Distribution Agreement

Tianchen Zhao April 8, 2019

Assessing Dynamic Relationships Between Oil Price, Macroeconomy and Stock Market Returns in the U.S, Canada and China: A Short-run SVAR Approach

By

Tianchen Zhao

Dr. Zhanwei (Vivian) Yue
Adviser

Department of Economics

Dr. Zhanwei (Vivian) Yue

Adviser

Dr. Elena Pesavento

Committee Member

Dr. Kelli Lanier

Committee Member

Dr. Manuela Manetta

Committee Member

2019

Assessing Dynamic Relationships Between Oil Price, Macroeconomy and Stock Market Returns in the U.S, Canada and China: A Short-run SVAR Approach

By

Tianchen Zhao

Dr. Zhanwei (Vivian) Yue

Adviser

An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Arts with Honors

Department of Economics

2019

Abstract

Assessing Dynamic Relationships Between Oil Price, Macroeconomy and Stock Market Returns in the U.S, Canada and China: A Short-run SVAR Approach

By Tianchen Zhao

Using structural VAR models (SVAR) with contemporaneous restrictions on the U.S., Canada and China, I empirically examine and compare how oil price, macroeconomy and stock returns interact across three countries. I find that first of all, a negative oil price shock has no significant impact on stock market returns. It is contractionary only in the U.S. and raises the Federal Funds Rate. Secondly, whether a "countercyclical policy" is present in each country depends on the source of increase in the output level. Also, a rising interest rate only lowers stock returns in the U.S. and Canada, and the "price puzzle" is found in the U.S. and China. Lastly, a bidirectional positive relationship between the production level and real equity returns is discovered in the U.S. and Canada, whereas in China, stock market movements positively contribute to the production level fluctuations, but not vice versa.

Assessing Dynamic Relationships Between Oil Price, Macroeconomy and Stock Market Returns in the U.S, Canada and China: A Short-run SVAR Approach

By

Tianchen Zhao

Dr. Zhanwei (Vivian) Yue

Adviser

A thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Arts with Honors

Department of Economics

2019

Acknowledgements

I want to thank my four thesis committee members, especially Dr. Zhanwei (Vivian) Yue, who is my advisor, and Dr. Elena Pesavento, for helping me throughout this process. I would be forever grateful to their insightful comments and professional advices. I would also like to thank my parents, Mrs. Xiaotong Shi and Mr. Qijun Zhao, as well as my girlfriend, Ms. Yiyin Yang, for their unwavering support and encouragement. They have motivated and enlightened me to work harder while enjoy every moment.

Table of Contents

1. Introduction

The study of interactions among oil price, macroeconomy and equity markets has been a large constituent of modern macro-financial economic analysis. Throughout recent 40 years, economists have constantly put effort in understanding how business-cycle fluctuations and monetary policies affect one another, as well as grasping the mutual contribution of oil price and stock markets to macroeconomic conditions. Economic intuitions suggest a "loop" that connects oil prices, stock market returns, output, general price level and interest rates. Specifically, changes in stock returns and oil prices alter people's wealth and costs of production in a country, which lead to fluctuations in output and price level. The central bank, alert to such movements in the economy, actively uses policy interest rate, which serves as the instrument of monetary policy, to regulate economic growth. Manipulating the policy interest rate helps the central bank either speed up or slow down the economic growth so that the economy can reach an equilibrium eventually (countercyclical policy). The adjustments in interest rate alters the borrowing costs of consumers, which puts either upward or downward pressure on output and inflation, due to a subsequent change in spending and investment behaviors (neoclassical channel). Interest rate also affects stock valuation, since it is used to discount future cash flow in the present value equity-valuation model. The stock returns may also respond to changes coming from productivity and demand factors that shift price level, as investors' confidence in firms' performances varies.

However, although the abovementioned economic principles may be widely acknowledged, how exactly do monetary policies adjust to and affect output and price level remains a huge issue. More systematic measurements are needed to answer the question. In addition, to grasp the precise connections between macroeconomy, oil price and equity markets also requires understanding results derived from reasonable methodologies. Economists, over the years, have upgraded the methods they use to fathom such relationships. They have progressed from using simple Pearson correlation techniques to complex multivariate time series model. One specific framework, the Structural Vector Autoregressive (SVAR) model, an identified VAR model first put forward by Christopher A. Sims (1980), has stood out among other econometric methodologies and been adopted by many economists. Both the long-run and short-run SVAR framework allow researchers to economically interpret the variables by putting restrictions on their interactions and trace out the dynamic effects of one on the other through impulse response functions.

Most of the existing research use the SVAR model to explore relationships between oil price, macroeconomic conditions and stock market returns only in the U.S., major European economies and Japan. Relatively few studies focus on smaller advanced countries, such as Canada, and even less literature study large developing countries, such as China, which play important roles in the world economy. Furthermore, only data as recent as 2010 are collected in related literature, which is apparently outdated and thus fails to capture more accurate results.

By focusing on monthly data from the U.S., Canada and China under a short-run SVAR framework, this paper aims to use impulse response functions to answer two main questions. First of all, how does empirical evidence from three countries support the validity of macro-financial economic principles? What's more, how is the evidence different/similar across the U.S., Canada and China?

The rest of the paper is organized as follows: Section II goes through the related literature, covering both theoretical and empirical evidence in an international context and advocate the contribution of this research. Section III outlines the econometric specification of the SVAR model and the economic interpretations of restrictions imposed on variables. Section IV presents the data as well as SVAR model identification. Section V demonstrates the estimation results, including stationarity, lags selection and Johansen cointegration test. Interpretations of the impulse response functions are provided. Section VI discusses deficiencies of the identification mechanism and potential improvements of the analysis. Section VII summarizes the findings and concludes the paper.

2. Literature Review

2.1 Non-SVAR Methodologies: Evidence on the Effects of Industrial Production and Interest Rates on Stock Returns.

In this subsection, I describe research that intend to grasp the relationships between macroeconomic factors and stock markets returns through non-SVAR model. Numerous papers study how the stock market is impacted by the state of the economy. Peiro (1996) and Wasserfallen (1989) indicate a positive, statistically significant relationship between stock returns and the industrial production, as well as a negative, statistically significant relationship between stock returns and interest rates in European countries and Japan. Such findings are supported by Janero and Negrut (2016), which uses Pearson Correlation analysis on the U.S. Economy. Janero, Ferrer and Miroslavova (2016), through a quantile regression analysis, not only confirms the sensitivity of U.S. stock market to interest rate and inflation changes, but also goes deeper in showing that sectors display varying responses to macroeconomic shocks.

However, although the empirical relationships mentioned align with public's intuitions, Cutler, Poterba, and Summers (1989) finds that the industrial production growth is significantly positively correlated with real stock returns, but not in a consistent manner. Roll (1988) agrees and further argues that macroeconomic events can only account for a very small proportion of total stock market variability. On the other hand, since above estimations only use constant-coefficient models, McQueen and Roley (1993), Boyd, Jagannathan, and Hu (2001) advocate more advanced time series analysis in understanding economic conditions and equity markets.

Cheung and Ng (1998) uses Johansen Cointegration method on U.S, Japan, Germany, Canada and Italy. The paper argues that stock returns comove with real macroeconomy empirically. Humpe and Macmillan (2009) found similar results using more recent data in U.S and Japan. It also concludes that Japanese industrial production is negatively influenced by the consumer price index and long-term interest rate. Alam (2009) analyzes the impact of interest rates and stock market returns for fifteen countries in a time series framework. It is found that interest rates have significantly negative relationships with either stock return or the growth rate of stock return.

Reduced-Form Vector Autoregressive (VAR) model is a popular approach among macroeconomists in modelling macroeconomic variables and stock returns. Chen et al. (1986) estimates such a model and suggest that the industrial production, long term interest rate, short term interest rate and inflation granger cause stock market returns. James et al (1985) argues that stock returns signals change in real activity, which in turn affects expected inflation. There are plenty studies on non-U.S. economies using the reduced-form VAR model (Gjerde and Saettem (1999) on Norway, Martinez and Rubio (1989) on Spain, and Kaneko and Lee (1995) on the U.S. and Japan).

However, the problems with the reduced-form VAR approach, as described in detail in the next section, are that it does not explicitly capture contemporaneous relationships among variables and its error terms are correlated, which makes it hard for one to see the clear effects of an economic shock on one variable. Thus, this paper uses a short-run Structural VAR framework (SVAR) that solves the two issues.

2.2 SVAR Model: Long-Run and Short-Run Restrictions

After Christopher Sims (1980) initiated basic identifications of the Structural VAR, such model has been used extensively to study macroeconomy and stock returns in both open and closed economies. A short-run SVAR model takes into account the contemporaneous effects among variables of interests, as well as properly identify uncorrelated structural shocks. Some literature applies long-run restrictions on variables under SVAR framework. The identification is often based on researchers' beliefs in whether one economic force has long-run impacts on another. The SVAR model in Rapach (2001) is characterized by money neutrality condition and natural-rate hypothesis, which state that U.S. money supply shocks have no long-run effects on real stock prices, the interest rate and output, as well as only aggregate supply shocks can affect the long-run level of real output. The conclusions from impulse response functions suggest that the increase in real output increases stock prices over time and the decrease in interest rate leads to a short-run increase in real stock prices (present-value equity valuation model). Lastrapes (1998) employs similar money neutrality assumptions on the U.S., Canada and European economies and finds similar results. SVAR model with contemporaneous restrictions makes appearances in abundant macroeconomic literature that deals with the role of monetary policies on stock prices in the U.S. This approach has been justified by many macroeconomists (Gordan and Leeper, 1994; Sims and Zha, 1998; Leeper and Roush, 2003; Kim and Roubini, 2000; Mojon and Peersman, 2003; Dedola and Lippi, 2005). Considerable research focus on the U.S. economy. Bernanke and Blinder (1992) assumes monetary policies do not affect the given macro variables in the same period. This key identification is supported by Bernanke and Mihov (1998), which extends the argument to include both reserves and interest rate as instruments for monetary policies. Thornbecke (1997), Patelis (1997) and Park and Ratti (2000) employ recursive short-run VARs to explore the impacts of the Federal Funds Rate on stock returns. Specifically, they conclude that a contraction in monetary policy lowers the stock prices (present-value equity valuation model). Christiano, Eichenbaum and Evans (1996) observes a rise in the interest rate can lead to a decline in the measure of real activity and GDP deflator. The integral identification in the paper is that policy shocks have no contemporaneous impact on aggregate output level.

International evidence on interactions between macroeconomics and stock returns is often derived from short-run SVAR framework. Mohanty (2012) uses quarterly macroeconomic data in India and argues that increasing policy interest rate has a significantly negative influence on the output growth and a moderating impact on inflation. Brischetto and Voss (1999) finds that monetary policy shocks have delayed and gradual effects on the price level and a small, temporary impact on the output in Australia. Cushman and Zha (1997) specifies an explicit monetary policy function with respect to Canadian economy. Impulse response functions suggest a contractionary monetary policy causes a prolonged fall in price level. Sousa and Zaghini (2005) models a global G5 framework and discover that similar effects of monetary policies in all five areas. It relies on a common identification mechanism, which states that information delays do not allow monetary policy to respond within the same period to price level movements. This assumption is also given credit in Sims and Zha (1998).

2.3 Oil Price's Effects on the Stock Price and Macroeconomy Around the World

Since oil is an important source of energy in almost every economy, its price fluctuations translate to varying costs of production, and thus may affect the overall price level. The volatility in oil price and reserves also make consumers uncertain about the future, which may constrain their consumption and investment decisions today (Bernanke, 1983 & Hamilton, 2003). A central topic in economics literature is the debate about how oil shocks influence macroeconomy and financial markets. Killian (2009) defines an oil shock as a combination of oil supply and demand shocks for global industrial commodities and oil market. It concludes that implications of higher oil price on the U.S. real GDP and inflation depend on the causes of the oil price increase. Hamilton (1996) characterizes a net increase of crude oil price as the proxy for oil shock. The argument is that increases in oil price affect the economy but decreases do not. Hamilton and Herrera (2004) uses a short-run SVAR model to counter Bernanke, Gertler and Watson (2004)'s conclusion that monetary policy can be used to effectively offset the negative impacts of an oil shock on output.

Many macroeconomists compare how an oil shock affects financial markets in developed countries (Kilian and Park, 2009; Ono, 2011; Apergis and Miller, 2009). However, the existing literature displays no consensus regarding how financial markets respond to an oil shock, with some suggesting a negative relationship (Sardosky, 1999; O'Neil and Terrell, 2008; Park and Ratti, 2008), while others negating any significant connections (Chen et al, 1986; Jones and Kaul, 1996). Using a SVAR model, Bastianin, Conti and Manera (2015) gauges the differential impacts of oil supply and oil demand shock on stock market volatility in G7 countries. It shows that oil demand, relative to oil supply, contributes significantly to the variability of the G7 stock markets. Gupta and Modise (2013) finds contrasting evidence in South Africa. Oil supply is proved to account for greater variations in stock variability. South African stock returns increase with oil price when global economic activity improves, whereas it decreases in response to oil supply shock.

2.4 Contribution of This Research

As indicated by previous literature, understanding interactions among macroeconomy, oil price shock and stock markets in developed countries, especially in the U.S., is a central topic of research. In comparison, Canadian economy and financial markets receive far less scholarly attention. Although many studies devote to tracing out such interactions in China, the largest emerging market (Cheng and Yip, 2017; Kojima, Nakamura and Ohyama, 2005; Lin, Fang and Cheng, 2014), a short-run SVAR approach is rarely applied. Thus, this paper takes a closer look at how such relationships in Canada and China are different from/ similar to those in the U.S., under a short-run SVAR framework.

In addition, the existing literature mostly include quarterly or monthly data that range as far back as 1950s to as recent as only 2010. This paper fills the gap through incorporating data from 2010 to 2018. The updated sample, with more data entries, hopefully would present a more complete picture of the interplay among variables.

Last but not least, this research hopes to examine the validity of some abovementioned models and theories, such as the standard present value equity valuation model and the relationship between the output and stock markets. It also aims to bring more empirical evidence to the debate on the effects of oil price on stock returns.

3. Short-run Structural Vector Autoregression (SVAR) Model

Consider a reduced-form Vector Autoregressive (VAR) Model:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \cdots + \alpha_k y_{t-k} + \varepsilon_t \quad (1)$$

$$E(\varepsilon_t \varepsilon_t') = \Sigma$$

Where y_t is a vector of n endogenous variables, α_i are coefficient matrices, ε_t are error terms, and Σ is the variance-covariance matrix of the error terms. In other words, the values of endogenous variables in this structure depend on not only their own lagged values but also on the lagged value of other variables.

However, estimations using a reduced-form VAR model have two flaws. First of all, (1) assigns explanatory power only to lagged value of y_t, rather than captures any contemporaneous relationships. The reduced-form VAR must be adjusted if short-run connections among variables are of interest. The other flaw of the reduced-form VAR is that its error terms are, in general, correlated, which is not a desired property for impulse response functions analysis, since it requires other shocks to be held constant when analyzing the impact of an economic shock to one equation. It is imperative to separate the correlated errors into uncorrelated economic shocks. As a result, one solution is to multiply a matrix, A, on both sides of (1), which yields the following.

$$Ay_t = A\alpha_0 + A\alpha_1 y_{t-1} + A\alpha_2 y_{t-2} + \cdots + A\alpha_k y_{t-k} + A\varepsilon_t \quad (2)$$

Let $C_i = A\alpha_i$, $u_t = A\varepsilon_t$, so (2) is equivalent as the follows.

$$Ay_t = C_0 + C_1 y_{t-1} + C_2 y_{t-2} + \cdots + C_K y_{t-k} + u_t \qquad (3)$$

Matrix A in (3) captures the contemporaneous relationships between variables. u_t is a vector of serially uncorrelated, zero mean structural shocks with an identity covariance matrix $\sum = E(u_t u_t') = I$. u_t is written as a linear combination of correlated errors in the reduced-form VAR, ε_t $(u_t = A\varepsilon_t)$. Since parameters in the reduced-form VAR model can be estimated, the SVAR model can be recovered from the reduced-form VAR.

$$E(\varepsilon_t \varepsilon_t') = \mathrm{E}\left(A^{-1} u_t u_t' A^{-1'}\right) = A^{-1} E(\varepsilon_t \varepsilon_t') A^{-1'} = A^{-1} A^{-1'} = \Sigma \quad (4)$$

According to Cholesky decomposition, it is legitimate to impose matrix A to be a lower triangular matrix with the entries on the diagonal being 1s and entries above the diagonal being 0s. Since covariance matrix of the reduced-form VAR, Σ, is symmetric, it has $\frac{n(n+1)}{2}$ pieces of information. With matrix A being a lower triangular matrix and 1s on the diagonal, there are exactly $\frac{n(n+1)}{2}$ restrictions on matrix A. Thus, a unique matrix A is achieved, and the entire SVAR model is recovered.

This type of identification can be thought of as imposing a causal ordering on variables in VAR model. A shock to one equation contemporaneously affects variables below that equation but affects variables above that equation with a lag. Thus, the ordering of variables reflects a set of economic beliefs in how variables in the system interact upon contact. Here the order of variable matters, since different orders produce different covariance matrix, Σ, which in turns produces different matrix A.

The specific value of matrix A capturing the contemporaneous relationships is often not meaningful. Instead, it is the dynamic impacts over time of one shock on others that offer insights on how macroeconomy, oil price and stock markets interact. Impulse response functions (IRFs) trace the evolution of endogenous variables under structural shocks, u_t. The intuitions of IRFs are as follows.

Consider a reduced-form VAR (p) model,

$$\phi(L)y_t = \varepsilon_t,$$

where

$$\phi(L) = I - \phi_1 L - \phi_2 L^2 - \phi_3 L^3 - \cdots - \phi_k L^k$$

is the matrix lag polynomial.

The MA representation of y_t is as follows.

$$y_t = \phi^{-1}(L)\varepsilon_t = \varepsilon_t + \sum_{i=1}^{\infty} \psi_i \, \varepsilon_{t-i}$$

where ψ_i is a m x m coefficient matrix.

Suppose there is a unit shock in ε_t, then its effect on y, s period ahead is

$$\frac{\partial_{y_{t+s}}}{\partial_{\varepsilon_t}} = \psi_s$$

Matrix ψ represents model's responses to a unit shock at time t in each of the variables.

The response of y_i to a unit shock in y_j is known as the impulse response functions,

$$\psi_{ij,1}, \psi_{ij,2}, \psi_{ij,3}, \dots$$

Where $\psi_{ij,k}$ is the ij th the entry of the matrix ψ (i, j = 1,…, m).

However, often times it is of interest to learn how new information on one variable adjust the forecast on its future value. Then it is imperative to have uncorrelated structural shocks, u_t. As indicated, $u_t = A\varepsilon_t$. The new MA representation of VAR model is then as follows.

$$y_t = \sum_{i=0}^{\infty} \psi_i A \, \varepsilon_{t-i}$$

Thus, the impulse response functions of y_i to a unit shock in y_j becomes $\psi_{ij,1}A, \psi_{ij,2}A, \psi_{ij,3}A, \ldots$

4. Data, Methodology and SVAR model specification

4.1 Data Overview

Monthly data is used in this paper, and time frame for each country varies slightly. Data ranges from January 1988 to August 2018 for the U.S., April 1991 to August 2018 for Canada, and January 1992 to June 2015 for China. The starting point is chosen to be 1988, because it is the year that U.S. and Canadian economy began to show growing integration in terms of its monetary policy instruments and inflation targeting regime (Li, Iscan and Xu, 2010).

The macroeconomic variables included for U.S. are the Industrial Production Index, Effective Federal Funds Rate, and Consumer Price Index. For Canada, the Total Production of Industry, Overnight Interest Rate, and Consumer Price Index are used. The Real GDP, 1-Year Deposit Benchmark Rate and Consumer Price Index are considered to represent macroeconomic conditions in China. All variables, except policy interest rate in each country, are log-transformed. The Industrial Production Index in the U.S, Canada, and the Real Output in China are proxies for the general output level in each country; the Consumer Price Index signals inflation, or price level. The Effective Federal Funds Rate and Overnight Interest Rate are the instruments of monetary policy in U.S. and Canada, whereas 1-Year Deposit Benchmark Rate is the key interest rate used to conduct monetary policy in China. Bernanke and Blinder (1992) argues for the superiority of using federal funds rate as the proxy for monetary policy actions. The U.S. and Canadian macroeconomic data are collected from the FRED (Federal Reserve

Economic Data) at Federal Reserve Bank at St. Louis, and data for China's macroeconomy is collected from Higgins, Zha and Zhong (2016).

The proxy for stock prices in U.S, Canada and China are the S&P500 index (SP500), S&P/TSX Composite index (TSX) and Shanghai Stock Exchange Index (SSE). Since the real stock returns are of interest, it is defined as the log first differences of stock prices adjusted for inflation (CPI) index. Although the "A-Share" in China consists of both SSE index and Shenzhen Composite index, here only SSE index is considered, due to its relatively large size and popularity (Cheng and Yip, 2017).

Rather than decomposed into supply and global demand shocks, as suggested by Killian (2009), the oil shock is constructed to be the net increase of West Texas Intermediate (WTI), a benchmark in crude oil pricing. According to Hamilton (1996), Hamilton and Herrera (2004) and Mork (1989), oil shock mainly affect the macroeconomy through lowering demand for consumptions and investments. Oil price volatility causes concerns and postpones investment decisions. Thus, an increase in oil price would have much higher impact than a decrease in oil price. Given such reasoning, the price of WTI in this month should be compared with the maximum value of WTI price during the preceding 12 months. If the current value exceeds the max value observed, the percentage change is recorded as data entry for the current month. If the value does not exceed previous year's maximum, zero is recorded instead. As a result, the data series is non-negative.

4.2 Short-run SVAR identification

Consider the structural VAR form in Section III, with contemporaneous restrictions:

$$Ay_t = C_1 y_{t-1} + C_2 y_{t-2} + \cdots + C_k y_{t-k} + u_t \quad (6)$$

$y_t = (OilShock, IPI, IR, CPI, SR)$, in which OilShock is the net increase of WTI crude oil price, IPI refers to the industrial production in the U.S, Canada and the Real GDP in China, IR is the policy interest rate in each economy, CPI refers to the Consumer Price Index, and SR is the real stock returns adjusted for inflation. As mentioned before, one identification is to impose A to be a lower triangular matrix with value of 1 on the diagonal and 0 above the diagonal. Thus, the reduced-form error, ε_t, can be written as follows.

$$u_t = A\,\varepsilon_t \Leftrightarrow \begin{bmatrix} u_{oil} \\ u_{as} \\ u_{mp} \\ u_{ad} \\ u_{portfolio} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} * \begin{bmatrix} \varepsilon_{oilshock} \\ \varepsilon_{IP} \\ \varepsilon_{IR} \\ \varepsilon_{CPI} \\ \varepsilon_{SR} \end{bmatrix}$$

A specific set of economic beliefs motivates such causal ordering of variables in y_t. First of all, the oil price is deemed to be predetermined to the entire system (Ahmed and Wadud, 2011; Bastianin, Conti and Manera. 2015; Basher, Haug and Sadorsky, 2011). Thus, an oil supply shock is a shock to oil price that does not respond to other variables contemporaneously (within the month). The aggregate supply shock ("as") refers to a shock to the productivity (technological advances, for example) in an economy. It is assumed to respond to a contemporaneous change in the oil price, but unresponsive to contemporaneous variations in the interest rate, price level and stock returns (Mohanty, 2012; Kim and Roubini, 2000; Lin, fang and Cheng, 2014). In other words, interest rate, price level and stock returns are expected to react to a productivity shock contemporaneously (Brischetto and Voss, 1999; Ruiz, 2015). The monetary policy shock represents an unanticipated deviation from an established pattern of the interest rate. The interest rate is expected to react to a contemporaneous change in oil prices and industrial production, but not in the price level and stock returns. The reason is that the interest rate in each country is the policy rate that serves as the instrument of central bank's monetary policy. The information regarding the general price level may not be available when monetary policy has to be made. As a result, policy variables are not contemporaneously affected by price level, which puts interest rate before CPI index on the list. In other words, it is assumed that central banks do not adjust interest rates in response to CPI and stock returns contemporaneously, but only with a lag. An aggregate demand shock ("ad") represents shifts in demand factors that affect price level. It is assumed to respond to interest rate, industrial production and oil price contemporaneously, but to stock returns with a lag. A portfolio shock is a change in risk premium that lead to fluctuations in stock returns, which is believed to react to all above mentioned shocks contemporaneously (Bjornland, 2008; Chatziantoniou, Duffy, Filis, 2013).

5. Estimation Results and Interpretations

5.1 Stationarity (Augmented Dickey-Fuller Test)

Before running the SVAR model, it is imperative to ensure that all series are stationary. In other words, series are integrated of order zero, *I(0)*. Otherwise, the model may suffer from the risk of spurious regression, leading to non-existent relationships. The Augmented Dickey-Fuller (ADF) Test can be used to indicate the existence of any unit root in the series. The null hypothesis is there is unit root (nonstationary). Table 1 below shows the output for ADF test. It suggests that the oil shock is stationary in level. However, other than the oil shock, macroeconomic and stock returns variables in U.S. and Canada are all nonstationary in level, but stationary in log first differences ("d" is the first difference operator), which means the percentage changes should be considered, instead of level data. In China, the logarithm of CPI index is stationary in log level. The policy interest rate in each country is treated in level, rather than transformed to logarithm or taken first difference, because of its role as the instrument of monetary policy and the fact that its small value (between 0 and 1) would not cause much damage.

		ADF	Prob.		ADF	Prob.
United States	OilShock*	-6.707	0.0000			
	LogIP	-1.87	0.6701	d.LogIP*	-4.889	0.0000
	FFR	-2.077	-2.875			
	LogCPI	-2.635	0.2641	d.LogCPI*	-7.908	0.0000
	LogRealSP500	-1.901	0.6544	d.LogRealSP500*	-7.631	0.0000
Canada	OilShock*	-7.987	0.0000			
	LogIP	-1.78	0.7143	d.LogIP*	-7.962	0.0000
	OIR	-2.62	-2.877			
	LogCPI	-2.712	0.2313	d.LogCPI*	-11.021	0.0000
	LogRealTSX	-2.793	-2.793	d.LogRealTSX*	-9.284	0.0000
China	OilShock*	-6.718	0.0000			
	LogRealGDP	-1.287	0.8911	d.LogRealGDP*	-10.986	0.0000
	1YBench	-1.178	0.683			
	LogCPI*	-3.669	0.0245			
	LogRealSSE	-3.255	0.0739	d.LogRealSSE*	-10.447	0.0000

Table 1. Augmented Dickey Fuller Test. "*" represents stationarity.

5.2 VAR model lags selection and Johansen Test for Cointegration

Including the optimal number of lags in the VAR model is of great importance. STATA program allows users to conduct lag selection test for VAR model, based on various information criterions, such as AIC (Akaike Information Criterion), etc. Table 2 reports the lag length results.

Lags	U.S.	Canada	China (1YBench)
0	-10.3814	-9.35762	-15.4706
1	-16.3764	-13.1783	-20.9189
2	-16.8545	-13.2109*	-21.0647
3	-16.9558	-13.1741	-21.0819*
4	-16.9801*	-13.061	-21.008
5	-16.9584	-13.0424	-20.9176

Table 2. AIC lags selection. "*" represents optimal lag length

The AIC shows a VAR model of order 4 for U.S., and order 2 for Canada. 3 lags should be included in the SVAR model for China.

Another important step before running a VAR model is to make sure there is no cointegrating relationships between the nonstationary variables in level. If cointegration exists, then VAR in differences would not be a valid model to apply (Vector Error Correction Model (VECM) should be a better substitute). Thus, it is necessary to check for cointegration among data. Table 3 illustrates the Johansen test results.

Rank 0	U.S.	Canada	China (1YBench)
Trace statistics	44.2327*	46.9639*	29.4242*
5% critical value	47.21	47.21	29.68
Eigenvalue max	26.921	23.901	20.1022
5% critical value	27.07	27.07	20.97

Table 3. Johansen Test for Cointegration. "*" indicates no cointegrating relationships (rank 0)

Both Trace statistics and max Eigenvalue statistics in three countries are less than 5% critical value at Rank 0, which means there exists no statistically significant cointegration among nonstationary series. Thus, the VAR model can proceed with log-first differenced data.

5.4 Impulse Response Functions of Stock Returns in U.S.

The impulse response of each variable to typical (one-standard deviation) structural shocks in U.S., Canada and China are presented in Figure 1 in the Appendix. The confidence interval is set to be 90%. If level “0” does not lie within the error band in a certain period, then the impulse response at that time period is considered to be of statistical significance. Figure 2 looks at the impulse response functions of industrial production, CPI index and S&P 500 index in a cumulative sense. Together with Figure 1, several key findings are as follows.

The first row of Figure 1 and 2 describes the reactions from U.S. macroeconomic indicators and stock returns to a negative WTI oil shock. Cumulatively, a negative oil shock puts a significant and persistent downward pressure on industrial production. This aligns with the result found in Mork, Olsen and Mysen (1994), and Hamilton (1996). However, it is notable that a decrease in output level in the U.S. does not occur immediately in Hamilton (2003). The use of Quarterly data and longer lag length in that paper may contribute to this difference. The short-term interest rate and Inflation level are raised in the short run (first 4 or 5 months) (Hooker, 2002). The possible story is that the U.S, a net-importer of oil, experiences an “imported inflation” when the crude oil price increases. This inflationary pressure urges the Fed to increase the Federal Funds Rate to battle potential rises in prices. However, U.S. is now under a transition from a net oil importer to net oil exporter, due to its massive domestic oil production. This may be the reason why there is not a continuous increase in the interest rate. The oil shock is also shown to have a short-lived negative influence on S&P 500 returns that disappears after 2 to 3 months. The short-run negative relationship between oil price and stock market in the U.S. aligns with some of the existing evidence (Sardosky, 1999; O’Neil and Terrell, 2008; Park and Ratti, 2008). Since oil is an important cost of production, many firms’ revenue is likely to be damaged by higher costs. However, the stock market as a whole does not exhibit any prolonged reactions of significance to the oil shock (Figure 2).

The second row of Figure 1 and 2 contain the impulse responses to an expansionary aggregate supply shock. After the industrial production is raised by some exogenous technological advances, positive reactions are received from the Federal Funds Rate and the price level, which is supported in Li, Iscan and Xu (2010). Such innovations gather concerns about higher inflation and increasing interest rate can be considered as a countercyclical policy, which refers to actions taken by the monetary authority to cool down economy when it is heating. Following a productivity shock, the stock returns periodically increase (from month 1 to 3 and 4 to 6). The rise in Federal Funds Rate can also be regarded as a defensive mechanism by the Fed, for fear of rising stock returns contributing to unexpected inflation. The accumulated IRF shows a prolonged increase exists in the stock market (Bingswanger, 2004). The result is in accordance with the discounted cash flow valuation model, in which a rise in real activity elevates stock valuation through its positive effects on dividends.

The impulse response functions to a monetary policy shock are found in the third row of Figure 1 and 2. An increase in the Federal Funds Rate causes the stock returns to only react with a decrease upon contact (Figure 1), which aligns with the standard present-value equity valuation model (a rise in interest rate increases the rates at which cash flows are discounted). The most intriguing result is the long-term rise in price level, which seems to suggest the uselessness of conducting monetary policy. This strange situation is also called the “price puzzle”, which is explained more in detail in section VI. Also, the response of the industrial production level to a monetary policy shock is rather insignificant, which suggests that such unexpected rise in the interest rate may not be contractionary.

The fourth row of Figure 1 and 2 describe the impulse responses to an aggregate demand shock, which captures the increase in demands side factors that significantly increase the price level. The production level responds with a short-run increase, but no long-run movement. Similarly, real stock returns only have a tiny decrease around month 5. A rise in price level causes a prolonged decrease in the Federal Funds Rate. This finding is, again, unexpected, since the interest rate should be increasing to control the inflation surge. Cumulatively, such a shock raises the industrial production in the first 7 months, which is supported by Bullard and Keating (1995) and Rapach (2001). Aggregate demand shock does not appear to affect the stock market in any significance.

Finally, a portfolio shock can be a reduction in the equity-risk premium, which increases the stock returns. The production of the industrial sector exhibits a long-term increase. The Federal Funds Rate is also increased across time, which is normal, due to a fall in bond prices. The interest rate increase can also be explained as tightening monetary policy, suggested by the persistent rise in the price level (Rapach, 2001). The "countercyclical policy" story can again apply in this case.

5.5 Impulse Response Functions in Canada

Figure 3 contains the structural responses of macroeconomic and stock returns variables in Canada. Figure 4 depicts the cumulative IRF of Canadian Industrial Production Index, CPI and TSX Composite returns. In Canada, a negative oil shock only has statistically significant impact on the price level in the short-run. An increase in price level occurs in the first 2.5 months. Unlike in the case of the U.S., where a negative oil shock generates much significance on other variables, the same oil shock does not receive much reaction other than from the price level. Given that Canada is the fourth largest oil exporters in the world, this result is somehow interesting, since one would normally expect at least some shifts in the stock market in Canada.

The second row of Figure 3 and Figure 4 contains the responses to an expansionary aggregate supply shock. The Overnight interest rate increases in the long-run, following a rise in IP index, which is similar to the Federal Funds Rate increase in the U.S. However, the price level does not seem to be affected significantly by such shock in Canada. Cumulatively, the TSX stock market reacts to supply shock with a prolonged increase. The response dies out around month 20. Similar result is found in the S&P500 index in the U.S, but the response of S&P 500 to a productivity innovation is much larger in magnitude and more persistent.

The third row of Figure 3 and Figure 4 describe the impacts of a contractionary monetary policy shock, which increases the Overnight Interest Rate. Cumulatively, the industrial production level increases in the short run (the first 4 months and then the effect disappears), which differs from the case in the U.S., where no significant movements occur in the industrial production. TSX stock returns, similar to S&P 500 returns in the U.S., decreases upon contact but not in the long-run. The standard present-value equity valuation model seems to apply in Canadian equity market. The biggest difference between the U.S. and Canada in terms of the effects of a contractionary monetary policy shock lies in the reactions from the overall price level in two countries. The "price puzzle" found in the U.S. does not seem to exist in Canada, since a rise in the policy interest rate does not lead to any increase in the price level of statistical significance.

Again, one can argue that the monetary policy shock may not be contractionary, as suggested by the rise in the industrial production index.

The impulse responses to an aggregate demand shock are recorded in the fourth row of Figure 3 and Figure 4. A slight decrease in the industrial production index during the first 2 months is caused by such shock. This is quite the opposite to the response of the U.S. industrial production, in which a longer period of increase occurs. Cumulatively, the stock market in both countries show no reaction to a rise in price level. Interestingly, the Overnight Interest Rate, similar to the Federal Funds Rate in the U.S., shows a small decrease in response to higher inflation. This pattern is unnormal, since the policy interest rate should be rising to check inflation.

The final row of Figure 4 and Figure 5 show that a positive portfolio shock, which increases the returns from TSX stock market, raises the industrial production index consistently. Thus, the positive connection between the equity market and industrial production is evidenced in both the U.S. and Canada. The positive portfolio shock also increases the price level in the short-run and the Overnight Interest Rate slightly from month 6 to month 15. The story of "countercyclical policy" still holds true to some degree in Canada, though less supported than it is in the U.S.

5.6 Impulse Response Functions in China

Figure 5 and 6 present the impulse response functions in China, with the 1-year Deposit Benchmark Rate as the policy interest rate. An WTI oil price net increase does not have significant impacts on real GDP level or the 1-year Deposit Benchmark Rate. The price level rises only upon contact. Under a negative oil price shock, only the policy interest rate in the U.S. (the Federal Funds Rate) increases for around 5 months, whereas the policy rate in China and Canada do not seem to respond. This would suggest the possibility that the Fed in the U.S. pays the closest attention to oil price fluctuations, potentially due to the most prolonged rise in the U.S. price level caused by such oil shock. Cumulatively, the stock market in China does not seem to react to an oil shock, similar to its counterparts in Canada and the U.S.

The second row of Figure 5 and 6 depict the responses of variables to a productivity shock that increases the real GDP. Both the 1-year Deposit Benchmark Rate and the price level increase in the long-run. Thus, the “countercyclical policy” story seems to apply in the U.S., Canada, and China. The difference is that the price level in Canada does not rise in response to an increase in the output. In China, cumulatively, the stock returns does not increase, given the rise in GDP. The positive mutual connection between production and stock market appears to be only valid in the U.S. and Canada, but not in China.

The third row of Figure 5 and 6 show the impacts of a monetary policy shock that raises the 1-year Deposit Benchmark Rate. The real GDP level does not seem to be affected cumulatively in the long run, other than a slight increase around month 3. This indicates that such monetary policy shock may not be contractionary. Also, unlike what happens in the U.S. and Canada, the real stock returns in China do not decrease upon contact with a rise in short-term interest rate. This suggests that the standard present-value equity valuation model lacks empirical evidence in China. Another notable response to rising short-term interest rate comes from the price level, which increases persistently. As a result, the presence of aforementioned “price puzzle” is supported with significant evidence in the U.S. and China, but not in Canada.

A positively aggregate demand shock that causes inflation expectedly increases real GDP over time. Thus, only in Canada does the demands shock have no effect on the industrial production level. In the U.S. and China, the production level increases over different horizons. Unexpectedly, the real returns of Chinese stock market decrease over time in response to a positive demand shock. Interestingly, the 1-year Deposit Benchmark Rate in China rises following a rise in inflation, which offers strong evidence of “countercyclical policy”. In the U.S, and Canada, however, the interest rate rather increases.

The final row of Figure 5 and 6 depict the responses to a positive portfolio shock that makes stock investments more profitable. Cumulatively, the real GDP is raised to a higher level in the long run, which is similar to the case of the U.S and Canada. However, the policy interest rate and the price level show no statistically significant changes to such portfolio shock, contradicting the evidence found in the U.S and Canada. The story of ‘countercyclical policy” does not seem to hold in China when a positive portfolio shock causes the output level to rise.

5.7 Summary of Results

A comparison of the IRFs across three countries yields the following results. Compared to Canada and China, a WTI oil price net increase constitutes a contractionary oil price shock that hits the industrial production in the U.S. (Hamilton, 2003). The U.S. central bank (the Federal Reserve) perceives a WTI oil price increase as much more alarming, possibly due to oil price shock's more prolonged positive pressure on the U.S. inflation level. This contradicts Hamilton's finding that the central bank is able to prevent the policy interest rate from rising in response to a contractionary oil price shock (Hamilton, 2003). The stock market as a whole in three countries do not react to a negative oil price shock.

The analysis presents mixed empirical evidence on the applicability of the "countercyclical policy" in three economies. When a productivity shock is present, it seems that the "countercyclical policy" is unanimously employed. Policy interest rate in three countries are very responsive to a positive productivity shock that increases the industrial production in the U.S and Canada, as well as real GDP in China. A positive aggregate demand shock increases the output production in U.S. and China over different periods (more consistent output rise in China) but has almost no effects in Canada. The "countercyclical policy" is found in China, as 1-year Deposit Benchmark Interest Rate increases persistently given a rise in inflation caused by greater demand. However, the policy interest rate in the U.S. and Canada rather decrease, which negates the existence of the "countercyclical policy" in these two countries. While a productivity shock and an aggregate demand shock seem to encourage the central bank in China to raise the policy interest rate in response to a heating economy, a positive portfolio shock has quite dissimilar influence. Chinese policy interest rate and price level do not rise following a promising stock market that boosts the real GDP, whereas the Fed in the U.S. increases the Federal Funds Rate in response to higher industrial production level generated by stock market boom. Together with abovementioned evidence, whether monetary authority in three countries resort to the "countercyclical policy" depends on the forces that lead to output increases.

Under the influence of rising interest rate, the U.S. and Canadian real stock returns decrease upon contact, while the Chinese stock market does not react significantly at all. Thus, the standard present-value equity valuation model receives some support from the U.S. and Canada, but not from China. Also, the "price puzzle", a bizarre situation where a rise in interest rate does not lower inflation, is present in U.S and China, but not in Canada.

A positive portfolio shock that increases real stock returns further provides evidence on the close connections between production level and stock market returns. A bidirectional positive relationship is only found in the U.S. and Canada, but not in China, since higher Chinese stock returns elevate real GDP consistently, but not vice versa.

6. Limitations and Potential Improvements

6.1 Model Identification

This paper uses a recursive VAR model that identifies contemporaneous relationships between variables through Cholesky decomposing the matrix A. However, such recursive model depends merely on one's basic economic judgment on whether one variable affects another within one unit of time period or with lags. It does not incorporate any complicated economic models in capturing the interactions among variables. The consequence can be that each shock is not completely and well identified. For example, Christiano et al. (1996), Kim and Roubini (2000) and Li, Iscan and Xu (2010) characterize monetary policy as a feedback rule, which relates the Federal Funds Rate to information set available to the Fed. Specifically, the Federal Funds Rate is a linear function of contemporaneous M2 and lagged value of other variable in the system, plus the monetary policy shock. The M2 can be further characterized by money market equilibrium condition, which states that the demand for money balances depends on income and the interest rate, which is the opportunity cost of holding money. Thus, M2 is regressed on the contemporaneous price level, output and the Federal Funds Rate, as well as the lag values of other variables, plus a shock to the equilibrium. Other than including contemporaneous M2 as a conditioning variable, Bjornland and Leitemo (2009), Becher et al. (2008) and Chatziantoniou, Duffy and Filis (2013) assume that contemporaneous stock returns also play a role in modelling the interest rate.

These examples demonstrate how to better identify structural shocks through building explicit economic models, instead of using reduced-form equations and Cholesky techniques. In other words, the restriction that shocks to variables only affect those below them contemporaneously and those above them with lags can be relaxed. Instead, depending on the different economic models, variables are linked together and thus, the casual ordering does not matter. The individual shock to an equation is thus given more reasonable economic meanings, which is important in forming more accurate impulse response functions.

6.2 The "Price Puzzle"

The previous impulse response functions for each country indicate that in the U.S. and China, a contractionary monetary policy, which increases the policy interest rate, not only does not lead to a fall in price level, but rather increases it persistently over time. This empirically positive relationship between the interest rate and inflation is termed the "prize puzzle", and it has made appearances in a plenty of macroeconomics literature. Sims (1992) analyzes five large industrial countries, excluding Canada, and regards home interest rate changes as representation of monetary policy shocks. He found positive interest rate innovations are connected to persistent increases in home price level. In order to resolve such issue, Gordan and Leeper (1994) and Sims and Zha (2006) specify explicit monetary policy functions, instead of relying on Cholesky techniques and reduced-form equations, to better identify monetary policy shocks. Eichenbaum and Evans (1995) and Strongin (1995) suggest that narrow monetary aggregates, such as non-borrowed reserves, may be better proxies for monetary policies. Sousa and Zaghini (2007) suggests that the "prize puzzle" can also be explained by the omission of useful price variable in forecasting inflation, such as the commodity price index.

Due to the relative simplicity of SVAR model in this paper, monetary policy may not be sufficiently identified, which may lead to the "price puzzle" in U.S. and China. Another possible reason that the "price puzzle" may occur in SVAR analysis may be the exclusion of the M2 or its equivalents as a critical force that interact with the policy interest rate. Specifically, in China, where banking system is dominated by state-owned and policy banks, government can mandate a certain amount of lending whenever it sees necessary. Thus, the central bank, in addition to changing target interest rates (both benchmark lending and deposit rate, as well as the Repo rate), conducts open market operations, sets Reserve Requirement Ratio (RRR) and adjusts loans target quantity in order to regulate economic growth. Given the multiple tools used by Chinese central bank, including only one policy interest rate out of three and not a measurement of money supply in a SVAR analysis does not capture the whole dynamic picture of monetary policy in China.

6.3. Heterogeneity in Canada and China

Besides the abovementioned identification issue, heterogeneity in Canadian and Chinese economy can also potentially influence the IRFs results. Canada is a small, advanced open country, which means that its macroeconomy may not only depend on a dynamic system of its own indicators, but also foreign economic conditions, such as those in the U.S. Literature has documented much evidence on the legitimacy of including U.S. macroeconomic variables in SVAR models to understand other economies. When studying the relationships between Canadian economy and stock prices, Li, Iscan and Xu (2010) incorporates the Federal Funds Rate in the U.S. as an external force and thus an unanticipated U.S. interest rate shock that hits the Canadian economy. It argues that Canada's trade and financial market openness allow its macroeconomy to be affected by larger, more dominant economy (the U.S.). Grilli and Roubini (1995) and Kim and Roubini (2000) also show that it is important to consider the U.S. monetary policy in empirical model of other G7 countries.

In SVAR model for China, the monetary policy is represented by the 1-year Deposit Benchmark Rate. However, as mentioned above, the relatively complex monetary policy in China makes use of multiple tools, which includes other important policy interest rates, the 1-year Lending Benchmark Rate and the Repo rate. Thus, a meaningful extension of the paper can be to model those two rates as a robustness check of the SVAR model in China. It would be interesting to see how Chinese macroeconomy interacts with the stock market with the Repo rate and the 1-year Lending Benchmark Rate as the instruments of the monetary policy and compare the differences/similarities with what is found in this paper.

7. Conclusion

Through identifying contemporaneous relationships among variables in Structural Vector Autoregression (SVAR) model. The Impulse Response Functions (IRFs) analysis indicates that first of all, a negative oil shock does not contribute to any stock market fluctuations of significance but elicit most attention from the Federal Reserve in the U.S. in adjusting the Federal Funds Rate to lower subsequent inflation. Secondly, the presence of the "countercyclical policy" in three countries is conditional on the source of output level increases. Thirdly, the standard present-value equity valuation model receives some support from the U.S. and Canada, but not China. What's more, the "price puzzle" is found in U.S. and China, but not in Canada. Last but not least, a positive bidirectional connection between production and stock returns is supported in U.S. and Canada, whereas in China, only a unidirectional relationship is found.

Future research can continue the exploration of this topic by using SVAR framework that characterizes variables under more advanced economic equations. With considerations in the external forces Canadian economy is exposed to and the complexity of Chinese monetary policy, hopefully future research can add to current findings and help present a more accurate picture of dynamic relationships between oil price, macroeconomy and stock returns in three countries.

References

Ahmed, H. J., & Wadud, I. M. (2011). Role of oil price shocks on macroeconomic activities: An SVAR approach to the Malaysian economy and monetary responses. *Energy Policy,39*(12),

Alam, M. M., & Uddi, G. S. (2009). Relationship between Interest Rate and Stock Price: Empirical Evidence from Developed and Developing Countries. *International Journal of Business and Management,4*(3).

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

Basher, S., Haug, A. A., & Sadorsky, P. (2011). Oil Prices, Exchange Rates and Emerging Stock Markets. *SSRN Electronic Journal*.

Bastianin, A., Conti, F., & Manera, M. (2015). The Impacts of Oil Price Shocks on Stock Market Volatility: Evidence from the G7 Countries. *SSRN Electronic Journal*.

Becher, D. A., Jensen, G. R., & Mercer, J. M. (2008). Monetary Policy Indicators As Predictors Of Stock Returns. *Journal of Financial Research,31*(4), 357-379.

Bernanke, B. (1983). Non-Monetary Effects of the Financial Crisis in the Propagation of the Great Depression. *The American Economic Review,73*(3), 257-276.

Bernanke, B., & Blinder, A. (1992). The Federal Funds Rate and the Channels of Monetary Transmission. *American Economic Association,82*(4), 901-921.

Bernanke, B., & Mihov, I. (1998). The Liquidity Effect and Long-Run Neutrality. *NBER Working Paper No. 6608*.

Bernanke, B., Gertler, M., & Watson, M. W. (2004). Oil Shocks and Aggregate Macroeconomic Behavior: The Role of Monetary Policy: A Reply. *Journal of Money, Credit, and Banking,36*(2), 287-291.

Bjørnland, H. C. (2008). Oil Price Shocks And Stock Market Booms In An Oil Exporting Country. *Scottish Journal of Political Economy,56*(2), 232-254.

Bjørnland, H. C., & Leitemo, K. (2009). Identifying the interdependence between US monetary policy and the stock market. *Journal of Monetary Economics,56*(2), 275-282.

Boyd, J., Jagannathan, R., & Hu, J. (2001). The Stock Markets Reaction to Unemployment News: Why Bad News is Usually Good for Stocks. *National Bureau of Economic Research*.

Bullard, J., & Keating, J. W. (1995). The long-run relationship between inflation and output in postwar economies. *Journal of Monetary Economics,36*(3), 477-496.

Chatziantoniou, I., Duffy, D., & Filis, G. (2013). Stock market response to monetary and fiscal policy shocks: Multi-country evidence. *Economic Modelling,30*, 754-769.

Cheung, Y., & Ng, L. K. (1998). International evidence on the stock market and aggregate economic activity. *Journal of Empirical Finance,5*(3), 281-296.

Cheng, A. Yip, I. (2017). China's Macroeconomic Fundamentals on Stock Market Volatility: Evidence from Shanghai and Hong Kong. *Review of Pacific Basin Financial Markets and Policies,* Vol. 20, No. 2.

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

Christiano, L. J., Eichenbaum, M., & Evans, C. (1996). The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds. *The Review of Economics and Statistics,78*(1), 16.

Cushman, D. O., & Zha, T. (1997). Identifying monetary policy in a small open economy under flexible exchange rates. *Journal of Monetary Economics,39*(3), 433-448.

Cutler, D. M., Poterba, J. M., & Summers, L. H. (1989). What moves stock prices? *The Journal of Portfolio Management,15*(3), 4-12.

Dedola, L., & Lippi, F. (2005). The monetary transmission mechanism: Evidence from the industries of five OECD countries. *European Economic Review,49*(6), 1543-1569.

Eichenbaum, M., & Evans, C. L. (1995). Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates. *The Quarterly Journal of Economics,110*(4), 975-1009.

Fraser, P., & Groenewold, N. (2006). US share prices and real supply and demand shocks. *The Quarterly Review of Economics and Finance,46*(1), 149-167.

Gjerde, Ø, & Sættem, F. (1999). Causal relations among stock returns and macroeconomic variables in a small, open economy. *Journal of International Financial Markets, Institutions and Money,9*(1), 61-74.

Gordon, D. B., & Leeper, E. M. (1994). The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification. *Journal of Political Economy,102*(6), 1228-1247.

Gupta, R., & Modise, M. P. (2013). Macroeconomic Variables and South African Stock Return Predictability. *Economic Modelling,30*, 612-622.

Hamilton, J. D. (1996). This is what happened to the oil price-macroeconomy relationship. *Journal of Monetary Economics,38*(2), 215-220.

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

Hamilton, J. D. (2008). Oil and the Macroeconomy, in New Palgrave Dictionary of Economics, 2nd edition, edited by Steven Durlauf and Lawrence Blume, Palgrave McMillan Ltd.

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

Higgins, Zha, & Zhong (2016). Forecasting China's Economic Growth and Inflation" *China Economic Review* 41 pp. 46-61

Hooker, Mark A. (1996). What Happened to the Oil-Macroeconomy Relationship?" *Journal of Monetary Economics*, 38, pp. 195-213

Humpe, A., & Macmillan, P. (2009). Can macroeconomic variables explain long-term stock market movements? A comparison of the US and Japan. *Applied Financial Economics,19*(2), 111-119.

James, C., Koreisha, S., & Partch, M. (1985). A VARMA Analysis of the Causal Relations Among Stock Returns, Real Output, and Nominal Interest Rates. *The Journal of Finance,40*(5), 1375-1384.

Jareño, F., & Negrut, L. (2015). US Stock Market And Macroeconomic Factors. *Journal of Applied Business Research (JABR),32*(1), 325.

Jareño, F., Ferrer, R., & Miroslavova, S. (2016). US stock market sensitivity to interest and inflation rates: A quantile regression approach. *Applied Economics,48*(26), 2469-2481.

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

Kaneko, T., & Lee, B. (1995). Relative Importance of Economic Factors in the U.S. and Japanese Stock Markets. *Journal of the Japanese and International Economies,9*(3), 290-307.

Kilian, L. (2009). Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market. *American Economic Review,99*(3), 1053-1069.

Kilian, L., & Park, C. (2009). The Impact Of Oil Price Shocks On The U.S. Stock Market. *International Economic Review,50*(4), 1267-1287.

Kim, S., & Roubini, N. (2000). Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach. *Journal of Monetary Economics,45*(3), 561-586.

Lastrapes, W. (1998). International evidence on equity prices, interest rates and money. *Journal of International Money and Finance,17*(3), 377-406.

Lee, B. (1992). Causal Relations Among Stock Returns, Interest Rates, Real Activity, and

Inflation. *The Journal of Finance,47*(4), 1591.

Leeper, E., & Roush, J. (2003). Putting M back in Monetary Policy. *Journal of Money, Credit and Banking,*1217-1256.

Li, Y. D., Işcan, T. B., & Xu, K. (2010). The impact of monetary policy shocks on stock prices: Evidence from Canada and the United States. *Journal of International Money and Finance,29*(5), 876-896.

Lin, C. Fang, C. Cheng, H. (2014). The Impact of Oil Price Shocks on the Returns in China's Stock Market. *Emerging Markets Finance & Trade.* September–October 2014, Vol. 50, No. 5, pp. 193–205.

Mcqueen, G., & Roley, V. V. (1993). Stock Prices, News, and Business Conditions. *The Review of Financial Studies,6*, 3rd ser., 683-707.

Mojon, B., & Peersman, G. (n.d.). A VAR description of the effects of monetary policy in the individual countries of the euro area. *Monetary Policy Transmission in the Euro Area,*56-74.

Mork, K. A. (1989). Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamiltons Results. *Journal of Political Economy,97*(3), 740-744.

Martinez, M. A., Rubio, G. (1989). Arbitrage pricing with macroeconomic variables: an empirical investigation using Spanish data. *Working Paper, Universidad del Pais Vasco.*

Mohanty, D. (2012). Evidence of Interest Rate Channel of Monetary Policy Transmission in India. *Working Paper Series. Reserve Bank of India*.

Mork, K. A., Olsen, O., & Mysen, H. T. (1994). Macroeconomic Responses to Oil Price Increases and Decreases in Seven OECD Countries. *The Energy Journal,15*(4).

O'Neill, T., Penm, J., & Terrell, R. (2008). The role of higher oil prices: A case of major developed countries. *Research in Finance,*287-299.

Ono, S. (1999) Oil price shocks and stock markets in BRICs. *The European Journal of Comparative Economics*, 8(1), 29-45.

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

Park, K., & Ratti, R. A. (2000). Real Activity, Inflation, Stock Returns, and Monetary Policy. *The Financial Review,35*(2), 59-78.

Patelis, A. D. (1997). Stock Return Predictability and The Role of Monetary Policy. *The Journal of Finance,52*(5), 1951.

Peiro, A. (1996). Stock prices, production and interest rates: Comparison of three European countries with the USA. *Empirical Economics,21*(2), 221-234.

Rapach, D. E. (2001). Macro shocks and real stock prices. *Journal of Economics and Business,53*(1), 5-26.

Ruiz, J. (2015). Response of Spanish stock market to ECB monetary policy during financial crisis. *The Spanish Review of Financial Economics,13*(2), 41-47.

Richard Roll (1988) The International Crash of October 1987, *Financial Analysts Journal*, 44:5, 19-35.

Ryota Kojima & Shinya Nakamura & Shinsuke Ohyama, 2005. "Inflation Dynamics in China," *Bank of Japan Working Paper Series 05-E-9, Bank of Japan.*

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

Sims, C. A. (1980). Macroeconomics and Reality. *Econometrica,48*(1), 1.

Sims, C. A. (1992). Interpreting the macroeconomic time series facts: The Effects of Monetary Policy. *European Economic Review,36*(5), 975-1000.

Sims, C. A., & Zha, T. (1998). Bayesian Methods for Dynamic Multivariate Models. *International Economic Review,39*(4), 949

Sims, C. A., & Zha, T. (2006). Does Monetary Policy Generate Recessions? *Macroeconomic Dynamics,10*(02).

Sousa, J. M., & Zaghini, A. (2007). Global Monetary Policy Shocks in the G5: A SVAR Approach. *SSRN Electronic Journal*.

Strongin, S. (1995). The identification of monetary policy disturbances explaining the liquidity puzzle. *Journal of Monetary Economics,35*(3), 463-497.

Thorbecke, W. (1997). On Stock Market Returns and Monetary Policy. *The Journal of Finance,52*(2), 635.

Voss, G. Brischetto, A. (1999) A Structural Vector Autoregression Model of Monetary Policy in Australia*. Reserve Bank of Australia. Research Discussion Paper.*

Vittorio Grilli & Nouriel Roubini, 1995. "Liquidity and Exchange Rates: Puzzling Evidence from the G-7 Countries,". *Working Papers*. 95-17, *New York University, Leonard N. Stern School of Business, Department of Economics.*

Wasserfallen, W. (1989). Macroeconomics news and the stock market: Evidence from Europe. *Journal of Banking & Finance,13*(4-5), 613-626.

Appendix: Impulse Response Functions (Figure 1 to Figure 6)

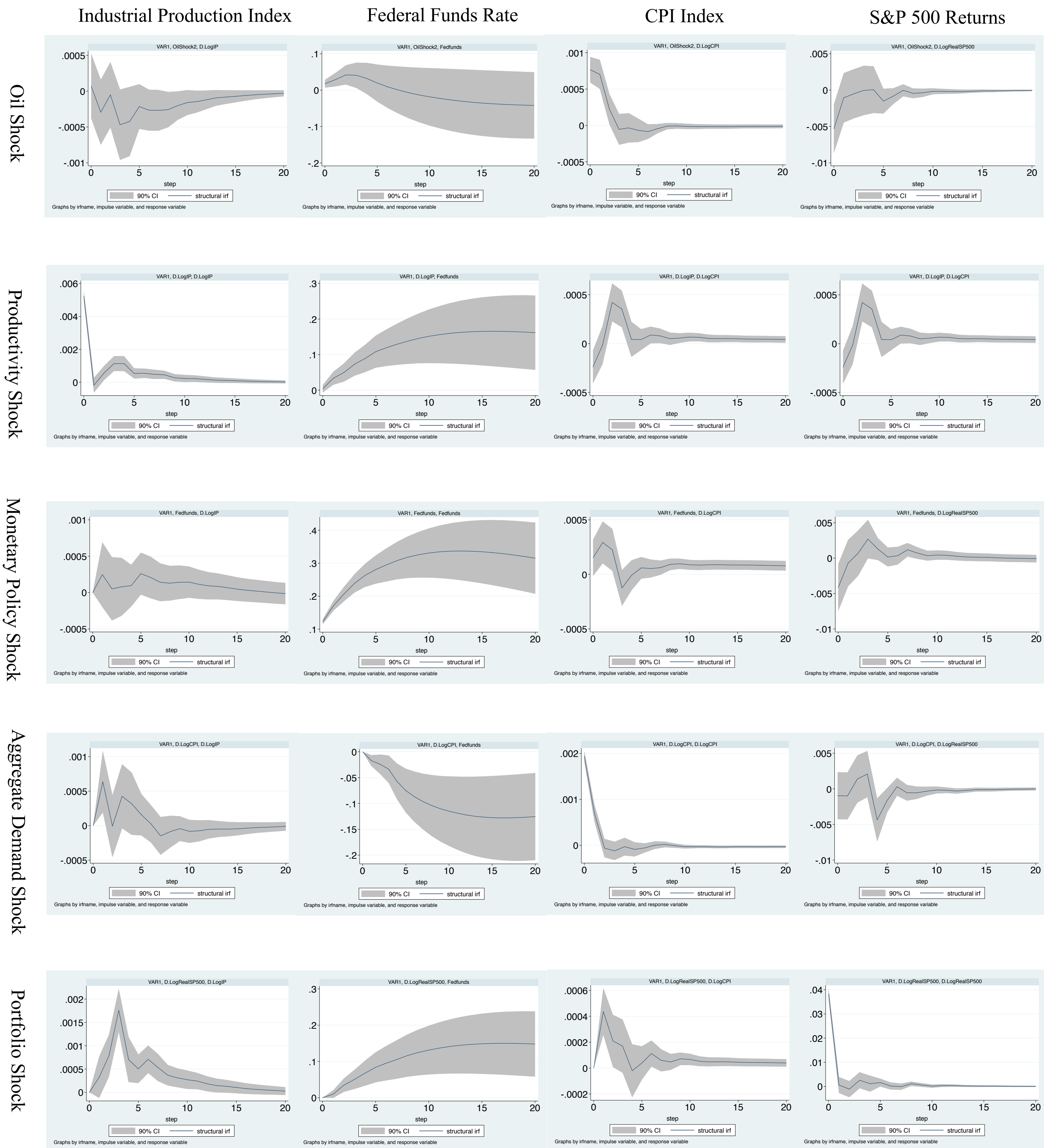

Figure 1. U.S. Impulse response functions to unit structural shock. Note: Y-axis: Shocks. X-axis: Response

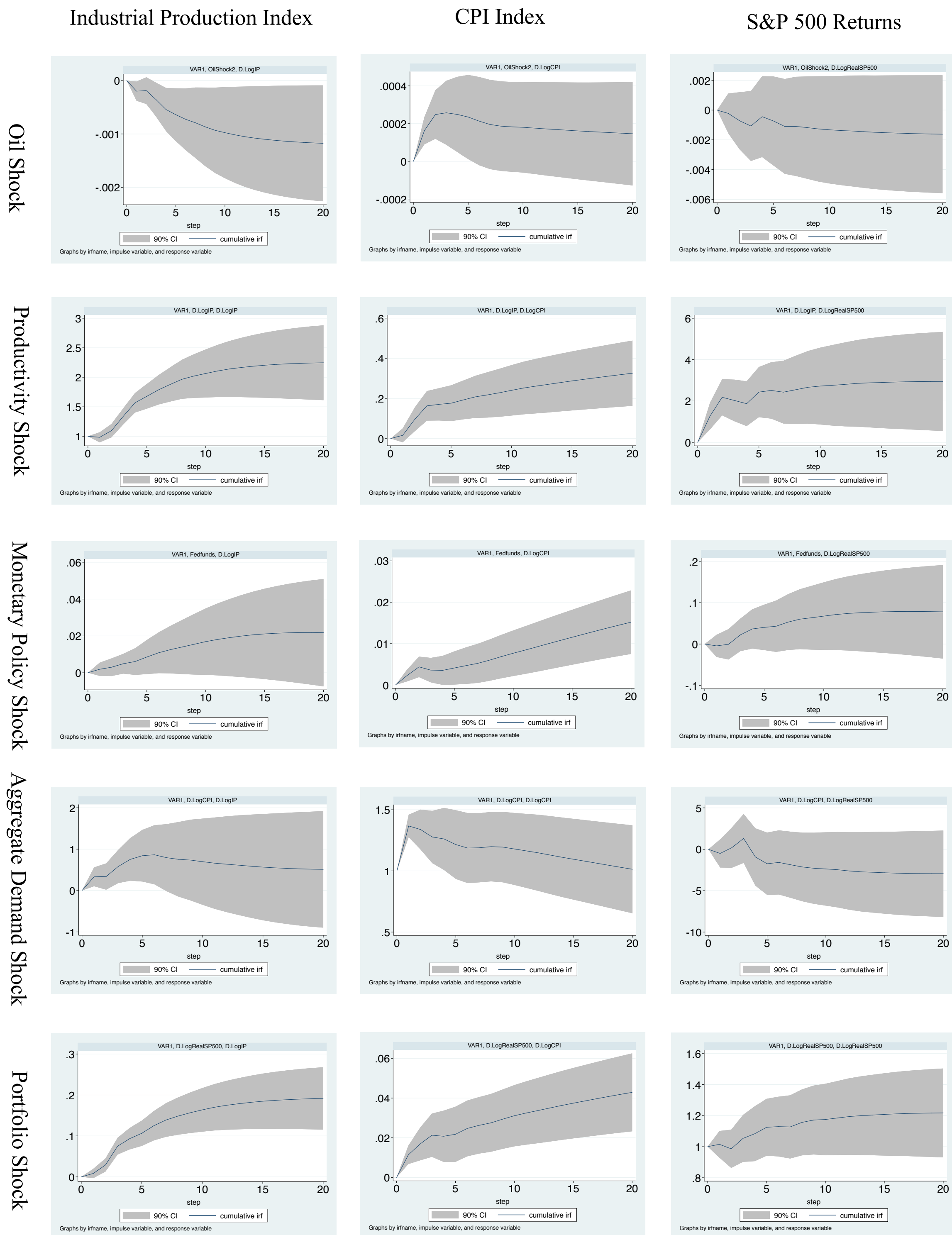

Figure 2. U.S. Accumulated Impulse response functions to unit structural shock. Note: Y-axis: Shocks. X-axis: Response

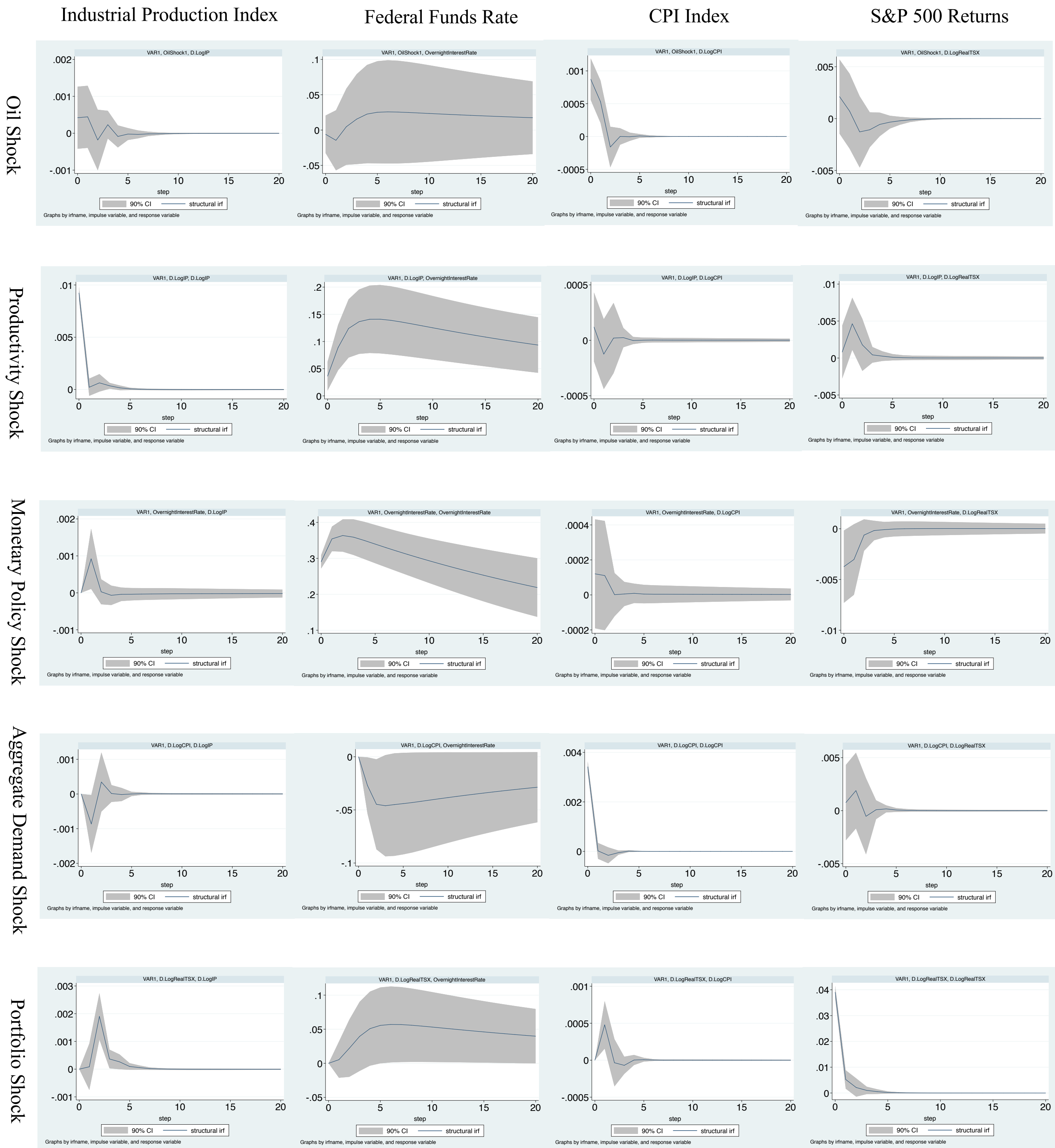

Figure 3. Canada Impulse response functions to unit structural shock. Note: Y-axis: Shocks. X-axis: Response

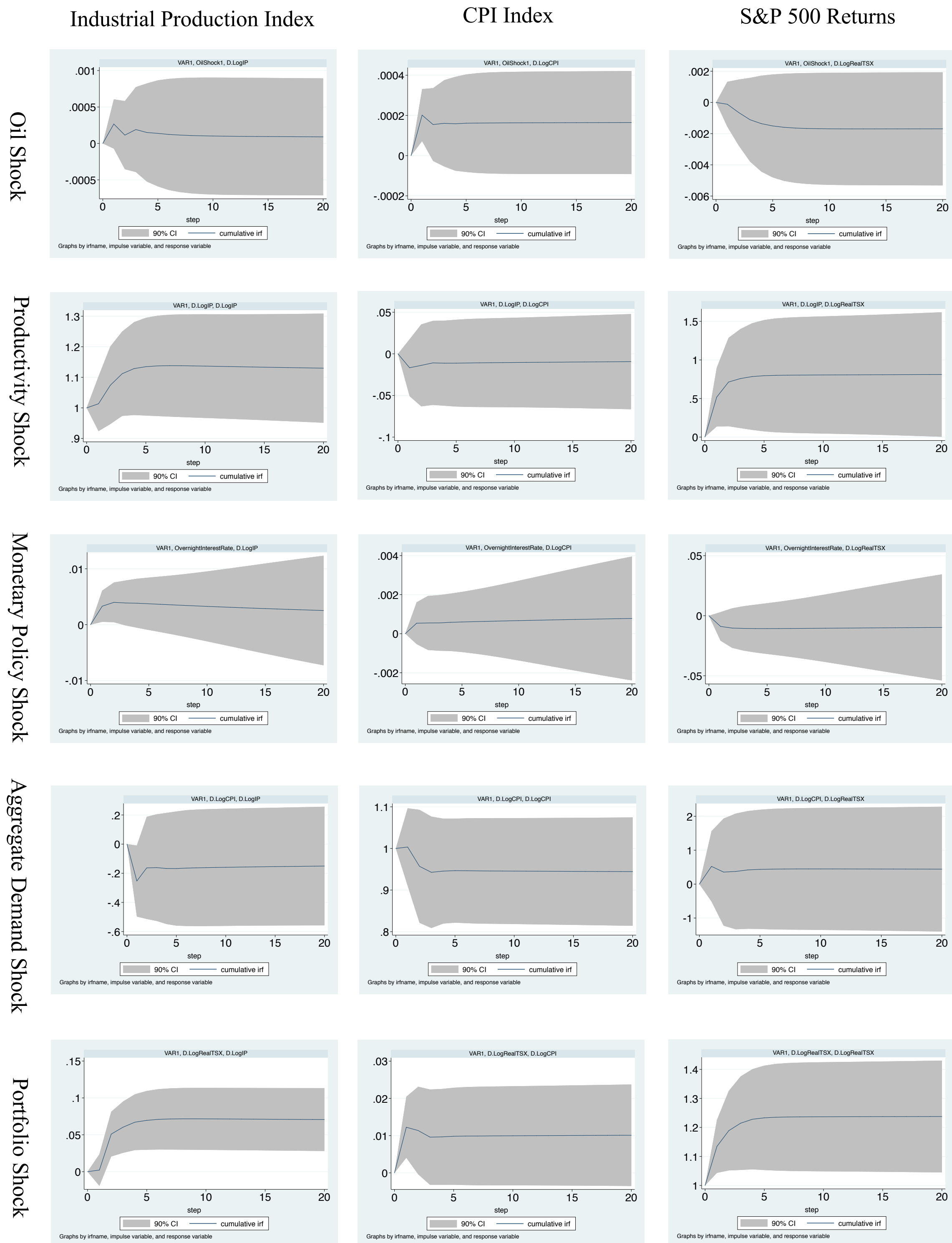

Figure 4. Canada Accumulated Impulse response functions to unit structural shock. Note: Y-axis: Shocks. X-axis: Response

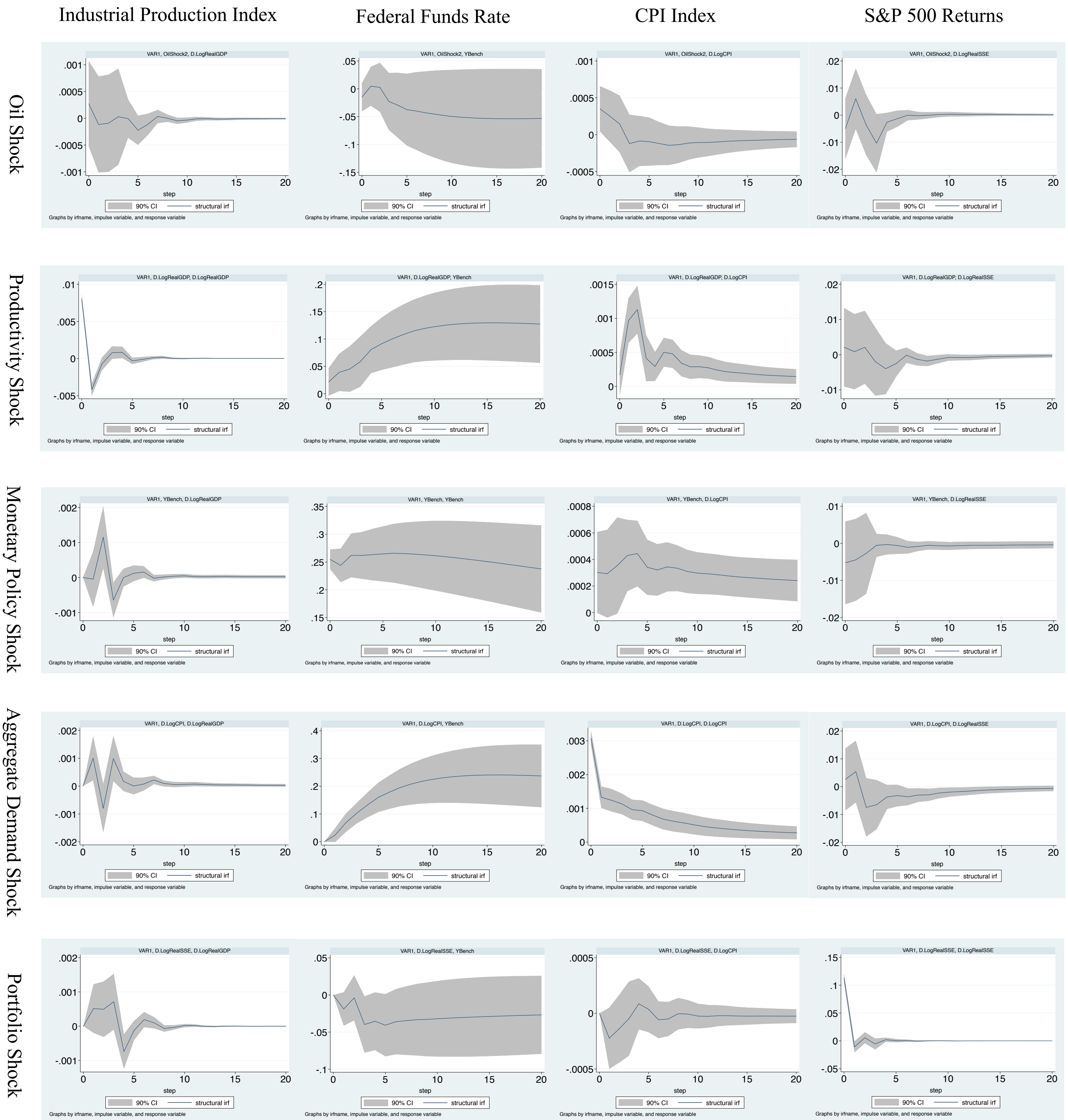

Figure 5. China Impulse response functions (1YBench) to unit structural shock. Note: Y-axis: Shocks. X-axis: Response

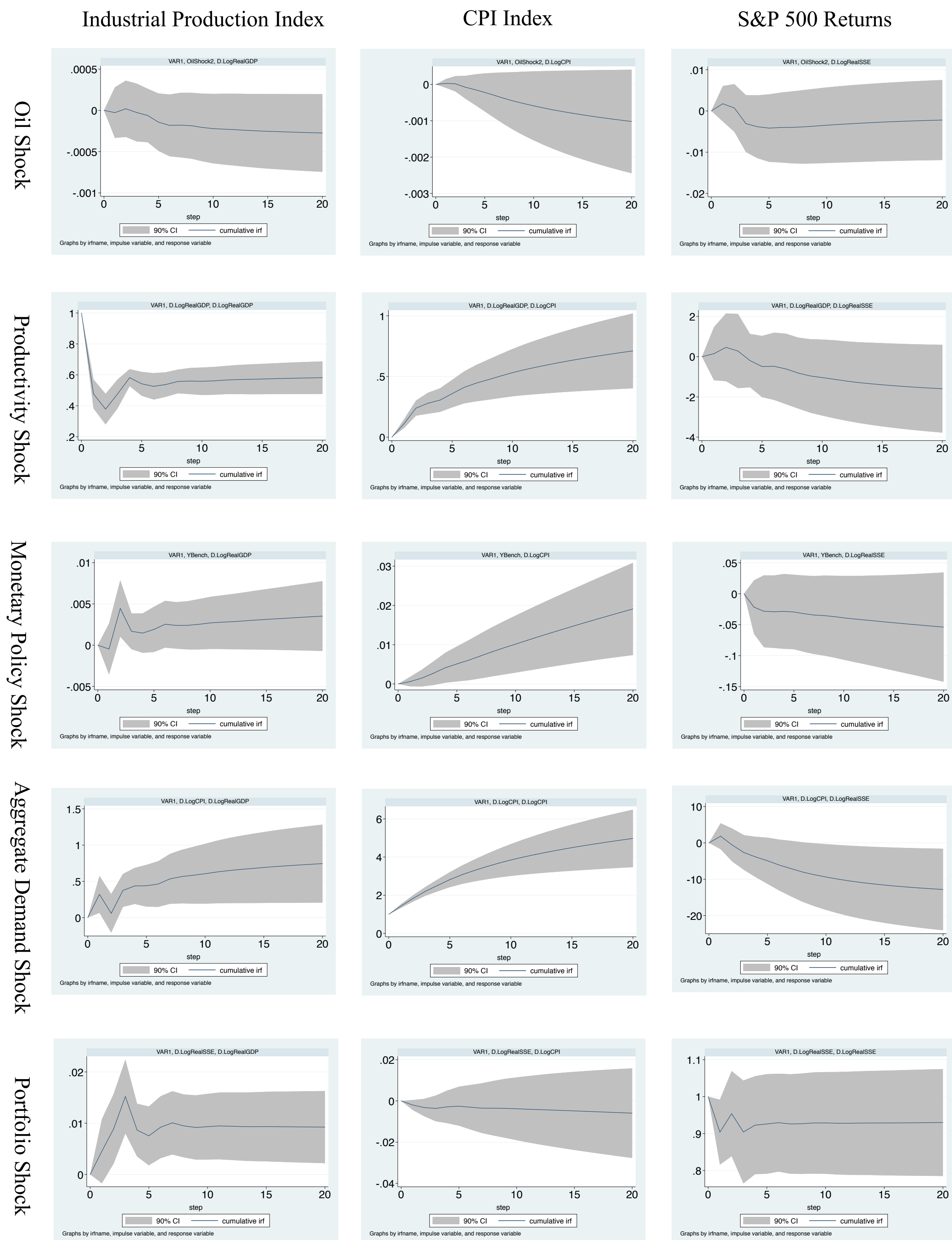

Figure 6. China Accumulated Impulse response functions to unit structural shock. Note: Y-axis: Shocks. X-axis: Response