Oil price, exchange rate, and Japanese stock returns*

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Abstract

This paper investigates economic forces affecting Japanese stock returns paying particular attentions to economic/structural interpretations of structural shocks behind oil price and exchange rate movements, extending the frameworks of Kilian (2009) and Ready (2018) by including exchange rate variable in their models. The performance of the extended Ready's model is much better than the extended Kilian's model. However, we find economic interpretation of the Ready's empirical framework difficult, because stock returns respond positively to oil price increase due to oil supply shocks and the signs of the impact of exchange rate shocks change in sub samples. Statistical interpretations of two models are rather straightforward: in both models, the residuals of oil price fluctuations that cannot be explained by other explanatory variables or structural shocks have positive impacts on Japanese stock returns. They are called oil-market-specific price shocks in Kilian's model and called oil supply shocks in Ready's model, because of their different identification strategies.

Keywords: oil prices, exchange rate, VAR

JEL Codes: F31, F41, Q43

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1 Introduction

Stock markets are considered as responding to economic forces including variables such as output growth, short-term interest rate, the term structure, inflation rate, and some measure of aggregate economic risk such as the yield spread between low and high grade bonds (Chen, Roll, and Ross [1986]; Campbell and Ammer [1993]; Bernanke and Kuttner [2005]). In the case of Japanese stock price, a couple of variables will be added to the list of such economic forces/variables. The first one is oil price since Japanese economy heavily relies on energy import. Another variable is Yen's exchange rate given that Japan's macroeconomic performance depends heavily on its export.

However, both oil prices and exchange rate are hardly exogenous variables. Both are influenced by their own supplies and demands. It is also highly likely that aggregate foreign demand shocks, which can be considered as exogenous variable for Japanese economy, have significant effects on both oil price and Yen's exchange rate simultaneously. Adding oil price and exchange rate to the right-hand side of the regression for stock returns is an important step, it would be difficult to provide sensible economic interpretations to the empirical results unless we impose some economic structure to the model. Since all economic variables are endogenous in ultimate sense, it is beyond our ability to provide a complete identification of the system. The main goal of this paper is merely to provide a better understanding of economic forces behind the Japanese stock return by paying particular attentions to its interaction with oil price and exchange rate.

There have been many important developments exploring economic forces behind oil price fluctuations and their impacts on real economy such as Hamilton (1983, 1996, 2003, 2011), Barsky and Kilian (2004), Blanchard and Gali (2007), Kilian (2009). These contributions pay little attentions to the impact of same economic forces to the exchange rate since they are analyzing US economy in most cases. Because of the importance of oil price and exchange rate to Japanese economy and stock markets, in our previous researches, we explore the interaction of oil price and exchange rate, and examine their impacts on Japanese economic performance by extending Kilian (2009)'s empirical framework (Iwaisako and Nakata 2015, 2017, 2019).

In this paper, we adopt to the same approach to examine the impacts of economic forces behind oil price and exchange rate fluctuations to Japanese stock returns. Hence, a part of our contributions in this paper can be considered as the direct extension of Kilian and Park (2009)'s paper on US stock returns, using Japanese data and including foreign exchange rate into the VAR system. More recently, Ready (2018) proposed the identification strategy with VAR system different from, but closely related to Kilian's to examine the impacts of economic forces affecting oil price fluctuations to US stock returns. In this paper, we also extend Ready's empirical framework by incorporating foreign exchange rate into his system. We examine the performance of such a system with Japanese data and compare it with the performance of our approach adopting to Kilian's works.

2 Framework of Analysis and Data

To examine the quantitative impact of exogenous changes in crude oil prices on the country's exchange rate and economy, it is important to make an identifying assumption that distinguishes economic/structural shocks behind the price movements (Hamilton 2003). The observed crude oil price fluctuations reflect the influence of both supply and demand, as well as additional economic forces or the temporary price fluctuations based on precautionary and/or speculative motives induced by expected future price movements. Therefore, to appropriately evaluate the effect of "pure exogenous oil price changes", we must make an assumption that identifies exogenous structural shocks as being distinct from actual oil price movements.

2.1 Kilian's structural VAR

In a series of papers (Kilian 2009; Kilian and Park 2009), Lutz Kilian addresses this issue by proposing a new measure of global real economic activity based on data on ocean freight transport fares, which is then used to identify the global demand for crude oil. To analyze the impact of exogenous shocks on the US economy, he assumes that the crude oil supply does not respond to shocks to the demand for oil within the same month.

Specifically, Kilian (2009) assumes that the current month's oil price movements are driven by three types of structural shocks. The first is changes in global crude oil supply capacity, or exogenous shocks to the oil supply, such as those induced by coordinated OPEC production cuts.

He referees to these as *oil supply shocks*. The second type of shocks are related to global economic conditions and referred to as *aggregate demand shocks*. Third, there would be changes in current demand for crude oil based on expected future oil price fluctuations. Such demand shocks are based on precautionary and/or speculative motives; in what follows, these are referred to as crude oil *market specific demand shocks*. For example, the increases of geopolitical risk in the Middle East was expected to generate precautionary demand for oil because of the increased possibility of future production cuts such as a rise in oil prices when "Arab Spring" took place in early 2010-2013 (Noguera-Santaella 2016). Alternatively, when the global economy expanded strongly in the mid-2000s, some investors might have expected further expansion, which would have generated speculative demand for oil in anticipation of further economic expansion and crude oil price increases (Singleton 2014). These demand shocks are considered oil *market specific demand shocks*.

Kilian estimates the following three-variable VAR system for oil production, global economic activity (aggregate demand), and the oil price:

$$X_t^K = \alpha_K + \beta_K X_{t-1}^K + u_t. \tag{1}$$

$$X_t^K \equiv \begin{bmatrix} \text{prod}_t \\ \text{real}_t \\ \Delta\text{poil}_t \end{bmatrix}, \quad u_t \equiv \begin{bmatrix} u_t^{\text{prod}} \\ u_t^{\text{real}} \\ u_t^{\text{poil}} \end{bmatrix}, \quad \text{E}\left[u_t u_t'\right] = V.$$

We use the rate of change, instead of the level or natural log of oil price in this paper based on the explanatory power for contemporaneous Japanese stock returns. Then, Kilian imposes the following restrictions on the observed variables and structural shocks:

$$u_t = \begin{bmatrix} u_t^{\text{prod}} \\ u_t^{\text{real}} \\ u_t^{\text{poil}} \end{bmatrix} = A_0 \epsilon_t = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} \epsilon_t^{SY} \\ \epsilon_t^{DE} \\ \epsilon_t^{OIL} \end{bmatrix}, \tag{2}$$

$$\text{E}\left[\epsilon_t \epsilon_t'\right] = I.$$

The variables in the VAR system and corresponding structural shocks, including exchange rate variable latter introduced in the subsection 2.3, are summarized in Table 1.

[Table 1]

The assumptions in equation (2) impose important restrictions to the relationship between the observed data series in the current month and the structural shocks causing their fluctuations. (i) The coefficients in the first row of A_0, which represent the effects of structural shocks on observed oil supply, are zero, except that a_{11} implies that the change in the crude oil supply in a particular month is not affected by any other shocks. (ii) The coefficients a_{21} and a_{22} in the second line of A_0, which represent the relationship between observed real economic activity and the structural shocks, are nonzero. This implies that global real economic activity in the current month is affected by the oil supply and demand shocks but NOT affected by the crude oil price in the same month ($a_{23} = 0$). (iii) All coefficients in the third row of A_0 are nonzero, which implies that the oil price in the current month is affected by all other structural shocks.

Having imposed such restrictions, Kilian (2009) estimates a monthly series for structural shocks and then converted them into quarterly data. He regresses US GDP growth on the quarterly structural shocks to investigate the effects of three different sources of oil price fluctuations, namely, oil supply shocks, oil price changes due to aggregate demand shocks, and oil price changes due to temporary oil market specific demand shocks. Employing the same structural shocks, Kilian and Park (2009) examined their impact on aggregate US stock returns as well as the returns on industrial portfolios.

2.2 Ready's structural VAR

The main focus of the identification strategy proposed by Kilian (2009) is economic shocks causing the fluctuations of oil prices and their impacts on macroeconomic variables. Hence, explanatory power of structural shocks for stock returns in Kilian and Park (2009) are not particularly impressive. This motivates Ready (2018) to develop a slightly different VAR system and corresponding identification strategy, to provide more satisfactory explantations for stock returns.

Ready (2018) introduce two types of demand side shocks. He argue that if the index of oil producing firms' stocks appreciates, it mainly reflects the increase of demand for oil. He also introduced the VIX as the measure of investors' perception of risks whose increase will increase the risk premium, hence discount rate. So the increase of VIX will cause the decline of current stock prices. As the result, supply shocks are captured by the remaining variation in oil prices. The variables and structural shocks in Ready's VAR system are summarized in panel (2) of Table 1. His identification strategy can be summarized as follows:

$$X_t^R = \alpha_R + \beta_R X_{t-1}^R + z_t. \tag{3}$$

$$X_t \equiv \begin{bmatrix} \text{VIX}_t \\ \Delta\text{Roil}_t \\ \Delta\text{poil}_t \end{bmatrix}, \quad z_t \equiv \begin{bmatrix} z_t^{VIX} \\ z_t^{Roil} \\ z_t^{poil} \end{bmatrix}, \quad \text{E}\left[z_t' z_t\right] = V.$$

$$z_t = \begin{bmatrix} z_t^{VIX} \\ z_t^{Roil} \\ z_t^{poil} \end{bmatrix} = B_0 \eta_t = \begin{bmatrix} b_{11} & 0 & 0 \\ b_{21} & b_{22} & 0 \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} \upsilon_t^{VIX} \\ \upsilon_t^{DE} \\ \upsilon_t^{SY} \end{bmatrix}, \tag{4}$$

$$\text{E}\left[\eta_t \eta_t'\right] = I.$$

where υ_t^{SY} is oil supply shocks, υ_t^{DE} is aggregate demand shocks, υ_t^{VIX} is risk shocks embodied in VIX. According to his calculation, roughly 78% of the variance in oil prices is classified as supply shocks and 21% as demand shocks, with the shocks to the VIX explaining only 1% of the total variance in oil price fluctuations.

For the next step, Ready regressed current stock returns on υ_t^{SY}, υ_t^{DE}, and υ_t^{VIX}. He finds that high oil prices from supply shocks v_t^{SY} are bad news for aggregate stock returns and explain3.6% of the monthly variation in the aggregate US market return, while rises in prices from demand shocks v_t^{DE} are associated with positive excess returns and will explain an additional 12.4% of the variation in stock returns.

2.3 Extending of VAR to include Exchange Rates

To investigate the effects of oil price and exchange rate to macroeconomic condition in a single empirical framework, we extend Kilian's VAR model by introducing exchange rate variable fx_t as a fourth variable to the VAR system (Iwaisako and Nakata 2015, 2017, 2019). We introduce another structural shock ϵ_t^{FX}, which represents a pure foreign exchange market shock that is not contemporaneously correlated with any of the other three structural shocks. In the following ϵ_t^{FX} is referred as *pure exchange rate shocks.* We assume current exchange rate shocks can be affected by all other structural shocks, but will not affect any other shocks. This means that we impose the following restrictions on the four-variable VAR system to identify the structural shocks as we did for the three-variable system in equation (2):

$$u_t = \begin{bmatrix} u_t^{\text{prod}} \\ u_t^{\text{real}} \\ u_t^{\text{poil}} \\ u_t^{\text{fx}} \end{bmatrix} = A_0 \epsilon_t = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} \epsilon_t^{SY} \\ \epsilon_t^{DE} \\ \epsilon_t^{OIL} \\ \epsilon_t^{EX} \end{bmatrix}. \tag{5}$$

The restriction imposed by equation (5) implies that while oil market specific demand shocks affect the contemporaneous exchange rate, pure foreign exchange rate shocks do not affect the current oil price. Admittedly, there is not a solid rationale for this assumption. But, preliminary analysis suggests that the shapes of the impulse response functions hardly change if the ordering of the temporary oil price shocks and exchange rate shock is switched. Thus, in what follows, our empirical results are based on the estimated VAR system that incorporates the exchange rate shock as a fourth structural shock.

Similarly, we estimate the VAR system incorporating exchange rate to Ready's system as follows:

$$z_t = \begin{bmatrix} z_t^{VIX} \\ z_t^{Roil} \\ z_t^{poil} \\ z_t^{\text{fx}} \end{bmatrix} = B_0 \epsilon_t = \begin{bmatrix} b_{11} & 0 & 0 & 0 \\ b_{21} & b_{22} & 0 & 0 \\ b_{31} & b_{32} & b_{33} & 0 \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix} \begin{bmatrix} \upsilon_t^{VIX} \\ \upsilon_t^{DE} \\ \upsilon_t^{SY} \\ \upsilon_t^{FX} \end{bmatrix}. \tag{6}$$

Since the interpretation of equation (6) and υ_t^{FX} are parallel to equation (5) and ϵ_t^{EX}, we skip a detailed discussion.

2.4 Data

In the empirical analyses below, we use monthly data for the following variables. World oil production data prod_t is taken from the web site of the U.S. Energy Information Administration (EIA). As a measure of global real economic activity real_t, we use the data tabulated by Lutz Kilian, which we downloaded from his web site. The data come in the form of an index that Kilian constructed from the data on shipping freight from Drewry Shipping Consultants, Inc. These two data series are identical to the data series used by various papers by Kilian and his coauthors. As an alternative to Kilian's measure of global demand, we also examine the average of OECD countries' industrial productions, ΔIP_t.

Data on crude oil prices were obtained from the IMF's Primary Commodity Price Statistics, and represent the average (dollar) price of North Sea Brent, West Texas Intermediate, and Dubai Fateh. We use two different exchange rate data. First one is real effective exchange rates Δrefx_t obtained from the web site of the Bank of International Settlements. Second is monthly average of daily closing Yen-Dollar rates Δavfx_t from the Bank of Japan's website. We use rates of change of both exchange rate variables. Because of their definitions the appreciation of Japanese Yen means the increase of Δrefx_t and the decline of Δavfx_t.

Following the procedures in Ready (2018), we use the stock price index of energy producing companies worldwide. (Important caveat here: Our index is the one provided by MSCI and the availability seems to be shorter than the one used in Ready's paper. If the use of different index will affect the empirical results must be examined in the future final version.) For the VIX data, the Chicago Board Options Exchange's CBOE Volatility Index are downloaded from their web site. As in Ready (2018), we estimate an ARMA(1,1) model to isolate unexpected changes and the residuals are used as innovations to VIX.

3 Estimation results

Using the data discussed in section 2.4, we estimate the VAR system from which we obtained impulse response functions and the corresponding structural shocks series. The sample period is January 2000 to June 2019. The end of sample is constrained by the availability of Kilian's index of global demand. We could extend it for the specifications without Kilian's index to December 2019. But, the results remain almost identical even if we added 6 month observations, so that they are not reported here.

3.1 Stock return responses to structural shocks

First, as the benchmark, we estimate the regression for Japanese stock returns including oil price (in natural log and log difference) and the rate of change in Yen's exchange rate.

$$RJA_t = \alpha + \beta_{OIL} \cdot \Delta \text{poil}_t + \beta_{FX} \cdot \Delta \text{fx}_t + \epsilon_t \tag{7}$$

The results are reported in Table 2. In all specifications, estimated coefficients of oil price Δpoil_t are positive, though it is statistically significant only when exchange rate variables are included in the specification (3) and (4). Positive responses of stock returns to oil price increase might look counterintuitive, if it is considered to represent oil supply shocks. However, the sample period we are considering here contains very limited episodes of oil supply shocks, so that oil price increases perhaps reflect positive demand shocks. Appreciation of yen's value has negative and statistically significant impacts on stock returns, either it is measured by real effective exchange rates or Yen-Dollar spot rates. In the simple specifications we are considering here, real effective exchange rates has more power in explaining contemporaneous stock returns.

[Table 2]

In Table 3, we report the regression results using structural shocks obtained from Kilian's original model ((1) and (2)) and the augmented Kilian's model with exchange rate variable ((3) and (4)). As the measure of global demand, Kilian's index used in (1) and (3), while OECD's industrial production is used in (2) and (3).

$$RJA_t = \epsilon_t \beta \quad (8)$$

In the regressions with Kilian's original structural shocks (1) and (2), all coefficients have expected signs: supply shocks are negative, real demand shocks are positive, and oil market specific price shocks are positive. Positivity of ϵ_t^{OIL} will be interpreted as positive spillover between stock market and energy market, which is a convincing empirical result in the context of the recent financialization of commodity markets. However, explanatory power of the regressions with Kilian's original structural shocks are very limited with R^2 at around 2%. The only variable statistically significant is oil market specific price shocks ϵ_t^{OIL} in (1).

[Table 3]

By introducing exchange rate shocks in (3) and (4), explanatory power of regressions are significantly improved, R^2 increased up to more than 13%. Exchange rate shocks ϵ_t^{REFX} are negative and statistically significant 1% level. Oil market specific price shocks ϵ_t^{OIL} are also positively significant. These points suggest that considering structural shocks behind oil price fluctuations and exchange rate movement provide more intuitive empirical results, overall explanatory power of the augmented Kilian's model are lower than that of simple benchmark regressions considered in Table 2.

In Table 4, we check the robustness of the regression results with the structural shocks by the augmented Kilian's model. For (3a) and (4a), the ordering of oil price and exchange rate are swapped in Cholesky factorization so that oil market specific price shocks ϵ_t^{OIL} are assumed to have no impact on contemporaneous exchange rate movements. Not surprisingly, statistical significance of ϵ_t^{OIL} have diminished in (3a) and (4a). In (3b) and (4b), we use spot Yen-Dollar rate as the exchange rate variable instead of real exchange rate. While empirical results in (3) and (4) are maintained, overall explanatory power of the regressions are lower with R^2 around 8.5% when spot exchange rate is used.

[Table 4]

Next, we report the regression results for Japanese stock returns using structural shocks obtained from Ready's original model (1) and the same model with exchange rate variable ((2) and (3)). Overall explanatory power of the regressions are much higher in Table 5 with R^2 around 27%. Signs of all variables are also as expected. Better performance of Ready's model is not particularly surprising since Kilian's VAR system is designed to explain fluctuations of oil prices, while Ready's analysis is aimed to explain US stock returns. Adding exchange rate variable to original Ready's model does not improve the performance of the regression in (2) and (3), while exchange rate shocks ϵ_t^{REFX} or ϵ_t^{AVFX} are statistically significant in explaining contemporaneous stock returns. Note that the structural shocks υ_t^{SY} υ_t^{DE}, and υ_t^{VIX} in (1) are different from the same shocks in (2) or (3) since they are calculated from different VAR systems.

[Table 5]

While the advantage of Ready's VAR system over Kilian's in explaining Japanese stock returns, economic interpretations of empirical results are different story. Table 6 presents correlations of

Kilian's and Ready's structural shocks both for their original specifications and the ones with exchange rate. There are some important observed in these two correlation matrices. First, pure exchange rate shocks by Kilian's and Ready's frameworks, ϵ_t^{REFX} and υ_t^{REFX} are highly correlated with each other at 86.5%. Hence, exchange rate fluctuations must contain additional information that are not embodied in other economic variables either in Kilian's and Ready's models. Considering exchange rate is certainly important to understand aggregate fluctuations in Japanese stock market.

[Table 6]

Second, the correlations between oil supply shocks ϵ_t^{SY} and υ_t^{SY} are almost zero or slightly negative at -5.4% for original three variable systems and -6.5% for the systems with exchange rates. In Kilian's system, ϵ_t^{SY} is directly derived from world oil production, while υ_t^{SY} in Ready's system are oil price fluctuations that cannot be explained by VIX shocks or returns of oil producing companies. To put it bluntly, υ_t^{SY} are just remaining or "garbage" in oil price fluctuations that cannot be explained by other structural shocks in the system. In that sense, calling υ_t^{SY} oil supply shocks in Ready's system is rather misleading. Similarly, "garbage" in Kilian's system are called oil market specific price shocks ϵ_t^{OIL}. Not surprisingly, the correlations between ϵ_t^{OIL} and υ_t^{SY} are high, little less than 75% in both correlation matrices in Table 6. Hence, we have to be very careful about their economic interpretations. In future research, what are common factors in ϵ_t^{OIL} and υ_t^{SY}, and if it is possible to explain them by some other economic variables should be explored.

3.2 VAR with monetary policy variables

Next, we estimate the VAR including stock returns RJA_t and monetary policy variables $\{Rrate_t, Term_t, dp_t\}$, using structural shocks ϵ_t calculated in the previous section as exogenous variables (Lee and Ni [2002]). Here, $Rrate_t$ is the deviation of short-term interest rate from 12 month average, $Term_t$ is the spread between long and short term interest rate, and dp_t is the log of dividend/price ratio.

In Table 7, the estimated regression for RJA_t in this VAR system using different sets of exogenous shocks ϵ_t are reported. For the parameter estimates of endogenous variables, two specifications yield similar results. Lagged stock return is positive, though significant only in the VAR with Ready's structural shocks. Estimated coefficients of $Rrate_t$ and $Term_t$ are both negative, which is consistent with theoretical predictions. Term-sturcture variable $Term_t$ is statistically significant at 5% level with Kilian's structural shocks and at 10% level with Ready's structural shocks. The signs of dp_t should be positive and the estimation results are negative, though they are insignificant in both VAR systems.

[Table 7]

Estimation results for two sets of exogenous shocks are both similar to the results in Table 3 and 5. Finally, R^2 are about 20% with the Kilian type exogenous shocks and 29% with the Ready type exogenous shocks. The former is 7 percentage point higher than R^2 for the regression with structural shocks alone. The difference is almost negligible when Ready's structural shocks are used. Panel B of Table 7 summarizes RJA_t's impulse responses to exogenous shocks with the VAR systems.

4 Conclusions

In this paper,we investigate economic forces affecting Japanese stock returns in two different types of structural VAR models had been proposed to analyze the impact of oil prices on US stock returns by Lutz Kilian (Kilian [2009], Kilian and Park [2009]) and by Ready (2018). We first calculated structural shock series by including exchange rate variables to their original models, then use them to explain Japanese stock returns. We find Ready's structural shocks have more explanatory power than Kilian's. This is not a surprising result, since current stock returns of US energy sector are included in Ready's VAR system. However, in Ready's VAR system, the structural shocks dubbed as oil supply shocks are the residuals of oil price movements that cannot be explained by other structural shocks. Its correlation with oil supply shockss directly derived from global oil production data in Kilian's system is zero or mildly negative. On the other hand, in Kilian's system, the residuals of oil price movements are called oil market specific price shocks. Their correlation with Ready's oil supply shocks stock are as high as 75%. So we have to be careful about economic interpretations of Ready's structural shocks

From statistical point of view, the interpretation of our finding should be straightforward. In any structural VAR model, the last structural shock series in the ordering of Cholesky factorization contain all residuals that cannot be explained by other structural shocks. What are these residuals have in common and the source of such a common factor should be examined more thoroughly in the future research.

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Table 1
Variables and Structural Shocks

(1) Kilian's VAR with exchange rate

Variables in the Structural VAR

prod_t	Growth rate of world crude oil production
real_t	Proxy for global real economic activity (Kilian)
$\triangle\text{IP}_t$	Change in OECD' industrial production average
$\triangle\text{poil}_t$	Change in crude oil price
$\triangle\text{refx}_t$	Change in real effective exchange rate
$\triangle\text{avfx}_t$	Change in spot Yen-Dollar exchange rate
vix_t	Surprises in VIX

Kilian's Structural Shocks

ϵ_t^{SY}	Oil supply shock
ϵ_t^{DE}	Aggregate demand shock by Kilian's index
ϵ_t^{IP}	Aggregate demand shock by industrial production
ϵ_t^{OIL}	oil-market-specific demand shock
ϵ_t^{REFX}	Pure exchange rate shock by real effective exchange rate
ϵ_t^{AVFX}	Pure exchange rate shock by Yen-Dollar exchange rate

Ready's Structural Shocks

υ_t^{SY}	Oil supply shock
υ_t^{DE}	Aggregate demand shock
υ_t^{VIX}	Risk shocks
υ_t^{REFX}	Pure exchange rate shock by real effective exchange rate
υ_t^{AVFX}	Pure exchange rate shock by Yen-Dollar exchange rate

Table 2

Regression for aggregate Japanese stock returns on oil prices and exchange rates

	(1)	(2)	(3)	(4)
$\triangle \text{poil}_t$	0.122	-	$0.062^{\dagger}$	0.109^{*}
	[0.043]		[0.033]	[0.035]
refx_t	-	-0.923^{**}	-0.865^{**}	-
		[0.148]	[0.144]	
avfx_t	-	-	-	0.672^{**}
				[0.145]
R^2	0.043	0.183	0.193	0.143
adj.R^2	0.039	0.179	0.186	0.135

Table 3
Regression for Japanese stock returns with Kilian's structural shocks

	(1)	(2)	(3)	(4)
ϵ_t^{SY}	-0.198	-0.269	-0.041	-0.109
	[0.255]	[0.262]	[0.258]	[0.269]
ϵ_t^{DE}	0.153	-	0.062	-
	[0.485]		[0.429]	
ϵ_t^{IP}	-	0.271	-	0.145
		[0.290]		[0.273]
ϵ_t^{OIL}	0.711^{*}	0.518	0.755^{*}	$0.582^{\dagger}$
	[0.328]	[0.338]	[0.317]	[0.306]
ϵ_t^{REFX}	-	-	-1.602^{**}	-1.711^{**}
			[0.367]	[0.400]
R^2	0.024	0.017	0.131	0.138
adj.R^2	0.011	0.005	0.116	0.123

Table 4
Regression for Japanese stock returns with Kilian's structural shocks: robustness check

	(3a)	(4a)	(3b)	(4b)
ϵ_t^{SY}	-0.041	-0.109	-0.115	-0.175
	[0.258]	[0.269]	[0.242]	[0.261]
ϵ_t^{DE}	0.062	-	0.118	-
	[0.429]		[0.457]	
ϵ_t^{IP}	-	0.145	-	0.180
		[0.273]		[0.276]
ϵ_t^{OIL}	0.359	0.137	0.755^{*}	$0.585^{\dagger}$
	[0.301]	[0.454]	[0.344]	[0.327]
ϵ_t^{REFX}	-1.734^{**}	-1.802^{**}	-	-
	[0.380]	[0.403]		
ϵ_t^{AVFX}	-	-	1.192^{**}	1.281^{**}
			[0.337]	[0.382]
R^2	0.131	0.138	0.085	0.086
adj.R^2	0.116	0.123	0.069	0.070

Table 5
Regression for Japanese stock returns with Ready's structural shocks

	(1)	(2)	(3)
υ_t^{VIX}	-2.431^{**}	-2.274^{**}	-2.331^{**}
	[0.371]	[0.378]	[0.386]
υ_t^{DE}	0.847^{**}	0.751^{**}	0.816^{**}
	[0.249]	[0.220]	[0.234]
υ_t^{SY}	-0.119	-0.151	-0.155
	[0.266]	[0.258]	[0.253]
υ_t^{REFX}	-	-0.784^{*}	-
		[0.333]	
υ_t^{AVFX}	-	-	0.719^{*}
			[0.337]
R^2	0.278	0.267	0.278
adj.R^2	0.269	0.254	0.266

Table 6

Correlations of Kilian's and Ready's structural shocks for Japan

(1) **Structural shocks by Kilian's and Ready's original models**

	ϵ_t^{SY}	ϵ_t^{DE}	ϵ_t^{OIL}
υ_t^{VIX}	0.061	−0.108	−0.080
υ_t^{DE}	−0.017	−0.010	0.329
υ_t^{SY}	−0.054	0.069	0.749

(2) **Structural shocks by augmented models with exchange rates**

	ϵ_t^{SY}	ϵ_t^{DE}	ϵ_t^{OIL}	ϵ_t^{REFX}
υ_t^{VIX}	0.031	−0.108	−0.088	0.195
υ_t^{DE}	0.003	0.011	0.305	0.001
υ_t^{SY}	−0.089	0.083	0.734	0.107
υ_t^{REFX}	−0.065	−0.043	−0.019	0.865

On the columns $(\epsilon_t^{SY}, \epsilon_t^{DE}, \epsilon_t^{OIL}, \epsilon_t^{REFX})$ are Kilian's structural shocks. On the rows $(\upsilon_t^{VIX}, \upsilon_t^{DE}, \upsilon_t^{SY}, \upsilon_t^{REFX})$ are Kilian's structural shocks.

Table 7

VAR for stock returns and monetary policy variables with structural shocks as exogenous variables

Panel A: Regressions for RJA_t in VAR system

	(1) Kilian	(2) Ready
RJA_{t-1}	0.065	0.144*
	[0.065]	[0.056]
$Rrate_{t-1}$	−2.952	−2.437
	[3.991]	[3.628]
$Term_{t-1}$	−1.243*	−1.012†
	[0.623]	[0.563]
dp_{t-1}	−0.252	−0.201
	[0.159]	[0.144]
ϵ_t^{SY}	−0.018	-
	[0.311]	
ϵ_t^{DE}	0.068	-
	[0.316]	
ϵ_t^{OIL}	0.775*	-
	[0.313]	
ϵ_t^{FX}	−1.705**	-
	[0.319]	
υ_t^{SY}	-	0.164
		[0.280]
υ_t^{DE}	-	0.822**
		[0.284]
υ_t^{VIX}	-	−2.419**
		[0.280]
υ_t^{FX}	-	−0.781**
		[−0.283]
R^2	0.199	0.292
adj.R^2	0.173	0.270

Table 7 continued

Panel B: Impulse responses of RJA_t to structural shocks as exogenous variables

	(1) Kilian
Supply ϵ_t^{SY}	-
Demand ϵ_t^{DE}	-
Oil Price ϵ_t^{OIL}	+
FX ϵ_t^{REFX}	−

	(2) Ready
Supply υ_t^{SY}	-
Demand υ_t^{DE}	+
VIX υ_t^{VIX}	−
FX υ_t^{REFX}	−