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Reverse globalization: Does high oil price volatility discourage international trade?

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ABSTRACT

This paper examines whether higher oil price volatility causes a reversal in globalization. Using a large annual panel data set covering 84 countries all over the world from 1984 to 2008, we investigate the impacts of oil price fluctuations on international trade, namely exports and imports. We present strong and robust evidence that international trade flows will be lower when oil prices fluctuate significantly. We therefore conclude that oil price volatility hurts globalization.

1. Introduction

It is argued that uncertainty arising from oil price volatility may reduce international trade flows because it raises the risks faced by both importers and exporters. The impacts of oil price fluctuations on global trade flows can be understood by the uncertainty channel. Fluctuations in oil prices may create uncertainty about the future path of the oil price, causing consumers to postpone irreversible purchases of consumer durable goods, and also causing firms to postpone irreversible investments. The reduction in domestic consumption and investment expenditures implies a reduction in aggregate demand, and thus reduces international trade.[1] Hence, oil price uncertainty may thus reverse globalization. This paper empirically examines whether higher oil price volatility discourages international trade and thus causes deglobalization.

Recent hikes and fluctuations in oil prices since 1999 have attracted attention and invoked concerns about their devastating effects on a variety of economic activities. The wide variability of oil prices is shown in Fig. 1, which plots the monthly world average oil price from 1957:M1 to 2011:M6. At the end of the 1970s, the price of oil reached around $40/barrel and then started to fluctuate. From 1999, oil prices began to rise again, especially after 2001, and climbed to record highs (around $133/barrel) in 2008. They fell back to $40/barrel by the end of 2008, and then continued to rise thereafter. Moreover, it can be observed that oil prices began to swing widely in the mid-1980s and continued to until recently. As described in McNally and Levi (2011),

> "…from the late 1970s until just a few years ago, following the price of gasoline was like riding the Disney World attraction, *It's a Small World*: a shifting but gentle, basically unremarkable experience. But over the past few years, it has felt more like *Space Mountain*: unpredictable, scary, and gut-wrenchingly uneven."

It has been shown that the dramatic rise in oil prices during the 1970s was associated with subsequent economic downturns.[2] Although there is some debate as to whether oil price shocks are the main cause of recessions,[3] Hamilton (2009b) asserts that the latest surge in oil prices between June 2007 and June 2008 was an important factor that contributed to the economic recession that began in the US in 2007:Q4. Moreover, a number of recent studies show that oil price shocks have significant effects on a variety of domestic economic activities. An increase in oil prices has a significant negative impact on GDP growth and contributes to a higher inflation rate for most countries (see Hamilton, 2009a; Cologni and Manera, 2008; Lardic and Mignon, 2008). Finally, Ordonez et al. (2011) show that the oil price shock is an important driving force of the cyclical labor adjustments in the US labor market, and the job-finding probability is the main transmission mechanism of such a shock.

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[1] Regarding the impact of uncertainty shocks, see, e.g., Bernanke (1983) and Bloom (2009).

[2] See Hamilton and Herrera (2004) for a review of the literature.

[3] See, e.g., Bohi (1989) and Blanchard and Gali (2008).

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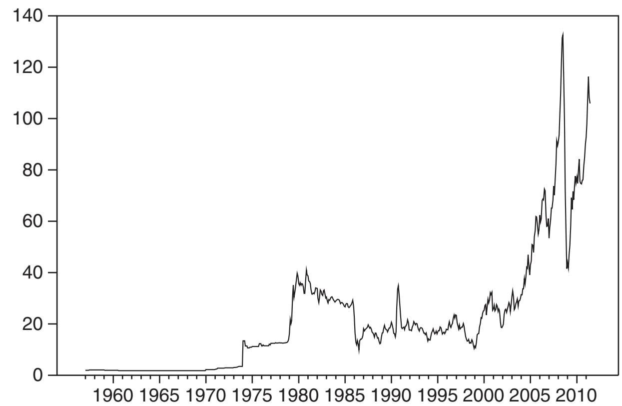

Fig. 1. Monthly oil prices (World average): 1957:M1–2011:M6.

Other than examining the adverse impacts on the domestic economy, it is also of interest to consider the impacts of spikes and volatility in oil prices from a global perspective. For example, Rubin (2009) argues that expensive oil makes the world become increasingly localized, and will eventually cause the end of globalization. As globalization was dependent on cheap transport, which in turn was dependent on cheap fuel, it is argued that peak oil may reverse globalization. As higher energy prices are impacting transport costs at an unprecedented rate, the cost of moving goods may become the largest barrier to global trade. Moreover, sluggish output growth and high inflation dampen import demand, and thus decrease international trade flows. Finally, the central bank may tighten monetary policy to offset the inflationary pressure, which results in an increase in interest rates and a further dampening of domestic demand for imports, leading to a decline in global trade.

Several previous studies have shown that oil price shocks affect international trade. Theoretically, Backus and Crucini (2000) consider an international stochastic growth model incorporating a third country that sells oil. They document that oil price shocks play a substantial role in explaining changes in the terms of trade in major industrialized countries after the collapse of the Bretton Woods system. Bridgman (2008) constructs a vertical specialization trade model with an energy-using transportation sector to investigate how oil prices affect global trade via changes in transport costs. Empirical evidence provides strong support for the view that oil price shocks have impacts on global economic activity. Using data from Germany, Lutz and Meyer (2009) find that an improvement in international competitiveness limits the negative impacts of increased oil prices. Kilian et al. (2009) show how different oil price shocks (demand and supply shocks) have impacts on several measures of oil exporters' and oil importers' external balances such as the oil trade balance, the nonoil trade balance, the current account, capital gains, and changes in net foreign assets. Korhonen and Ledyaeva (2010) use vector autoregressive (VAR) models to examine the impact of oil price shocks on both oil-producing and oil-consuming economies. For oil exporters, although they benefit from high oil prices directly, they are also hurt by the indirect effects of positive oil price shocks, as countries importing oil will have lower growth and lower import demand, which then curtails the oil producers' exports. As for oil importers, they are hurt directly by positive oil price shocks, but may receive indirect benefits via higher demand from the oil exporters. That is, some of the additional revenues from rising oil prices for oil exporters may be used to increase imports from the rest of the world, helping to stabilize oil-importing countries. Finally, Abu-Bader and Abu-Qarn (2010) implement a battery of tests for structural breaks and find that oil shocks played the main role in determining the changes in trade ratios in the 1970s.

Regarding the impact of oil price volatility on economic activity, it has been shown in Ferderer (1996) that empirically, oil price variability has an adverse impact on aggregate output. Sadorsky (1999) estimates a VAR model and provides evidence that oil price volatility shocks play an important role in affecting real S& P 500 stock returns. Sadorsky (2003) shows that the conditional volatilities of oil prices have a significant impact on the conditional volatility of US technology stock prices. Guo and Kliesen (2005) present evidence that a volatility measure of oil prices has a negative and significant effect on future gross domestic product growth over the period 1984–2004. Henriques and Sadorsky (2011) investigate how oil price volatility affects the strategic investment decisions of a large panel of US firms, and show that there is a U-shaped relationship between oil price volatility and firm investment. Elder and Serletis (2010) estimate a bivariate GARCH-in-mean VAR, and find evidence that volatility in oil prices has had a negative and statistically significant effect on several measures of investment, durables consumption, and aggregate output.

However, there are few previous empirical studies on oil price volatility and its impacts on international trade. To fill this gap, this paper empirically investigates whether the spikes, and in particular the fluctuations, in oil prices discourage international trade. To the best of our knowledge, this paper is the first attempt to examine the impacts of oil price volatility on international trade using a large panel data set with 84 countries from 1984 to 2008. We first use a structural VAR model with new identification assumptions proposed by Kilian (2009) to identify three different structural innovations in the crude oil market: oil supply shock, global aggregate demand shock, and oil-market-specific demand shock. We then show that the increase in oil prices due to oil supply shocks discourages trade while the increase in oil prices due to oil-specific demand has positive impacts on trade. The impacts of a positive global aggregate demand shock are negative but insignificant.

Moreover, we compute three different measures of oil price volatility using daily oil future price data: standard deviation, realized volatility, and conditional variance from a GARCH model. We then examine the impacts of oil price uncertainty on international trade. Strong evidence is found that higher oil price fluctuations cause a decline in international trade, which is robust to alternative measures of oil price fluctuations. We have also shown that such a negative impact is prominent for net oil importers, while an insignificant effect of oil price volatility for net oil exporters exists. Finally, we find somewhat weak evidence that for net oil importers, energy efficiency help mitigate the negative impacts of oil price volatility on international trade. In sum, we thus conclude that oil price fluctuations hurt globalization.

2. Empirical strategy

In this section, we first describe how to identify structural oil price shocks in a VAR model proposed by Kilian (2009). We then present our measures of oil price volatility. Finally, the empirical models to examine the impacts of oil price variability on international trade will be discussed.

2.1. Measuring oil price shocks

Using a newly developed measure of global real economic activity, Kilian (2009) employs a structural VAR analysis disentangling demand and supply shocks in the crude oil market and finds that the impacts of oil demand and oil supply shocks are quite different. We consider the following structural VAR model proposed by Kilian (2009):

$$\Phi(L)y_t = e_t, \tag{1}$$

where $D(L) = I - \Phi_0 - \Phi_1 L - \cdots - \Phi_p L^p$ is the lag polynomial. Vector y_t is:

$$y_t = \begin{bmatrix} \Delta prod_t \\ rea_t \\ rop_t \end{bmatrix}, \tag{2}$$

where $\Delta prod_t$ is global crude oil production growth, rea_t is a measure of real activity in global industrial commodity markets, and rop_t is the log real oil price. It is worth noting that the data for global crude oil production and real global economic activity are available at monthly frequency.

The term e_t represents a vector of serially and mutually uncorrelated structural innovations. Letting ε_t denote the vector of the reduced-form VAR innovations, and following the identification assumptions in Kilian (2009), we have:

$$\begin{bmatrix} \varepsilon_{1t}^{\Delta prod} \\ \varepsilon_{2t}^{rea} \\ \varepsilon_{3t}^{rop} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} e_t^{os} \\ e_t^{gd} \\ e_t^{od} \end{bmatrix}. \quad (3)$$

According to Kilian (2009), e_t^{os} represents shocks to the global supply of crude oil ("oil supply shocks"). The second structural shock e_t^{gd} captures shocks to the global demand for all industrial commodities (including crude oil) that are driven by global real economic activity ("global demand shocks"). Shock e_t^{od} is the oil-market-specific demand disturbance, which captures the shift in precautionary demand for crude oil ("oil-market-specific demand shocks", or simply, "oil demand shocks"). That is, it reflects increased concerns about the availability of future oil supplies. We then follow Kilian (2009) to construct measures of the annual shocks by averaging the monthly structural innovations for each year:

$$\hat{\xi}_t^i = \frac{1}{12}\sum_{m=1}^{12} e_{m,t}^i, \quad (4)$$

where $e_{m,t}^i$ represents the i-th structural shock in the m-th month of the t-th year of the sample, and $i=\{gd, od\}$. For the oil supply shock, we define it as:

$$\hat{\xi}_t^{os} = -\frac{1}{12}\sum_{m=1}^{12} e_{m,t}^{os}, \quad (5)$$

such that a positive value of $\hat{\xi}_t^{os}$ causes an increase in oil prices, which is consistent with $\hat{\xi}_t^{gd}$ and $\hat{\xi}_t^{od}$. That is, all shocks are normalized such that a given shock implies an increase in the price of oil.[4]

2.2. Measuring oil price volatility

We use daily oil price data (op_t^d) to compute the annual oil price volatility, ov_t. Letting $r_t=\log(op_t^d)-\log(op_{t-1}^d)$ be the daily oil price return, and D be the number of trading days in the year, we consider the following three different measures of oil price volatility.

1. Standard deviation:

$$ov_t = SD_t = \sqrt{\frac{1}{D-1}\sum_{t=1}^{D}\left(r_t - \frac{1}{D}\sum_{t=1}^{D} r_t\right)^2};$$

2. Realized volatility:

$$ov_t = RV_t = \sum_{t=1}^{D} r_t^2;$$

3. GARCH(1,1) model: we consider a GARCH(1,1) model for daily oil price returns:

$$r_t = \mu + \epsilon_t, \quad \epsilon_t = \varphi_t \sigma_t, \quad \varphi_t \sim N(0,1),$$
$$\sigma_t^2 = c + a\epsilon_{t-1}^2 + b\sigma_{t-1}^2,$$

and then compute the annual oil price volatility as the average of the daily conditional variance:

$$ov_t = \text{GARCH}_t = \frac{1}{D}\sum_{t=1}^{D}\sigma_t^2.$$

2.3. Empirical model

We now turn to our main focus regarding the impacts of oil price volatility on international trade by considering the following panel regression model:

$$\Delta\log\left(\text{Trade}_{j,t}\right) = \alpha_j + \beta ov_{t-1} + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta\log\left(Y_{j,t-1}\right) + \theta\Delta\log\left(Y_{j,t-1}^*\right) + \rho\Delta\log\left(\text{Trade}_{j,t-1}\right) + u_{j,t}, \quad (6)$$

where $j=1,2,\ldots,N$ is a country index, and $t=1,2,\ldots,T$ is a time index. Total real trade volume of country j is the sum of real exports and real imports: $\text{Trade}_{j,t}=(\text{Exports}_{j,t}+\text{Imports}_{j,t})$. We use real GDP of country j to measure domestic demand denoted by $Y_{j,t}$, while $Y_{j,t}^* = \sum_{i\neq j} w_{j,i} Y_{i,t}$ is the distance weighted sum of real GDP for all countries except country j as a proxy of foreign demand. The weight $w_{j,i}$ is computed by following Harris (1954) as the inverse distance between corresponding countries.[5]

The term ov_t is a measure of oil price volatility, and $\hat{\xi}_t^{os}$, $\hat{\xi}_t^{gd}$, and $\hat{\xi}_t^{od}$ are structural shocks to oil supply, global demand, and oil-specific demand, respectively, according to Eqs. (4) and (5). Finally, α_j denotes the fixed-effect dummies.

The parameters of interest are β, ϕ^{os}, ϕ^{gd}, and ϕ^{od}. The coefficient β measures the effect of oil price volatility on international trade, which is expected to be negative. Recall that we define $\hat{\xi}_t^{os}$ as the negative shock to oil supply. That is, a positive value of $\hat{\xi}_t^{os}$ causes an oil supply disruption and a higher oil price. As reported in Kilian (2009), unanticipated oil supply disruptions significantly lower real GDP, which lowers demand for imports and hence lowers international trade. Hence, if $\phi^{os}<0$, a rise in oil prices due to lower oil production will decrease trade volumes. A positive value of $\hat{\xi}_t^{gd}$ boosts global demand and hence may increase international trade, which implies $\phi^{gd}>0$. Oil-specific demand shocks may reflect increased concerns about future oil supply shortfalls, and raised oil prices due to oil-specific demand shocks may induce higher oil exports for oil exporters and higher oil import and/or higher nonoil export for oil importers (see Kilian et al. (2009)). We thus also expect that the oil-specific demand shock may have an immediately positive impact on trade, $\phi^{od}>0$. Finally, domestic demand and foreign demand may increase trade as conventional wisdom expects.

3. Data and preliminary tests

To construct annual oil price volatility, we follow Henriques and Sadorsky (2011) and use daily NYMEX futures prices on West Texas Intermediate (WTI), which is available since April 4, 1983 from the US Energy Information Administration (EIA).[6] We thus investigate annual data with the sample covering 84 countries from 1984 to 2008 (a total of 2100 observations). The sample ends in 2008 because of data availability for all countries. A list of the countries is reported in Table 1.

[4] These yearly averages will not be exactly uncorrelated, but their empirical correlation is so low that little is lost by treating them as uncorrelated.

[5] The data for distance is available on Kristian Skrede Gleditsch's webpage: http://privatewww.essex.ac.uk/ksg/data-5.html.

[6] The reason we do not use oil spot prices is because of data availability. Daily data for WTI spot oil prices are only available from January 2, 1986. However, the spot and futures prices are highly correlated, as the correlation coefficient from January 2, 1986 to August 9, 2011 is 0.9985.

Table 1
List of countries included in analysis.

Argentina	Dominican Republic	Korea	Rwanda
Australia	Ecuador	Lesotho	Saudi Arabia
Austria	Egypt	Luxembourg	Senegal
Bahamas	Finland	Madagascar	Seychelles
Bahrain	France	Malawi	Singapore
Barbados	Gabon	Malaysia	Solomon Islands
Belize	Gambia,	Malta	Spain
Bolivia	Germany	Mauritius	Sri Lanka
Brazil	Greece	Mexico	Swaziland
Burkina Faso	Grenada	Morocco	Sweden
Burundi	Guatemala	Nepal	Switzerland
Cameroon	Honduras	Netherlands	Thailand
Canada	India	New Zealand	Togo
Central African	Indonesia	Niger	Tonga
Chad	Ireland	Nigeria	Trinidad and Tobago
Colombia	Israel	Norway	Tunisia
Costa Rica	Italy	Pakistan	Turkey
Cote d'Ivoire	Jamaica	Papua New Guinea	United States
Cyprus	Japan	Peru	Uruguay
Denmark	Jordan	Philippines	Vanuatu
Dominica	Kenya	Portugal	Venezuela

Data for merchandise exports and imports in current US dollars (lines 70 and 71) are obtained from International Financial Statistics (IFS) published by the International Monetary Fund (IMF). GDP data in current US dollars is obtained from the World Bank's World Development Indicators (WDI). Following Sadorsky (2011), we deflate exports, imports, and GDP by the PPP relative adjusted consumer price index obtained from Penn World Table (PWT 7.0).[7]

To estimate the structural shocks from the structural VAR model in Eq. (1), we use monthly data from 1973:M1 to 2008:M12. This particular start date of the sample is chosen subject to the availability of global crude oil production data (barrels per day), which are obtained from the US EIA.[8] An index of global real economic activity in industrial commodity markets as used in Kilian (2009) is available from Lutz Kilian's website.[9] The monthly WTI oil prices are obtained from the IFS.

As a preliminary investigation, I implement the Im et al. (2003) test (IPS) to examine the time-series properties of the panel data. Table 2 reports the descriptive statistics and the IPS test results (Z_{tbar} and $Z_{\tilde{t}bar}$ statistics) for each variable in Eq. (6). Clearly, all test statistics are able to reject the null hypothesis that these series contain a unit root.

4. Empirical results

Fig. 2 presents the three structural shocks ($\hat{\xi}_t^{os}$, $\hat{\xi}_t^{gd}$, and $\hat{\xi}_t^{od}$) identified by the structural VAR model in Eq. (1), where all shocks are normalized such that a given shock implies an increase in the price of oil. There are some interesting observations to be made from the time-series plots. First, the spike in oil prices in 1999 was mainly due to oil supply (following the Iranian Revolution) and global demand shocks. Moreover, the steep decline in oil price of 2008 is because of the sharp reduction in global demand since the recent global recession resulting from the financial and credit crunch and the collapse of the mortgage market in 2007.

Fig. 3 shows the three alternative measures of oil price volatility: standard deviation (SD_t), realized volatility (RV_t), and GARCH conditional variance ($GARCH_t$). It can be observed that these series move together over time, and the correlation coefficients are $corr(SD_t, RV_t)=0.979$, $corr(SD_t, GARCH_t)=0.977$, and $corr(RV_t, GARCH_t)=0.994$, respectively. According to Figs. 1 and 3, it is worth noting that oil price volatility rises during periods of sharp oil price increases (such as 1990 and 2008) and periods of sharp oil price declines (such as 1986).

Table 2
(Im et al., 2003) Panel unit root test statistics (IPS).

	Z_{tbar}	$Z_{\tilde{t}bar}$
$\Delta log(\text{Trade}_{j,t})$	−19.489 [0.00]	−12.033 [0.00]
$\Delta log(Y_{j,t})$	−14.175 [0.00]	−8.886 [0.00]
$\Delta log(Y^*_{j,t})$	−18.062 [0.00]	−11.238 [0.00]
Oil supply shock ($\hat{\xi}_t^{os}$)	−22.920 [0.00]	−13.674 [0.00]
Global demand shock ($\hat{\xi}_t^{gd}$)	−20.795 [0.00]	−12.839 [0.00]
Oil-specific demand shock ($\hat{\xi}_t^{od}$)	−27.042 [0.00]	−15.079 [0.00]
Oil price volatility (ov_t)		
Standard deviation (SD_t)	−28.625 [0.00]	−16.835 [0.00]
Realized volatility (RV_t)	−27.030 [0.00]	−16.229 [0.00]
Conditional variance ($GARCH_t$)	−28.591 [0.00]	−16.822 [0.00]

Note: *p*-values are reported in parentheses.

In Table 3, we report the benchmark empirical results. Results without the other control variables are shown in the first three columns. Clearly, we have found a negative and significant relationship between lagged oil price volatility and international trade, which is robust to different measures of oil price volatility. That is, higher oil price volatility hurts trade. We then add other explanatory variables as in Eq. (6) and show the results in columns (4) to (6). Most of the signs of the coefficients are as expected. An increase in oil price due to oil supply shocks discourages trade. On the other hand, a positive oil-specific demand shock has positive impacts on trade. Finally, higher domestic and foreign demand (proxied by domestic real GDP and distance-weighted sum of foreign real GDP) induce larger trade. All of the above estimates are highly statistically significant. Although the impact of a positive global demand shock is not consistent with prior expectation, the estimate is statistically insignificant. Does oil price volatility have a substantial effect on trade after controlling for other determinants? Yes. We can see that the estimates of the coefficients on the three different measures of oil price volatility are still negative and highly significant. To sum up, we have shown strong evidence that higher oil price volatility leads to a reduction in international trade.

We further investigate whether the relationship between oil price volatility and trade may differ for net oil exporters and net oil importers. According to the data for exports and imports of crude oil including lease condensate (thousand barrels per day) in 2009,[10] the net oil exporters in our sample countries are Argentina, Brazil, Cameroon, Canada, Chad, Colombia, Denmark, Ecuador, Gabon, Guatemala, Malaysia, Mexico, Nigeria, Norway, Saudi Arabia, Tunisia, and Venezuela. We then consider the following empirical model:

$$\Delta log\left(\text{Trade}_{j,t}\right) = \alpha_j + \beta_1\left[ov_{t-1} \times D_{j,t-1}\right] + \beta_2\left[ov_{t-1} \times \left(1 - D_{j,t-1}\right)\right] + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta log\left(Y_{j,t-1}\right) + \theta\Delta log\left(Y^*_{j,t-1}\right) + \rho\Delta log\left(\text{Trade}_{j,t-1}\right) + u_{j,t}, \quad (7)$$

where for all t,

$$D_{j,t} = \begin{cases} 1, & \text{if country j is a net oil exporter,} \\ 0, & \text{otherwise,} \end{cases}$$

is a dummy variable to indicate a net oil-exporting country. Hence, β_1 and β_2 are coefficients measuring the impacts of oil price volatility on international trade for net oil-exporting and net oil-importing countries, respectively.

The results presented in Table 4 suggest that for net oil-importing countries, oil price volatility significantly reduces trade. However, for net oil exporters, the impacts of oil price volatility are no longer statistically significant. In Table 4, we also report the *F* statistics and

[7] The Penn World Table data code is pc.
[8] See the August 2011 Monthly Energy Review, the US EIA.
[9] See http://www-personal.umich.edu/lkilian/paperlinks.html.
[10] Data are available on the US Energy Information Administration website.

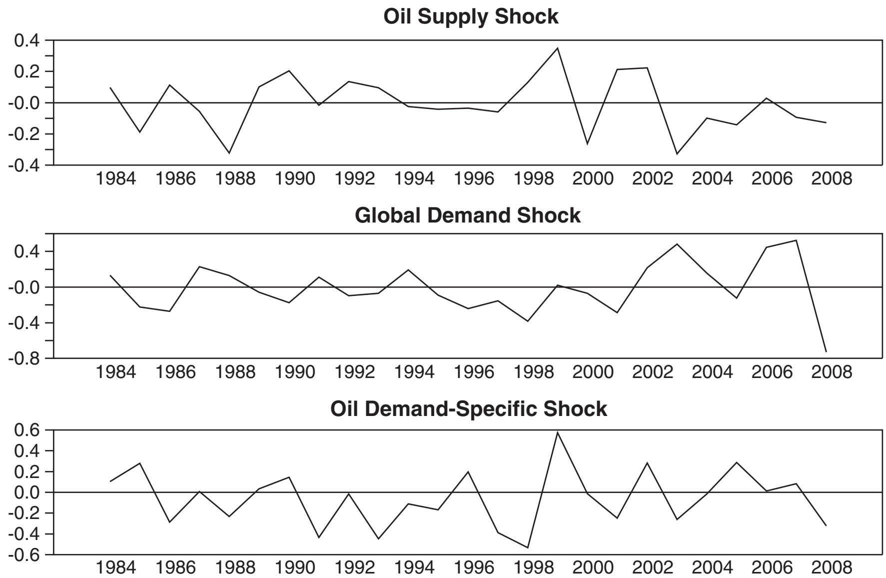

Fig. 2. Annual structural shocks identified in the structural VAR model (Eq. (1)): 1984–2008.

associated p-values for testing the null hypothesis that $H_0: \beta_1 = \beta_2$. Low p-values for the F test provide evidence that volatility has different consequences for a country's trade flows, which depends on whether the country is a net oil exporter or not.

Finally, we investigate how oil price volatility affects exports and imports separately. In Table 5, the dependent variables are changes in (log) real merchandise exports ($\Delta log(\text{Exports}_{j,t})$) and imports ($\Delta log(\text{Imports}_{j,t})$), respectively. Evidence presented in Table 5 indicates that higher oil price volatility hurts exports significantly. However, it is worth nothing that in terms of imports, the impacts are negative though insignificant. As a further investigation, we focus on how oil price variations affect real exports and real imports for net oil exporters versus net oil importers. Results in Table 6 show that for net oil importers, oil price fluctuations have significantly negative impacts on both exports and imports. As for net oil exporters, the impacts on imports are all positive while the results are mixed for exports. However, all of the estimates on the volatility's impacts are statistically insignificant for net oil exporters.

5. Energy efficiency and the volatility's impacts

For oil importers the effect of oil price volatility on trade flow may depend on energy efficiency. That is, the negative impact may decrease due to the declining share of energy in consumption, which in turn may result from more service-oriented economies, more energy-efficient technologies, and more diversified types of energy consumption.

In order to examine this issue, we consider the following empirical model for net oil importers

$$\Delta log\left(\text{Trade}_{j,t}\right) = \alpha_j + \gamma\left(e_{j,t}\right) \times ov_{t-1} + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta log\left(Y_{j,t-1}\right) + \theta\Delta log\left(Y^*_{j,t-1}\right) + \rho\Delta log\left(\text{Trade}_{j,t-1}\right) + u_{j,t}, \quad (8)$$

where $\gamma(e_{j,t}) = \gamma_0 + \gamma_1 e_{j,t}$, and $e_{j,t}$ is the total primary energy consumption per unit of GDP obtained from the US Energy Information Administration. Lower $e_{j,t}$ indicates lower energy intensity and higher energy

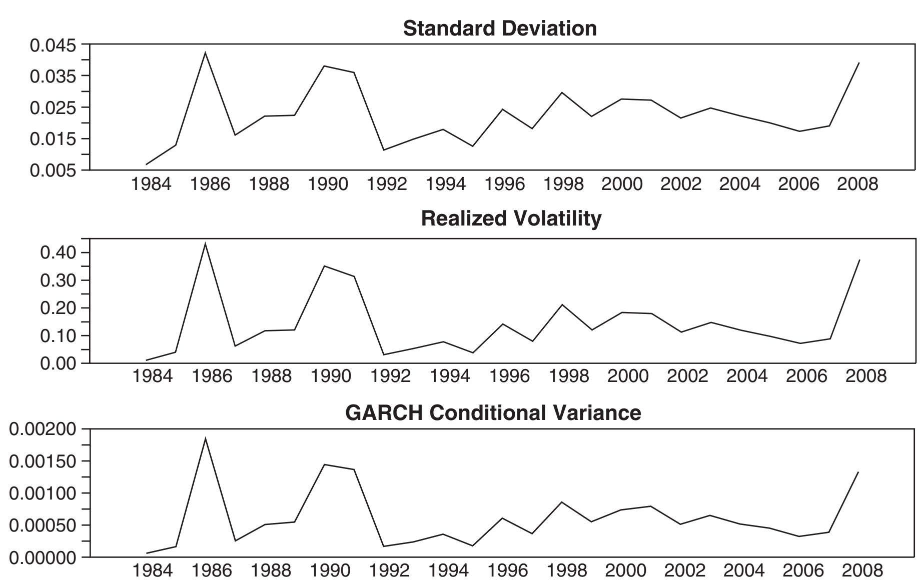

Fig. 3. Annual oil price volatility: 1984–2008.

Table 3
Benchmark empirical results (Annual data, 1984–2008 with 84 countries).

	(1)	(2)	(3)	(4)	(5)	(6)
Oil price volatility						
SD_{t-1}	-1.005^{**}			-1.119^{**}		
	(0.448)			(0.547)		
RV_{t-1}		-0.108^{***}			-0.118^{***}	
		(0.035)			(0.043)	
$GARCH_{t-1}$			-24.056^{***}			-26.756^{***}
			(8.418)			(10.258)
$\Delta log(\text{Trade}_{j,t-1})$	-0.078^{***}	-0.082^{***}	-0.081^{***}	-0.192^{***}	-0.198^{***}	-0.198^{***}
	(0.023)	(0.023)	(0.024)	(0.036)	(0.036)	(0.036)
$\hat{\xi}_t^{os}$				-0.058^{**}	-0.054^{**}	-0.056^{**}
				(0.026)	(0.026)	(0.026)
$\hat{\xi}_t^{gd}$				-0.013	-0.011	-0.011
				(0.015)	(0.015)	(0.015)
$\hat{\xi}_t^{od}$				0.040^{***}	0.039^{**}	0.039^{**}
				(0.016)	(0.016)	(0.016)
$\Delta log(Y_{j,t-1})$				0.256^{***}	0.256^{***}	0.256^{***}
				(0.056)	(0.055)	(0.055)
$\Delta log(Y^*_{j,t-1})$				0.074^{***}	0.082^{*}	0.081^{*}
				(0.044)	(0.044)	(0.044)
R^2	0.041	0.043	0.043	0.067	0.070	0.069

Note: The empirical model is $\Delta log(\text{Trade}_{j,t}) = \alpha_j + \beta ov_{t-1} + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta log(Y_{j,t-1}) + \theta\Delta log\left(Y^*_{j,t-1}\right) + \rho\Delta log(\text{Trade}_{j,t-1}) + u_{j,t}$, where $ov_t = SD_t$, RV_t or $GARCH_t$. Standard errors are in parentheses. Asterisks ***, ** and * indicate rejection of the null at 1%, 5% and 10%, respectively.

Table 4
Empirical results: net oil-importers vs. net oil-exporters (Annual data, 1984–2008).

	(1)	(2)	(3)
$SD_{t-1} \times D_{j,t-1}$	0.673		
	(1.085)		
$SD_{t-1} \times (1-D_{j,t-1})$	-1.665^{***}		
	(0.616)		
$RV_{t-1} \times D_{j,t-1}$		0.006	
		(0.085)	
$RV_{t-1} \times (1-D_{j,t-1})$		-0.155^{***}	
		(0.048)	
$GARCH_{t-1} \times D_{j,t-1}$			1.079
			(20.37)
$GARCH_{t-1} \times (1-D_{j,t-1})$			-35.167^{***}
			(11.549)
$\Delta log(\text{Trade}_{j,t-1})$	-0.191^{***}	-0.198^{***}	-0.197^{***}
	(0.036)	(0.036)	(0.036)
$\hat{\xi}_t^{os}$	-0.059^{***}	-0.055^{**}	-0.056^{***}
	(0.026)	(0.026)	(0.026)
$\hat{\xi}_t^{gd}$	-0.013	-0.011	-0.011
	(0.015)	(0.015)	(0.015)
$\hat{\xi}_t^{od}$	0.041^{***}	0.040^{***}	0.040^{***}
	(0.016)	(0.016)	(0.016)
$\Delta log(Y_{j,t-1})$	0.260^{***}	0.260^{***}	0.260^{***}
	(0.056)	(0.055)	(0.056)
$\Delta log(Y^*_{j,t-1})$	0.071^{*}	0.080^{*}	0.079^{*}
	(0.044)	(0.044)	(0.044)
R^2	0.070	0.072	0.071
F-stat [p-value]	3.651 [0.056]	2.842 [0.092]	2.501 [0.114]

Note: The empirical model is $\Delta log(\text{Trade}_{j,t}) = \alpha_j + \beta_1[ov_{t-1} \times D_{j,t-1}] + \beta_2[ov_{t-1} \times (1-D_{j,t-1})] + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta log(Y_{j,t-1}) + \theta\Delta log\left(Y^*_{j,t-1}\right) + \rho\Delta log(\text{Trade}_{j,t-1}) + u_{j,t}$, where $ov_t = SD_t$, RV_t or $GARCH_t$. Dummy variable $D_{j,t} = 1$ indicates net oil exporters while $D_{j,t} = 0$ represents net oil importers. Standard errors are in parentheses. F-stat and [p-value] are the F statistic and associated p-value for testing $H_0: \beta_1 = \beta_2 = 0$. Asterisks ***, ** and * indicate rejection of the null at 1%, 5% and 10%, respectively.

efficiency. If high energy efficiency help mitigate the reverse effects of oil price volatility, it is expected that $\gamma_0 < 0$ and $\gamma_1 < 0$. According to the estimates of γ in Table 7, no evidence is found that high energy efficiency help mitigate the negative impacts of oil price fluctuations.

6. High-frequency data

In our main empirical exercise, using a panel data set at an annual frequency allows us to investigate a large number of countries (84 countries) around the world. However, annual data may fail to account for some short-run dynamic interactions between variables. To check whether our main findings are robust, we use quarterly data from 1984:Q1 to 2009:Q4 to re-examine our main empirical conclusions in light of new evidence from high-frequency data. Now we obtain 104 time-series observations at the expense of the number of countries, which is reduced to 17. The sample countries include Australia, Austria, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Netherlands, Norway, Spain, Sweden, Switzerland, the UK, and the US. Because the Penn World Table data is not available at quarterly frequency, the quarterly exports and imports in US dollars are now converted into domestic currency, and then deflated by domestic consumer price index.[11]

[11] The nominal exchange rates are obtained from the Federal Reserve Economic Data (FRED), Federal Reserve Bank of St. Louis, and the consumer prices are obtained from the OECD Main Economic Indicators (MEI) database.

Table 5
Exports and imports (Annual data, 1984–2008 with 84 countries).

	Exports			Imports		
	(1)	(2)	(3)	(4)	(5)	(6)
SD_{t-1}	−1.440***			−0.514		
	(0.731)			(0.558)		
RV_{t-1}		−0.136***			−0.067	
		(0.057)			(0.044)	
$GARCH_{t-1}$			−31.192**			−14.756
			(13.678)			(10.45)
$\Delta log(\text{Export}_{j,t-1})$	−0.141***	−0.144***	−0.144***			
	(0.033)	(0.033)	(0.033)			
$\Delta log(\text{Import}_{j,t-1})$				−0.159***	−0.162***	−0.162***
				(0.033)	(0.033)	(0.033)
$\hat{\xi}_t^{os}$	−0.073**	−0.070**	−0.071**	−0.057***	−0.054**	−0.055**
	(0.035)	(0.035)	(0.035)	(0.027)	(0.027)	(0.027)
$\hat{\xi}_t^{gd}$	−0.014	−0.012	−0.012	−0.012	−0.01	−0.011
	(0.021)	(0.021)	(0.021)	(0.016)	(0.016)	(0.016)
$\hat{\xi}_t^{od}$	0.051**	0.049**	0.049**	0.026	0.026	0.026
	(0.022)	(0.022)	(0.022)	(0.017)	(0.017)	(0.017)
$\Delta log(Y_{j,t-1})$	0.183***	0.180***	0.180***	0.289***	0.289***	0.289***
	(0.072)	(0.072)	(0.072)	(0.056)	(0.056)	(0.056)
$\Delta log(Y^*_{j,t-1})$	0.134**	0.141***	0.140***	−0.035	−0.029	−0.03
	(0.057)	(0.057)	(0.057)	(0.043)	(0.043)	(0.043)
R^2	0.063	0.064	0.064	0.061	0.063	0.062

Note: The empirical model is $\Delta log(X_{j,t}) = \alpha_j + \beta ov_{t-1} + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta log(Y_{j,t-1}) + \theta\Delta log\left(Y^*_{j,t-1}\right) + \rho\Delta log(X_{j,t-1}) + u_{j,t}$, where the dependent variable is X_t = Exports$_t$ or Imports$_t$. Oil price volatility is $ov_t = SD_t$, RV_t or $GARCH_t$. Standard errors are in parentheses. Asterisks ***, ** and * indicate rejection of the null at 1%, 5% and 10%, respectively.

We first show the quarterly structural shocks ($\hat{\xi}_t^{os}, \hat{\xi}_t^{gd}$, and $\hat{\xi}_t^{od}$) and the quarterly oil volatility (SD_t, RV_t and $GARCH_t$) in Figs. 4 and 5. Comparing Figs. 2 and 3, it is of no surprise that the quarterly data exhibit greater variability. Table 8 reports the results with quarterly panel data. It is evident that our empirical findings remain unchanged: when oil prices are more volatile, global trade flows will be lower. We thus conclude that our main results are robust to higher-frequency data.

Table 6
Exports and imports for net oil-exporters vs. net oil-importers (Annual data, 1984–2008 with 84 countries).

	Exports			Imports		
	(1)	(2)	(3)	(4)	(5)	(6)
$SD_{t-1} \times D_{j,t-1}$	0.051			1.155		
	(1.457)			(1.109)		
$SD_{t-1} \times (1-D_{j,t-1})$	−1.894***			−1.027*		
	(0.825)			(0.631)		
$RV_{t-1} \times D_{j,t-1}$		−0.059			0.073	
		(0.114)			(0.087)	
$RV_{t-1} \times (1-D_{j,t-1})$		−0.159***			−0.110**	
		(0.064)			(0.049)	
$GARCH_{t-1} \times D_{j,t-1}$			−14.467			16.602
			(27.349)			(20.799)
$GARCH_{t-1} \times (1-D_{j,t-1})$			−36.240**			−24.360**
			(15.435)			(11.806)
$\Delta log(\text{Exports}_{j,t-1})$	−0.141***	−0.144***	−0.143***			
	(0.033)	(0.033)	(0.033)			
$\Delta log(\text{Imports}_{j,t-1})$				−0.159***	−0.163***	−0.163***
				(0.033)	(0.033)	(0.033)
$\hat{\xi}_t^{os}$	−0.074**	−0.070**	−0.072**	−0.058**	−0.055**	−0.056**
	(0.035)	(0.035)	(0.035)	(0.027)	(0.027)	(0.027)
$\hat{\xi}_t^{gd}$	−0.014	−0.012	−0.012	−0.012	−0.01	−0.011
	(0.021)	(0.021)	(0.021)	(0.016)	(0.016)	(0.016)
$\hat{\xi}_t^{od}$	0.051**	0.050**	0.050**	0.026	0.026	0.026
	(0.022)	(0.022)	(0.022)	(0.017)	(0.017)	(0.017)
$\Delta log(Y_{j,t-1})$	0.185***	0.183***	0.183***	0.293***	0.29***5	0.295***
	(0.072)	(0.072)	(0.072)	(0.056)	(0.056)	(0.056)
$\Delta log(Y^*_{j,t-1})$	0.132**	0.140**	0.138**	−0.036	−0.031	−0.032
	(0.057)	(0.057)	(0.057)	(0.043)	(0.043)	(0.043)
R^2	0.064	0.065	0.064	0.064	0.065	0.064
F-stat	1.398	0.606	0.498	3.028	3.476	3.039
p-value	[0.237]	[0.436]	[0.480]	[0.082]	[0.062]	[0.082]

Note: The empirical model is $\Delta log(X_{j,t}) = \alpha_j + \beta_1[ov_{t-1} \times D_{j,t-1}] + \beta_2[ov_{t-1} \times (1-D_{j,t-1})] + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta log(Y_{j,t-1}) + \theta\Delta log\left(Y^*_{j,t-1}\right) + \rho\Delta log(X_{j,t-1}) + u_{j,t}$, where the dependent variable is X_t = Exports$_t$ or Imports$_t$. Oil price volatility is $ov_t = SD_t$, RV_t or $GARCH_t$. Dummy variable $D_{j,t} = 1$ indicates net oil exporters while $D_{j,t} = 0$ represents net oil importers. Standard errors are in parentheses. F-stat and p-value are the F statistic and associated p-value for testing $H_0: \beta_1 = \beta_2 = 0$. Asterisks ***, ** and * indicate rejection of the null at 1%, 5% and 10%, respectively.

Table 7
Energy efficiency and the impacts of oil price volatility (Annual data, 1984–2008 with 67 countries for net-oil importers).

	(1)	(2)	(3)
SD_{t-1}	−1.686***		
	(0.680)		
$SD_{t-1} \times e_t$	8.99E-05		
	(8.30E-05)		
RV_{t-1}		−0.147***	
		(0.055)	
$RV_{t-1} \times e_t$		4.55E-06	
		(7.09E-06)	
$GARCH_{t-1}$			−33.751***
			(13.219)
$GARCH_{t-1} \times e_t$			0.001
			(0.002)
$\Delta log(\text{Trade}_{j,t-1})$	−0.181***	−0.188***	−0.187***
	(0.032)	(0.032)	(0.032)
$\hat{\xi}_t^{os}$	−0.191***	−0.186***	−0.188***
	(0.024)	(0.024)	(0.024)
$\hat{\xi}_t^{gd}$	−0.037***	−0.034**	−0.034**
	(0.014)	(0.014)	(0.014)
$\hat{\xi}_t^{od}$	0.047***	0.045***	0.045***
	(0.015)	(0.015)	(0.015)
$\Delta log(Y_{j,t-1})$	0.133***	0.135***	0.135***
	(0.052)	(0.052)	(0.052)
$\Delta log(Y_{j,t-1}^*)$	0.134***	0.143***	0.142***
	(0.043)	(0.043)	(0.043)
R^2	0.104	0.106	0.106

Note: The empirical model is $\Delta log(\text{Trade}_{j,t}) = \alpha_j + \gamma(e_t) \times ov_{t-1} + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta log(Y_{j,t-1}) + \theta\Delta log\left(Y_{j,t-1}^*\right) + \rho\Delta log(\text{Trade}_{j,t-1}) + u_{j,t}$, where $ov_t = SD_t$, RV_t or $GARCH_t$. The time-varying coefficient $\gamma(e_{j,t}) = \gamma_0 + \gamma_1 e_{j,t}$, and $e_{j,t}$ is the total primary energy consumption per unit of GDP to measure energy efficiency. Standard errors are in parentheses. Asterisks ***, ** and * indicate rejection of the null at 1%, 5% and 10%, respectively.

7. Concluding remarks

This paper investigated whether high oil price volatility causes reverse globalization, i.e., whether or not oil price fluctuations discourage international trade. Using a large annual panel data set covering 84 countries all over the world from 1984 to 2008, we found strong evidence that oil price volatility does decrease global trade flows. We have also considered different structural oil price shocks following Kilian (2009)'s approach. The evidence suggests that the increase in oil prices due to oil supply shocks has a significantly negative effect on international trade. On the other hand, positive oil-specific demand shocks cause higher trade flows.

We further divide the data set into two categories, net oil exporters and net oil importers, to see whether the oil price volatility international-trade nexus changes for different types of countries. We show that for net oil-importing countries, the negative impacts on trade from oil price fluctuations are statistically significant, while an insignificantly positive impact is found for oil-exporting countries.

The main empirical findings are robust to different measures of globalization (trade, exports, or imports) and different data frequency. Moreover, it is found that energy efficiency is unable to mitigate the negative impact of oil price volatility on international trade flows for oil importers. Our quantitative examination thus concludes that oil price fluctuations hurt globalization.

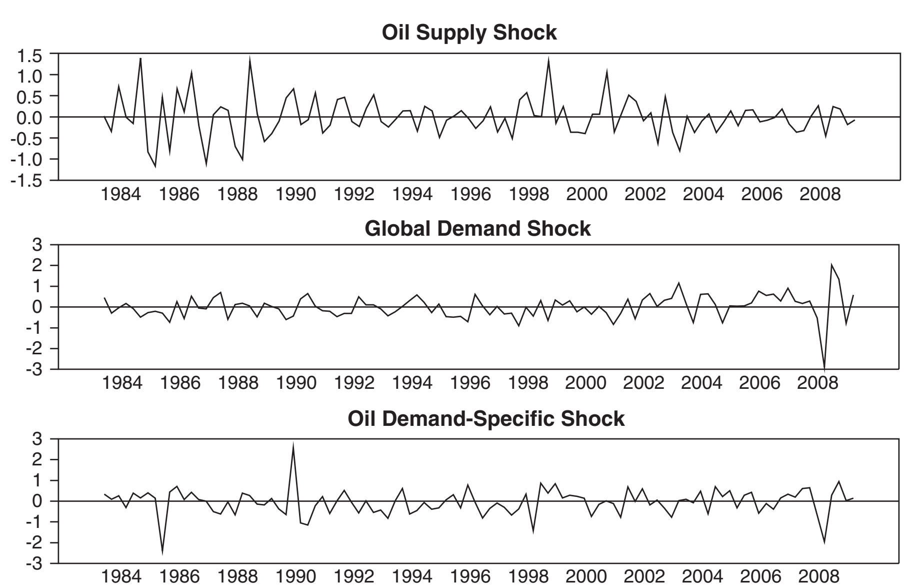

Fig. 4. Quarterly structural shocks identified in the structural VAR model (Eq. (1)): 1984:Q1–2009:Q4.

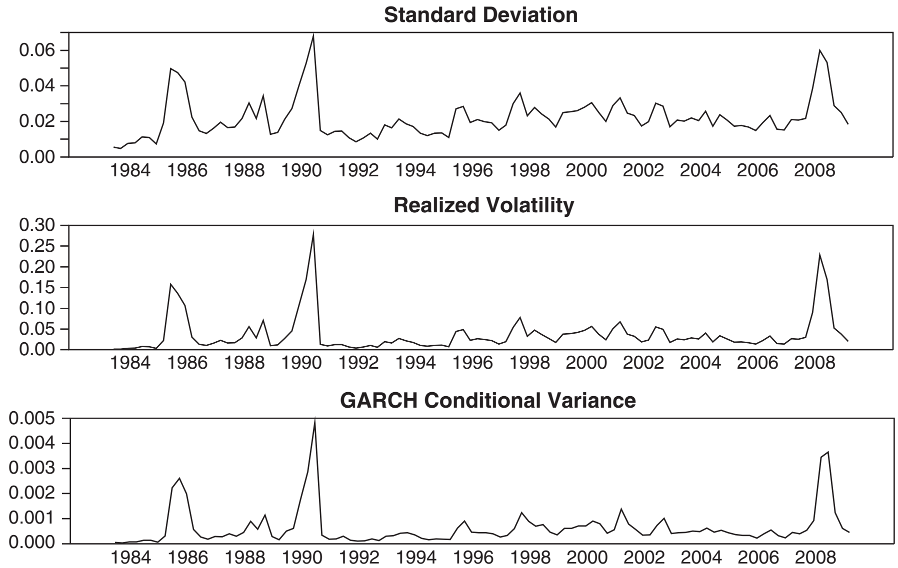

Fig. 5. Quarterly oil price volatility: 1984:Q1–2009:Q4.

Table 8
Benchmark empirical results: (Quarterly data, 1984Q1–2009Q4 with 17 countries).

	(1)	(2)	(3)	(4)	(5)	(6)
Oil price volatility						
SD_{t-1}	−1.955***			−1.921***		
	(0.142)			(0.142)		
RV_{t-1}		−0.521***			−0.536***	
		(0.035)			(0.035)	
$GARCH_{t-1}$			−28.996***			−29.760***
			(2.085)			(2.129)
$\Delta log(\text{Trade}_{j,t-1})$	−0.504***	−0.519***	−0.523***	−0.528***	−0.552***	−0.556***
	(0.021)	(0.021)	(0.021)	(0.024)	(0.024)	(0.024)
$\hat{\xi}_t^{os}$				−0.009***	−0.009***	−0.008***
				(0.003)	(0.003)	(0.003)
$\hat{\xi}_t^{gd}$				0.002	0.005*	0.006**
				(0.003)	(0.003)	(0.003)
$\hat{\xi}_t^{od}$				−0.008***	−0.009***	−0.008***
				(0.003)	(0.002)	(0.003)
$\Delta log(Y_{j,t-1})$				−0.059	−0.053	−0.049
				(0.043)	(0.042)	(0.042)
$\Delta log(Y^*_{j,t-1})$				0.337***	0.370***	0.360***
				(0.046)	(0.045)	(0.046)
R^2	0.286	0.298	0.288	0.317	0.334	0.322

Note: The empirical model is $\Delta log(\text{Trade}_{j,t}) = \alpha_j + \beta ov_{t-1} + \phi^{os}\hat{\xi}_t^{os} + \phi^{gd}\hat{\xi}_t^{gd} + \phi^{od}\hat{\xi}_t^{od} + \delta\Delta log(Y_{j,t-1}) + \theta\Delta log\left(Y^*_{j,t-1}\right) + \rho\Delta log(\text{Trade}_{j,t-1}) + u_{j,t}$, where $ov_t = SD_t$, RV_t or $GARCH_t$. Standard errors are in parentheses. Asterisks ***, ** and * indicate rejection of the null at 1%, 5% and 10%, respectively.

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