Oil Price Shocks and the Stock Market: Evidence from Japan

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ABSTRACT

We study, using a structural vector autoregressive (SVAR) model, the relationship between oil price shocks and the Japanese stock market. We find that oil price shocks that arise from changes in aggregate global demand are positively correlated to returns on the Japanese stock market. Thus, in contrast to the conventional wisdom, a rise in oil price is not always bad news for the Japanese stock market. On the other hand, the Japanese stock market reacts negatively to oil price increases related to oil-market specific demand shocks. Finally, different from prior research using U.S. stock market data, we find that supply and demand shocks in the global crude oil market affect returns to the Japanese stock market index through changes to expected real cash flows rather than to changes to expected returns.

Keywords: Oil price shocks, Japan, Stock market, Japanese Crude Cocktail, Structural VAR

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1. INTRODUCTION

A central question for economists and financial analysts is: how does the economy respond to changes in the price of oil? The answer to this question is important for many decisions including the formulation of macroeconomic policy, asset pricing, risk management and portfolio management. Despite a large body of literature on the effects of oil price shocks on the economy, the underlying causes of oil price increases have not been considered until recently. Killian (2009) is the first to disentangle the effects of demand and supply side shocks underlying the evolution of the real price of oil. He finds, in contrast to previous studies (see for example, Lee, Ni and Ratti, 1995; Hamilton, 1996; Jones, Leiby and Paik, 2004; Huntington, 2007 and Gronwald, 2008), that the U.S. economy responds very differently to the different factors that underlie oil price shocks. However, much remains unknown about the response to oil price shocks in economies other than the U.S.

In this paper, we use a structural VAR approach to study the relationship between a crude oil price relevant for the Japanese market (the Japanese Crude Cocktail price) and returns to an aggregate Japan stock market index. We use short-run exclusion restrictions that allow us (unlike much of the early literature on the effects of oil price shocks on the Japanese stock market) to separately study the effect on Japanese stock market index returns of oil shocks arising from oil market supply shocks, surges in aggregate demand due to increased global economic activity and oil market specific demand shocks. In addition, we study whether following supply and demand side shocks to the price of crude oil Japanese stock market index returns are impacted through changes in expected cash flows and/or by changes in discount rates.

Our two main results are as follows. First, in contrast to previous literature, we find that an increase in the real price of oil is not always bad news for the Japanese stock market (see for example, Jones and Kaul, 1996; Huang, Hwang and Peng, 2005; Huang and Guo, 2008).

More specifically, higher real oil prices due to an increase in the global aggregate demand for industrial commodities result in higher stock prices in Japan. Oil price shocks are bad news for the Japanese stock market only when high real oil prices arise from oil-market specific demand shocks related to shifts in the precautionary demand for crude oil in response to concerns about shortfall in future production. Further, in contrast to prior research, we find that the supply shocks arising from unexpected oil production disruption play a less important role in explaining changes in stock prices compared to global aggregate demand shocks and oil-market specific demand shocks. Second, we find that crude oil price shocks contribute more to the variation in Japanese real stock returns than that reported for U.S. stock market index returns. We also find, in contrast to results for the U.S. market, that Japanese stock market index returns are affected by crude oil price shocks through changes to expected real cash flows rather than to changes in expected returns. These results are robust to alternate model specifications and data sources.

The rest of the paper is organized as follows. Section 2 reviews the existing literature. Section 3 describes the data and methodology. Section 4 presents the empirical results and results of robustness tests. Section 5 discusses the results and implications for these of the assumptions underlying the exclusion restrictions we use. Section 6 concludes the paper.

2. LITERATURE REVIEW

The empirical literature on the effects of oil price shocks on stock price uses a variety of econometric tools. Several authors (see for example, Sadorksy, 2001; Boyer and Filion, 2007; Nandha and Faff, 2008) employ regression analysis using industry or firm-level data. Their general conclusion is that oil price shocks affect specific industry groups in different ways. For example, oil-related industries such as the oil and gas sector where oil is a key output, an increase in oil price leads to higher expected cash flows and to positive changes in stock returns subsequently. In the case of other industries, such as automobiles, leisure and travel, higher oil prices are negatively related to stock prices. The main drawback in using regressions-based analysis is that it treats oil prices as exogenous with respect to the global economy and it is now generally accepted that crude oil prices are endogenous with respect to the global macroeconomic conditions (see for example Barsky and Kilian, 2004).

A second strand of research uses VAR models that control the reverse causality from global macroeconomic aggregates to the price of oil. However, these models do not distinguish between oil price shocks driven by supply shocks and demand shocks in oil markets and consequently there is a little consensus as to the nature and economic meaning of the effects. For example, Huang, Masulis and Stoll (1996) find no evidence that oil price shocks have an impact on U.S. stock returns. Sadorsky (1999) finds that both oil prices and oil price volatility play important roles in affecting U.S. real stock returns. Huang and Guo (2008) find a negative relationship between oil price shocks and Japanese stock returns. Park and Ratti (2008) find a positive response of real stock returns to an oil price increase for Norway but a negative reaction in 12 other European countries.

More recent literature, beginning with Kilian (2009) uses structural VARs. For example, Kilian and Park (2009) find that the oil market fundamentals play an important role in explaining the U.S. aggregate stock returns. They also find that the responses of real U.S. stock returns to oil price shocks differ substantially, depending on the underlying causes of a higher price of oil. Apergis and Miller (2009) criticize the use of both stationary and non-stationary variables in the VAR estimation in Kilian (2009) and Kilian and Park (2009). Apergis and Miller (2009) use a modified VAR and find using a sample of G-7 countries and Australia that the effects of oil shocks, although statistically significant, produce a minor impact on stock returns. In the case of Japan they find that oil market shocks do not have any significant affect on Japanese stock market index returns.

Finally, a strand of the literature uses other time series methods to study the responses of stock market to oil price shocks. Jones and Kaul (1996), for example, study the reaction to oil shocks in the U.S., Canada, UK and the Japanese stock markets. They rely on the return decomposition in Campbell (1991) and find that for the U.S. and Japan markets there is substantial negative impact of oil shocks on stock returns. Some studies have used non-linear time series methods; Huang, Hwang and Peng (2005) for example use a regime-switching VAR models while Aloui and Jammazi (1009) use regime-switching EGARCH models.

3. DATA AND METHODOLOGY

3.1. Data

We use monthly stock and oil market data[1] in this paper and our sample period starts from January 1988 and ends in December 2009. For the Japanese stock market data we use Datastream's Japanese country equity index[2] as a proxy for the Japanese stock market. We also obtain and use dividend growth data based on this index. Next, we use the 'Japan Crude Cocktail' (JCC) price as the relevant crude oil price for the Japanese economy. The JCC price is the average price of customs-cleared crude oil imported into Japan. We obtain this monthly nominal JCC price from the Trade Statistics of Japan and deflate the nominal price using the Japanese CPI. Figure 1 plots the demeaned natural log real price of JCC, where the gray background bar is the OECD based recession indicators for Japan from the peak through the trough. The graph shows that the JCC price is sensitive to exogenous events such as political instabilities, wars, and global macroeconomic conditions. For example, there is a significant increase in the price of oil during the Persian Gulf War in 1990; a sharp drop in the real price of oil follows the Asian crisis from 1997 to 1998; and the recent crises is followed by a price

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[1] A detailed description of the data and their transformations we use and the sources are provided in the Appendix.

[2] The Datastream Japan country equity index is computed based on the top 1,000 domestic listed companies by market-value. It is therefore broader based than the Nikkei 225 index.

fall in late 2008-2009. Further, we also use global crude oil production data that reflects OPEC cartel activities and political instabilities for both OPEC and non-OPEC countries. This data is obtained from the Energy Information Administration (EIA). Finally, as proxy for global economic activity, following Kilian (2009)[3] , we use a measure constructed from an equal-weighted index of the percent growth rates of a panel of single voyage bulk dry cargo ocean shipping freight rates measured in dollars per metric ton. The rationale behind using this proxy is that increases in the shipping rates reflects well changes in the global demand for industrial commodities (including that of emerging countries such as China and India) given that supply of ocean-going vessels is likely to be inelastic in the short run.

3.2. Methodology

We use a structural VAR model to disentangle supply and demand-side sources underlying oil price changes and their relation to the Japanese stock market index returns. Our SVAR model can be written as:

$$B_0 X_t = \alpha + \sum_{i=1}^{p} A_i X_{t-i} + u_t \qquad (1)$$

where X_t is a 4 x 1 vector of endogenous variables and divided into two blocks: the first block includes changes in the global oil production (Q_t), an index of global real economic activity index (Y_t), the real price of JCC (P_t) to capture the supply and demand conditions in the global crude oil market; the second block includes the real returns to the Japanese stock market index (R_t). The intercept vector is α, A_i is a matrix of coefficient parameters, B_0 is the contemporaneous coefficient vector of X_t and u_t captures the structural shocks in the oil market and Japanese stock market.

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[3]This data is available at Kilian's homepage http://www-personal.umich.edu/~lkilian/reaupdate.txt. The reader is referred to Kilian (2009) for details on the construction of this index.

Note that, equation (1) contains contemporaneous terms on the left hand side and would yield inconsistent parameter estimates using ordinary least square estimation. We therefore obtain its reduced-form representation by multiplying both sides by B_0^{-1}, resulting in:

$$X_t = A_0 + \sum_{i=1}^{p} A_i X_{t-i} + \varepsilon_t \tag{2}$$

where $A_0 = B_0^{-1}\alpha$, $A_i = B_0^{-1}B_i$ and $\varepsilon_t = B_0^{-1}u_t$. To allow for sufficient dynamics in the system, we follow Hamilton and Herrera (2004) and use a lag length of two years (i.e. $p = 24$)[4]. Note that the reduced-form residuals ε_t are correlated between each equation and can be viewed as a weighted average of the structural shocks u_t. In order to orthogonalize the shocks, we impose a recursive[5] structure on the contemporaneous terms, and the structural shocks u_t are identified by decomposing the reduced-form errors ε_t as follows:

$$\varepsilon_t = \begin{pmatrix} \varepsilon_t^Q \\ \varepsilon_t^Y \\ \varepsilon_t^P \\ \varepsilon_t^R \end{pmatrix} = \begin{bmatrix} a & 0 & 0 & 0 \\ b & c & 0 & 0 \\ d & e & f & 0 \\ g & h & i & j \end{bmatrix} \begin{pmatrix} u_t^{oil\ supply\ shock} \\ u_t^{aggregate\ demand\ shock} \\ u_t^{oil\text{-}market\ specific\ demand\ shock} \\ u_t^{other\ shocks\ to\ stock\ returns} \end{pmatrix} \tag{3}$$

In the global oil market block, we disentangle three structural demand and supply shocks that drive the real price of oil. First, $u_t^{oil\ supply\ shock}$ denotes the *oil supply shock* that reflects a shift of global oil supply not driven by changes in the macroeconomic environment but production disruptions due to political instabilities, wars or changes in production quotas set by the OPEC countries. Next, $u_t^{aggregate\ demand\ shock}$ is the *aggregate demand shock* which captures the shifts in the demand for all industrial commodities including crude oil driven by

[4] Hamilton and Herrera (2004), Kilian (2009), Kilian and Park (2009) suggest that a lag length of about 24 months is adequate to capture the dynamics effects in the data. We report results using 24 lags since we find that our results are qualitatively similar when alternate lags are used (see section 4 for details). Further this also allows for ease in comparison with related results in the literature.

[5] Recursive ordering implies that the first variable in the system will not react contemporaneously to any shocks from the remaining variables, but all other variables can react to shocks in the first variable, and so on. This restriction is concerned with the contemporaneous relations only.

state of the global business cycle, such as the unexpected strong demand from emerging Asia. Finally, $u_t^{oil\text{-}market\, specific\, demand\, shock}$ denotes the *oil-market specific demand shock* that captures innovations to the demand for crude oil which are orthogonal to aggregate demand shocks such as precautionary demand that may be driven by forward-looking behaviour. Intuitively, this can also be thought of as precautionary demand arising from revisions to expectations to future demand and supply conditions in the crude oil market. These expectations may arise from the anticipation of faster growth in emerging economies or from expected shortfalls in future production volumes because of the political uncertainties in oil-producing countries (as in Kilian and Murphy, 2011). In the Japanese stock market block, $u_t^{other\, shocks\, to\, stock\, returns}$ termed as "other shocks to stock returns" is the shock to real Japanese stock returns that is unrelated to global crude oil demand or crude oil supply shocks.

The restrictions on B_0^{-1} are based on the following assumptions and economic intuition. The first assumption is that global crude oil supply does not respond to the demand shocks in the crude oil market immediately. This is plausible since making changes to oil output is costly in the short-run and oil producers therefore base their production plans on expectations of medium-term demand. The second assumption is that increases in the real price of oil driven by oil-market specific demand shocks do not affect global economic activity immediately. This assumption relies on the fact that there is no empirical evidence of instantaneous feedback from changes in the real price of oil to the dry cargo ocean freight rates that form the basis of our measure of global real activity (see for example Kilian, 2009; Kilian and Murphy, 2012). Our third assumption is that innovations to the real price of oil that cannot be explained based on oil supply shocks or aggregate demand shocks can be considered as shocks that reflect changes in the demand for oil as opposed to changes in the demand for all industrial commodities (these are therefore referred to as oil specific demand shocks). For the Japanese stock market block, we assume that the Japanese stock market is affected only by global crude oil production, the global business cycle and the real price of oil with a delay at least one month i.e. imposed through the exclusion restrictions in the last column of B_0^{-1}. The assumption relies on the evidence that innovations to the price of oil are predetermined with respect to the macroeconomic aggregates such as real output, consumptions and stock returns (see for example, Lee and Ni, 2002; Edelstein and Kilian, 2009; Kilian and Park, 2009).

4. EMPIRICAL ANALYSIS

4.1. Results of Unit Root Tests

We begin our analysis with tests for unit roots in variables used in our estimation (e.g., Q_t, Y_t, P_t, R_t). We employ Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests and report results both with and without a trend. We determine the optimal lag length using the Schwarz-Bayes Information Criterion for the ADF test and a Newey-West automatic bandwidth selection criterion for the PP and KPSS tests. The null hypotheses for ADF and PP are the existence of a unit root I(1), so if the series is stationary I(0), the ADF and PP tests should reject the null hypothesis. In contrast, the null hypothesis of the KPSS statistic is that the series is stationary i.e. I(0).

Table 1 reports the results of the ADF, PP and KPSS tests for each series. We find that we can reject the null hypothesis that Q_t, Y_t and R_t contain a unit root at the 1% significant level, and for P_t at 5% using the ADF test without a trend. We find that the PP and KPSS tests suggest that the P_t real price of JCC contains a unit root. However, we use this price series in our analysis, in common with prior literature (see for example Kilian and Murphy, 2012), for the following reasons. First, differencing the JCC price series will result in removal of the slow-moving component in this price series making it difficult to allow for the persistent effect of aggregate demand shocks. Second, even if the JCC is approximately a random walk it is not clear, given the nature of standard unit root tests, whether this is a unit root or not. Third, the estimated impulse response is robust even if the stationary assumption is violated. We note however that the cost of not taking the first difference is a loss of asymptotic efficiency, which leads to a wider error band (see for example, Kilian, 2010; Kilian and Murphy, 2012). Hence, the non-stationarity of the real JCC price series is not a major concern if impulse responses are reasonably estimated.

4.2. Factors underlying Shocks to the Real Price of Oil in Japan

We now report results from our analysis of the response of the real JCC price to shocks from the global crude oil market. Figure 2 depicts the impulse responses, for horizons up to 15 months, of the real price of the JCC to the three supply and demand shocks that drive the global crude oil market. The one and two-standard error bands are indicated by dashed and dotted lines respectively in the graphs. In order that all shocks have a positive impact on the real price of oil (i.e. a higher price), we normalize oil supply shocks to represent an oil supply disruption and the demand shocks are normalized to represent a demand expansion. We draw inferences based on statistics estimated using a recursive-design wild bootstrap method with 2,000 replications (see for example Goncalves and Kilian, 2004).

The first panel of Figure 2 shows that oil supply shocks caused by unexpected oil production disruptions result in an increase in the real price of oil. However, these effects are small and insignificant based on one-standard error bands. On the other hand, the two demand shocks have larger and more persistent effects. First, aggregate demand shocks caused by unexpected increases in global demand for all industrial commodities lead to a persistent increase in the real price of oil. The response reaches its peak at 8% after six months, followed by a declining trend and stabilizes after about ten months. This is highly statistically significant for the first four months based on one-standard error bands – see second panel of Figure 2. Second, oil-market specific demand shocks that are orthogonal to aggregate demand shocks - such as a precautionary oil demand shock - cause an immediate increase in the real price of oil of over 8% but the effect declines sharply after three months as shown in panel three of Figure 2. This is likely due to high rates of world oil production capacity utilization signalling tightness in the market and raising fears about a future oil shortage. It implies that when market participants anticipate a major oil shock due, for example, to political unrest in the Middle East, they might be willing to pay a higher premium for the same quantity of oil to protect themselves from possible shortfalls in oil delivery in the future (see also similar evidence in Alquist and Kilian, 2010 and Baumeister and Peersman, 2012).

Clearly, impulse response estimates only assess the timing and magnitude of the responses of real price of oil to one-time structural shocks and the relative importance of each shock may be quite different from one historical episode to the next (Kilian, 2009). In Figure 3 we report the results of the variance decomposition of the real price of crude oil. Here each panel depicts the cumulative impact of each shock through time. We find, based on these results that the real JCC price is primarily driven by aggregate demand shocks and oil-market specific demand shocks with a relatively smaller contribution from oil supply shocks. For example, the JCC price decline during the 1997 Asian Crisis and recent financial crisis in late 2008 is largely driven by the decreased global economic activity and precautionary demand rather than the oil supply disruptions. The recent price rise between 2003 and mid-2008 further underlines the role and importance of these demand shocks.

In sum, the impulse response and historical decomposition results indicate that the real price of the JCC responds differently to supply and demand shocks in both timing and magnitude. Our findings are similar with results in related work on Japan (Fukunaga, Hirakata and Sudo, 2010) who report that supply shocks play a smaller role for understanding changes in the real price of the oil as compared to demand shocks.

4.3. Supply and Demand Factors and Japanese Real Stock Returns

We now report our results about how Japanese real stock returns respond to oil market demand and supply shocks. Figure 4 depicts the cumulative impulse responses, for a horizon up to 15 months, of real stock returns to each of the three supply and demand shocks. We find that oil supply shocks due to unanticipated disruptions of crude oil production do not affect stock returns much – as seen in the first panel of Figure 4. This likely arises from the fact that the market anticipates that Japan has strategic oil reserves that include both state and privately held stockpiles about whose volume there is information in the public domain. The second panel shows that an unexpected increase in global demand for all industrial commodities causes a significant positive impact on the Japanese real stock returns. This response reaches its maximum after about six months (almost 3%) and is then followed by a slight declining trend. This reaction is likely because positive innovations to the global business cycle initially stimulate the Japanese economy but they could also drive up the oil price which might be seen as having an adverse effect on the Japanese economy in the long-run. As in section 4.2, we find that the recent oil price surge is primarily driven by an aggregate demand shock which explains why the Japanese stock market has not been adversely affected in recent years. Finally, the conventional wisdom is that oil price shocks lower stock prices. However, this is likely to happen only when higher oil prices are driven by oil-market specific demand shocks arising from revisions to expectations about future demand and supply conditions when agents anticipate a lower global production due to international conflicts and political disturbances in oil-producing countries. As shown in the third panel of Figure 4, we find that oil-market specific demand shocks gradually and persistently negatively affect Japan stock market returns after a half-year lag.

We now turn to the important question of evaluating how much of the variation in Japanese real stock returns can be attributed to each supply and demand shock. We do this by computing the forecast error variance decomposition of Japanese real stock market index returns. Table 2 reports the average contribution of each shock to the total variation in real stock market index returns in percentage terms[6]. We find that, in the short-run, the effect of all three supply and demand shocks on real stock market index returns is minor. However, as the horizon increases the explanatory power of demand and supply shocks in the global crude oil market increases significantly. We find that, over longer horizons, more than 42% the variations in real stock market index returns are driven by the global crude oil market, where the aggregated demand shocks alone account for 24% of the variability of returns, and oil supply shocks account for 12% and 6% from the oil-market specific demand shocks. We conclude that shocks to the global crude oil market play an important role affecting the Japanese stock market.

4.4. Oil Price Shocks, Expected Returns and Cash Flows

We now explore the relation between oil price shocks and stock returns through their effects on expected cash flows and/or expected discount rates. We do this using Campbell's (1991) return decomposition where the log real return on a stock in period *t*, R_t can be written as the sum of expectations about cash flows and variations in discount rates:

$$R_t - E_{t-1}(R_t) = \left[E_t\left(\sum_{i=0}^{\infty} \rho^i D_{t+i}\right) - E_{t-1}\left(\sum_{i=0}^{\infty} \rho^i D_{t+i}\right)\right] - \left[E_t\left(\sum_{i=0}^{\infty} \rho^i R_{t+i}\right) - E_{t-1}\left(\sum_{i=0}^{\infty} \rho^i R_{t+i}\right)\right] \quad (4)$$

where E_t is the expectation at time *t*, D_t is the real dividend growth rates, ρ is the discount

[6] We also report the standard errors in parentheses under percentage of each variances explained, they are estimated through Monte Carlo techniques with 2,000 replications.

coefficient that is slightly less than one, and it is computed as follows: $\rho \equiv 1/1+exp\left(\overline{d-p}\right)$, where $\overline{d-p}$ is the average log dividend-price ratio.

In order to incorporate the changes in real stock returns arising from a given supply or demand shock in the crude oil market, following Kilian and Park (2009), we write equation (4) in terms of the responses to unanticipated disturbances in the crude oil market. First, we normalize all expectations of period *t-1* in equation (4) to zero. Next, the changes in real cash flows and changes in expected returns relative to the baseline in response to an unexpected disturbance in the crude oil market are written as:

$$R_t - E_{t-1}(R_t) = E_t(R_t) - E_{t-1}(R_t) = \psi_{0j} - 0 = \psi_{0j} \tag{5}$$

$$\left[E_t\left(\sum_{i=0}^{\infty}\rho^i D_{t+i}\right) - E_{t-1}\left(\sum_{i=0}^{\infty}\rho^i D_{t+i}\right)\right] = \sum_{i=0}^{\infty}\rho^i \delta_{ij} - 0 = \sum_{i=0}^{\infty}\rho^i \delta_{ij} \tag{6}$$

$$\left[E_t\left(\sum_{i=0}^{\infty}\rho^i R_{t+i}\right) - E_{t-1}\left(\sum_{i=0}^{\infty}\rho^i R_{t+i}\right)\right] = \sum_{i=0}^{\infty}\rho^i \varphi_{ij} - 0 = \sum_{i=0}^{\infty}\rho^i \psi_{ij} \tag{7}$$

where ψ_{0j} is measured by the first element of the impulse response coefficients of real stock returns to a shock *j* in the crude oil market in month *t*; ψ_{ij} is the impulse response of real stock returns in period *I* to a given structural shock *j* in the crude oil market and all these coefficients are obtained using the methodology in Section 4.3; δ_{ij} is the impulse response of real dividend growth rates and these coefficients are obtained by re-estimating model (1) by replacing real stock returns in the last element of X_t with real dividend growth rates on the Datastream Japan Index. Further details about the data and results are in the Appendix.

We then formally test whether different supply and demand shocks in the global crude oil market affect real Japanese index stock returns through changes in changes in real dividend growth and/or changes in expected discount rates. The null and alternative hypotheses can be written as:

$$H_0 : \psi_{0j} = \sum_{i=0}^{\infty} \rho^i \delta_{ij} \approx \sum_{i=0}^{36} \rho^i \delta_{ij} \tag{8}$$

$$H_0 : \psi_{0j} = -\sum_{i=0}^{\infty} \rho^i \psi_{ij} \approx -\sum_{i=1}^{36} \rho^i \psi_{ij} \tag{9}$$

$$H_1 : \psi_{0j} = \sum_{i=0}^{36} \rho^i \psi_{ij} - \sum_{i=0}^{36} \rho^i \psi_{ij} \tag{10}$$

where the infinite sum is truncated at 36 lags i.e. 3 years. Table 3 reports the Wald-test statistics and *p*-values for null hypotheses in equation (8) and (9). First, neither null hypothesis is rejected at 10% significance levels for any of the three shocks in Panel A. Second, we can reject the null hypotheses on that Japanese real stock returns do not respond to all three shocks from expected real dividend growth – see results from Panel B. Taken together our empirical results imply that Japanese real stock returns are affected by supply and demand shocks in the global crude oil market through changes of expected real cash flows rather than changes of expected returns or discount rates.

4.5. Results of Robustness Checks

We now report results of tests for robustness of our results reported earlier. First, we find that our results are robust to the use of different lag lengths (i.e., 12 and 18) in the VAR. We find that impulse responses of real stock returns do not change qualitatively when alternative lag lengths are used.

Next, we replace some of the variables in our model with alternate proxy variables. First, we use the Baltic Dry Index (BDI)[7] which tracks worldwide international shipping prices of various dry cargoes as a different measure of the world economy activity instead of the index we use as in Kilian (2009). We find that the directions of the responses to the

[7] We obtain this data from Datastream.

structural shocks are qualitatively similar. In addition, we use the FTSE Japan Stock index[8] instead of the DataStream Japan stock market index and re-estimate our structural VAR model. Again, this does not qualitatively change our main conclusions.

5. DISCUSSION OF RESULTS

5.1. Comparison with Prior Research

This section compares our findings with selected prior studies that study the impact of oil price shocks and stock market returns using U.S. and Japanese data. Our results differ from those reported in Kilian and Park's (2009) for the U.S. stock market in several respects. For example, we find that Japanese stock market index returns respond more positively to aggregate demand shocks than that reported using U.S. stock market index data. We note that an unexpected increase in the global demand for industrial commodities tends to stimulate an economy, but it also drives the oil price and the prices of other imported industrial commodities prices up and this might retard economic growth (Kilian, 2008). However, it is not clear a priori which effect will dominate. In our data, the net effects of such a shock on the Japanese stock market are statistically positive in the short-run while the negative impact is smaller than that reported for U.S. market index returns. This result is consistent with a number of recent international comparison studies which find that the negative effects of oil price increases on Japan's real economic activity are much smaller than those for other oil-importing countries including the U.S. (see for example, Jiménez-Rodríguez and Sánchez, 2005; Blanchard and Galí, 2007).

We also find that an oil-market specific demand shock due to increases in the precautionary demand for oil related to concerns about future oil supply shortfalls has stronger negative effects on Japan stock returns than seen for the U.S. stock market. This

[8] FTSE Japan stock index includes 450 largest listed companies, which also provides a good proxy for the Japan aggregate stock market.

result is likely due to the fact that Japan, the third-largest oil consumer in the world (after the U.S. and China), depends almost entirely on imports from the Middle East[9] to meet its consumption needs. Consequently, one might expect that any anticipated future supply disruptions would have a bigger impact on the Japanese economy than on the U.S. However, the Japanese government has a national energy strategy to reduce its vulnerability to crude oil price fluctuations. For example, Japan maintains a large strategic oil and gas reserve inventory that represents more than 150 days consumption. Further, the Japanese government places a substantial amount of investment in research and development on energy-efficient technologies and also relies on nuclear energy and natural gas to reduce its share of oil consumed in Japan's primary energy mix. As a result, Japan has one of the lowest energy intensities as compared to the other developed economies, and oil as a percentage of Japan's total primary energy demand has fallen from around 80% of the energy mix in the 1970s to 46% in 2009 (Japan EIA, 2011). In addition, the Japanese government imposes a much higher level of taxes on petroleum products than the U.S., so that consumers and businesses might see smaller price movements and be less responsive to demand shocks than the U.S. does (IEA Japan Energy Policies, 2008).

Our variance decomposition also shows that aggregate demand shocks play a more important role in explaining the variation for the Japanese real stock returns as compared to the U.S. market (Kilian and Park, 2009). One possible explanation for this is the composition of the Japanese aggregate stock market. For example Fukunaga, Irakata and Sudo (2010), who classify industries into oil-intensive and export-dependent industries, find that the latter have a larger increase in the stock prices with respect to the global demand shocks. The Japanese aggregate stock market index has more export-dependent industries as compared to the U.S. stock market index. Therefore, at the aggregate market level, the global demand

[9] Roughly 80% of Japanese crude oil imports from the Middle East, up from 70% in the mid-1980s.

shocks should also cause a bigger impact on Japanese aggregate stock market returns than it does for the U.S. stock market.

Finally, for the U.S. stock market changes in both expected real cash flows and expected real discount rates are important in explain innovations to stock market index returns arising from supply and demand side shocks to crude oil market prices (see Kilian and Park, 2009). However, we find that aggregate Japanese real stock returns are driven mainly by fluctuations in real cash flows. This difference is likely because Japanese firms have different corporate governance and payout policies as compared to U.S. firms. First, the ownership structure of Japanese firms is typically highly concentrated among few corporate stockholders, while the ownership in large U.S. firms is relatively dispersed. Therefore, in contrast to U.S. firms, there is a smaller scope for information asymmetry and agency problems in Japan, and Japanese firms are able to adjust their dividends more often and cut their dividends quicker in respond to poor performance (see for example, Dewenter and Warther, 1998; Chay and Suh, 2009). Second, again in contrast to U.S. firms, cash dividends remain a major form of payout across the firms in Japan. Further, Denis and Osobov (2008) report that the proportion of U.S. firms paying dividends has declined from 61% to 19%, while for Japanese firms this changed from 89% to 83% over the period 1989-2002.

Another possible explanation may lie in the role of the Bank of Japan (BOJ)'s monetary policies (Bernanke, 2000). In theory, oil price shocks can adversely affect stock prices through the discount rate channel as monetary policy makers tend to raise interest rates in anticipation of the higher inflation triggered by higher oil prices. A rise in interest rate implies a higher required rate of return and lowers firms' future cash flows and subsequently leads to a lower stock price. We note that the BOJ reduced its policy interest rates to very low levels to stimulate the economy and fight deflation; the zero-interest-rates policy from 1999 to 2000, the quantitative easing policy from 2001 to 2006, and the near zero interest rate policies during the recent global financial crisis from 2008 to the end of our sample period. A possible reason therefore for failing to find changes in discount rates as having any effect on innovations to Japanese stock returns may be because of the persistent low interest rates and deflation seen in Japan since the mid – 1990s.

Next, we turn to a comparison of our results to those in prior work on the effects of oil price shocks on the Japanese stock market that does not distinguish between oil price innovations driven by crude oil supply shocks versus those driven by demand shocks. For example, Jones and Kaul (1996) test whether the reaction of international stock markets to oil shocks can be justified by current and future changes in real cash flows and/or changes in expected returns using Campbell's (1991) return decomposition. Their results for both U.S. and Japan show the substantial negative impact of oil shocks on stock returns. In particular, they find that the negative impact is most dramatic in the case of Japan with the adjusted R-squared is over 25%. We note here that Jones and Kaul (1996) use a different econometric estimation methodology i.e. a linear regression model. Apart from this aspect their results could be different since their methodology treats oil prices as exogenous with respect to the global economy. Other studies such as, Huang and Guo (2008) and Huang, Hwang and Peng (2005) also find that Japanese stock returns react negatively to an increased real oil price shock.

We note here that Apergis and Miller (2009) also use a methodology that builds on Kilian (2009) to study the impact of oil price shocks on several international stock markets including Japan. However, they only find marginal evidence that oil-market shocks contribute to explain the variation in Japanese real stock returns i.e., 3.3% of the changes in the Japanese real stock returns are accounted for by oil supply shocks, aggregate demand shocks account for 2.2% and 2.7% from the oil-specific demand shocks. It is likely that the main reason for this difference between our results and those reported in Apergis and Miller

(2009) might be due to their use of first-order differenced real prices of oil to remove non-stationarity. This differencing, as we point out earlier, removes the slow-moving component and reduces the chance of detecting persistent effects of global shocks on the demand for all industrial commodities (see Kilian and Murphy 2012, for a similar argument). In addition, Apergis and Miller (2009) include seven lags in their VAR model, whereas Hamilton and Herrera (2004), suggest that the dynamic effects are more persistent and can be assessed using longer lag lengths (e.g., 12, 18 or 24). Another possible reason for the difference in results could be that we use the JCC price that reflects the landed price to Japanese consumers while Apergis and Miller (2009) use a world oil price deflated by the Japanese CPI.

5.2. Discussions about Exclusion Restrictions

We now discuss the plausibility of the economic assumptions behind our statistical exclusion restrictions and discuss conditions under which these assumptions may not hold and the likely caveats that might arise to the interpretation of our results.

The first exclusion restriction in the VAR is based on the assumption that global crude oil production does not respond to the demand shocks in the crude oil market immediately but does so with a delay for at least a month. There is a general consensus in the literature that the supply of crude oil is inelastic in the short-run (see for example, Hamilton, 2009; Baumeister and Peersman, 2012; Kilian and Murphy, 2012). This has also found support in studies using oil industry firm level data. For example Kellogg (2011), using monthly well-level oil production data from Texas, finds that there is essentially no response of oil production to demand shocks in the short-run. Killian (2010) introduces the possibility of weak feedback from demand shifts to the price of gasoline and observes that a vertical short-run supply curve need not be literally true for the baseline VAR analysis to be informative. However it is possible that there may be certain circumstances under which this exclusion restriction may not strictly hold. For example, there could be predictable changes in demand for crude oil when market participants incorporate expectations about likely disruptions of events that may affect oil production and therefore its supply. Further, we have not accounted for the role of both government and private reserves – the threat of using these or actual use of this may result in changes in supply that may occur even in the very short run. Another possibility is that crude oil supply is a function of existing capacity utilization in the industry. If the existing level of supply is at a low level of utilization due to say planned cutbacks then there would be capacity slack that would enable higher production in the relatively short run. Such situations might create a situation where the short-run oil supply curve may not be vertical, as assumed in our exclusion restrictions, over periods during which we analyze the impulse responses.

The second exclusion restriction imposed in the VAR is that increases in the real price of oil driven by shocks that are specific to the oil market will not lower global real economic within the same month. We note that it is plausible that consumers and businesses may not revise their consumption plans immediately regardless of whether a higher oil price is trigged by unanticipated oil supply disruptions or increase in the precautionary demand for oil. In this case, it may be more appropriate to impose an over-identifying restriction on $b = 0$ to limit the short-run response of real activity to oil supply shocks. Empirically however it turns out that the unrestricted estimate of b is close to zero[10] thus making this point moot (Kilian, 2012).

The third assumption in our exclusion restrictions is that innovations to oil prices are predetermined with respect to stock returns. In effect this assumption rules out instantaneous feedback from Japan stock markets to oil prices while allowing oil prices to respond to all past information. In other words, this implies that feedback from domestic stock market

[10] Imposing the over-identifying restriction on $b = 0$ hardly effects the results.

shocks is negligible in the short-run. We note that Kilian and Vega (2011) formally test this identifying assumption of no feedback within the month from U.S. macroeconomic aggregates to the oil prices. They do not find any compelling evidence of feedback at daily or monthly horizons and it would appear that the assumption relied on seems to be reasonable.

Finally, we note that some recent studies recover the structural shocks in the crude oil market by restricting the sign on the impact multiplier matrix (see for example, Baumeister and Peersman, 2012; Kilian and Murphy, 2011, 2012). In contrast to the exclusion restrictions used in this paper, sign-identified models do not require researchers to impose exact restrictions on the magnitude of the contemporaneous impact of the shocks. As a result it is not necessary, for example, to impose a zero impact elasticity of oil supply or demand. However, these models are more restrictive in other aspects. For instance, unlike structural VAR models based on short-run restrictions, sign-identified models do not provide unique point estimates of the structural impulse response functions, but a set of solutions that are all equally consistent with the identifying assumptions. As a result, additional assumptions are required to narrow down the range of admissible structural models (see Fry and Pagan, 2010; Kilian, 2012 for a critical review of sign-restricted models). Kilian and Murphy (2012), for example, use sign restrictions in conjunction with bounds on the implied effect of oil supply and demand elasticity. They find results broadly consistent with Kilian's (2009) findings about the relative importance of supply and demand shocks for the real oil price using structural VAR models identified by short-run restrictions. It would be of great interest to study in greater detail the use of sign restrictions and we leave this for future work.

6. CONCLUSION

We use a structural VAR model to study the link between oil price shocks and the Japanese stock market. We find that the response of Japanese real stock returns to oil price shocks differs extensively depending on the specific underlying causes of a higher oil price. For example, oil-market specific demand shocks from unexpected increases of precautionary demand for crude oil caused by concerns about future oil supply shortfalls lower the stock returns in Japan. In contrast, when an oil price increase is driven by aggregate demand shocks, we find a positive relationship between the oil price shocks and the Japanese stock market. However, oil supply shocks from unanticipated disruptions of crude oil production have no significant effect on returns on an aggregate Japanese stock market index.

Next we study whether the reaction of Japanese real stock returns to different shocks in the crude oil market is related to changes in expected cash flows or changes in expected discount rates. We find the responses of the Japanese stock market to all shocks in the crude oil market can be attributed almost entirely to changes in real cash flows.

In addition, we compare and discuss the oil price shocks transmission mechanisms in the U.S. and Japanese markets. We find that the Japanese stock market reacts stronger to the unexpected increases in global demand and to the unexpected increases of precautionary demand for oil than the U.S. stock market. In addition, aggregate demand shocks play a more important role in explaining the variation in Japan than U.S. real stock returns. The impact on Japanese stock returns arising from supply and demand shocks in the global crude oil market mainly comes from variations in expected cash flows rather than changes in discount rates, while both changes in cash flows and discount rates are significant factors in the U.S. market. However, further work using Japanese data at the firm level is required to study and explore the channels through which oil price shocks affect Japanese firms. We leave this to future work.

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Table 1: Unit Root Tests

Variables	ADF Test		PP Test		KPSS Test	
	Without Trend	With Trend	Without Trend	With Trend	Without Trend	With Trend
Q_t	-17.54***	-17.94***	-17.56***	-18.85***	0.11	0.04
Y_t	-2.63***	-3.21	-2.60***	-3.11	0.78***	0.28***
P_t	-2.12**	-3.41*	-1.438	-2.62	1.24***	0.41***
R_t	-14.94***	-14.93***	-14.93***	-14.93***	0.04	0.04
D_t	-14.49***	-14.50***	-14.41***	-14.41***	0.23	0.10

Notes: This table reports the results of unit roots tests for all five variables that are proposed to use in our VAR model. Q_t is the first-order difference on global crude oil production, Y_t is the real economic activity index proposed by Kilian (2009); R_t is the real price of oil imported by Japan; R_t is the real Japan stock returns and D_t is the real Japanese dividend growth rates. We use Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests, and report results with and without a trend. The null hypotheses for ADF and PP are 'the series has a unit root I(1)', while the null hypothesis of the KPSS test is 'the series is stationary I(0)'.
*Significant at 10% level; **Significant at 5% level; ***Significant at 1% level.

Table 2: Percentage of the Forecast Error Variance of the Japanese Real Stock Returns Explained by Each Structural Shock in the Crude Oil Market

Horizon Months	Oil Supply Shock	Aggregate Demand Shock	Oil-Market Specific Demand Shock	Other Shocks
1	0.0 (0.6)	1.0 (1.4)	0.1 (0.7)	98.9(1.6)
2	2.7 (2.6)	0.9 (1.5)	0.7 (1.6)	95.7 (3.4)
3	3.3 (2.8)	1.5 (2.1)	0.9 (1.9)	94.2 (3.8)
12	8.4 (3.7)	5.6 (3.8)	3.4 (3.5)	82.6 (5.5)
∞	12.2 (7.5)	24.1 (15.5)	6.5 (8.7)	57.3 (11.6)

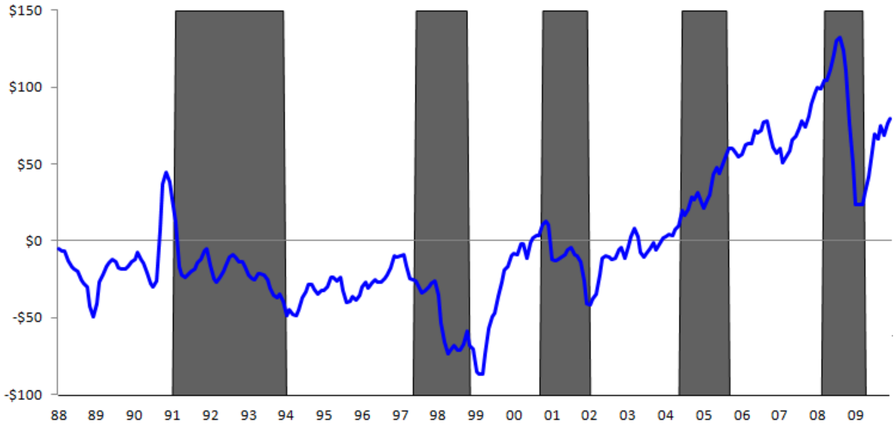
Notes: This table reports the results of the variance decomposition for each supply and demand shock on Japanese real stock returns. It presents the percentage contribution of each shock, namely oil supply shock, aggregate demand shock, oil-market specific demand shock, and other shocks, to the overall variability of real stock returns for 1-month, 2-month, 3-months, 12-month and infinity ahead. Standard errors estimated by Monte Carlo with 2,000 replications are reported in parentheses.

Table 3: Tests of the Impact Response of Japan Real Stock Returns and Dividend Growth

Panel A: The Impact Responses of Real Dividend Growth		
	Wald Test Statistic $H_0 : \psi_{0,j} = \sum_{i=0}^{36} \rho^i \delta_{ij}, \; j = 1,2,3$	**P-Value**
Oil supply shocks	0.1112	0.7387
Aggregate demand shocks	0.0401	0.8413
Oil-market specific demand shocks	0.8385	0.3598
Panel B: The Impact Responses of Real Stock Returns		
	Wald Test Statistic $H_0 : \psi_{0,j} = -\sum_{i=1}^{36} \rho^i \psi_{ij}, \; j = 1,2,3$	**P-Value**
Oil supply shocks	7.8261	0.0051
Aggregate demand shocks	11.0202	0.0009
Oil-market specific demand shocks	2.8523	0.0912

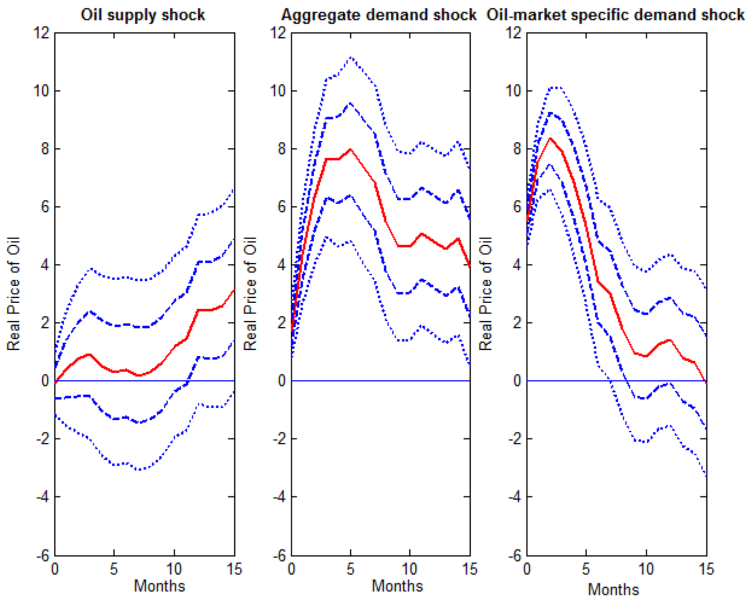
Notes: ψ_{ij} denotes the response of real stock returns i periods after each oil supply, aggregate demand shock and oil-market specific demand shock, $j = 1,2,3$ while δ_{ij} denotes the response of real dividend growth to these three shocks. Panel A presents the Wald-test statistics and p -values for null hypothesis 'the impact change in real stock returns arising from a given shock of the global crude oil market can be fully attribute to changes in expected real dividend growth'. The Panel B presents the Wald-test results for null hypothesis 'the impact change in real stock returns arising from a given shock from the global crude oil market can be fully attributed to changes in expected returns'.

Figure1: Real Price of Japan Crude Cocktail (JCC)



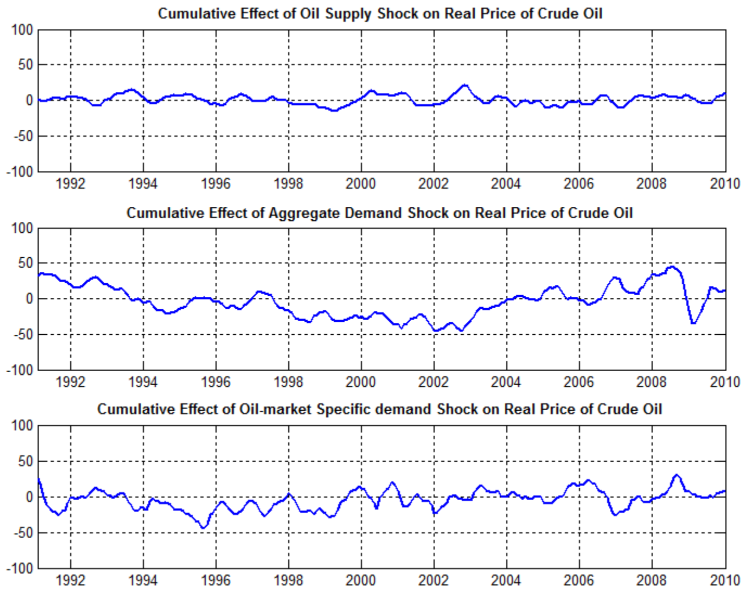
Notes: Figure 1 plots the demeaned natural log real oil price imported into Japan. The sample spans the period from January 1988 to December 2009. The gray background bar is the OECD based recession indicators for Japan from the peak through the trough.

Figure 2: Impulse Responses of Real Price of Japan Crude Cocktail (JCC) to Three Structural Shocks with One - and Two - Standard Error Bands



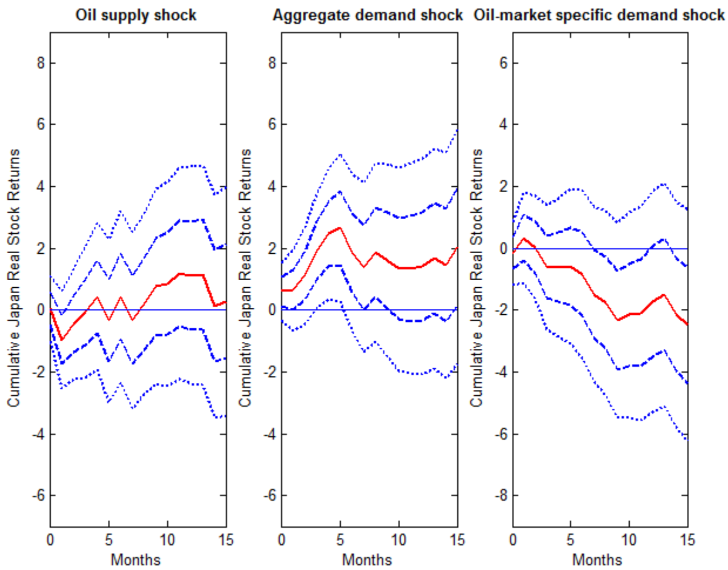
Notes: The estimates are based on the structural VAR model in equation (1). The three panels plot the impulse responses of the real price of JCC to each of the three demand and supply shocks that affect the crude oil market. Each panel measures how a unit impulse of structure shocks at time t impact the level of oil price at time $t+s$ for different values of s. Here we limit s until 15-month ahead. All shocks have been normalized to represent an increase in the real price of oil. The confidence intervals are constructed using a recursive-design wild bootstrap with 2,000 replications.

Figure 3: Historical Decomposition of Real Price of Japan Crude Cocktail (JCC)



Notes: The estimates are based on the structural VAR model in equation (1). This figure plots the historical decomposition of fluctuations in the real price of JCC. It shows the cumulative effect of a sequence of structure shocks that affect the real JCC prices spanning the period from January 1988 to December 2009.

Figure 4: Cumulative Responses of Japanese Real Stock Returns to Three Structural Shocks with One-and Two-Standard Error Bands



Notes: The estimates are based on the structural VAR model in equation (1). The three panels plot the impulse responses of Japanese real stock returns to each of the three demand and supply shocks that affect the crude oil market. Each panel measures how a unit impulse of structure shocks at time t impact the level of oil price at time $t+s$ for different values of s. Here we limit s until 15-month ahead. The oil supply shock has been normalized to represent a negative one standard deviation shock, while the aggregate demand shock and oil-market specific demand shock have been normalized to represent positive shock. The confidence intervals are constructed using a recursive-design wild bootstrap with 2,000 replications.

Appendix

I. Data and Sources Descriptions for Data Used to Obtain Main Results

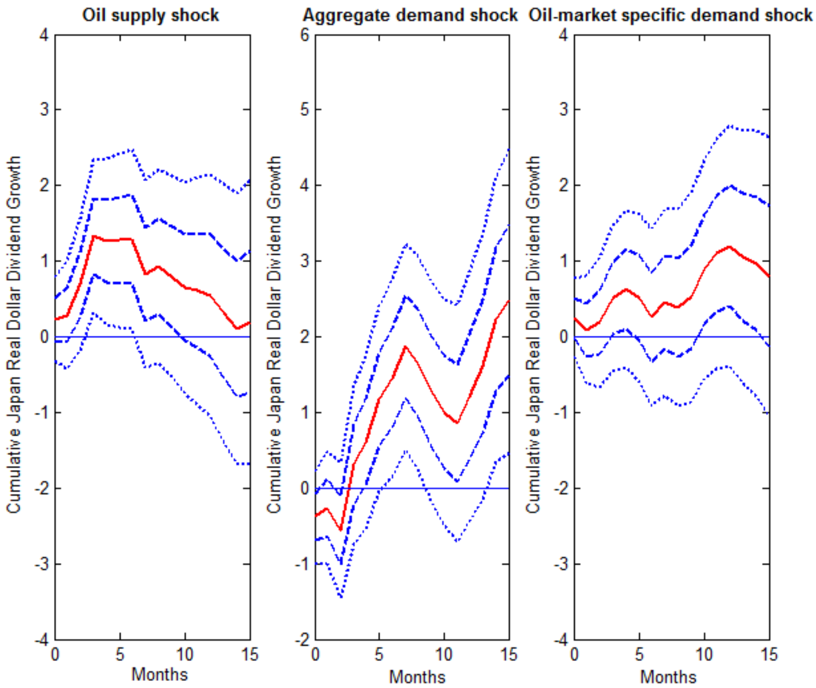
We obtain our data from different sources, and made different transformations as follows:

Variables	Raw Data Series	Transformations	Sources of Data
Changes in global oil production	Global Oil Production	Annualized percentage change	Energy Information Administration, Monthly Energy Review
Japanese real stock returns	DataStream Japan Country Index on aggregate stocks	1. Compute the Japanese real stock prices by deflating the nominal price index; 2. Take the first difference in the logarithms of the real price index.	DataStream
Japanese real dividend growth rate	DataStream Japan Country Index on dividend yield	1. Compute the dividend series by multiplying the dividend yields and aggregate Japan stock prices; 2. Deflate the nominal dividend series; 3. Take the first difference in the logarithms of the real dividend series.	DataStream
Real price of Japanese oil	Japan Crude Cocktail (JCC) in Yen per kiloliter (KL)	1. Translate the JCC price in Yen per KL into Barrel (i.e., 0.159 KL per barrel); 2. Exchange the JCC price in Yen per Barrel into JCC price in dollar price with yen/dollar exchange rate obtained from Federal Reserve Bank of St. Louis; 3. Deflate this nominal price of oil.	Trade Statistics of Japan
Global real economic activity	Single-voyage freight rates	See Kilian (2009) for detailed information on how to construct this series.	Kilian's homepage http://www-personal.umich.edu/~lkilian/reaupdate.txt.

II. Effects on Japanese Real Dividend Growth Rates

We investigate the response of real dividend growth rates to demand and supply shocks in the crude oil market. We do this by replacing real stock returns in the last element of X_t with real dividend growth rates, and then re-estimating model (1). The cumulative impulse responses of real dividend growth rates to each of the three demand and supply shocks in the crude oil market are shown in Figure C1. Our findings are similar to those reported in Kilian and Park (2009) using U.S. market data, they also find that expected dividend growth does not remain constant in response to oil supply and demand shocks. We find that unanticipated oil supply disruptions lead to a higher real dividend. Next, we find that aggregate demand shocks lead to an immediate fall in dividend growth followed by an increase after three months. Further we find that oil-market specific demand shocks have only marginal effects on the real dividend growth.

Figure C1. Cumulative Responses of Japanese Real Dividend Growth to Three Structural Shocks with One-and Two-Standard Error Bands



Notes: The estimates are based on the structural VAR model in equation (1). The three panels plot the impulse responses of Japanese real dividend growth to each of the three demand and supply shocks that affect the crude oil market.. Each panel measures how a unit impulse of structure shocks at time t impact the level of oil price at time $t+s$ for different values of s. Here we limit s until 15-month ahead. The oil supply shock has been normalized to represent a negative one standard deviation shock, while the aggregate demand shock and oil-market specific demand shock have been normalized to represent positive shock. The confidence intervals are constructed using a recursive-design wild bootstrap with 2,000 replications.