WORKING PAPER SERIES

How do international stock markets respond to oil demand and supply shocks?

Jochen H. F. Güntner

Working Paper No. 28/2011

OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG
FACULTY OF ECONOMICS AND MANAGEMENT

Impressum (§ 5 TMG)
Herausgeber:
Otto-von-Guericke-Universität Magdeburg
Fakultät für Wirtschaftswissenschaft
Der Dekan

Verantwortlich für diese Ausgabe:
Jochen H. F. Güntner
Otto-von-Guericke-Universität Magdeburg
Fakultät für Wirtschaftswissenschaft
Postfach 4120
39016 Magdeburg
Germany

http://www.fww.ovgu.de/femm

Bezug über den Herausgeber
ISSN 1615-4274

How do international stock markets respond to oil demand and supply shocks?*

Jochen H. F. Güntner[†]

University of Magdeburg

December 21, 2011

Abstract

Building on Kilian and Park's (2009) structural VAR analysis of the effects of oil demand and supply shocks on the U.S. stock market, this paper studies the responses of a broader set of stock markets in six OECD member countries. The focus is on the differences and commonalities in the response of stock prices in net oil exporting and net oil importing economies during 1974-2011. Structural oil price shocks aid our understanding of historical fluctuations in stock returns – in particular of the 2008 stock market crash. I find that unexpected shortfalls in global oil supply have no significant impact on the stock market in any of the six countries. While an increase in global aggregate demand consistently raises oil prices and cumulative stock returns, the effect is more persistent for net oil exporters and more pronounced for Norway. Other, e. g., precautionary oil demand shocks have a detrimental impact on the stock market in oil importing countries, a statistically insignificant effect for Canada, and a significantly positive effect for Norway. Oil prices account for a larger fraction of the forecast error variance in global relative to national stock returns.

Keywords: Net oil exporters; Oil price shocks; Stock market returns; Structural VAR estimation

JEL Classification: C32, O57, Q41, Q43

---

*I would like to thank Lutz Kilian, Dirk Bethmann, Gerhard Schwödiauer, and Abdolkarim Sadrieh for their helpful comments and guidance. I am grateful to Fabian Flechtner for excellent research assistance and to Matthias Held for providing some of the stock market data.

[†]Jochen Güntner is Research Associate at the Chair of International Economics, Otto-von-Guericke-University Magdeburg. Address: PO Box 4120, 39016 Magdeburg, Germany. e-mail: jochen.guentner@ovgu.de, telephone: +49 391 67-12163, fax: +49 391 67-11177.

1 Introduction

Building on the structural VAR model of the global market for crude oil in Kilian (2009), the present paper analyzes the relationship between structural oil price shocks and the stock market in six OECD Member States. The sample incorporates four of the world's largest net oil importers – the U.S., Japan, Germany, and France – as well as two large net oil exporters, namely Canada and Norway. Structural oil supply shocks, aggregate demand shocks, and other oil demand shocks are isolated from monthly data from January 1974 to April 2011. Beyond extending Kilian and Park's (2009) analysis for the U.S. to cover several countries and the recent financial crisis period, I focus on whether a country's net position in global petroleum markets affects the relationship between oil prices and national stock market returns.

Changes in the real price of oil are frequently considered an important factor driving the fluctuations in stock prices. The potential predictive power gives the relationship highest relevance to researchers and investors alike. Moreover, the importance of the response of asset markets to oil demand and supply shocks for understanding the transmission of oil price shocks has recently been highlighted in Kilian et al. (2009). Although the relationship between oil markets and stock markets has been studied extensively, there is no consensus in the literature on its appropriate nature.

While Kling (1985) concludes that increases in the real price of oil are associated with a stock market decline, Chen et al. (1986) do not find any effect of oil price changes on the stock market. Building on a standard cash flow dividend model and quarterly data, Jones and Kaul (1996) report a stable negative reaction of aggregate stock returns to oil shocks in the U.S. and Canada. In contrast, the VAR-based study of Huang et al. (1996) provides little evidence of a relationship between daily stock returns and daily oil price futures. Using monthly data from 1947:1 to 1996:4, Sadorsky (1999) concludes that oil prices drive fluctuations in real stock returns, and that the relation has intensified over time. The latter results are based on a structural multivariate model where changes in the oil price are ordered second in the VAR. Wei (2003), in turn, concludes that the oil price surge of 1973-74 cannot explain the subsequent decline in U.S. stock prices. More recently, Park and Ratti (2008) aim at identifying effects that are systematic across the U.S. and 13 European countries, documenting a statistically significant impact of oil price changes on real stock returns contemporaneously or within one month. Over their sample period from 1986:1 to 2005:12, only Norway displays a (qualitatively) positive response to an increase in the real price of crude oil.

Based on industry-specific stock prices or index data, Sadorsky (2001) and El-Sharif et al. (2005) find that real stock returns of oil and gas companies in Canada and the UK, respectively, are positively sensitive to an oil price increase. Nandha and Faff (2008) analyze 35 worldwide industry indices from Datastream between April 1983 and September 2005. In their study, an increase in the real price of oil has a negative impact on equity returns for all sectors except mining and the oil and gas industries.

While several of the more recent contributions based on VAR analyses respect the widely accepted endogeneity of crude oil prices[1] (see Barsky and Kilian, 2002, 2004; Hamilton, 2003, 2008) and account for reverse causality from global macroeconomic aggregates to the price of oil, there is a second common weakness. All of the above impose a stable relationship between the real price of crude oil and stock markets. Only recently, it has been recognized that this cannot be true because the composition of structural oil supply and oil demand shocks that drive the real price of oil constantly evolves over time. Kilian and Park (2009) show that an increase in the real price of oil has very different implications for U.S. real stock returns, depending on the underlying structural shock. As a consequence, regressions of stock returns on the oil price that do not distinguish between the effects of supply and demand shocks will be biased towards a zero coefficient or indicate an unstable relation, as in Sadorsky (1999). At best, such estimates represent the response of the stock market to an average oil price shock during the corresponding sample period (compare also Kilian, 2008b).

Following the existing literature, I distinguish three types of shocks to the global oil market. *Oil supply shocks* reflect unexpected changes in physical petroleum production. *Aggregate demand shocks* correspond to changes in the current demand for crude oil that are driven by the global business cycle. Kilian (2009) proposes a novel measure of global real economic activity based on single voyage dry cargo ocean shipping freight rates. Due to the significant lead time in shipbuilding, higher freight rates indicate strong global demand for industrial commodities. *Other oil demand shocks* reflect changes in demand

[1]These VAR models rule out immediate feedback from stock markets to the real price of oil, imposing thus *predeterminedness* of the latter with respect to current but not past observations of the former.

that are orthogonal to the global business cycle. While Kilian and Park (2009) interpret them as precautionary demand shocks[2], arising from shifts in the conditional variance as opposed to shifts in the conditional mean of oil production, this depends on the interpretation of the model. Controlling for inventory changes in a structural VAR of the global oil market, Kilian and Murphy (2011) highlight that precautionary demand shocks are but one example of what they label a *speculative demand shock*. Another example are revisions to expectations about the future supply of oil relative to the future demand for oil. Due to the fact that *other oil demand shocks* represent a mix of different structural shocks, I will stick to this more general denomination in the rest of the paper.

The model coherently identifies structural oil supply and demand shocks. The recent dip in the real price of oil is attributed to the cumulative effects of low aggregate and other oil demand, whereas the global slowdown of real economic activity alone is held responsible for the contemporaneous worldwide stock market crash.

My results suggest that unexpected shortfalls in the global supply of crude oil have little impact on the stock market in any of the six countries under consideration, whereas a positive innovation to global aggregate demand consistently raises oil prices and cumulative stock returns. The latter effect lasts longer for net oil exporters and is particularly pronounced in Norway. Other oil demand shocks have a detrimental impact on the stock market in oil importing countries, a statistically insignificant effect for Canada, and a significant positive effect for Norway. The impulse responses of a global measure of real stock returns seem to be dominated by large net oil importers.

In the short run, the share of forecast error variance attributed to structural oil shocks is significantly larger for Canada and Norway than for any net oil importer in the sample. At longer forecast horizons, this difference disappears. In accordance with Kilian and Park's (2009) finding for the U.S., structural oil supply and oil demand shocks explain between 16% (Germany) and 23% (France) of the long-run forecast error variance in national stock returns. Moreover, there is evidence that the predictive power of structural oil price shocks is larger from a global point of view, indicating that country-specific residual shocks to the stock market partially cancel out.

There is one prior study of international stock markets building on the structural decom-

[2]A formal study of the precautionary demand hypothesis can be found in Alquist and Kilian (2010).

position of oil supply and demand shocks in Kilian (2009).[3] Aspergis and Miller (2009) find that stock market returns in the G-7 and Australia respond little to oil price shocks during 1981-2007, i. e. their significant effects are small in magnitude, while the direction of responses is consistent with the results for the U.S. in Kilian and Park (2009). I challenge their approach for two reasons: Aspergis and Miller (2009) use differenced data on the real price of oil and Kilian's (2009) index of real economic activity which is a business cycle index and stationary, by construction.[4] Moreover, a lag length of seven in monthly data might be too short to fully capture the effects of oil price shocks on the stock market (see, e. g., Hamilton and Herrera, 2004; Baumeister and Kilian, 2011). Hence, their finding of homogeneous responses for a net oil exporter like Canada and a net importer like the U.S. is not convincing in the face of the results presented here.

The rest of the paper is organized as follows. Section 2 is devoted to the methodology of VAR specification and identification. Section 3 presents the empirical results obtained from the structural model. Section 4 concludes.

2 Methodology

2.1 VAR Specification

Following Kilian and Park (2009), I set up a four-variables autoregressive model in the vector $\mathbf{z}_t = (\Delta prod_t, rea_t, rpo_t, \Delta stx_t)'$, where $\Delta prod_t$ denotes the percentage change in world crude oil production, rea_t represents an index of global real economic activity, rpo_t is the country-specific real oil price, and Δstx_t the real rate of return on a representative domestic stock market portfolio. Note that all data are monthly, the second and third series are in logs, while the first and last series are in log differences.

We are interested in estimating the following structural VAR(24) model:

$$\mathbf{A}_0\mathbf{z}_t = \alpha + \sum_{i=1}^{24} \mathbf{A}_i\mathbf{z}_{t-i} + \varepsilon_{\mathbf{t}}, \tag{1}$$

where $\varepsilon_{\mathbf{t}}$ represents the vector of orthogonal structural innovations. I follow the existing literature and choose a lag order of 24 in monthly data, accounting thus for two years worth of past observations of all four variables.

[3] Moreover, Kilian et al. (2009) study the effects of oil demand and supply shocks on several measures of the external balance for a broad aggregate of oil exporting and oil importing countries, respectively.

[4] Wrongly imposing a unit root on a stationary time series renders the estimates inconsistent.

Conditional on $\mathbf{A}_0$ being invertible, the reduced-form representation of (1) is given by

$$\begin{aligned}
\mathbf{z}_t &= \underbrace{\mathbf{A}_0^{-1}\alpha}_{\nu} + \underbrace{\mathbf{A}_0^{-1}\mathbf{A}_1\mathbf{z}_{t-1}}_{\mathbf{B}_1\mathbf{z}_{t-1}} + \ldots + \underbrace{\mathbf{A}_0^{-1}\mathbf{A}_{24}\mathbf{z}_{t-24}}_{\mathbf{B}_{24}\mathbf{z}_{t-24}} + \underbrace{\mathbf{A}_0^{-1}\varepsilon_{\mathbf{t}}}_{\mathbf{e}_t} \\
&= \nu + \sum_{i=1}^{24}\mathbf{B}_i\mathbf{z}_{t-i} + \mathbf{e}_t, \qquad (2)
\end{aligned}$$

where $\mathbf{e}_t$ denotes a vector of possibly contemporaneously correlated innovations, while ν_t and $\mathbf{B}_i$, $i = 1, \ldots, 24$, are the intercept and slope coefficients of the reduced-form VAR. Straightforward multivariate least squares estimation of (2) yields consistent estimates of the matrix of coefficients, $\hat{\mathbf{B}} \equiv \left[\hat{\nu}\ \hat{\mathbf{B}}_1 \ldots \hat{\mathbf{B}}_{24}\right]$, and the reduced-form disturbances, $\hat{\mathbf{e}}_t$.

2.2 Identification

We are not interested in the reduced-form estimates, but in the shocks and parameters of the structural VAR. Building on Kilian (2009), I distinguish three structural demand and supply shocks that drive the real price of oil: changes in the worldwide physical production of petroleum (*oil supply shocks*); shocks to the current demand for crude oil induced by higher economic activity (*aggregate demand shocks*); and changes in the demand for crude oil that are uncorrelated with the global business cycle (*other oil demand shocks*). Any remaining shocks to real stock returns which are not attributable to oil market innovations are merged in a residual category (*other shocks to stock returns*). Note that the latter have no structural interpretation.

By definition, $\mathbf{e}_t = \mathbf{A}_0^{-1}\varepsilon_t$. Hence the covariance matrix of reduced-form innovations is

$$\underbrace{E\left(\mathbf{e}_t\mathbf{e}_t'\right)}_{\Sigma_{\mathbf{e}_t}} = \mathbf{A}_0^{-1}\underbrace{E\left(\varepsilon_t\varepsilon_t'\right)}_{\Sigma_{\varepsilon_t}}\left(\mathbf{A}_0^{-1}\right)' = \mathbf{A}_0^{-1}\left(\mathbf{A}_0^{-1}\right)', \qquad (3)$$

where the last step imposes $\Sigma_{\varepsilon_t} = I_4$, i. e. the diagonal entries of the covariance matrix of structural shocks are normalized to 1, while the diagonal of $\mathbf{A}_0^{-1}$ remains unrestricted. Note that I can replace the expression on the left by its consistent least-squares estimate, $\Sigma_{\hat{\mathbf{e}}_t}$. Because the sample covariance matrix is (4×4) and symmetric, we must impose 6 restrictions upon $\mathbf{A}_0^{-1}$ in order to exactly identify the structural VAR.

In this case, the lower-triangular vectorization of (3), $\text{vech}\left(\Sigma_{\mathbf{e}_t} - \mathbf{A}_0^{-1}(\mathbf{A}_0^{-1})'\right) = 0$, represents a classical method-of-moments (MoM) problem with 10 nonlinear equations in the

10 unknown, non-zero elements of the inverse matrix of contemporaneous coefficients, $\mathbf{A}_0^{-1}$. Provided that the order and rank conditions are fulfilled, it is straightforward to solve the problem numerically.

Imposing a recursive ordering upon $\mathbf{A}_0^{-1}$, the vector of structural shocks, ε_t, are identified by decomposing the reduced-form errors in $\mathbf{e}_t$ as follows:

$$\mathbf{e}_t \equiv \begin{pmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{rpo} \\ e_t^{\Delta stx} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \cdot \begin{pmatrix} \varepsilon_t^{oil\ supply\ shock} \\ \varepsilon_t^{aggregate\ demand\ shock} \\ \varepsilon_t^{other\ oil\ demand\ shock} \\ \varepsilon_t^{other\ shocks\ to\ stock\ returns} \end{pmatrix} \tag{4}$$

While a recursive structure is particularly convenient, we must ensure that the implied restrictions are economically justified. Following the existing literature, the identification in (4) postulates that the short-run supply curve of crude oil is vertical, i. e. innovations to real economic activity or oil market-specific demand do not affect oil production *within the same month.* In light of significant adjustment costs in petroleum production and the uncertainty of whether an observed change in oil demand represents a transitory shock or a permanent shift, the assumption that crude oil supply adjusts with a lag appears highly plausible (compare Kilian, 2009; Hamilton, 2009).

It is equally reasonable that the real price of oil instantaneously responds to both supply and demand shocks. The latter are subdivided into aggregate demand shocks, associated with changes in real economic activity that are not explained by crude oil supply shocks, and other oil demand shocks. Aggregate demand shocks are the structural counterpart of the reduced-form innovations in the real economic activity index, rea_t. Accordingly, they represent shocks to the demand for *all kinds of* industrial commodities associated with the global business cycle. The zero restriction on the second line and third row entry of $\mathbf{A}_0^{-1}$ is consistent with a low short-run price elasticity of the demand for crude oil and matches the sluggish response of global real economic activity after major oil price increases.

Other oil demand shocks subsume shifts in demand that are not explained by the global business cycle. These can be precautionary demand shocks, i. e. pure uncertainty shocks that do not affect the expected levels of future demand or supply (see also Alquist and Kilian, 2010), as well as changes in expected future demand for crude oil or changes in expected future supply of crude oil (see Kilian and Murphy, 2011). To the extent that market participants immediately react to revisions in expectations, other oil demand shocks are assumed to have an immediate impact on the real price of oil, while neither oil production nor real economic activity respond *within the same month*.

Due to the fact that providers of shipping services hold large buffer stocks of bunker fuels, the use of monthly data suggests also imposing a vertical demand curve. I. e., one would expect that oil price changes do not affect real economic activity within the same month, regardless of whether they are induced by changes in oil supply or other demand shocks. Indeed, the unrestricted estimate of a_{21} is close to zero.[5]

Ordering real stock returns last implies that the global oil market block is assumed to be contemporaneously predetermined with respect to domestic stock markets. Predeterminedness of energy prices is a common identifying assumption in the empirical literature and formally tested in Kilian and Vega (2011). They find no evidence of feedback from a wide range of U.S. macroeconomic aggregates to the price of WTI crude oil at monthly frequency. In line with the efficient market hypothesis, real stock returns may respond immediately to oil supply, aggregate demand, and other oil demand shocks, whereas reverse causality from orthogonal stock market innovations to oil supply, the global business cycle, and oil demand are excluded, on impact.

By virtue of these restrictions, the structural VAR in (1) is exactly identified. Imposing a recursive structure is particularly convenient, as it allows to identify $\mathbf{A}_0^{-1}$ by Cholesky-decomposing the sample covariance matrix of reduced-form residuals, $\Sigma_{\hat{\mathbf{e}}_t}$.

3 Sample and Data

3.1 Sample of Countries

The countries in this paper are selected to reveal potentially differing effects of oil price shocks on global and national stock markets. Differences might arise in two dimensions. Since Kilian (2009), economists are aware that – depending on its cause – an unexpected increase in the real price of oil can have very different implications for the U.S. economy. Kilian and Park (2009) document a logical consequence of this result, namely that the

[5] Imposing the overidentifying restriction, $a_{21} = 0$, on the VAR's global oil market block hardly affects the results in Kilian (2009). Conditional on the other identifying restrictions being correct, Hansen's J-test does not reject the null hypothesis of a vertical aggregate demand curve.

Top net oil importers			**Top net oil exporters**		
Rank	Country	1000 Barrels per Day	Rank	Country	1000 Barrels per Day
1	**United States**	9,631	1	Saudi Arabia	7,322
2	China	4,328	2	Russia	7,194
3	**Japan**	4,261	3	Iran	2,486
4	**Germany**	2,319	4	UAE	2,303
5	India	2,233	**5**	**Norway**	2,125
6	South Korea	2,142	6	Kuwait	2,124
7	**France**	1,791	⋮	⋮	⋮
⋮	⋮	⋮	**14**	**Canada**	1,158

Table 1: Top world net oil importers and exporters of petroleum in 2009
Source: U.S. Energy Information Administration (www.eia.gov)

responses of the U.S. stock market to oil price shocks are heterogeneous, as well.

While I study a sample of countries and include the recent financial crisis, the focus is on the effect of a country's net position in global petroleum markets on the relation between structural oil price shocks and national stock market returns. For this reason, I analyze both net oil exporters and net oil importers. Drawing on a measure of worldwide real stock returns, my analysis also embraces a global perspective.

Table 1 lists world top net exporters and importers of petroleum in 2009. Reliable data on consumer price indices, bilateral exchange rates, and stock market returns for China, India, and South Korea are available for the last two decades, at best. For oil exporting countries, however, the data issue is much more severe. Among the largest net exporters of crude oil, the required time series are merely available for Norway and Canada. Since 1974, many emerging markets and developing countries underwent fundamental political and economic regime changes. For obvious reasons, the leading Russian stock exchange, MICEX, only opened in 1992. Similarly, none of the dominant oil exporting countries in the Middle East has a sufficient stock market history.[6]

As a consequence, my sample is limited to six OECD members: the U.S., Japan, France, Germany, Canada, and Norway. Note that it contains the first, third, fourth, and seventh net oil importing country and should thus provide a comprehensive picture. Norway and Canada, however, only rank fifth and fourteenth among world's largest net oil exporters. The potential differences between the two subgroups might thus be understated.

[6]E.g., the Saudi Arabian stock exchange ESIS was introduced in 1990 and replaced by Tadawul in 2001, while the first markets in the United Arab Emirates (UAE) were not founded until 2000.

3.2 Data Description

The VAR(24) is estimated on monthly data of the variables in $\mathbf{z}_t = (\Delta prod_t, rea_t, rpo_t, \Delta stx_t)'$. For $\Delta prod_t$, I use annualized percent changes in the global supply of crude oil. Data on petroleum production in millions of barrels is obtained from the *U.S. Energy Information Administration* (EIA). For rea_t, I employ Kilian's (2009) index of world real economic activity, based on single voyage bulk dry cargo ocean shipping freight rates.[7] The latter two variables are identical for all countries and the global economy.

In line with Kilian (2009), my measure of the real oil price, rpo_t, is based on nominal U.S. refiners' acquisition cost of imported crude oil as reported by the EIA. For the U.S. and from a global perspective, it is straightforward to deflate this price by the U.S. consumer price index (CPI) and the OECD CPI for all member countries, respectively, whereas the relevant oil price for the other countries in my sample must reflect fluctuations in the bilateral exchange rate. Accordingly, I convert the acquisition cost of imported crude oil to domestic currency, using average monthly nominal exchange rates from the *European Central Bank* (ECB) and the *St. Louis Federal Reserve Economic Data* (FRED), and deflate by the corresponding CPI.[8,9]

We finally require a measure of real stock market returns, Δstx_t. Arguably, the leading indices are the S&P500 for the U.S., the CDAX for Germany, the NIKKEI225 for Japan, the S&P/TSX composite for Canada, the CAC40 for France, and the OBX for Norway. As observations on the latter two only start in July and January of 1987, respectively, I substitute the corresponding Morgan Stanley Capital International (MSCI) developed markets indices for them. Similarly, my measure of global stock market returns is based on the MSCI World price index.[10] The nominal data are log-differenced after deflating by the respective country's CPI in order to obtain real returns.

[7] The advantage of this global economic activity index over, e. g., an index of OECD industrial production – the closest proxy for monthly world industrial production – is that it neither requires exchange rate weighting nor does it exclude emerging economies such as China and India.

[8] For the sake of consistency, I use seasonally unadjusted OECD consumer price indices, throughout. Where seasonally adjusted CPIs were available, deflating by the latter did not affect my results.

[9] One might argue that the relevant oil price for Germany, France, and especially Norway is rather the price of Brent crude. While monthly time series on the latter only start in 1981, the correlation with my oil price measure is $> .99$, indicating mainly a level difference.

[10] The MSCI World is a free-float adjusted market capitalization weighted index of 1600 securities from 24 developed markets. Only two of them – Hong Kong and Singapore – aren't members of the OECD. All stock market data are from Datastream. In accordance with leading country indices, I restrict the analysis to *price indices* and abstract from dividend payments or corporate actions.

4 Empirical Results

4.1 Historical Decomposition

The following subsection illustrates the value of the structural model in (1) and (4). Instead of focusing on any single country from my sample, the historical decompositions of rpo_t and Δstx_t are based on the global measure of real stock market returns described above. Figure 1 decomposes the fluctuations in the real price of oil over the sample period into the cumulative effects of oil supply and demand shocks, respectively, recovered from the structural model. All three panels are scaled identically in order to emphasize the relative importance of each disturbance.

Obviously, supply shocks account for a relatively small fraction of historical oil price fluctuations, while aggregate demand shocks are more important, inducing low-frequency cycles in the real price of oil. The dominant component, however, is the cumulative effect of other oil demand shocks. In contrast to supply and aggregate demand shocks and consistent with the speculative demand interpretation in Kilian and Murphy (2011), the latter trigger immediate and pronounced oil price changes. In response to exogenous political events, market participants are prone to sudden reversals of their expectations or act based on uncertainty about the future availability of crude oil.

I abstain from a detailed analysis of specific historical episodes based on Figure 1, as (i) my results are largely identical and (ii) there is little, if anything, left to add in this dimension to the comprehensive and instructive discussion for the U.S. in Kilian (2009). Instead, I want to briefly highlight two empirical observations.

The historical decomposition suggests that unexpected political or military events in the middle east such as the Iranian Revolution affect the real price of oil mainly by triggering sharp changes in speculative oil demand rather than by disrupting global oil production. This is consistent with the finding in Barsky and Kilian (2002, 2004) that the timing of fluctuations in supply during such periods does not coincide with the timing of oil price changes. Measures of actual production fail to reflect shifts in expectations.

Figure 1 also illuminates the recent rise and fall of the real price of oil. The persistent upward trend after 2003 was almost exclusively fueled by high global demand for industrial commodities, in general, while the pronounced drop of 2008 is attributed to a sudden stop in aggregate and other oil demand as well as to generous petroleum supply.

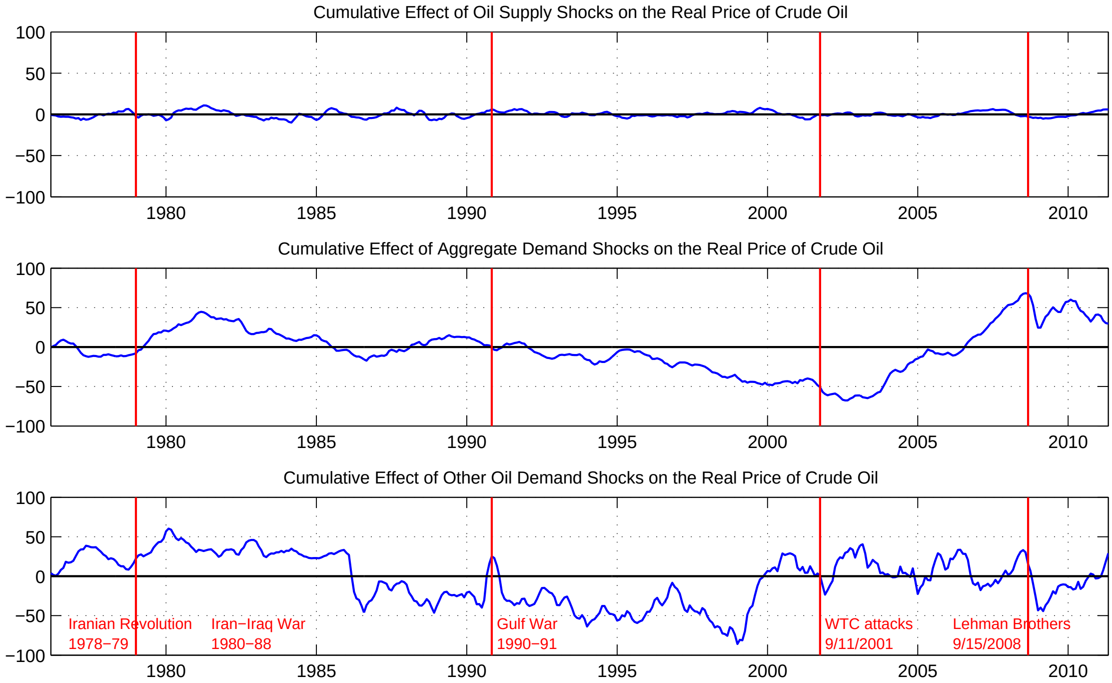

Figure 1: Historical decomposition of fluctuations in the real oil price from 1976:1–2011:4

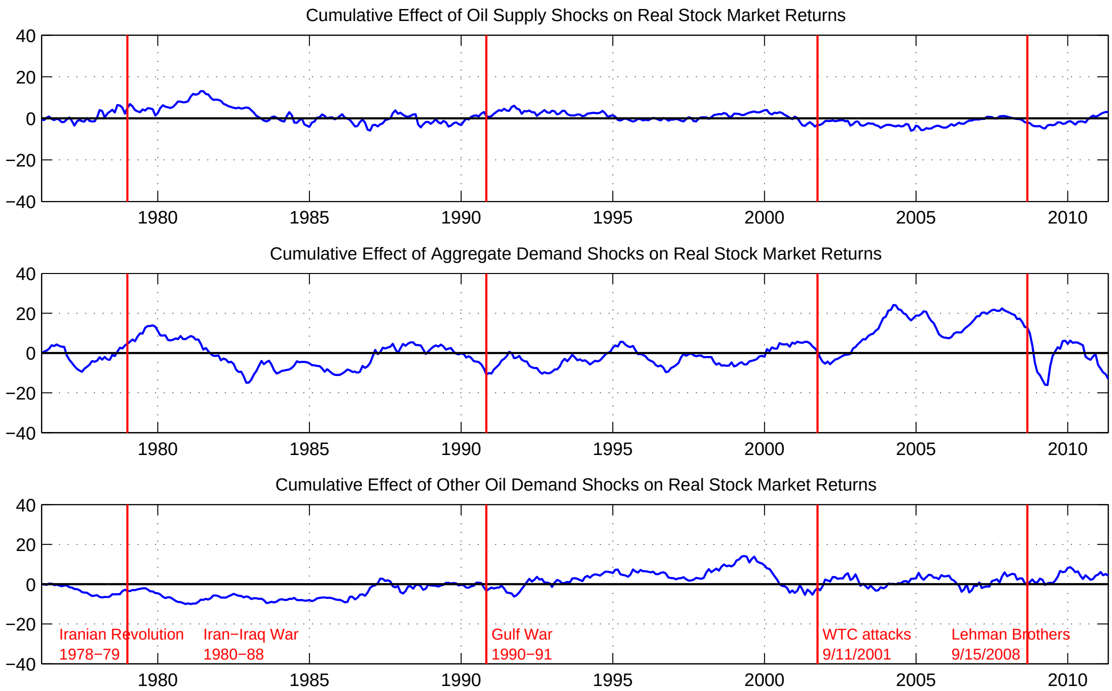

Figure 2: Historical decomposition of fluctuations in cumulative global real stock returns from 1976:1–2011:4

Figure 2 plots the cumulative effects of structural oil supply and demand shocks on real stock market returns measured by the MSCI World price index. This is equivalent to the historical decomposition of rpo_t, re-performed on the fourth variable in the VAR. Since the residual category of stock market shocks does not have a structural interpretation, it is omitted throughout the discussion of empirical results.

For a large part of the sample period, the cumulative effects of structural oil shocks on real stock returns are more loosely connected to particular historical episodes than in Figure 1. E. g., during the Iranian Revolution, a temporary shortfall in petroleum supply seems to have impaired global stock returns, whereas there is no noticeable deflection in either aggregate or other oil demand. In contrast, the persistently elevated oil price throughout the Iran-Iraq War, driven by high other oil demand, had a negative cumulative effect on real stock market returns.

Interestingly, the Gulf War which caused a sharp increase in oil demand and the real price of oil is not held responsible for lower stock returns in the early 90's. Instead, the latter are plausibly associated with the global recession of 1991.[11] In a similar way, the model assigns the boom and bust of world stock markets in the previous decade to the global business cycle. Note, in particular, the enormous downturn in the cumulative effects of aggregate demand shocks around the bankruptcy of Lehman Brothers. While adverse supply shocks seem to have contributed somewhat to the worldwide stock market crash, there is no evidence of a systematic component of other oil demand.

4.2 Structural Impulse Responses

4.2.1 Oil Market Variables

Figure 3 plots the impulse responses of global oil production, real economic activity, the real price of crude oil, and the global stock market to a typical, one-standard-deviation innovation in each of the structural shocks *from a global perspective*, i. e. based on the MSCI World index and the CPI for all OECD members. Note that the impulse response functions of oil supply and the stock market correspond to the *cumulative* responses of $\Delta prod_t$ and Δstx_t. For the sake of consistency, a negative oil supply shock is confronted with positive demand shocks. All three tend to increase oil prices. Confidence intervals

[11] For the U.S., the National Bureau of Economic Research (NBER) timed July 1990 as the peak and March 1991 as the trough of the recession.

are constructed using a recursive-design wild bootstrap in order to account for potential conditional heteroskedasticity of unknown form in the VAR residuals.[12]

Although I present the impulse responses of $prod_t$, rea_t, and rpo_t for the world economy, only, they are qualitatively identical and quantitatively very similar for the entire sample. Recall that country-specific oil prices reflect fluctuations in bilateral exchange rates and differences in consumer price indices. Moreover, the plots are almost identical to the structural impulse responses obtained from a recursively identified three-variable model without stock returns (compare Kilian, 2009). I interpret this as evidence for (i) little feedback from national stock markets to the global oil market, and (ii) no systematic (country-specific) role of bilateral exchange rates for the propagation of shocks to the oil price expressed in domestic currency.

Consider the first row of Figure 3. An unexpected oil supply shock triggers an immediate sharp drop in world crude oil production that is reversed to about 50% over a horizon of six months.[13] Nevertheless, the negative impact remains statistically significant for two years. Surprisingly, supply shocks have only a small, marginally significant effect on the real price of oil and no significant impact on cumulative stock returns. Real economic activity slightly decreases in response to a negative supply shock. Again, the effect is only marginally significant at a horizon of around four months.

On average over the sample period, aggregate demand shocks trigger large, persistent, and statistically significant booms in real economic activity which do not die off until 20 months later. Higher aggregate demand leads to a continuous oil price increase that is statistically significant, on impact, and remains so for at least 15 months. Cumulative stock returns, as measured by the MSCI World index, rise significantly by up to 3% for more than one year after the shock. There is some evidence of a delayed response of petroleum production to aggregate demand shocks. The expansion in supply is partially significant at a horizon of four to 13 months.

Other oil demand shocks raise the real price of oil sharply, on impact. The maximum increase occurs within three months, while petroleum prices decline over the remaining horizon. The shock also implies a modestly lower oil production in the following month, although there is little noticeable effect on supply afterwards. The response of world

[12] Gonçalves and Kilian (2004) introduce the procedure and prove its asymptotic validity.

[13] The partial reversal can be attributed to an offsetting higher production by competing oil producers.

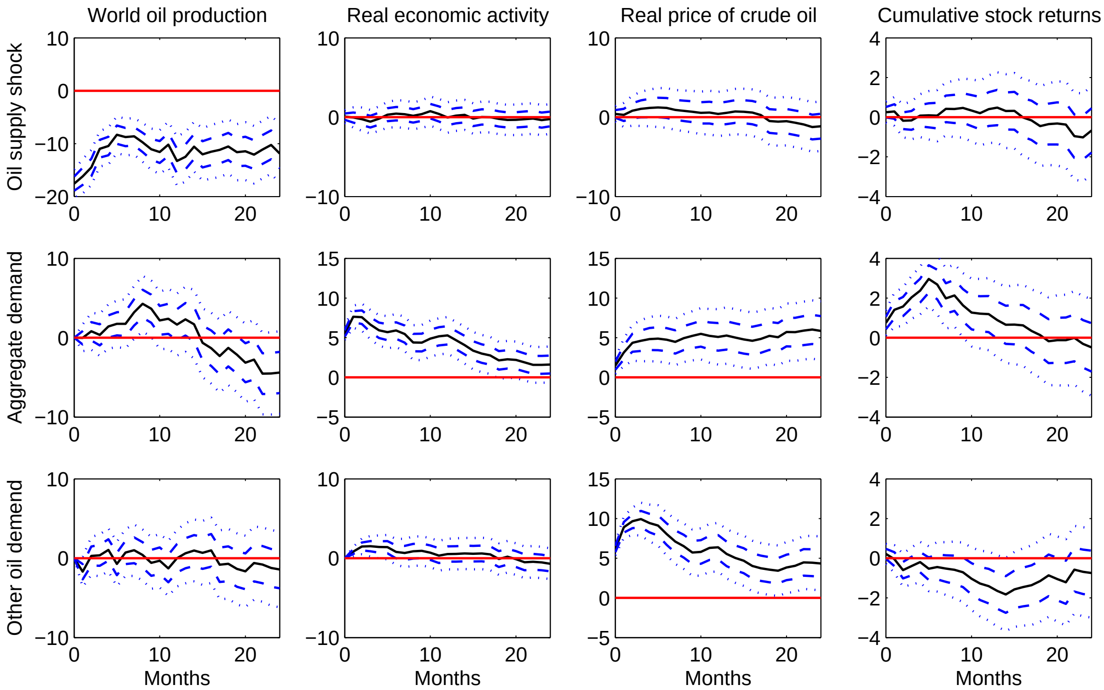

Figure 3: Impulse response functions to one-standard-deviation structural oil market shocks for the MSCI World index (Point estimates with one- and two-standard error confidence intervals)

Note: Confidence intervals based on a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004)

economic activity is hump-shaped and weakly significant for about half a year. Moreover, global real stock returns steadily decrease to a statistically significant minimum of -1.8%, accumulated.

Against conventional wisdom, Figure 3 suggests that the real price of crude oil responds relatively little to unexpected oil supply shocks.[14] Oil price changes are mainly driven by fluctuations in other oil demand such as precautionary demand, for example.

Although sample periods differ in 52 months, i. e. by more than 10% of my observations, I take a global instead of a U.S. perspective, and include real stock returns as a fourth variable, the impulse responses of $prod_t$, rea_t, and rpo_t in Figure 3 are very similar to the structural estimates in Kilian (2009), supporting thus the robustness of the original global oil market model and suggesting that the identification of oil demand and supply shocks is not sensitive to ordering stock market returns last in the VAR.

[14]This is consistent with the evidence in Kilian (2008a) that oil supply shocks have little predictive power for the real price of oil.

4.2.2 Real stock returns

In the following, I focus on the response of country-specific stock returns to oil demand and supply shocks. Figure 4 plots the cumulative impulse responses of real stock market returns to a negative one-standard-deviation oil supply shock. Recall that the shortfall in production had little impact on the real price of oil from a global perspective (compare Figure 3) as well as for the countries in my sample.

On average over the sample period, a typical negative supply shock has no statistically significant effect on national stock markets. This pattern holds for net oil exporting and net oil importing countries, alike, and is also consistent with the global perspective. Only for Germany and Canada, there is modest evidence of a reduction in cumulative stock returns at longer horizons.

This finding can be attributed to the fact that disruptions in physical petroleum supply have but a relatively small and temporary effect on the real price of oil. Hence, they are less likely to impair the longer-run profitability of corporate investments which matters for the buying and selling decisions of investors. Recall that many historical geopolitical events like the Iranian revolution were not followed by an actual slow-down in world

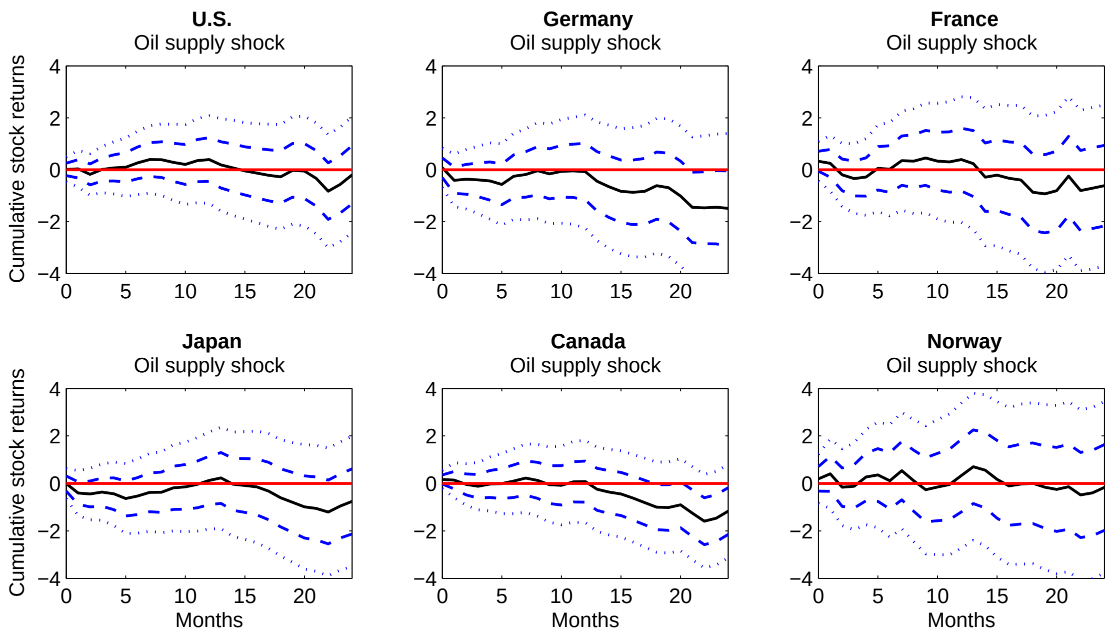

Figure 4: Cumulative impulse responses of stock market returns to a negative oil supply shock (Point estimates with one- and two-standard error confidence intervals)

Note: Confidence intervals based on a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004)

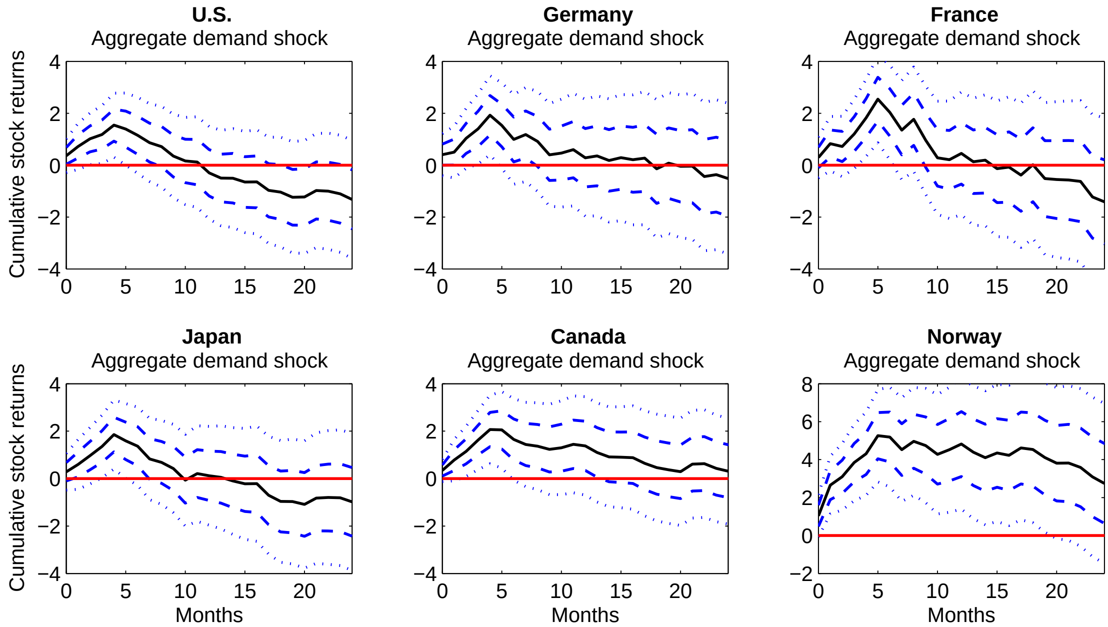

Figure 5: Cumulative impulse responses of real stock returns to a positive aggregate demand shock (Point estimates with one- and two-standard error confidence intervals)

Note: Confidence intervals based on a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004)

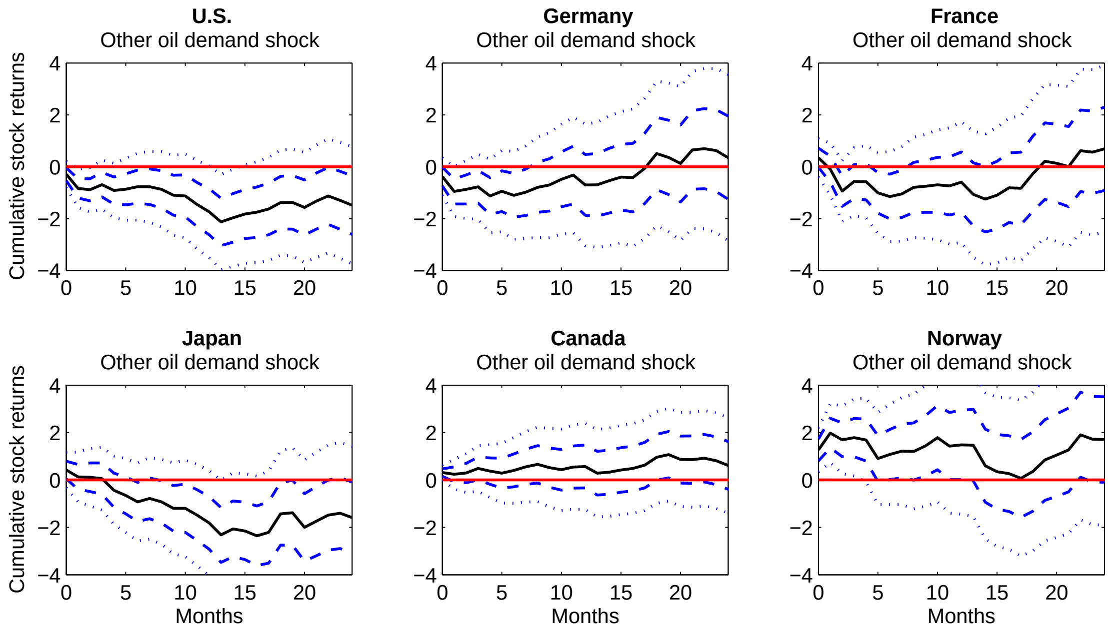

Figure 6: Cumulative impulse responses of real stock returns to an other, e. g., a precautionary oil demand shock (Point estimates with one- and two-standard error confidence intervals)

Note: Confidence intervals based on a recursive-design wild bootstrap (see Gonçalves and Kilian, 2004) crude oil production.

Figure 5 illustrates the cumulative impulse responses of real stock returns to a typical aggregate demand shock. Against conventional wisdom, an increase in the real price of crude oil is associated with *higher* stock market returns, if it arises from an unexpected increase in global real economic activity. For all countries in the sample, cumulative real stock returns rise by between 1.7 and 5.3% within six months after the shock. Note that the effect is statistically significant at the approximate 5% error level.[15]

Moreover, there is a clear difference between net oil importers and net oil exporters. After the initial increase in stock market returns, the cumulative impulse responses quickly fall back to zero for the U.S., Germany, France, and Japan. In fact, there is some evidence of an *overshooting* of returns after one year. Note, however, that the latter observation is weakly significant for the U.S. stock market and insignificant otherwise.

In contrast, the point estimates for Canada and Norway are (partially) significant for several additional months and positive throughout.[16] On average over the sample period, the positive stock market effect of an increase in the real price of oil driven by the global business cycle lasts longer for net oil exporters and is particularly pronounced for Norway. Again, the response of real stock returns in the developed world is dominated by net oil importers like the U.S. and Japan.

Figure 6 plots the impulse responses of cumulative stock returns to a positive oil market-specific demand shock, causing an immediate pronounced and persistent increase in the real price of crude oil. A typical other oil demand shock such as a shift in precautionary demand, for example, impairs stock markets in net oil importing states. Within two years, all countries in the corresponding subsample experience a (partially) significant reduction in cumulative stock returns. Note that the U.S. and Japan – ranking first and third among net oil importers in Table 1 – as well as Germany and France – ranking fourth and seventh – seem to share similar patterns, respectively. For the U.S. and Japan, the negative effect accumulates over time and is most significant around one year after the shock, in accordance with the MSCI World returns in Figure 3. For France

[15] For the U.S., Kilian and Park (2009) arrive at a qualitatively identical but quantitatively less significant response. In principle, the difference might either be due to the different sample period or to the fact that they measure real stock returns based on the Center of Research in Security Prices (CRSP) value-weighted market portfolio. Very likely, it arises from the clear comovement of global real economic activity and U.S. stock prices during the recent financial crisis.

[16] For both countries, this holds up to a horizon of 40 months after the aggregate demand shock.

and Germany, the negative response peaks within six months after the shock. The level of statistical significance is higher for the German stock market.

The picture is reversed for the two net oil exporters in my sample. On average over the sample period, an increase in other oil demand raises cumulative real stock returns in Canada and Norway. The corresponding point estimates are strictly positive up to a horizon of two years and beyond. While the impulse response is not significantly different from zero for Canada, it is statistically significant for about four months in the case of Norway, and partially significant throughout the first year.[17]

4.2.3 Net oil exporters and importers

From Figure 4, a typical negative supply shock has little impact on the stock market in oil exporting and oil importing countries, alike. The picture is more diverse for aggregate demand shocks. An unexpected hike in global real economic activity raises cumulative real stock returns, although it is associated with an increase in the real price of crude oil. While the effect dissipates relatively quickly for net oil importers, it is persistent for the two net exporters in my sample, in particular for Norway.

Taking a closer look at Figure 5, we can almost sort the point estimates of the peak response of cumulative stock returns according to a country's net position in the global oil market. It is least pronounced for the U.S. (+1.54%), Japan (+1.86%), and Germany (+1.92%), and higher for France (+2.54%), Canada (+2.07%), and Norway (+5.26%). Although the wide confidence intervals render any differences in impulse responses statistically insignificant, it seems that the extent to which an economy relies on petroleum imports influences the effect of oil price shocks on domestic stock market returns.

Figure 6 supports this hypothesis. A shock to other oil demand such as a precautionary demand shock triggers a drop in cumulative real stock returns that remains significant for the largest net importers in my sample, while it becomes statistically insignificant for both France and Germany, after about eight months. With regard to net exporters, the positive response of stock market returns is significant for Norway.

Note that the confidence intervals for Norway and the U.S., respectively Germany, are disjoint during the first quarter. Remarkably, the short-run effects of other oil demand

[17] I obtained qualitatively identical results for Norway, using the OBX computed since January 1987 and a corresponding subsample or drawing on earlier stock prices provided by the Norges Bank.

shocks on real stock returns for the largest oil importer and the largest oil exporter in my sample differ at the 5% significance level. The positive effect persists for both Canada and Norway up to a horizon of 24 months, while it is or becomes insignificant as the confidence intervals fan out.

In line with Kilian and Park's (2009) finding for the U.S., an unexpected increase in the real oil price can both raise and depress real stock returns in net oil importing countries, depending on the source of the shock. My results for Canada and Norway suggest that the response is more persistent and more pronounced in the case of an aggregate demand shock and even qualitatively reversed for other oil demand shocks.

In general, an increase in the real price of oil triggered by high other oil demand impairs domestic stock market returns. In order to overturn this adverse effect, it is not sufficient to be a "marginal" net oil exporter. The significantly positive response of cumulative stock returns for Norway in Figure 6 can be attributed to the relative importance of oil-related companies for a small economy with large reserves of crude oil. According to the Global Industry Classification Standard (GICS), the index weights of companies engaged in oil and gas exploration and production, drilling, equipment and services, or storage and transportation account for 45.97% of the OBX. The broader GICS category "energy" represents 26.6% of the Canadian S&P/TSX Composite index, 11.6% of the S&P500, and only 1.6% of the Japanese S&P/TOPIX150.[18] To the extent that oil and gas industries benefit from a non-structural increase in the price of oil, whereas all other sectors lose (see, e. g., Nandha and Faff, 2008), and with regard to the distinct weights in country-specific stock market indices, my results are even more plausible.

4.3 Variance Decomposition

To quantify the fraction of stock market volatility explained by structural shocks is of primary interest to practitioners and investors. For this reason, Table 2 summarizes the results of a forecast error variance decomposition (FEVD) of real stock market returns for the six countries in my sample as well as for developed markets, as a whole.

At the one month forecast horizon, oil demand and supply shocks account for 1.8% (U.S.) or less of the forecast error variance in net oil importers' domestic stock returns. The share of actual physical disruptions of crude oil supply is negligible, except for France.

[18] I was unable to obtain consistent classifications for the NIKKEI225, the French MSCI, or the CDAX.

	U.S.				Japan			
horizon	supply	aggr.dem.	oil.dem.	other	supply	aggr.dem.	oil.dem.	other
1	0.001	1.051	0.718	98.23	0.000	0.423	0.890	98.69
6	0.607	3.696	3.314	92.38	0.947	3.523	2.440	93.09
12	1.118	5.744	4.361	88.77	1.239	6.452	3.455	88.86
∞	5.318	8.940	7.373	78.37	3.010	8.909	10.42	77.66
	Germany				**France**			
horizon	supply	aggr.dem.	oil.dem.	other	supply	aggr.dem.	oil.dem.	other
1	0.020	0.565	0.504	98.91	0.329	0.266	0.358	99.05
6	0.836	3.309	2.124	93.73	1.218	4.179	3.687	90.92
12	1.271	5.328	2.534	90.87	1.496	9.062	3.701	85.74
∞	2.963	7.154	5.877	84.00	4.445	11.72	6.981	76.85
	Canada				**Norway**			
horizon	supply	aggr.dem.	oil.dem.	other	supply	aggr.dem.	oil.dem.	other
1	0.341	1.438	1.173	97.05	0.068	1.997	2.953	94.98
6	0.552	6.332	1.168	91.95	0.915	9.075	4.580	85.43
12	1.167	7.891	1.736	89.21	1.804	10.19	4.938	83.07
∞	5.047	9.866	4.046	81.04	2.923	11.76	7.821	77.50
	MSCI World							
horizon	supply	aggr.dem.	oil.dem.	other				
1	0.376	3.278	0.285	96.06				
6	1.751	8.822	3.230	86.20				
12	2.361	12.85	3.942	80.85				
∞	5.894	14.38	7.592	72.12				

Table 2: Contribution of oil supply, aggregate demand, other oil demand, and other shocks to the forecast error variance of real stock returns at selected horizons (in %)

Even in the very short run, this fraction is about twice as large for Canada, mainly due to aggregate demand shocks. Strikingly, supply and demand shocks to the global crude oil market account for more than 5% of the stock market variation in Norway, where other oil demand shocks alone contribute 2.95% to the FEVD. With increasing horizon, oil shocks also become more relevant in oil importing countries. At six months, the accumulated share amounts to 7.7% for the U.S., 6.9% for Japan, 6.3% for Germany, 9.1% for France, and 8% for Canada, whereas it has increased to almost 15% for Norway.[19]

The increase in predictive power for Norwegian stock returns slows down, afterwards, and the country-specific shares converge in the very long run. At an infinite forecast horizon, the fractions explained by oil supply and demand shocks range from 16% for Germany to 23.1% for France, while Norway no longer represents an outlier in the sample.

[19] Again, this finding can be attributed to the relative and absolute importance of oil companies for the Norwegian economy and the stock market, in particular.

Recall that the residual category "other" in Table 2 summarizes all shocks to real stock returns that are not explained by fluctuations in the real price of oil. These innovations can be country-specific or global, yet orthogonal to the oil market. To the extent that a nonnegligible fraction of national forecast errors is idiosyncratic, one expects that the latter partially offset each other. As a consequence, the predictive power of structural oil demand and supply shocks for stock market returns should be larger from a global perspective than for individual countries, on average.

Indeed, oil demand and supply shocks explain a larger part of the FEVD of MSCI World returns than for any economy in the sample, except for Norway at the one and six month horizon. At an infinite forecast horizon, 28% of unexpected fluctuations in global stock returns are attributed to oil market shocks. It is not surprising that more than half of this fraction is associated with the global business cycle.

5 Conclusion

In this paper, I adopt the econometric methodology in Kilian and Park (2009) to analyze the effects of structural oil supply and demand shocks on national stock market returns for a sample of OECD members, containing both net oil importers and net oil exporters. On the importing side, my sample embraces the U.S., Japan, Germany, and France; on the exporting side Canada and Norway. Moreover, I study the relation between oil prices and the global stock market, approximated by the MSCI World index.

Using monthly data from 1974 to 2011, my empirical results for the impulse responses in the oil market support the findings in Kilian and Park (2009). Unexpected shortfalls in world crude oil supply have no significant impact on any national or my measure of the global stock market. A typical increase in aggregate demand raises the real price of oil and cumulative stock returns in all countries, although the effect is more persistent for net oil exporters and more pronounced for Norway. On average over the sample period, other oil demand shocks such as a precautionary demand shock, for example, have a detrimental impact on the stock market of oil importing countries, a statistically insignificant effect on Canadian, and a significantly positive effect on Norwegian returns. From a global perspective, stock market impulse responses are dominated by the net oil importers in my sample, in particular by the U.S. and Japan.

A country-specific FEVD of real stock returns reveals that, at short forecast horizons, the explanatory power of structural oil price shocks increases with the weight of oil-related companies in the economy and the corresponding stock index. At longer horizons, the distinction between net oil exporters and importers or between specialized and diversified economies seems to disappear. Interestingly, the fraction of structural oil price shocks in the FEVD of MSCI World returns is consistently higher than the average for individual countries. This observation might be due to the fact that idiosyncratic, non-structural innovations in real stock returns are partially canceling out. In the long run, oil supply and demand shocks account for almost 28% of the forecast error variance in global stock market returns.

References

Alquist, R., Kilian, L., 2010. What do we learn from the price of crude oil futures? Journal of Applied Econometrics 25 (4), 539–573.

Aspergis, N., Miller, S. M., 2009. Do structural oil-market shocks affect stock prices? Energy Economics 31 (4), 569–575.

Barsky, R. B., Kilian, L., 2002. Do We Really Know that Oil Caused the Great Stagflation? A Monetary Alternative. In: Bernanke, B. S., Rogoff, K. (Eds.), NBER Macroeconomics Annual 2001. Vol. 16. MIT Press, Cambridge, MA, pp. 137–183.

Barsky, R. B., Kilian, L., 2004. Oil and the Macroeconomy since the 1970s. Journal of Economic Perspectives 18 (4), 115–134.

Baumeister, C., Kilian, L., 2011. Real-Time Forecasts of the Real Price of Oil. forthcoming: Journal of Business and Economic Statistics.

Chen, N.-F., Roll, R., Ross, S. A., 1986. Economic Forces and the Stock Market. The Journal of Business 59 (3), 383–403.

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

Gonçalves, S., Kilian, L., 2004. Bootstrapping autoregressions with conditional heteroskedasticity of unknown form. Journal of Econometrics 123 (1), 89–120.

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

Hamilton, J. D., 2008. Oil and the Macroeconomy. In: Durlauf, S. N., Blume, L. E. (Eds.), The New Palgrave Dictionary of Economics, 2nd Edition. Palgrave Macmillan.

Hamilton, J. D., 2009. Understanding Crude Oil Prices. Energy Journal 30 (2), 179–296.

Hamilton, J. D., Herrera, A. M., 2004. Oil Shocks and Aggregate Macroeconomic Behavior: The Role of Monetary Policy. Journal of Money, Credit, and Banking 36 (2), 265–286.

Huang, R. D., Masulis, R. W., Stoll, H. R., 1996. Energy Shocks and Financial Markets. Journal of Futures Markets 16 (1), 1–27.

Jones, C. M., Kaul, G., 1996. Oil and the Stock Markets. Journal of Finance 51 (2), 463–491.

Kilian, L., 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, L., 2008b. The Economic Effects of Energy Price Shocks. Journal of Economic Literature 46 (4), 871–909.

Kilian, L., 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, L., Murphy, D. P., 2011. The Role of Inventories and Speculative Trading in the Global Market for Crude Oil. mimeo, University of Michigan.

Kilian, L., Park, C., 2009. The Impact of Oil Price Shocks on the U.S. Stock Market. International Economic Review 50 (4), 1267–1287.

Kilian, L., Rebucci, A., Spatafora, N., 2009. Oil shocks and external balances. Journal of International Economics 77 (2), 181–194.

Kilian, L., Vega, C., 2011. 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, J. L., 1985. Oil price shocks and stock market behavior. The Journal of Portfolio Management 12 (1), 34–39.

Nandha, M., Faff, R., 2008. Does oil move equity prices? A global view. Energy Economics 30 (3), 986–997.

Park, J., Ratti, R. A., 2008. Oil price shocks and stock markets in the U.S. and 13 European countries. Energy Economics 30 (5), 2587–2608.

Sadorsky, P., 1999. Oil price shocks and stock market activity. Energy Economics 21 (5), 449–469.

Sadorsky, P., 2001. Risk factors in stock returns of Canadian oil and gas companies. Energy Economics 23 (1), 17–28.

Wei, C., 2003. Energy, the Stock Market, and the Putty-Clay Investment Model. American Economic Review 93 (1), 311–323.

Otto von Guericke University Magdeburg
Faculty of Economics and Management
P.O. Box 4120 | 39016 Magdeburg | Germany

Tel.: +49 (0) 3 91/67-1 85 84
Fax: +49 (0) 3 91/67-1 21 20

www.fww.ovgu.de/femm

ISSN 1615-4274