock price literature. Growth in this topic has been substantial over the past 20 years with Google Scholar citations increasing some sevenfold between 1997 and 2018. Research investigating the impact that oil prices have on stock prices has used a number of different empirical approaches. The most common approaches are multi-factor models and VARs. Multi-factor models are easy to justify on a theoretical basis because they fit well within finance theory like APT. Multi-factor models are easy to estimate and can be extended to include asymmetric effects, time varying parameters and GARCH effects in the error term. VARs are attractive because they impose little or no structure on the dynamic relationship between the variables being investigated. Specific structure can be imposed though SVARs or sign restrictions. Switching models are useful in that they allow estimation of the transition from one state to another. Data-driven approaches like copulas and wavelets have increased in popularity. These approaches can be used to look at specifics of tail risk (copulas) or how the dynamics between stock prices and oil prices change in the time-frequency domain (wavelets). Copulas and wavelets are statistical techniques that can be used on their own or as a filtering tool whereby the filtered data can then be estimated using more conventional econometric techniques. Overall, there is a large literature showing that changes in oil prices affect stock returns. For oil consuming companies, positive oil price changes leads to lower stock returns. For oil producing companies, positive oil price changes leads to higher stock returns.

Looking forward there are several important factors to consider when conducting research on the topic of oil and stock prices. First, world energy intensity has been decreasing since 1990. Over this time period energy intensity in non-OECD countries, the world average, and OECD countries declined by 40%, 32%, and 28%, respectively.[3] Declining energy intensity implies that oil price changes will most likely have a lesser impact on economic activity and stock prices in the future. Second, countries that are currently heavily oriented towards manufacturing (like emerging markets) are the ones that are most likely to be affected by oil price changes. Third, the impact of oil prices on national stock markets depends upon whether a country is an oil exporter or oil importer. Fourth, new empirical techniques and combinations of existing techniques should help to further our understanding of this important topic. Analyzing data at different frequencies is also useful as is mixed frequency analysis. Fifth, the literature needs to move beyond testing relationships between oil prices and stock prices and instead focus more on practical implications like portfolio analysis, risk management, and hedging.

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Notes

1 https://fred.stlouisfed.org/series/WTISPLC.
2 This search was conducted on 24 October 2018. The total number of citations from 1997 to 2017 is 53,329.
3 www.eia.gov/todayinenergy/detail.php?id=27032.

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