Crawford School of Public Policy

CAMA

Centre for Applied Macroeconomic Analysis

Policy Uncertainty in China, Oil Shocks and Stock Returns

CAMA Working Paper 32/2014
April 2014

Wensheng Kang
Department of Economics, Kent State University

Ronald A. Ratti
School of Business, University of Western Sydney and
Centre for Applied Macroeconomic Analysis, ANU

Abstract

This paper examines the interdependence of China's policy uncertainty, the global oil market, and stock market returns in China. A structural VAR model is estimated that shows a positive shock to economic policy uncertainty in China has a delayed negative effect on global oil production, real oil prices and real stock market returns. Shocks to oil market specific demand significantly raise China's economic policy uncertainty and reduce the real stock market returns. As measured by a spillover index the interdependence between these variables is rising since 2003 as China's influence in the oil market increases. An equivalent spillover index calculated for the U.S. is smaller and largely flat over time.

Keywords

China's policy uncertainty, China's stock market return, Oil shocks, Structural VAR

JEL Classification

E44, G15, P40, Q43

Address for correspondence:

(E) cama.admin@anu.edu.au

Policy Uncertainty in China, Oil Shocks and Stock Returns

by

Wensheng Kang
Kent State University, Department of Economics, USA
wkang3@kent.edu

Ronald A. Ratti
University of Western Sydney, School of Business, Australia
and Centre for Applied Macroeconomic Analysis
r.ratti@uws.edu.au

Abstract

This paper examines the interdependence of China's policy uncertainty, the global oil market, and stock market returns in China. A structural VAR model is estimated that shows a positive shock to economic policy uncertainty in China has a delayed negative effect on global oil production, real oil prices and real stock market returns. Shocks to oil market specific demand significantly raise China's economic policy uncertainty and reduce the real stock market returns. As measured by a spillover index the interdependence between these variables is rising since 2003 as China's influence in the oil market increases. An equivalent spillover index calculated for the U.S. is smaller and largely flat over time.

JEL classification: E44, G15, P40, Q43

Key words and phrases: China's policy uncertainty, China's stock market return, Oil shocks, Structural VAR

Policy Uncertainty in China, Oil Shocks and Stock Returns

1. Introduction

China is the largest energy user in the world whose oil consumption amounts to more than 11% of the global oil consumption in 2012. According to the US Energy Information Agency, China's oil consumption growth was half of the world's oil consumption increase in 2011.[1] China became the world's second largest oil consumer in 2003. China's oil intake is forecast to be 17.5 million barrels per day by 2030, overtaking the United States as the world's largest oil consumer (World Energy Outlook 2012).[2] This rising demand for oil has made China increasingly influential in world energy markets. China's continued growth and financial sophistication makes it increasingly of interest as a place for investment by global investors. As the world's fastest growing large economy, economic policy issues on the economic transition from command economy to market-oriented economy have dominated the Chinese policy agenda over the past 30 years.

In this paper we examine the interdependence of the global oil market, real stock market returns in China, and China's policy uncertainty. A rapidly growing literature has established a link between oil price shocks and the economy and the stock market in China.[3] In a recent paper Baker et al. (2013) construct an index of economic policy uncertainty for the U.S. and find that higher policy uncertainty leads to persistent negative effects on aggregate output and employment in United States. Studies have also appeared connecting economic policy

---

[1] Hamilton (2011) notes that the newly industrialized economies have absorbed over two-thirds of the increase in world oil consumption since 1998. Kilian and Hicks (2013) associate increases in real oil price over 2003-2008 with unexpectedly strong growth in emerging economies. Beirne et al. (2013) estimate the effects of individual countries on oil demand and find that China's GDP growth attaches a premium to the price of oil that is rising over time.

[2] To be found at http://iea.org/publications/freepublications/publication/English.pdf. The International Energy Agency forecasts China to overtake the US around 2025 as the world's largest importer of oil (World Energy Outlook, 2009).

[3] This literature is reviewed in the next section and includes contributions by Fan et al. (2007), Cong et al. (2008), Du et al. (2010), Tang et al. (2010), Zhang and Chen (2011), Li et al. (2011), Zhu et al. (2011) and even more recent contributions.

uncertainty to stock market returns. Brogaard and Detzel (2012) find that across 21 countries, an increase in economic policy uncertainty significantly reduces stock market returns. Antonakakis et al. (2013) find that correlations between US stock market returns, volatility and economic policy uncertainty vary over time and that a rise in the volatility of policy uncertainty reduces stock market returns.[4] An economic policy uncertainty measure for China is constructed by Baker et al. (2013).[5]

It is recognized in this paper that the relationship between the global oil market and China's stock market is interrelated with policy uncertainty in China. The availability of an economic policy uncertainty measure for China means that it is possible to examine the interdependence of policy uncertainty and real stock market returns for the World's second largest economy with the global oil market. This issue is of importance given the centrality of the global oil market to the World economy, the importance of China in influencing both, and the importance of understanding factors that influence the price of oil.

Our study shows that oil price increases and economic policy uncertainty in China are interrelated and influence real stock market returns. For example, oil price increases, caused by precautionary demand for oil over uncertainty about future oil supply relative to oil demand, significantly raise China's economic policy uncertainty and reduces real stock market returns. In turn, a positive shock to economic policy uncertainty in China has a delayed negative effect on

[4] Chang et al. (2013) examine political uncertainty and stock price for seven OECD countries and find that stock prices fall with policy change in the UK and US but not in the other countries. US economic policy uncertainty has also been related to oil prices. Kang and Ratti (2013) observe that US economic policy uncertainty increases with increases in the real price of oil. Li et al. (2013) find a bidirectional causal relationship between stock returns and China's economic policy uncertainty for several sub-periods.

[5] The measure of economic policy uncertainty for China (by Baker et al. (2013)) is based on a scaled frequency count of articles about policy-related economic uncertainty in Hong Kong's leading English-language newspaper, the South China Morning Post. Relevant articles must include the terms, China (or Chinese), economy (or economic), uncertain (or uncertainty), policy (or spending, budget, political, interest rates, reform), and government (or Beijing, authorities, tax, regulation, regulatory, central bank, People's Bank of China, PBOC, deficit, WTO).

global oil production over 4-11 months, real oil prices after 6 months, and real stock market returns from the 3rd month through to the 18th month.

The interdependence of the global oil market and China's policy uncertainty and stock market appears to be intensified over recent years. We find that more than 40% the variation in policy uncertainty and real stock market return are driven by the global crude oil market after 12 months, respectively, over 1995-2011. A rolling sample analysis shows that the real stock market returns responded differently to the oil supply and demand shocks and the policy uncertainty in both timing and magnitude, as the economic policy changes took place in China along with the dramatic price fluctuations in the global market for crude oil since 2003.

These results are related to the theoretical work of Pastor and Veronesi (2012), but with an additional implication. Pastor and Veronesi (2012) develop a general equilibrium model predicting stock prices fall at the announcement of a policy change on average. We incorporate oil price shocks in the analysis to show that economic policy changes are not exogenous but determined by various economic/political forces. The direct effects of oil shocks on real stock returns are amplified by endogenous policy uncertainty responses. Our study also contributes to the oil literature following the seminal paper by Kilian (2009), in which oil supply and demand shocks predetermined with respect to macroeconomic aggregates are assumed but not tested in the structural VAR model. We utilize the values and relevant t-statistics of partial correlation coefficients to determine the identifying restrictions on the structural VAR model.[6] It turns out the evidence supports Kilian's (2009) assumption and is consistent with Kilian and Vega's (2011) empirical findings.

[6] The method is introduced by Swanson and Granger (1997) for a structural VAR model and by George et al. (2008) in a Bayesian VAR framework.

The paper is organized as follows. The literature on the relationship between oil price shocks and the stock market in China is reviewed in Section 2. Section 3 describes data sources. Section 4 presents the structural VAR model. Section 5 discusses empirical results about the dynamics of oil price shocks and China's policy uncertainty and stock market returns. Section 6 concludes.

2. Literature Review

Studies focusing on the relation between oil shocks and China's economy and macroeconomic variables are fairly new.[7] Fan et al. (2007) construct a computable general equilibrium model for China and find that increases in world oil price have negative effects on income, investment, consumption, imports and exports. Du et al. (2010) show that positive shocks to world oil prices decrease economic growth and increase inflation in China. Tang et al. (2010) find that positive oil price innovations raise the inflation rate and interest rate, but negatively affect real output and real investment with a delay, because of price control policies in China.

In theory oil price shocks affect stock prices by influencing consumer and business spending on goods and services and since oil is an input in production. Oil price shocks can also affect firm value by influencing the discount rate for cash flow through the expected rate of inflation and the expected real interest rate. Higher volatility in oil prices also increases uncertainty at firms and in the economy with effects on firm value. Uncertainty about economic

[7] The relationship between oil price shocks and real activity has been closely examined for a number of countries. Following Hamilton's (1983) work connecting oil price shocks with real activity in the United States, Lee et al. (1995), Hamilton (1996), Jimenez-Rodriguez and Sanchez (2005), Cunado and Perez de Garcia (2005) and Cologni and Manera (2008) have confirmed that fluctuations of oil prices affect real economic activity in the US and in other countries. Oil price shocks have also been linked to stock returns. Narayan et al. (2014) in an examination of the effect oil prices on economic growth for 28 developed and 17 developing countries finds greater evidence of predictability for developed countries.

policy will interact with these connections between oil price shocks and stock prices. A number of recent studies have examined the relation between oil shocks and Chinese stock market returns.[8]

Cong et al. (2008) find that increased oil volatility raises stock returns in China's mining and petrochemical sectors. Zhang and Chen (2011) argue that Chinese stock returns are associated with the volatility of world oil prices. Li et al. (2011) find that oil prices have an impact in the short-run on a number of China's sector stock indices including hydropower, transportation, utilities, mining, manufacture, and industry, metal and paper-making sector. Zhu et al. (2011) take a panel threshold cointegration model and find bidirectional Granger causality between oil price shocks and OECD and non-OECD (including China's) stock markets.

Li et al. (2012) find panel cointegration relationship between oil prices and sectoral Chinese stock prices and that real oil price has a positive long-run effect on sector stocks. Ou et al. (2012) use a structural dynamic factor model to investigate the impact of world oil price shocks on a range of China's macroeconomic variables and find that stock prices are sensitive to oil price shocks. Jiao et al. (2012) using a structural vector autoregression model find that a positive oil price shock significantly increases profit and investment in China's petroleum and natural gas extraction industry. Broadstock et al. (2012) examine how oil prices affect Chinese energy-related stock returns and find that the relationship strengthened during the global financial crisis.

Cong and Shen (2013) find that energy price, stock market, and real activity in China are cointegrated and that a 1% rise in energy price reduces stock price by about 0.5%. A contrary

[8] A large body of work has explored the link between oil price shocks and stock market returns. Most studies find that an oil price shock has a significant negative effect on stock returns for oil importing developed countries: Sadorsky (1999) and Ciner (2001) for the US; Papapetrou (2001) for the US and for Greece; O'Neil et al. (2008) for US, UK and France; Park and Ratti (2008) for the US and European oil importing countries. Nandha and Faff (2008) find a negative relationship for global industry indices. Arouri (2011) shows that most European stock market sectors are influenced by changes in oil prices but that responses vary widely across sectors.

view concerning significant effects of oil price on China's stock market is provided by Nguyen and Bhatti (2012) who using parametric copula methods find that the Chinese stock market seems largely independent from oil prices over 2000-2009. Aloui et al. (2012) examine 25 emerging market countries and find that conditional oil risk is not priced for the largest oil-importing countries India, Korea, China and Taiwan.

Economic policy in China is also connected with energy issues. Wen et al. (2014) note that to ensure energy security, control carbon dioxide emissions and maintain economic growth, policymakers in China have focused policy on investigating new energy sources (nuclear and renewable energy) as an offset to oil, coal and natural gas, particularly since the release of the 11th Five-year Plan in 2006. Geng and Ji (2014) discuss energy policies designed to increase China's energy supply security including energy price reform to improve energy use, investment in research and development, clean energy and power grid infrastructure, and strategic reserves.

3. Data

3.1. Data Sources

All data are monthly and the sample period, from January 1995 to December 2011, is determined by the availability of the index of Chinese economic policy uncertainty. The measure of China' economic policy uncertainty is based on Baker et al. (2013).[9] It reflects media coverage of economic policy uncertainty, constructed by the month-by-month searches of the South China Morning Post and Hong Kong's leading English-language newspaper for articles

[9] The measure on US economic policy uncertainty is a weighted average of four uncertainty components: news-based policy uncertainty, CPI forecast interquartile range, tax legislation expiration, and federal government expenditures forecast interquartile range. Baker et al. (2013) set the weights to 1/2 on the news-based policy uncertainty and 1/6 on the taxation legislation expiration, CPI forecast interquartile range, and federal government expenditures forecast interquartile range. Constructing economic policy uncertainty index in China basically follows the method of constructing US news-based policy uncertainty. The data can be found at http://www.policyuncertainty.com/.

containing the term ‘uncertainty’ and items related to the economy and to economic policies. The number of articles that discuss both Chinese economy and policy uncertainty each month quantifies the economic policy uncertainty in that month.[10]

World production of crude oil, as a proxy for oil supply, and price of Brent crude oil, as a proxy for world price of oil, are drawn from the U.S. Department of Energy. The percent change in oil supply is measured by $100\times$ the log differences in world crude oil production in millions of barrels pumped per day averaged by month. The real price of oil is the nominal price of oil deflated by the Chinese CPI from the National Bureau of Statistics of China. Global real aggregate demand is measured by the index of global real economic activity constructed by Kilian (2009).[11] The index of real aggregate demand is based on the equal-weighted dry cargo freight rates. An increase in this index indicates a higher demand for shipping services arising from increases in real economic activity of the world. An advantage of the measure is that it includes activity in emerging economies such as China and India that are excluded from conventional measures of global economic activity based on OECD countries.

The aggregate Chinese stock market index is the Shanghai Stock Exchange (SSE) composite that is a value-weighted market portfolio including all stocks (about 975 companies with a total market capitalization of RMB 14,838 billion at the end of 2011) [12] that are traded at the Shanghai Stock Exchange. The aggregate Chinese stock market index return is deflated by the China’s CPI from National Bureau of Statistics of China to obtain a real stock return variable.

3.2. Data Description

[10] The raw counts about the news uncertainty are normalized by the number of news articles that contain the term ‘today’ in order to mitigate the volume accumulation and high-frequency noise problems.

[11] The data is available at Kilian’s webpage: http://www-personal.umich.edu/~lkilian/paperlinks.html.

[12] See the Shanghai Stock Exchange (SSE) at http://edu.sse.com.cn/sseportal/en/home/home.shtml. The data are available from Yahoo! Finance or from Compustat Global Advantage.

Figure 1 presents total petroleum consumption/passenger car production in China respectively over 1998-2011. Oil demand in China has increased dramatically from 4.1 in 1998 to 9.8 million barrels per day in 2011. World Energy Outlook 2012 predicts a raise of about 7.69 million barrels per day in Chinese oil consumption and a drop of about 5 million barrels per day in United States by 2030 relative to current levels. According to the Organisation Internationale des Constructeurs d'Automobiles (OICA) report, China produced a total of 5,071 passenger cars in 1998 and more than 14 million passenger cars (about 3 million in U.S.) in 2011.[13]

Figure 2 shows real prices of Brent crude oil and the index of economic policy uncertainty in China over 1995:01-2011:12. The timing of the outbreak of major historical events is marked in the figure. It can be seen that all dates of well-known events are followed by rises in the uncertainty. The index spikes over the periods of consequential economic reforms such as township and village enterprises (TVEs) bankruptcy in 1995-1996, privatization and restructuring in 1997-2000, accession to World Trade Organization in 2001, and government report aimed at poverty reduction in 2007. Index values rise substantially after major (world) events, for example, SARS outbreak in 2002/2003, first Olympics in China in 2008, global financial crisis in 2008/2009, and Euro crisis in 2010. The index reaches its peak when Xi-Li Administration began with legislation aimed at corruption and poverty in 2011/2012.

Note that these events and Bloom's (2009) choice of major uncertainty shocks coincide with events that trigger oil price shocks identified by Hamilton (2009) and Kilian (2009). For example, the 2008-2009 financial crises are associated with shocks to the precautionary demand for oil. The 1st/2nd Gulf Wars and Arab Spring are related to supply-side oil price shocks and oil-market specific demand shocks.

[13] The data is available at OICA: http://oica.net/category/production-statistics/1998-statistics/.

4. Methodology

In recent years it has been noted that it is important to identify the source of oil price shocks when examining their impact on stock market activity. Kilian and Park (2009) show that stock returns are adversely affected by positive oil specific demand shocks, but oil price increases associated with increases in global aggregate demand have a positive effect on stock market returns. Hamilton (2009) distinguishes oil price shocks due to demand side influence, due to strong global demand in recent decades driven by rapid growth in major developing economies including China, and supply influence, due to changes in world oil production.[14]

A structural VAR model is used to separate the three structural oil price shocks - shocks to world oil production, shocks to global demand for commodities and oil market specific demand shocks - and to assess their relationship with China's economic policy uncertainty and stock market returns. The structural representation of the VAR model of order p is

$$A_0 y_t = c_0 + \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t, \tag{1}$$

where $y_t = (\Delta prod_t, rea_t, rpo_t, pu_t, ret_t)$ is a 5×1 vector of endogenous variables, A_0 denotes the 5×5 contemporaneous coefficient matrix, c_0 represents a 5×1 vector of constant terms, A_i refers to the 5×5 autoregressive coefficient matrices, and ε_t stands for a 5×1 vector of structural disturbances. The endogenous variables in the model are world oil production ($\Delta prod_t$), global demand for all industrial commodities (rea_t), real oil prices (rpo_t), policy uncertainty (pu_t), and the stock market returns (ret_t).

[14] Filis et al. (2011) and Basher et al. (2012) find that oil price shocks due to aggregate demand factors influence stock returns, whereas oil price shocks due to supply factors do not influence stock returns. They find that positive oil market specific demand shocks reduce stock returns. Apergis and Miller (2009) report that structural shocks have influence on stock returns, but that the magnitude of the effect is small. Wang et al. (2013), Filis et al. (2011) and Park and Ratti (2008) note that it is also important to distinguish between the effect of oil price shocks on the stock markets of oil importing and exporting countries.

We follow Kilian (2009) and Kilian and Park (2009) and take $p = 24$.[15] The long lag of 24 allows for a potentially long-delay in effects of structural oil price shocks on the policy uncertainty and for a sufficient number of lags to remove serial correlation.[16] Hamilton and Herrera (2004) argue that a lag length of 24 months is sufficient to capture the dynamics in the data in modeling business cycles in commodity markets.

The reduced form VAR is obtained by multiplying both sides of Equation (1) with A_0^{-1} which has a recursive structure such that the reduced form errors e_t are linear combinations of the structural errors ε_t in the following,

$$e_t = \begin{bmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{rpo} \\ e_t^{pu} \\ e_t^{ret} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{\Delta prod} \\ \varepsilon_t^{rea} \\ \varepsilon_t^{rpo} \\ \varepsilon_t^{pu} \\ \varepsilon_t^{ret} \end{bmatrix}, \qquad (2)$$

in which $\varepsilon_t^{\Delta prod}$ reflects the oil supply-side shocks, ε_t^{rea} captures the real aggregate demand shocks, ε_t^{rpo} denotes the oil market specific demand shocks, ε_t^{pu} measures the economic policy uncertainty shocks, and ε_t^{ret} is the stock market shocks.

The first block of identifying restrictions on A_0^{-1} is motivated by Kilian (2009). The economic intuition is that crude oil supply does not respond to contemporaneous changes in oil demand within a given month. This exclusion restriction is likely because of the high adjustment

[15] The previous literature has shown that long lags are important in structural models of the global oil market to account for the low frequency co-movement between the real price of oil and global economic activity.

[16] While AIC and FPE suggest choosing a model with three lags, the likelihood-ratio tests select a model with more than twenty-four lags. Sims (1998) and Sims, Stock and Watson (1990) argue that even variables that display no inertia do not necessarily show absence of long lags in regressions on other variables. Given the standard nature of these tests, we use the long lag of 24 as in common with prior literature (e.g., Kilian (2009) and Kilian and Park (2009)). The robustness check shows similar results of impulse response functions and variance decompositions when we perform some variations on the analysis with respect to the lag length and the ordering of the VAR.

cost of oil production. It is often the case that oil producers make forecasts of oil demand once a year to set production based on expected trend, not high-frequency variation, in demand. Fluctuation in the real price of oil will not affect global real economic activity within a given month due to the sluggishness of the global real reaction. Innovations in the global real economic activity are referred to as shocks to the global demand for all industrial commodities, whereas oil price innovations associated with fluctuations in precautionary demand for oil are referred to as shocks to the oil-market specific demand and represent an exogenous shift driven by uncertainty about future oil supply shortfalls.

The second block of identifying restrictions on A_0^{-1} shows that economic policy uncertainty orders after oil price shocks. It is motivated by Kilian and Vega (2011) who argue that oil prices are predetermined with respect to U.S. macroeconomic aggregates within a given month. The stock market return ordered last is motivated by Pastor and Veronesi (2012) who build a general equilibrium model predicting stock prices fall at the announcement of a policy change on average. These model specifications are in line with the standard approach of treating innovations to the price of oil as predetermined with respect to the economy (e.g., Kilian and Park (2009) and others).

In Equation (2) $e_t \sim N(0,\Sigma)$ in the reduced-form VAR model and the partial correlation coefficients quantifying the contemporaneous correlation between two components of the errors, $\rho_{ij} = -\sigma^{ij} / \sqrt{\delta^{ii}\delta^{jj}}$, where σ^{ij} denotes the elements of the precision matrix Σ^{-1}, are [17]

[17] Values in the parenthesis of the matrix are absolute t-statistic to which the standard error is generated by recursive-design wild bootstrap with 2,000 replications proposed by Gonçalves and Kilian (2004).

$$\begin{bmatrix} & rea & rpo & pu & ret \\ \Delta prod & 0.212 & 0.013 & 0.030 & -0.140 \\ & (1.46) & (0.08) & (0.20) & (0.93) \\ rea & & 0.232 & -0.164 & 0.091 \\ & & (1.58) & (1.12) & (0.61) \\ rpo & & & 0.052 & -0.223 \\ & & & (0.34) & (1.57) \\ pu & & & & 0.016 \\ & & & & (0.10) \end{bmatrix}.$$

The result provides supporting evidence on the identifying restrictions on A_0^{-1} in the structural VAR model, in that the contemporaneous correlation between oil price shocks and China's economic policy uncertainty and real stock market returns is small and statistically insignificant within a given month.[18]

To investigate the stationarity of the variables in the structural VAR model, we conduct the Augmented Dicky-Fuller (ADF) and Phillips-Perron (PP) tests for each series. We find that we can reject the null hypothesis, based on the ADF test, that $\Delta prod_t$, rea_t, pu_t and ret_t contain a unit root at the 5% significant level, and for rpo_t at 10%. We also find that the PP test suggests that real price of oil (rpo_t) contains a unit root.[19] In this study the nonstationarity of the real price of oil is not a major concern since the impulse response estimates presented below are reasonably estimated.[20]

---

[18] Swanson and Granger (1997) suggest using the value of partial correlation coefficients to determine the variable ordering and relevant t-statistics for identifying restriction on the VAR models. George et al. (2008) show that, when the value is small, for example less than 0.3, zero contemporaneous correlation between two components of the errors is normally realized in the Bayesian stochastic search for model restriction selections.

[19] Specifically, the p-values of z-test are 0.00, 0.01, 0.08, 0.03 and 0.00 for $\Delta prod_t$, rea_t, rpo_t, pu_t and ret_t, respectively, by the ADF test with a drift and 4 lags determined by Schwarz-Bayes information criterion. The MacKinnon approximate p-values are 0.00, 0.15, 0.62, 0.00 and 0.00 for $\Delta prod_t$, rea_t, rpo_t, pu_t and ret_t, respectively, by PP test with a drift and 4 lags determined by Newey-West automatic bandwidth selection criterion. The result is similar when using the ADF and PP tests with trend.

[20] We also conduct the ADF Generalized Least Squares test that suggests real prices of oil (rpo_t) contain a unit root. The nonstationary of the real price of oil may lead to a loss of asymptotic efficiency reflected in a wider error bands

5. Empirical Results

5.1. Responses to Structural Shocks

Figure 3 reports the responses to one-standard deviation structural shocks from the global crude oil market, policy uncertainty, and stock market, for horizons up to 18 months. One-standard error and two-standard error bands indicated by dashed and dotted lines, respectively, are computed by conducting recursive-design wild bootrap with 2,000 replications proposed by Gonçalves and Kilian (2004). All structural shocks have been normalized and the reduced-form VAR model is consistently estimated using the least-squares method in order to construct the structural VAR representation of the model.

The first column of Figure 3 shows the effects of an unanticipated oil production disruption. A sharp decline in global oil production is followed by a substantial reversal of that decline within 6 months. This shock triggers transitory and partially statistically significant decreases in global demand for commodities for about 4 months. It also causes an increase in the real price of oil after 5 months that is very persistent and highly statistically significant. The effects of an unanticipated oil production disruption on economic policy uncertainty in China are not statistically significant. An unanticipated oil production disruption is associated with decreases in real stock market returns in China that are statistically significant in a window between 1 and 6 months.

The responses to shocks to global demand for commodities are shown in the second column of Figure 3. In the second row of the second column in Figure 3, a shock to global demand persists for an extended period, weakening by the 8^{th} month and then strengthening for

---

in the estimation. However, differencing the real price series results in removal of the slow moving component in the series, and incorrectly differencing the real price of oil would cause the estimates to be inconsistent given the nature of standard unit root tests. Since the estimated impulse response is robust even if the stationary assumption is violated, we use the level of the real price of oil as in common with prior literature (e.g., Kilian (2009) and Kilian and Park (2009)).

several months before weakening again. An unexpected increase in global demand for commodities leads to a rise in both oil supply and real price of oil that becomes statistically significant after a year. A positive unanticipated innovation in global demand results in a statistically insignificant effect on policy uncertainty for 8 months, followed by a negative effect on policy uncertainty that is statistically significant 9 to 11 months later. A positive global demand shock increases real stock market returns that are statistically significant after 9 months.

In the third column of Figure 3, positive oil market specific demand shocks associated with the precautionary demand for oil have a small impact on oil production, a statistically significantly positive impact on global demand in 3 months following impact, and a statistically significantly positive impact on real prices of oil over 6 months. A positive oil market specific demand shock predicts increases in policy uncertainty and decreases in real stock returns that are highly statistically significant after 3 months for an extended period of time.

An unanticipated increase in China's policy uncertainty results in the reduction of global oil production that is statistically significant in 4-11 months in column 4 of Figure 3. The reactions of the aggregate demand to the policy uncertainty shocks are only partially statistically significant after 11 months in column 4 of Figure 3. A surprise rise in the policy uncertainty also significantly reduces real prices of oil in a window between 7 and 11 months. On the other hand, shocks to the policy uncertainty have an immediate and large effect on the economic policy uncertainty that gradually erode within 8 months. This shock also causes a persistent decline in real stock market returns that is statistically significant from the 3rd month through the 18th month.

Shocks to stock market returns in China have relatively small effects on the oil market. In column 5 of Figure 3, a positive shock to China's stock returns predicts increases in global oil production and in global demand that are statistically significant in 8 to 12 and in 10 to 12 month windows, respectively. A positive shock to China's stock returns is not associated with a statistically significant effect on real oil price or on policy uncertainty in China.

In sum, oil price shocks and economic policy uncertainty are interrelated and influence stock market returns. Oil market specific demand shocks cause significantly increased policy uncertainty and significantly reduced real stock returns (in the 4th and 5th rows of column three of Figure 3). Global demand expansions also cause decreased policy uncertainty and increased real stock returns with a delay of about 9 or 10 months (in the 4th and 5th rows of column two of Figure 3). A positive shock to economic policy uncertainty in China has a significantly delayed negative effect on global oil production, real oil prices and real stock market returns (in the 1st, 3rd and 5th rows of column four of Figure 3). One explanation of the interdependence is the fact that China's increased oil consumption largely depends on the imported oil supply, thus raising the interactions between the world oil price and China's macroeconomy.

5.2. Variance Decompositions

An important question after having identified oil price shocks is how much of the variation of the real economic activity they explain. Decomposition of the forecast error variance into components provides us with useful insight on the percent contribution of structural shocks in the oil market to the variation of the economic policy uncertainty and the real stock market returns.

Panel A of Table 1 reports the forecast error variance decompositions (FEVDs) of the policy uncertainty. In the first few months the effects of three structural oil price shocks on the policy uncertainty are negligible. Over time the explanatory power of the oil shocks increases. After 12 months 15.9% and 20.1% of the volatility in the policy uncertainty are accounted for by the innovations of aggregate demand and precautionary demand for oil, respectively, whereas the FEVDs of the policy uncertainty to shocks in oil supply is 6.3% over the same longer term. On the other hand, we also find that, over 12 months in Panel B of Table 1, 16%, 8.5%, and 16.2% of the variations in real stock market returns are driven by oil market specific demand, oil production, and aggregate demand shocks, respectively. The policy uncertainty shocks alone account for 7.2% of the variability of returns after 12 months.

To provide an intuitive measure of interdependence of the oil market and the policy uncertainty and stock market, we follow Diebold and Yilmaz (2009, 2013) to report the spillover table/index from the variance decomposition associated with all five variables in the VAR model. While the spillover table presents a familiar notion of variance decompositions associated with all variables in the VAR model, the spillover index aggregates the interdependence effects across these variables to reveal the spillover trends, cycles and bursts into a single measure for a given forecast horizon.[21] In Panel C of Table 1, the off-diagonal elements give the 12-step ahead forecast error variance of a variable coming from shocks arising in the other variable. Then, $1/5 \times$ the sum of off-diagonal elements provides us with the spillover index measuring the degree of connectedness for the oil market and the policy uncertainty and stock market. The spillover index 0.374 is highly statistically significant that reinforces the finding that oil price shocks and economic policy uncertainty are interrelated and influence stock market returns.

5.3. Rolling Sample Analysis

As many changes took place over recent years along with the dramatic price fluctuations in the global market for crude oil since 2003, we present rolling sample analysis to investigate the changes in the dynamics of oil shocks on the policy uncertainty and stock market over time.

[21] The robustness check shows similar results when we perform some variations on the analysis with respect to the rolling window width, the forecast horizon, and the ordering of the VAR.

We estimate the structural VAR model using 96-month rolling samples in order to assess the degree and nature of spillover variation starting in January 2003.

The spillover index in Figure 4 displays an increasing trend indicating the interdependence is intensified between the global oil market and China's policy uncertainty and stock market over time. It differs from an equivalent spillover index calculated for the US that is smaller and largely uneventful except for the year 2008-2009.[22] These results reflect the fact that Chinese oil intake is forecast to be overtaking the United States as the world's largest oil consumer.

In Figure 5 contributions from oil supply shocks to the total variation of real stock market returns increase radically in the early 2011 because of the exogenous political event the Arab Spring in the Middle East. The contributions from oil market specific demand shocks also rise dramatically starting from 2007 and reach the peak in the year 2008-2009 because of the oil spike followed by the global financial crisis. All these events are associated with increased economic policy uncertainty in China. In the late 2011, contributions from the policy uncertainty and from the aggregate demand become higher to the forecast error variance of real stock market returns. It indicates that the real stock market returns response differently to the oil supply and demand shocks and the policy uncertainty in both timing and magnitude in China.

6. Conclusion

In this paper we examine the interdependence of China's policy uncertainty, the global oil market, and stock market returns in China using monthly data and a structural VAR model. It

[22] The US case utilizes monthly data over 1985:1-2011:12. The aggregate US stock market return is from Center for Research in Security Prices (CRSP) and adjusted by the US CPI. The world production of crude oil as a proxy for oil supply and US refiner's acquisition cost of crude oil as a measure on the prices of oil are drawn from the US Department of Energy. We use US economic policy index from Baker et al. (2013) and the aggregate demand index from Kilian (2009).

is found that oil price increases and economic policy uncertainty in China are interrelated and influence real stock market returns. Oil market specific demand significantly raises China's economic policy uncertainty and reduces the real stock market returns, whereas a positive shock to economic policy uncertainty in China has a significantly negative effect on global oil production, real oil prices and real stock market returns in a longer term. At the same time, global demand expansions cause decreased policy uncertainty and increased real stock returns with a delay of at least half a year. The interdependence between these variables is rising since 2003 as China's influence in the oil market increases. An equivalent spillover index calculated for the U.S. is smaller and largely flat since 2003.

The results are of interest to investors and financial market participants. The paper contributes to information on stock sector vulnerability in a major economy to change in oil prices and economic policy uncertainty. Results are useful in showing that the relationship between oil price and stock return in China depends on domestic policy uncertainty. Potentially this informs investors on portfolio strategies on oil price risk and diversification possibilities across countries.

References

Aloui, C., Nguyen, D. K. and Njeh, H. (2012). 'Assessing the impacts of oil price fluctuations on stock returns in emerging markets', *Economic Modelling*, 29(6), pp. 2686-2695.

Antonakakis, N., Chatziantoniou, I. and Filis, G. (2013). 'Dynamic co-movements of stock market returns, implied volatility and policy uncertainty', *Economics Letters*, 120(1), pp. 87-92.

Apergis, N. and Miller, S. M. (2009). 'Do structural oil-market shocks affect stock prices?' *Energy Economics*, 31(4), pp. 569-575.

Arouri, M. E. H. (2011). ‘Does crude oil price move stock prices in Europe? A sectoral investigation’, *Economic Modelling*, 28, pp. 1716-1725.

Baker, S. R., Bloom, N. and Davis, S. J. (2013). ‘Measuring economic policy uncertainty’. Available at: www.aeaweb.org/aea/2013conference/program/retrieve.php?pdfid=519.

Basher, S. A., Haug, A. A. and Sadorsky, P. (2012). ‘Oil prices, exchange rates and emerging stock markets’, *Energy Economics*, 34, pp. 227-240.

Beirne, J., Beulen, C., Liu, G. and Mirzaei, A. (2013). ‘Global oil prices and the impact of China’, *China Economic Review*, 27, pp. 37-51.

Bloom, N. (2009). ‘The impact of uncertainty shocks’, *Econometrica,* 77, pp. 623-685.

Broadstock, D. C., Cao, H. and Zhang, D. (2012). ‘Oil shocks and their impact on energy related stocks in China’, *Energy Economics*, 34, pp. 1888-1895.

Brogaard, J. and Detzel, A. (2012). ‘The asset pricing implications of government economic policy uncertainty’. Available at: http://conference.darden.virginia.edu/ifc/selected_papers/policyuncertainty_Detzel_11152012.pdf.

Chang, T., Chen, W.-Y., Gupta, R. and Nguyen, D. K. (2013). ‘Are stock prices related to political uncertainty index in OECD countries? Evidence from bootstrap panel causality test’. Available at: https://web.up.ac.za/sitefiles/file/40/677/WP_2013_60.pdf.

Ciner, C. (2001). ‘Energy shocks and financial markets: Nonlinear linkages’, *Studies in Non-Linear Dynamics and Econometrics*, 5, pp. 203-212.

Cologni, A. and Manera, M. (2008). ‘Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries’, *Energy Economics*, 30, pp. 856-888.

Cong, R.-G. and Shen, S. (2013). 'Relationships among energy price shocks, stock market, and the macroeconomy: Evidence from China', The Scientific World Journal 2013, Article ID. 171868, pp. 1-9.

Cong, R. G., Wei, Y. M., Jiao, J. L. and Fan, Y. (2008). 'Relationships between oil price shocks and stock market: an empirical analysis from China', *Energy Policy*, 36, pp. 3544–3553.

Cunado, J. and Perez de Gracia, F. (2005). 'Oil prices, economic activity and inflation: evidence for some Asian countries', *Quarterly Review of Economics and Finance,* 45, pp. 65-83.

Diebold, F. X. and Yilmaz, K. (2009). 'Measuring financial asset return and volatility spillovers, with application to global equity markets', *Economic Journal*, 119, pp. 158-171.

Diebold, F. X. and Yilmaz, K. (2013). 'On the network topology of variance decompositions: measuring the connectedness of financial firms' *Journal of Econometrics*, forthcoming.

Du, L., He, Y. and Wei, C. (2010). 'The relationship between oil price shocks and China's macro-economy: An empirical analysis', *Energy Policy*, 38, pp. 4142-4151.

Fan, Y., Jiao, J. L., Liang, Q. M. and Han, Z. Y. (2007). 'The impact of rising international crude oil price on China's economy: an empirical analysis with CGE model', *Int. J. Global Energy Issues* 27, pp. 404–424.

Filis, G., Degiannakis, S. and Floros, C. (2011). 'Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries', *International Review of Financial Analysis*, 20(3), pp. 152-164.

Geng, J.-B. and Ji, Q. (2014). 'Multi-perspective analysis of China's energy supply security', *Energy*, 64, pp. 541-550.

George, E. I., Sun, D. and Ni, S. (2008). 'Bayesian stochastic search for VAR model restrictions', *Journal of Econometrics*, 142, pp. 553-580.

Gonçalves, S. and Kilian, L. (2004). 'Bootstrapping autoregressions with conditional heteroskedasticity of unknown form', *Journal of Econometrics*, 123, pp. 89-120.

Hamilton, J. D. (1983). 'Oil and the Macroeconomy since World War II', *Journal of Political Economy*, 91, pp. 228-248.

Hamilton, J. D. (1996). 'This is what happened to the oil price-Macroeconomy relationship', *Journal of Monetary Economics*, 38, pp. 215-220.

Hamilton, J. D. (2009), 'Causes and consequences of the oil shock of 2007-08', *Brookings Papers on Economic Activity*, Spring, pp. 215-261.

Hamilton, J. D. (2011). 'Nonlinearities and the macroeconomic effects of oil prices', *Macroeconomic Dynamics*, 3, pp. 364-378.

Hamilton, J. D. and Herrera, A. M. (2004). 'Oil shocks and aggregate macroeconomic behavior: The role of monetary policy: comment', *Journal of Money, Credit and Banking*, 36, pp. 265-286.

Jiao, J.-L., Gan, H.-H. and Wei, Y.-M. (2012). 'The impact of oil price shocks on Chinese industries', *Energy Sources, Part B: Economics, Planning and Policy*, 7(4), pp. 348-356.

Jimenez-Rodrgiuez, R. and Sanchez, M. (2005). 'Oil price shocks and real GDP growth, empirical evidence for some OECD countries', *Applied Economics*, 37, pp. 201-228.

Kang, W. and Ratti, R. A. (2013), 'Structural oil price shocks and policy uncertainty', *Economic Modelling*, 35, pp. 314-319.

Kilian, L. (2009). 'Not all oil price shocks are alike: disentangling demand and supply shocks in the crude oil market', *American Economic Review*, 99, pp. 1053-1069.

Kilian, L. and Hicks, P. (2013). 'Did unexpectedly strong economic growth cause the oil price shock of 2003-2008 ?' *Journal of Forecasting*, 32, pp. 385–394.

Kilian, L. and Park, C. (2009). ‘The impact of oil price shocks on the U.S. stock market’, *International Economic Review*, 50, pp. 1267-1287.

Kilian, L. and Vega, C. (2011). ‘Do energy prices respond to U.S. macroeconomic news? A test of the hypothesis of predetermined energy prices’, *The Review of Economics and Statistics*, 93, pp. 660-671.

Lee, K., Ni, S. and Ratti, R. A. (1995). ‘Oil shocks and the macroeconomy: The role of price variability’, *Energy Journal*, 16, pp. 39-56.

Li, C., Qi, Z., Tan, L., Tang, J. and Wang, X. (2011). “Sector effects of oil price fluctuation in China stock market’, *ICIC Express Letters*, 5(11), pp. 4169-4174.

Li, S.-F., Zhu, H.-M. and Yu, K. (2012). ‘Oil prices and stock market in China: A sector analysis using panel cointegration with multiple breaks’, *Energy Economics*, 34, pp. 1951-1958.

Li, X.-L., Balcilar, M., Gupta, R. and Chang, T. (2013). ‘The causal relationship between economic policy uncertainty and stock returns in China and India: Evidence from a bootstrap rolling-window approach’. Available at: https://web.up.ac.za/sitefiles/file/40/677/WP_2013_45.pdf.

Nandha, M. and Faff, R. (2008). ‘Does oil move equity prices? A global view’, *Energy Economics*, 30, pp. 986-997.

Narayan, P. K., Sharma, S., Poon, W. C. and Westerlund, J. (2014). ‘Do oil prices predict economic growth? New global evidence’, *Energy Economics*, 41, pp. 137-146.

Nguyen, C. C. and Bhatti, M. I. (2012). ‘Copula model dependency between oil prices and stock markets: Evidence from China and Vietnam’, *Journal of International Financial Markets, Institutions and Money*, 22, pp. 758-773.

Ou, B., Zhang, X. and Wang, S. (2012). ‘How does China's macro-economy response to the world crude oil price shock: A structural dynamic factor model approach’, *Computers and Industrial Engineering*, 63(3), pp. 634-640.

O'Neil, T. J., Penn, J. and Terrell, R. D. (2008). ‘The role of higher oil prices: A case of major developed countries’, *Research in Finance*, 24, pp. 287-299.

Papapetrou, E. (2001). ‘Oil price shocks, stock market, economic activity and employment in Greece’, *Energy Economics*, 23, pp. 511-532.

Park, J. and Ratti, R. A. (2008). ‘Oil prices and stock markets in the U.S. and 13 European countries’, *Energy Economics*, 30, pp. 2587-2608.

Pastor, L. and Veronesi, P. (2012). ‘Uncertainty about government policy and stock prices’, *Journal of Finance*, 4, pp. 1219-1264.

Sadorsky, P. (1999). ‘Oil price shocks and stock market activity’, *Energy Economics*, 21, pp. 449-469.

Sims, C. A. (1998). ‘Econometric implications of the government budget constraint’, *Journal of Econometrics*, 83, pp. 9-19.

Sims, C. A., Stock, J. H. and Watson, M. (1990). ‘Inference in linear time-series models with some unit roots’, *Econometrica*, 58, pp. 113-144.

Swanson, N. R. and Granger, C. W. J. (1997). ‘Impulse response functions based on a causal approach to residual orthogonalization in vector autoregressions’, *Journal of American Statistical Association*, 92, pp. 357-367.

Tang, W., Wu, L. and Zhang, Z. (2010). ‘Oil price shocks and their short- and long-run effects on the Chinese economy’, *Energy Economics*, 32, S3-S14.

Wang, Y., Wua, C. and Li, Y. (2013). ‘Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries’, *Journal of Comparative Economics*, 41(4), 1220-1239.

Wen, X., Guo, Y., Wei, Y. and Huang, D. (2014). ‘How do the stock prices of new energy and fossil fuel companies correlate? Evidence from China’, *Energy Economics*, 41, pp. 63-75.

Zhang, C. and Chen, X. (2011). ‘The impact of global oil price shocks on China’s stock returns: Evidence from the ARJI(-h_t)-EGARCH model’, *Energy*, 36, pp. 6627-6633.

Zhu, H.-M, Li, S.-F. and Yu, K. (2011). ‘Crude oil shocks and stock markets: A panel threshold cointegration approach’, *Energy Economics*, 33, pp. 978-994.

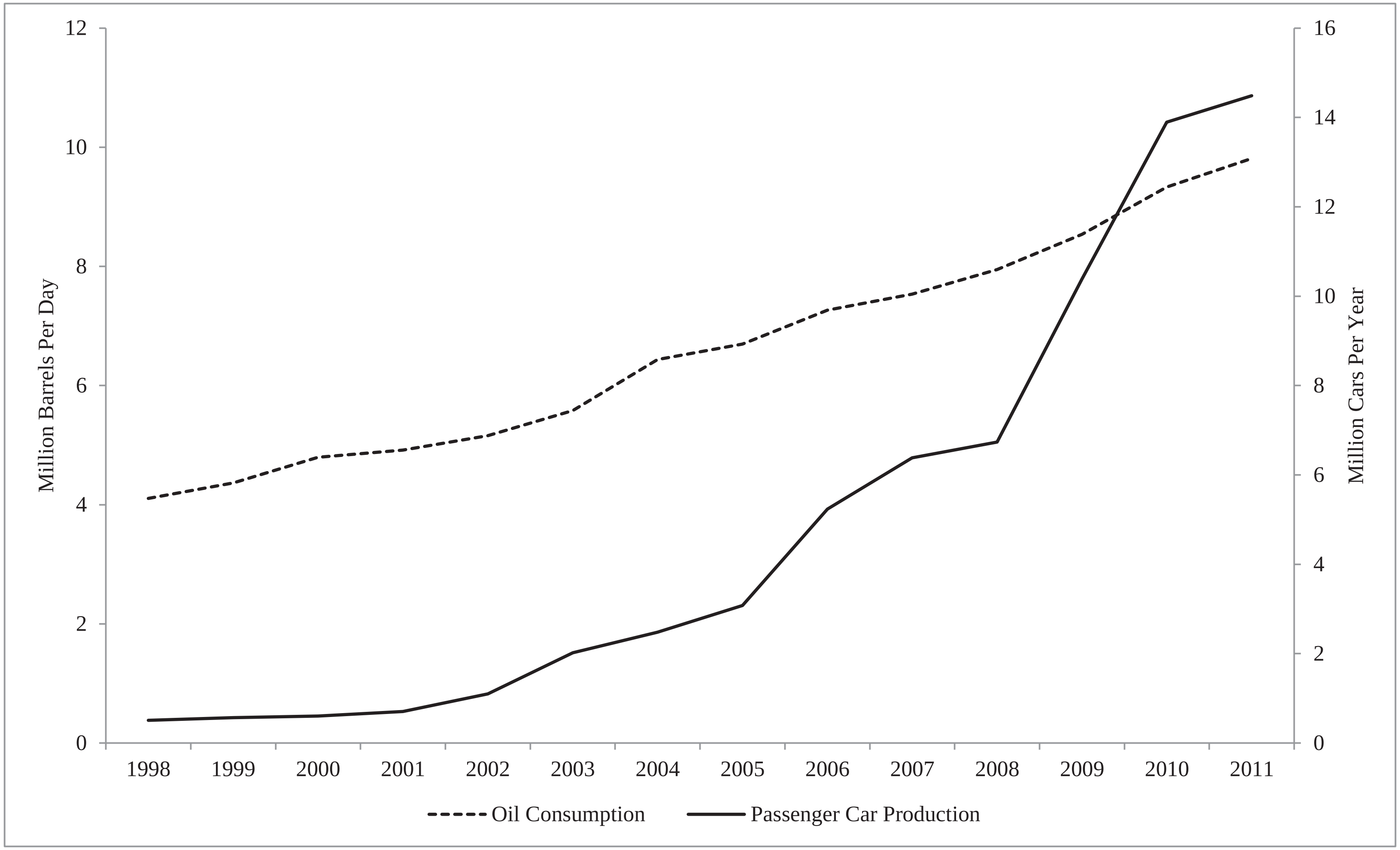


Figure 1. Total petroleum consumption/car production in China.
Notes: the historical oil consumption data from 1998-2011 is drawn from U.S. Energy Information Administration and the historical car production data from 1998-2011 is obtained from Organisation Internationale des Constructeurs d'Automobiles (OICA).

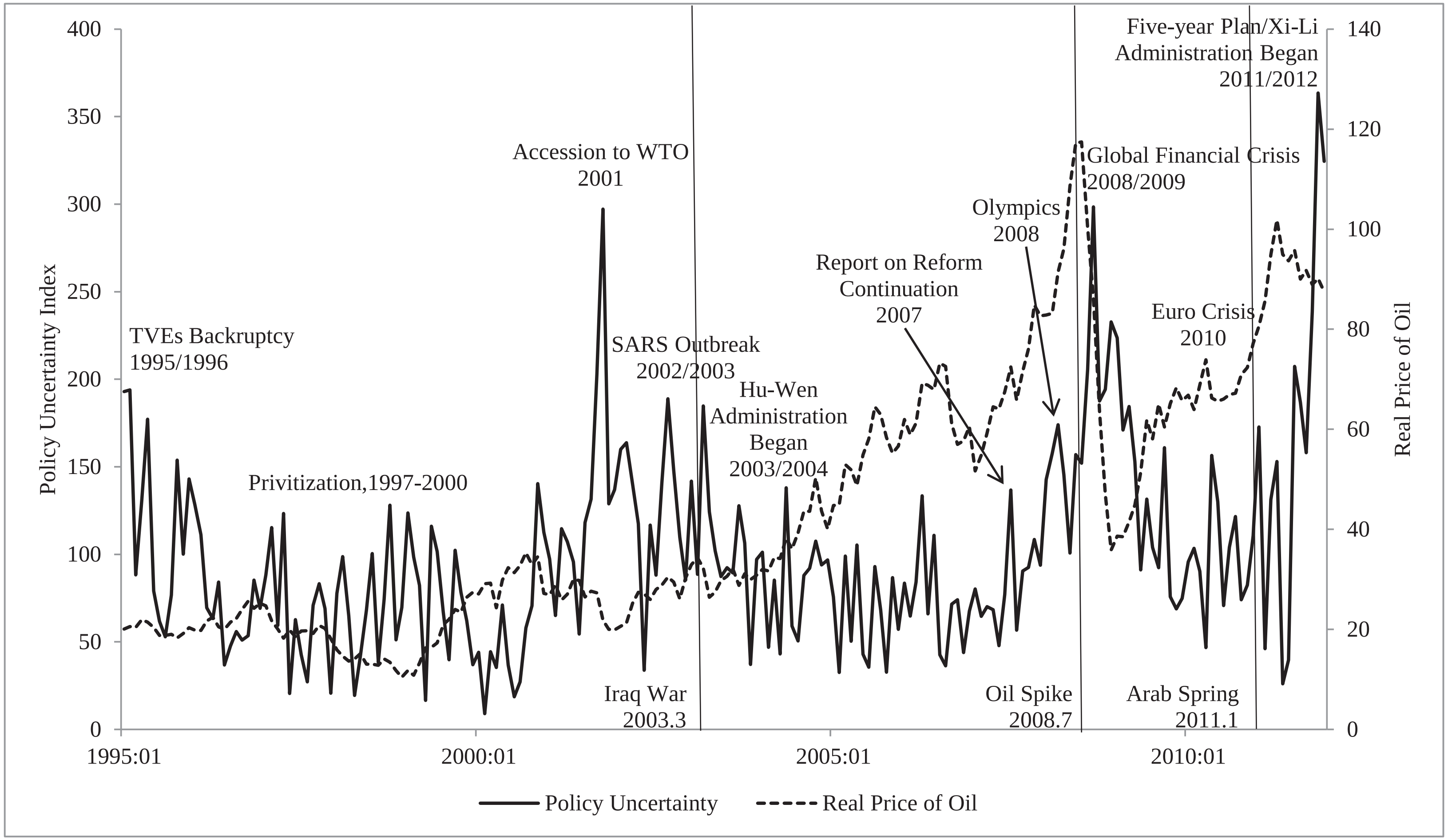
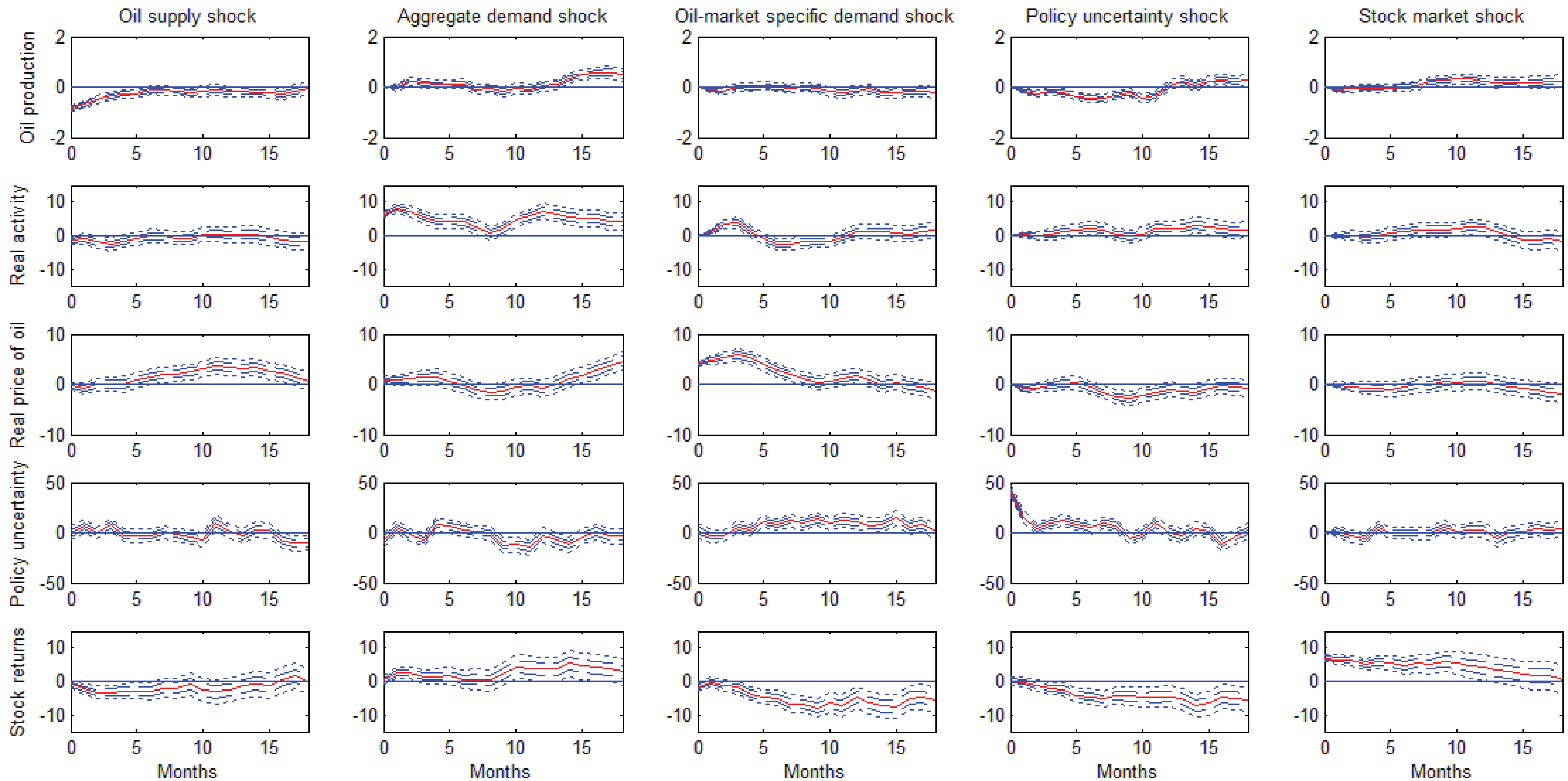


Figure 2. Real price of crude oil/economic policy uncertainty, 1995:1-2011:12.
Notes: the index of economic policy uncertainty is constructed by Baker et al. (2013), and the real price of oil is the nominal price of oil deflated by China's consumer price index.

Figure 3. Responses to One-Standard Deviation Structural Shocks



Notes: Point estimates, with one- and two-standard error bands, derived from the structural VAR model described in the text. The confidence intervals were constructed using a recursive-design wild bootstrap. Responses to real stock returns are cumulative.

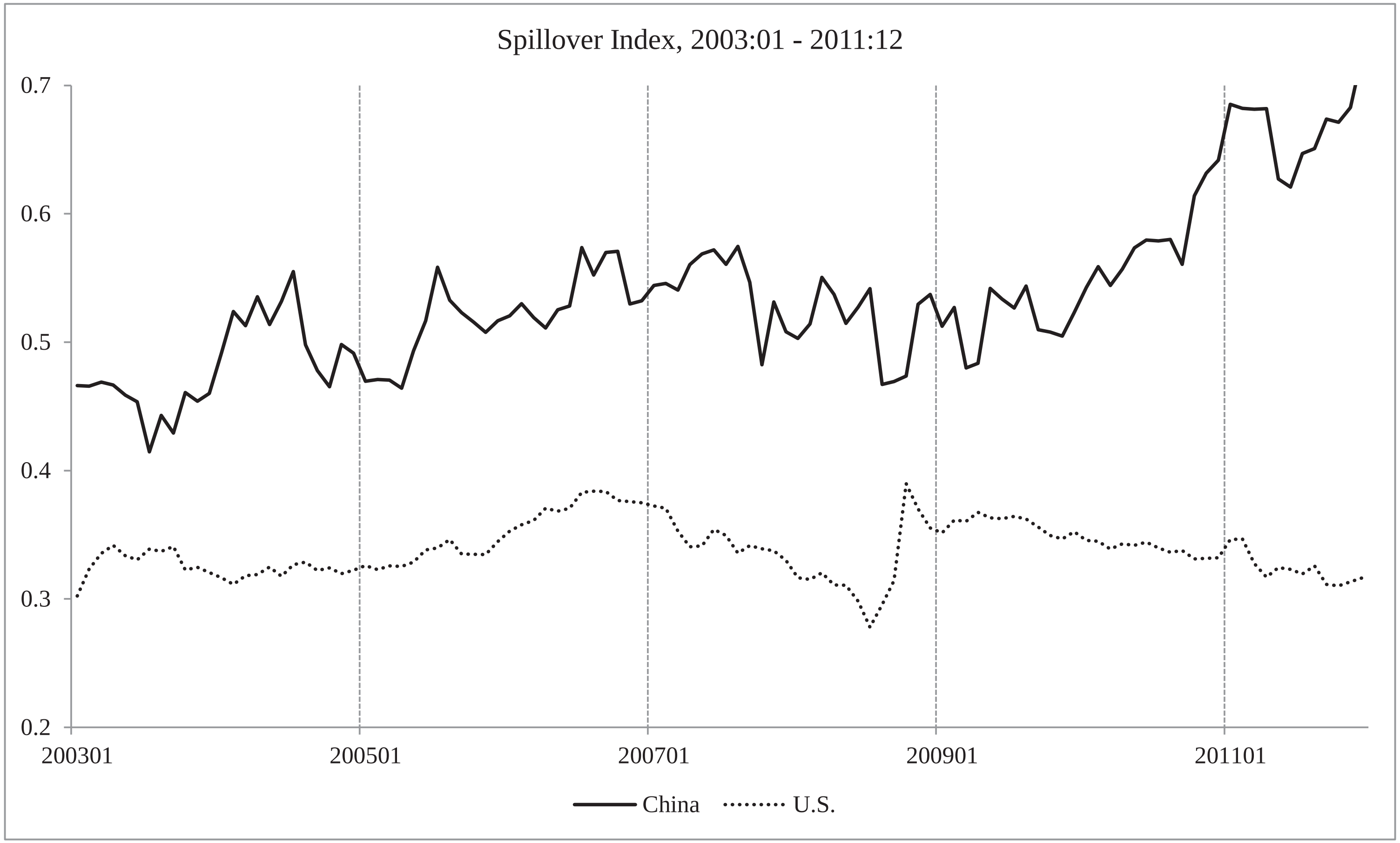


Figure 4. The spillover plot of oil shocks, policy uncertainty and real stock market returns in China and U.S., 2003:01-2011:12.
Notes: Moving return spillover indexes are defined in the text as the sum of forecast error variance decomposition contributions from one variable structural shocks to the other variables when the forecast horizon is 12, estimated using 96-month rolling windows for China and estimated using 216-month rolling windows for United States.

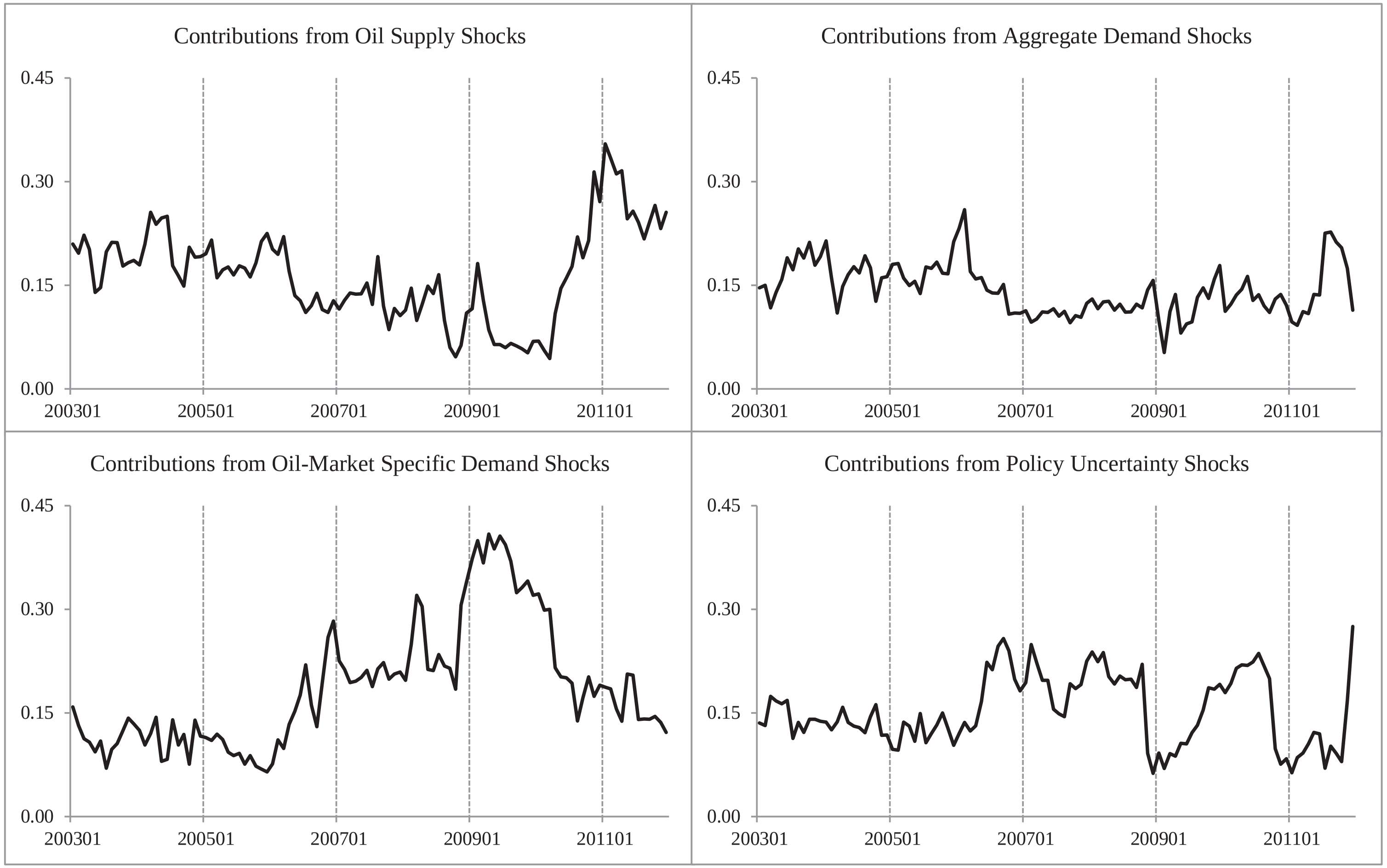


Figure 5. Contributions to the forecast error variance of real stock returns from shocks to oil supply, aggregate demand, real price of oil and policy uncertainty, 2003:01-2011:12.

Notes: The forecast error variance decomposition is calculated when the forecast horizon is 12, estimated using 96-month rolling windows.

Table 1. Forecast Error Variance Decomposition

Panel A. Forecast Error Variance Decomposition of Economic Policy Uncertainty over Horizons

Horizon	Oil Supply Shock		Aggregate Demand Shock		Oil-Market Specific Demand Shock		Policy Uncertainty Shock		Stock Market Shock	
1	0.000	(0.00)	0.024	(0.48)	0.002	(0.06)	0.973	(14.58)	0.000	(0.01)
3	0.023	(0.48)	0.039	(0.80)	0.011	(0.25)	0.922	(11.78)	0.006	(0.21)
12	0.063	(1.32)	0.159	(2.37)	0.201	(2.75)	0.550	(6.88)	0.026	(0.68)
24	0.168	(2.41)	0.173	(2.54)	0.210	(2.96)	0.415	(5.11)	0.035	(0.72)
60	0.157	(2.48)	0.205	(3.15)	0.201	(3.12)	0.363	(5.09)	0.074	(1.32)

Panel B. Forecast Error Variance Decomposition of Real Stock Returns over Horizons

Horizon	Oil Supply Shock		Aggregate Demand Shock		Oil-Market Specific Demand Shock		Policy Uncertainty Shock		Stock Market Shock	
1	0.020	(0.44)	0.002	(0.05)	0.049	(0.86)	0.000	(0.01)	0.930	(11.49)
3	0.056	(1.06)	0.078	(1.27)	0.081	(1.36)	0.021	(0.53)	0.764	(8.53)
12	0.085	(1.74)	0.162	(2.73)	0.160	(2.85)	0.072	(1.75)	0.521	(7.52)
24	0.149	(2.96)	0.140	(3.06)	0.225	(4.08)	0.148	(2.96)	0.339	(6.39)
60	0.174	(3.48)	0.192	(3.91)	0.239	(4.77)	0.141	(3.10)	0.254	(5.48)

Panel C. Spillover Table When Forecast Horizon H=12

	Contributions From									
Contributions To	(1) Oil Supply Shock		(2) Aggregate Demand Shock		(3) Oil-Market Specific Demand Shock		(4) Policy Uncertainty Shock		(5) Stock Market Shock	
(1)	0.671	(8.88)	0.123	(2.25)	0.049	(1.13)	0.122	(2.30)	0.035	(1.02)
(2)	0.043	(0.63)	0.734	(6.12)	0.126	(1.85)	0.046	(0.78)	0.052	(0.71)
(3)	0.163	(1.57)	0.054	(0.73)	0.657	(5.32)	0.111	(1.18)	0.015	(0.26)
(4)	0.063	(1.31)	0.159	(2.28)	0.201	(2.70)	0.550	(6.86)	0.026	(0.71)
(5)	0.085	(1.73)	0.162	(2.76)	0.160	(2.79)	0.072	(1.82)	0.521	(7.68)
Total Spillover Index: 0.374 (10.33)										

Notes: Panel-A shows percent contributions of the variability of economic policy uncertainty to structural shocks over horizons in China over 1995:1-2011:12. Panel-B shows percent contributions of the variability of real stock returns to structural shocks over horizons in China over 1995:1-2011:12. Panel-C shows the forecast error variance decomposition when the forecast horizon is 12 in China over 1995:1-2011:12. The values in parentheses represent the absolute t-statistic when coefficients' standard errors were generated using a recursive-design wild bootstrap.