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International Transmission Of U.s. Real, Nominal, And Financial Shocks

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INTERNATIONAL TRANSMISSION OF U.S. REAL, NOMINAL, AND FINANCIAL SHOCKS

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To my loving children Shikha and Sandeepta, wife Sharada, and mother Yeshodha

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INTRODUCTION

This research is intended to develop better understanding of economic shock transmission process from one country to another. As the world has become increasingly integrated in recent years, the shock originated in one country has direct and dramatic impact on other countries. This has been observed recently when we passed through a terrible economic crisis that indeed originated in the U.S. but spread all over the world leading to a severe contraction in output and hardship for millions of people around the globe. This situation, in fact, led us to ponder over how the economic landscapes of other countries are affected when economically integrated another country is hit by a shock. We investigate this question by estimating a vector autoregression (VAR) model and identify the U.S. real, nominal, and financial shocks and observe their effects on the U.S. as well as on the G-7 macroeconomic variables.

In the following chapter, we examine the international transmission effects of first two economic shocks - real and nominal shocks. A classical work on investigating the transmission effects of such shocks is found in famous Mundell-Fleming model, which predicts that an increase in foreign interest rates as a result of monetary tightening abroad under fixed exchange rate regime would result in output reduction both at home and abroad. The increase in foreign interest rates as a result of expansionary government spending, however, would result in the expansion of foreign output but a reduction in domestic output. Under flexible exchange rate system, there would be an expansion of domestic output and a contraction in foreign output after monetary contraction abroad but expansion in output both at home and abroad following expansion in government spending abroad. The recently emerged New Open Economy Macroeconomics (NOEM) models predict different transmission effects than the Mundell-

Fleming model[1]. The Redux model, one of the classical works in this group of literature and developed by Obstfeld and Rogoff (1995), predicts that the monetary shocks in the domestic country raise the level of domestic output but shows an ambiguous effect on foreign output. Exchange rate overshooting, one of the pioneering predictions of the Dornbusch's (1976) dynamic Mundell-Fleming model, is, however, absent in this model.

To investigate further the transmission effects of real and nominal shocks, we develop a theoretical rational expectation open economy macroeconomic model, and this mode's long-run implications are used to identify monetary and real shocks in the U.S.. While the identification technique as pioneered by Blanchard and Quah (1989) is applied to exploit long-run implications of the model, appropriate sign restrictions as implied by the model's short-run dynamics are also exploited (into the contemporaneous coefficient matrix of the VAR model) to account for the short-run implications of the model. The effects of identified shocks on output, exchange rates, and inflation are observed for U.S. relative to each of six other G-7 countries. The theoretical model draws primarily on the open economy macro model developed by Obstfeld (1985), while other ingredients of the model are also extracted from Mundell (1963), Fleming (1962) and Dornbusch (1976)[2].

The empirical results show that there is a positive and persistent increase of U.S. real GDP relative to other countries' real GDP, and a depreciation of U.S. currency relative to other currencies following a supply shock in the U.S.. While the results with output and exchange rates are consistent with the predictions of the model, the response of relative price of home-produced

[1] A detailed survey on the evolution and foundation of NOEM is found in Lane (2001). Imperfect competition, be it in product and/or factor markets, in general equilibrium setup is a key ingredient of the models in NOEM. These models aim to overcome the limitations of Mundell-Fleming model and emphasize international dimension of optimal monetary policy and desirability of international monetary policy cooperation. A far from complete list for further references includes Clarida, Gali, and Gertler (2002), Corsetti and Pesenti (2005), and Woodford (2007).

[2] For introducing nominal rigidity, we rely on a very simple price setting equation as pioneered by Flood (1981) and Mussa (1982), in which price adjustment is completed within one period.

goods to the price of foreign-produced goods after a supply shock does not confirm with the model's predictions. As with demand and monetary shocks, the response of relative real GDP is mostly in line with the model's predictions, whereas real and nominal effective exchange rates do not response as expected in the model following demand and monetary shocks. The variance decompositions show that relative real GDP is largely governed by supply shocks whereas demand shocks causes most of the variations in real effective exchange rates. Monetary shocks lead to a substantial variation in price differential between the countries. Most notable result of this study is the existence of exchange rate overshooting following a supply shock.

Chapter 3 investigates the transmission effects of U.S. financial shocks on the U.S. and other G-7 macroeconomic variables. Past studies have already justified the association between financial and real sector. The nature of link is procyclical where financial crisis leads to a contraction in real activities (Borio (2007), Goodhart (1996), and Minsky (1992)). Bernanke and Gertler (1995) and Bernanke, Gertler, and Gilchrist (1999) propose a model in which financial accelerator plays a significant role that reinforces the effects of financial cycles on the real economy by changing the values of collateral that ultimately affect the willingness of the financial system to make available of the credit.

In analyzing the potential link between financial and real sector, we at the beginning closely observe the behavior of stock prices and federal funds rate in the U.S. for a daily data starting from 1957. This basic specification is then extended to observe the effects of U.S. financial shocks to other U.S. and international macroeconomic variables by estimating recursive vector autoregression. The identification strategy we apply in this study for the VAR estimation is similar to Sims (1980) and Kim (2001).

The results show that the financial shocks in the stock market has no any definite effect on the behavior of federal funds rate, which is customary believe that Federal Reserve does not respond to stock market volatility in the very short-run. The effect of monetary policy shocks, however, exerts a negative effect on stock prices, and the effects die out after 10 days. Other U.S. macroeconomic variables also exhibit expected responses following the shocks on the U.S. financial system. The positive innovation to U.S. financial stress index (FSI), for example, has negative impact on U.S. real GDP and industrial production. The difference between asset and liabilities, which can be defined as capital requirements, on the other hand, also respond negatively to financial shocks, which support the evidence that banks face dire capital crunch following the crisis. The international transmission effect of U.S. financial shocks is also in line with the expectation, leading to a decline in the real GDP in the rest of G-7 countries following a financial stress in the US. This shock also leads to a decline in the interest rates in all other countries, showing that other countries follow the U.S. policy of reducing interest rates after crisis happens in the U.S.. The stock prices decline in other countries as well when the U.S. economy is hit by financial shocks.

We conclude the findings of this research in Chapter 4. Our conclusion is that all three shocks real, nominal and financial shocks have significant and direct impact on macroeconomic variables of G-7 countries. This mandates for appropriate policy responses to be adopted by these countries to address the transmission effects in the region. This chapter also provides an account of possible areas that this research can be extended to in the future.

CHAPTER 2

INTERNATIONAL TRANSMISSION OF U.S. REAL AND NOMINAL SHOCKS

1. Introduction

This study examines the international transmission of U.S. real and nominal shocks on key macroeconomic variables of G-7 countries. We develop a theoretical rational expectation open economy macroeconomic model, and this mode's long-run implications are used to identify monetary and real shocks. While the identification technique as pioneered by Blanchard and Quah (1989) is applied to exploit long-run implications of the model, appropriate sign restrictions as implied by the model's short-run dynamics are also exploited (into the contemporaneous coefficient matrix of the VAR model) to account for the short-run implications of the model. The effects of identified shocks on output, exchange rates, and inflation are observed for U.S. relative to each of six other G-7 countries. The theoretical model draws primarily on the open economy macro model developed by Obstfeld (1985), while other ingredients of the model are also extracted from Mundell (1963), Fleming (1962) and Dornbusch (1976)[3].

Transmission effects of shocks beyond international borders have been experimented in many theoretical and empirical works with varied range of predictions. The famous Mundell-Fleming model, for example, predicts that an increase in foreign interest rates as a result of monetary tightening abroad under fixed exchange rate regime would result in output reduction both at home and abroad. The increase in foreign interest rates as a result of expansionary government spending, however, would result in the expansion of foreign output but a reduction

[3] For introducing nominal rigidity, we rely on a very simple price setting equation as pioneered by Flood (1981) and Mussa (1982), in which price adjustment is completed within one period.

in domestic output. The effects of monetary and real shocks are rather different under flexible exchange rate system, leading to an expansion of domestic output and a contraction in foreign output after monetary contraction abroad but expansion in output both at home and abroad following expansion in government spending abroad. The models in New Open Economy Macroeconomics (NOEM) literature suggest different transmission effects than the Mundell-Fleming model. A seminal work of NOEM, the Redux model, developed by Obstfeld and Rogoff (1995) predicts that the domestic monetary shocks raise the level of domestic output but shows an ambiguous effect on foreign output. An interesting result of this model is the lack of exchange rate overshooting, which is in contrary to the prediction of Dornbusch's (1976) dynamic Mundell-Fleming model. The exchange rate overshooting is, however, restored in Betts and Devereux's (2000a) model, which assumes incomplete exchange rate pass-through as opposed to complete exchange rate pass-through in Redux model[4].

Within the premises of such diversified theoretical predictions, this study provides a fresh account of international transmission effects of U.S. real and nominal shocks in rest of G-7 countries by estimating a structural Vector Autoregression (SVAR) model. Earlier applications of VAR analysis in open economy macroeconomics are found in Clarida and Gali (1994) and Eichenbaum and Evans (1995). Clarida and Gali (1994) identify sources of real exchange rate fluctuations for post-Bretton Woods period for U.S., Japan, Germany, and Canada. The estimation of structural VAR in their study produces consistent results with the predictions of the Mundell-Fleming model showing that demand shocks lead to appreciation and monetary shocks lead to depreciation of the home currency. Eichenbaum and Evans (1995) also find the results

[4] A detailed analysis of transmission of shocks in incomplete exchange rate pass-through is found in Corsetti and Pesenti (2007). The authors in this paper demonstrate the shock transmission process in three different sorts of incomplete exchange rate pass-through: local currency pricing (LCP), producer currency pricing (PCP), and dollar pricing (DP). In all these settings, the shocks are transmitted differently. Transmission effects are different for these three settings.

similar to Clarida and Gali (1994). Kim (2001), on the other hand, estimates structural VAR to identify unidirectional effect of the US monetary policy shocks to the macroeconomic variables of G-7 countries and finds that the U.S. monetary expansion has a positive spillover effects on real GDP and industrial production of non-U.S. G-6 countries. Kim's results, however, do not seem to be consistent with the predictions of Mundell-Fleming and sticky price NOEM models.

Despite the prevalence of growing literatures that use VAR in explaining transmission effects of economic shocks, earlier studies were primarily designed for closed economy, and, if at all extended for open economy, the extensions were basically designed to explain exchange rate fluctuations. This study, however, provides a most recent contribution to explain the effects of shocks also on output and prices. As a prima facie attempt, we also notably include in our estimation the short-run implications of the model into the VAR estimation, which lacks in the earlier studies.

The empirical results show that there is a positive and persistent increase of U.S. real GDP relative to other countries' real GDP, and a depreciation of U.S. currency relative to other currencies following a supply shock. While the results with output and exchange rates are consistent with the predictions of the model, the response of relative price of home-produced goods to the price of foreign-produced goods after a supply shock does not confirm with the model's predictions. As with demand and monetary shocks, the response of relative real GDP is mostly in line with the model's predictions, whereas real and nominal effective exchange rates do not response as expected in the model following demand and monetary shocks. The variance decompositions show that relative real GDP is largely governed by supply shocks whereas demand shocks causes most of the variations in real/nominal effective exchange rates. Monetary shocks lead to a substantial variation in price differential between the countries. Most notable result of this study is the existence of exchange rate overshooting following a supply shock.

Rest of the chapter is organized as follows: Section 2 describes the theoretical model. Section 3 provides an account of empirical strategy. Results are discussed in Section 4. Section 5 concludes.

2. Model Framework

Mondell-Fleming model is extensively-used model in policy-related research by central banks for over four decades, and the model derived here is similar to this model but extended as stochastic Mondell-Fleming model as pioneered by Obstfeld (1985). Following Clarida and Gali (1994), all variables used are U.S. relative to foreign country, which essentially makes this model as a two-country model. Foreign interest rates are set to zero without loss of generality. All variables except interest rates are in log.

The demand side of the economy is represented by the following IS equation

$$y_t^d = \varphi(s_t - p_t) - \phi(i_t - E_t(p_{t+1} - p_t)) + d_t \qquad (1)$$

where d_t is aggregate demand shock, and $i_t - E_t(p_{t+1} - p_t)$ is an *ex ante* real interest rate. Provided that φ and ϕ are positive, real exchange rate ($s_t - p_t$) and demand shocks have positive effects on aggregate demand whereas real interest rates have negative effect.

The LM equation is given by

$$m_t^s - p_t = y_t^d - \kappa i_t \qquad (2)$$

where $\kappa > 0$ and income elasticity of money demand is assumed to be unity.

Nominal rigidity is introduced in the following price-setting equation

$$p_t = E_{t-1}\breve{p}_t + \theta(\breve{p}_t - E_{t-1}\breve{p}_t) \tag{3}$$

where $\breve{p}$ is a shadow value of flexible price equilibrium. If $\theta = 1$, prices are instantaneously perfectly flexible, and if $\theta = 0$ they are completely fixed one period in advance. $0 < \theta < 1$ demonstrate intermediate degrees of price rigidity.

The following uncovered interest parity equation demonstrates the capital market equilibrium

$$i_t = E_t(s_{t+1} - s_t) \tag{4}$$

The shock processes are captured by the following three equations:

$$y_t^s = y_{t-1}^s + \omega_t \tag{5}$$

$$d_t = d_{t-1} + \mu_t - \tau\mu_{t-1} \tag{6}$$

$$m_t = m_{t-1} + \xi_t \tag{7}$$

The supply shocks and monetary shocks are assumed to be pure random walks (equations (5) and (7)). The demand shocks also exhibit random walks; however, following Clarida and Gali (1994) a portion of the shocks are assumed to be reverting in the next period as demonstrated by the last term in equation (6). The introduction of this term in the demand shock process has implication for the application of Blanchard and Quah (1989) technique to estimate structural VAR model described in Section 3.

Flexible price solution $(\theta = 1)$[5]

[5] The flexible price solution is, in fact, a hypothetical solution, because we cannot characterize steady state in stochastic environment as economy is constantly hit by shocks. We therefore prefer to term this solution as shadow flexible price solution.

Solution for real exchange rates:

Set $y_t^s = y_t^d$, assume real exchange rate $\hat{q}_t = s_t - p_t$, and substitute interest parity equation (4) into IS equation to get different equation for real exchange rates as

$$\hat{q}_t = \frac{y_t^s - d_t}{\varphi + \phi} + \frac{\phi}{\varphi + \phi} E_t \hat{q}_{t+1}$$

Using method of undetermined coefficients gives the solution for real exchange rates as

$$\hat{q}_t = \frac{y_t^s - d_t}{\varphi} + \frac{\tau}{\varphi}\left(\frac{\phi}{\varphi + \phi}\right)\mu_t \qquad (8)$$

Equation (8) demonstrates that real exchange rate is affected only by real and demand shocks but not by monetary shocks.

Solution for Price:

Substitute (4) into (2) to get

$$\hat{p}_t = m_t^s - y_t^s + \kappa E_t (s_{t+1} - s_t)$$

Add $\kappa\hat{p}$ in both sides, add and subtract $\kappa E_t \hat{p}_{t+1}$ in the right hand side, apply definition of real exchange rates $\hat{q}_t = s_t - p_t$, and arrange the terms to get

$$(1+\kappa)\hat{p}_t = m_t - y_t + \kappa(E_t \hat{q}_{t+1} - \hat{q}_t) + \kappa E_t \hat{p}_{t+1} \qquad (9)$$

From solution of real exchange rates in equation (8) and also using the shock processes, we obtain

$$E_t(\hat{q}_{t+1} - \hat{q}_t) = \left(\frac{\kappa}{\varphi + \phi}\right)\mu_t \qquad (10)$$

Substitute this in equation (9) to obtain a stochastic difference equation for price as

$$\tilde{p}_t = \frac{m_t - y_t}{1+\kappa} + \frac{\tau\kappa}{(\varphi+\phi)(1+\kappa)}\mu_t + \frac{\kappa}{1+\kappa}E_t\tilde{p}_{t+1}$$

Using method of undetermined coefficients we obtain the solution for $\tilde{p}_t$ as

$$\tilde{p}_t = m_t - y_t + \beta\mu_t \tag{11}$$

where $\beta = \dfrac{\kappa\tau}{(1+\kappa)(\varphi+\phi)}$

Prices are affected by all three shocks in flexible price equilibrium as observed in equation (11).

Sticky price solution $(0 < \theta < 1)$:

Solution for price:

Substitute price solution equation (11) into price setting equation (3) to get

$$p_t = \tilde{p}_t - (1-\theta)(\xi_t - \omega_t + \beta\mu_t) \tag{12}$$

where $\tilde{p}_t$ is flexible price solution.

As can be seen in equation (12), the deviation of price from long-run equilibrium is negatively affected by demand and monetary shocks and positively by supply shocks.

Solution for real exchange rate:

Substitute (12) and (1) into (2) to obtain

$$m_t - \tilde{p}_t + (1-\theta)[\xi_t - \omega_t + \beta\mu_t] = d_t + \varphi q_t - (\phi+\phi)(E_t q_{t+1} - q_t) - \kappa E_t(p_{t+1} - p_t) \tag{13}$$

Substitute (11) into (12) and get the expression for $E_t(p_{t+1} - p_t)$ as

$$E_t(p_{t+1} - p_t) = -\beta\mu_t + (1-\theta)[\xi_t - \omega_t + \beta\mu_t] \tag{14}$$

Substitute (14) and (10) into (11) to obtain stochastic difference equation for q_t as

$$(\varphi + \phi + \kappa)q_t = y_t - d_t + (1-\theta)(1+\kappa)(\xi_t - \omega_t) - \theta(1+\kappa)\beta\mu_t + (\phi + \kappa)E_t q_{t+1}$$

Using method of undetermined coefficients gives the solution for q_t as

$$q_t = \frac{y_t - d_t}{\varphi} + \frac{\tau(\phi+\kappa) - \beta\varphi\theta(1+\kappa)}{\varphi(\varphi+\phi+\kappa)} d_t + \frac{(1-\theta)(1+\kappa)}{\varphi+\phi+\kappa}(\xi_t - \omega_t)$$

Using (8) we can also have the solution for q_t as

$$q_t = \breve{q}_t + \frac{(1+\kappa)(1-\theta)}{\varphi+\phi+\kappa}[\xi_t - \omega_t + \beta\mu_t] \tag{15}$$

For the solution of nominal exchange rates, q_t and p_t are substituted in the expression for nominal exchange rates $s_t = q_t + p_t$ to obtain

$$s_t = \breve{s}_t + (1-\varphi-\phi)\frac{(1-\theta)}{\varphi+\phi+\kappa}[\xi_t - \omega_t + \beta\mu_t] \tag{16}$$

The solution for nominal exchange rates show that the deviation of real and nominal exchange rates from long-run equilibrium is positively affected by demand and monetary shocks and negatively by supply shocks, given $(\varphi - \phi) < 0$. This shows that supply shocks can produce exchange rate overshooting, and this implication is tested empirically by estimating a VAR in Section 4.

Solution for aggregate demand:

By using (4) we can write IS equation as

$$y_t^d = \varphi q_t - \phi E_t(\Delta q_{t+1})) + d_t \tag{17}$$

Forwarding one period ahead, using (10) and taking expectation for (15) to get

$$E_t(\Delta q_{t+1}) = \frac{\tau}{\varphi+\phi}\mu_t - \frac{(1+\kappa)(1-\theta)}{\varphi+\phi+\kappa}[\xi_t - \omega_t + \beta\mu_t] \tag{18}$$

Substituting (17) and (15) into (16) to obtain the solution for aggregate demand as

$$y_t^d = y_t + \frac{(1+\kappa)(1-\theta)(\varphi+\phi)}{\varphi+\phi+\kappa}[\xi_t - \omega_t + \beta\mu_t] \tag{19}$$

This equation exhibits that the deviation of real GDP from long-run equilibrium is positively affected by demand and monetary shocks and negatively by supply shocks, given $(\varphi - \phi) < 0$.

In the short-run all variables are affected by all three shocks contemporaneously as shown by equations (12), (15), (16), and (18) but in the long-run the system becomes triangular as output is affected only by supply shocks (equation (5)), real exchange rates by supply and demand shocks (equation (8)), and price by all three demand, supply and monetary shocks (equation (11)). Both these long-run and short-run implications of the model are used in estimating structural VAR model described in the next section.

3. Empirical Strategy

3.1 Structural VAR Model

A two-country world is described by a following structural equation

$$By_t = \Gamma(L)y_t + e_t \tag{20}$$

where B is a contemporaneous coefficient matrix in structural equations, y_t is 3×1 data vector which includes U.S. relative output, relative real/nominal effective exchange rates, and relative prices. e_t is a 3×1 vector of structural shocks - aggregate supply shocks, aggregate demand shocks, and monetary shocks. e_t are assumed to be serially uncorrelated with Var(e_t) = Σ as a diagonal matrix with unit variances of structural disturbances on the principal diagonal.

The VAR is estimated in the reduced-form equation as

$$y_t = \Phi(L)y_t + u_t \tag{21}$$

where $\Phi(L) = B^{-1}\Gamma(L)$, $u_t = B^{-1}e_t$, and $Var(u_t) = \Omega$.

Using the relationship $u_t = B^{-1}e_t$ and the assumption of $\Sigma = I$ gives Ω as

$$\Omega = B^{-1}B^{-1'} \tag{22}$$

Reduced-from model, which downsizes the structural representation of the system, leads to identification problem. To recover the parameters of structural equations and the innovations thereto, we must impose restrictions on the structural system. There are two ways to restrict the system: first, the short-run restrictions employ both recursive (Sims (1980)), and non-recursive frameworks (Bernanke (1986), Sims(1986)) in the matrix B and the second, the long-run restrictions employ restriction on long-run multipliers. The identification strategy we apply here is long-run restrictions as suggested by Blanchard and Quah (1989). To apply this approach, the equations (19) and (20) are represented in the moving average form as

$$y_t = \Theta(L)e_t \tag{23}$$

$$y_t = \Psi(L)u_t \tag{24}$$

From equations (23) and (24), the relationship between the structural and reduced-form parameters becomes

$$\Theta(1) = \Psi(1)B^{-1} \tag{25}$$

The matrix $\Psi(1)$ is obtained by using reduced-form estimated parameters $\hat{\Phi}'s$ from equation (21), and B^{-1} is estimated by using maximum likelihood estimation[6]. The long-run restrictions are applied in the matrix $\Theta(1)$ to recover B^{-1}. The restrictions come from long-run implication of the model described in Section 2. That the model demonstrates that output is not affected by demand and monetary shocks and real exchange rate is not affected by monetary shocks makes the matrix of long-run multipliers $\Theta(1)$ a lower triangular matrix. This lower triangular condition helps identify matrix B^{-1}, and thereby $\Theta(L)$, and finally the impulse responses and variance decompositions.

In order to exploit the short-run implications of the model, we use the relationship $u_t = B^{-1}e_t$, in which appropriate sign restrictions are imposed on the matrix B^{-1} so that the contemporaneous effects of the innovations are accordingly transmitted to the reduced-from disturbances and thereby to variables used in the model. The model's short-run dynamics implies that the supply shocks have negative adjustment process (that is, the difference between long-run equilibrium values and short-run sticky price values) for relative GDP and real effective exchange rates and positive for relative prices, whereas demand and monetary shocks have positive adjustment process for relative real GDP and relative real effective exchange rates but negative for real/nominal effective exchange rates (equations 12, 15, and 19). To incorporate this short-run characteristics of the model into the VAR estimation, we convert B^{-1} matrix into a new matrix, say C^{-1}, such that $C^{-1} = MB^{-1}N$ where $m_{11}=1$, $m_{22} = 1$ and $m_{33} = -1$, and $n_{11}=-1$, $n_{22}=1$ *and*

[6] To obtain $\Psi(1)$, the equation (20) is first represented in state-space form for Wold representation where the reduced-form estimated parameters $\hat{\Phi}'s$ from equation (21) are used which provide us a 3×3 matrix $\Psi(1)$. The details on how to estimate $\Psi(1)$ is in gauss codes, which can be made available upon request. Unlike in Clarida and Gali (1994), we estimate B^{-1} by using maximum likelihood estimation. The likelihood function for this estimation is: $\mathcal{L}(\Omega, \hat{\Pi}) = -\left(\frac{Tn}{2}\right)\log(2\pi) + \left(\frac{T}{2}\right)\log|\Omega^{-1}| - (1/2)\sum_{t=1}^{T} \hat{\varepsilon}_t'\Omega^{-1}\hat{\varepsilon}_t$ where, $\Omega = B^{-1}(B^{-1})'$

$n_{33}=1$. With this specification, an important issue arises here and needs to be addressed. The results must be interpreted in growth rates. The shocks have effects only on the *deviations* of the variables from the long-run equilibrium in the short-run sticky price solution. As implied by the price setting rule, it is assumed that the long-run value is attained in the next period, thus the first difference can best be represented as short-run deviations of the variables from the long-run, which we do to obtain empirical results in VAR estimation.

3.2 Data

The international financial statistics (IFS) published by International Monetary Fund (IMF) is a major source of data for this study. As suggested by previous researchers, this is a rich source of data for open economy macro analysis, and the data in this source is available for large number of cross-sections ranging for many years. The study is confined only to G-7 countries (United States, United Kingdom, Canada, France, Germany, Italy, and Japan). This confinement is relevant in the sense that these countries have closer economic ties, and the shocks generated in any of these countries will have direct impact on the economies of other countries. For the estimation, we use quarterly data ranging from 1980Q1 to 2009Q2. The variables used are: real GDP, real effective exchange rates and GDP deflator. Since the quarterly flows of real GDP for U.S., CAN, JAP are not available in the IFS, they are obtained from OECD to generate consistent real GDP series for all countries. For exchange rates, we use effective exchange rates in place of ordinary exchange rates between two countries. Effective exchange rates are obtained by suitably weighing the exchange rate index for the country itself and the index of 20 other industrial countries. The justification for using such rates comes from the fact that our sample includes major industrial countries and such rates truly reflect the exchange rate behavior in these countries.

4. Empirical Results

This section summarizes the results obtained from estimating structural VAR model described in Section 3. The variables used for this estimation are: log of relative real gross domestic product (RGDP), the log of relative real effective exchange rates (REER/NEER), and the log of relative GDP deflator (DEF), of the U.S. to foreign country. Since all these variables demonstrate unit roots (Table 1), the VAR uses their first differences. The lag length in the unit root tests are determined by Ng and Perron (1995)'s approach, which supports for 4 lags[7]. The first differences transform the variables used in the VAR specification as output growth rate differential, real effective exchange rates differential, and inflation differential.

Table 1. Unit Root Tests[#]

Variables (first difference)	Augmented Dicky-Fuller (ADF) Test Statistics					
	US/CAN	US/FRA	US/GER	US/ITA	US/JAP	US/UK
loggdp	-2.61	-3.95	-3.73	-3.72	-3.49	-3.95
logreer	-2.73	-3.76	-4.13	-3.78	-4.01	-3.82
logprice	-2.93	-1.85	-2.62	-2.16	-4.07	-3.14

#Tests were conducted in the specification with intercepts with 4 lags
Critical values for 1%, 5%, and 10% are, respectively, -3.49, -2.89, and -2.58.

Before explaining the impulse responses and variance decompositions, we first summarize the expected dynamics of the variables to supply, demand and monetary shocks as implied in our model.

[7] According to this approach, we set an upper bound for p, say p_{max}, and estimate the ADF test regression with this upper bound. As suggested by Schwert (1989), the p_{max} is obtained by using the formula $p_{max}=[12.(T/100)^{1/4}]$ where T is the number of observations. When the absolute value of the t-statistic for testing the significance of the last lagged difference turns significant (as a rule of thumb greater than 1.6), p is set to be pmax, otherwise the lag length is reduced by one by one and perform this repeatedly until we have t-statistic for testing the significance of the last lagged difference becomes significant. In our test, for example, Schewert's criteria sets p_{max} as 12. t-values for the last term in ADF test for loggdp US/CAN starting from maximum 12 lags are, respectively, .09, 1.23,-0.79,-0.84,-0.17,1.41,-0.63,-1.47,1.62, which supported for 4 lags.

Table 2. Responses of relative RGDP, REER and DEF to Supply, Demand and Monetary Shocks as Suggested by the Model and Empirical Results

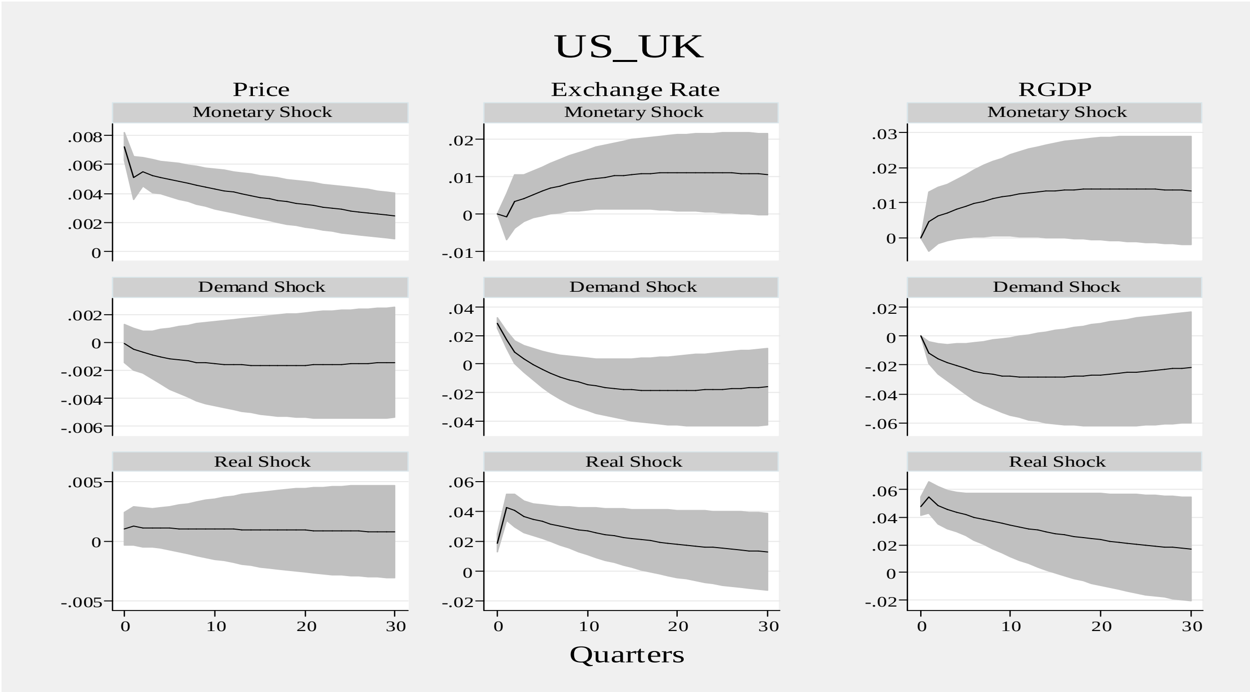
Shocks	RGDP		REER		DEF	
	Model	Actual	Model	Actual	Model	Actual
Supply (Real)	Positive	*Confirmed*	Positive	Confirmed	Negative	Contradicted (except for US/FRA)
Demand (Nominal)	Positive	Contradicted	Negative	Contradicted	Positive	Contradicted (except for US/FRA and US/CAN)
Monetary (Nominal)	Positive	Confirmed (except for US/ITA)	Positive	Contradicted (except US/UK and US/FRA)	Positive	Confirmed

As shown in Table 2, the model described in the previous section predicts that the response of relative output in response to all three shocks is positive. The relative real effective exchange rates, on the other hand, depreciate in response to supply and monetary shocks but appreciate in response to demand shocks. The relative prices are observed positive in response to demand and monetary shocks but negative in response to supply shocks.

The impulse responses of relative U.S. real GDP, REER, and price levels to all shocks are reported in Figure 1.

The impulse responses of relative real GDP to supply shocks is mostly consistent with the predictions of the model. The impulse responses demonstrate that there is a positive response of home country's real GDP relative to foreign country's to supply shocks, which is valid for all country pairs. The one standard deviation of a supply shock, for example for the U.S./U.K pair, produces 5.0 percent increase in the U.S. real GDP relative to the U.K.'s real GDP at the beginning quarter and then the effect dies out. The relative real GDP exhibits persistence following real shocks whereas it exhibits hump-shaped in response to monetary shocks.

Figure 1. Impulse responses



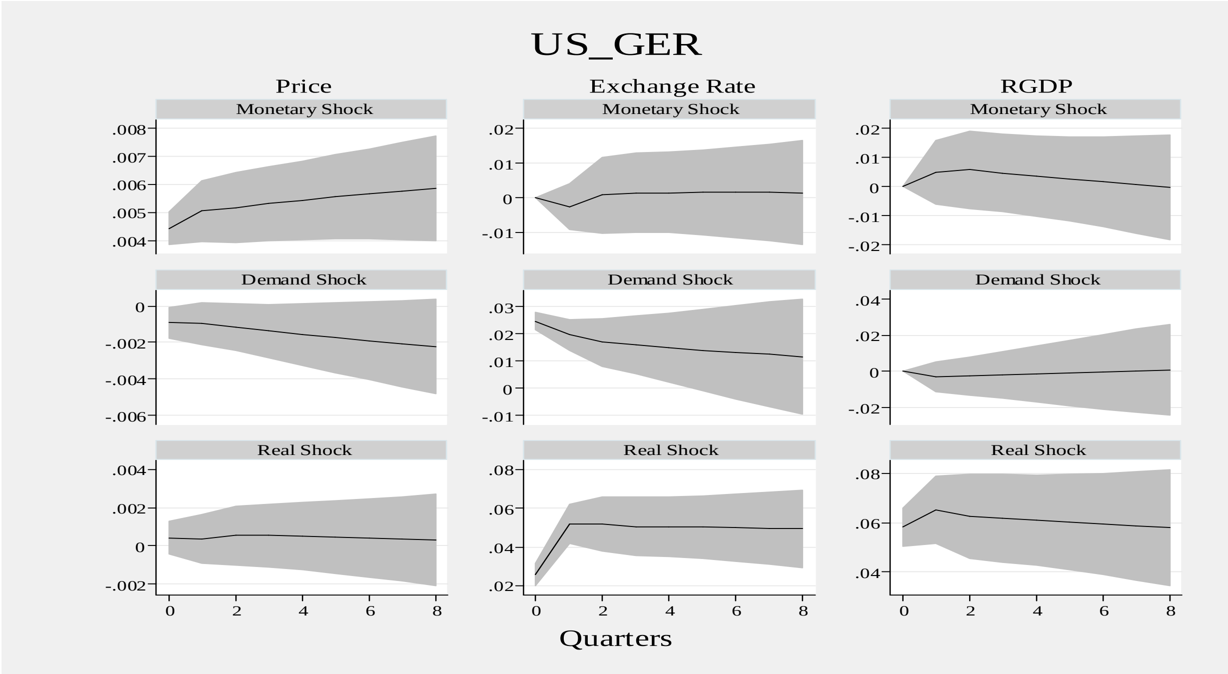
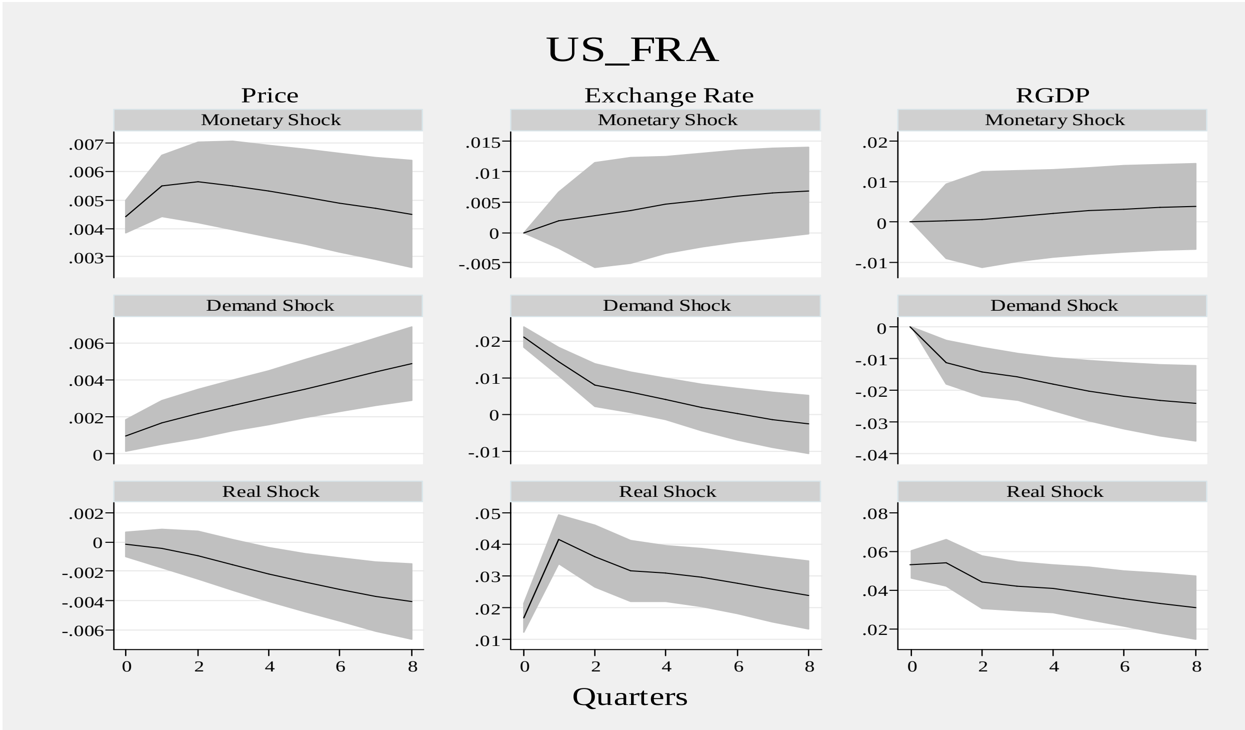


Figure 1 (continued)



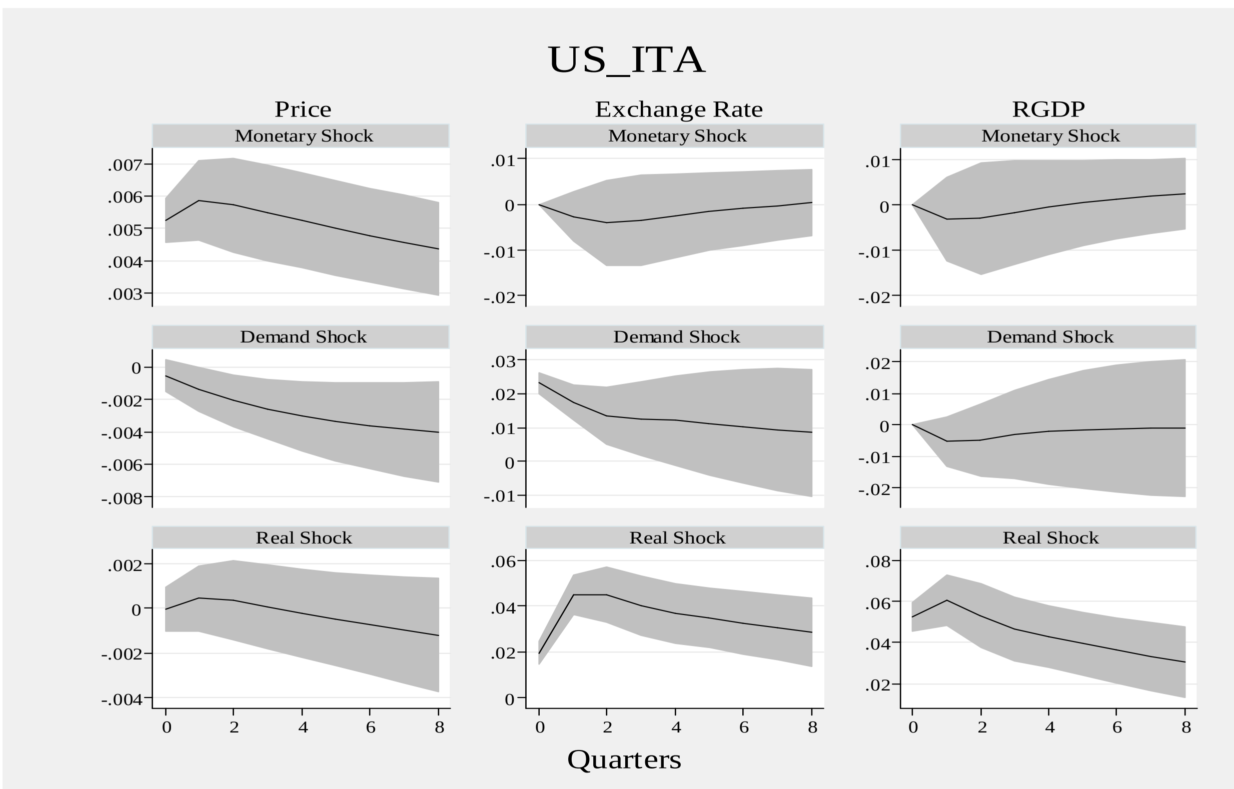
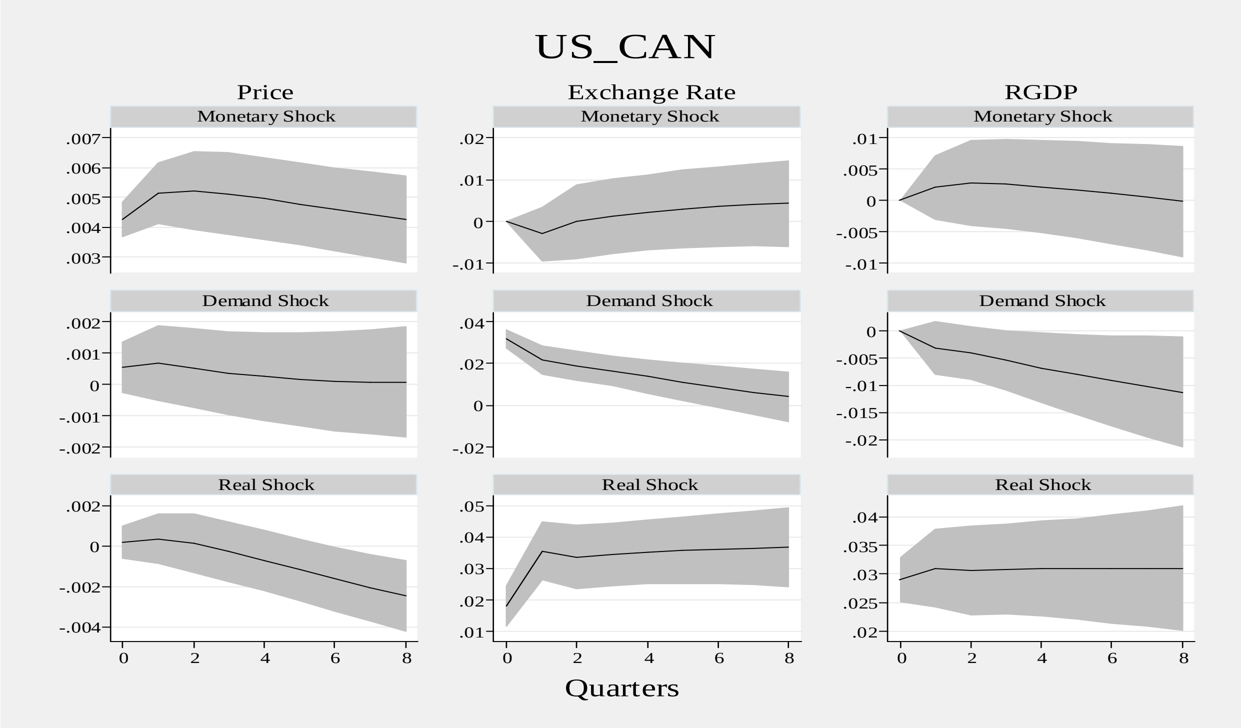
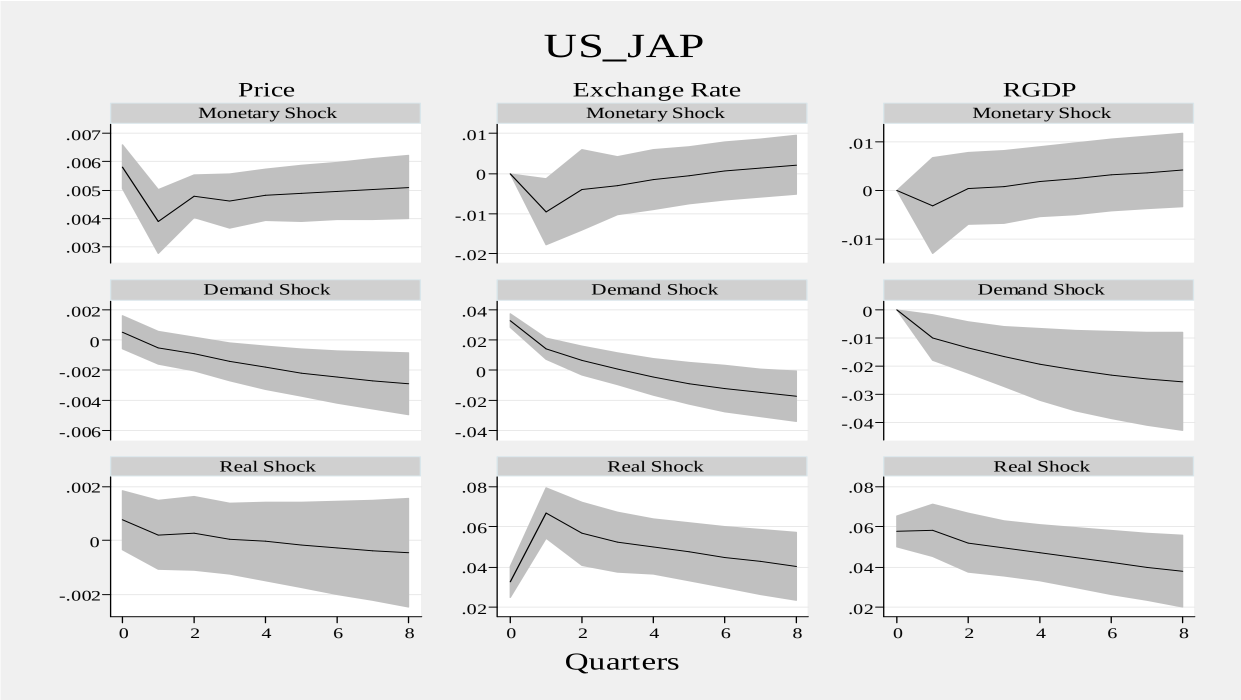


Figure 1 (continued)





The response of relative real effective exchange rates to supply shocks is also consistent with the model's predictions. The relative real effective exchange rates depreciate for all country pairs when there is a positive supply shock, a similar result as found in Stockman (1987) and Huizinga (1987). The supply shock effects on real exchange rates continues to depreciate for all time horizons, which is attributable to our identification strategy in which supply shocks have long-run effects on the real exchange rates. In response to demand shocks, however, the relative real exchange rates do not appreciate as contrary to what has been suggested by the model. This can be justified with an argument that the demand shock generated in home country resulted in higher import demand leading to home country's currency depreciation. This is convincingly possible for the open economies such as those included in our sample. The effect of demand shocks on relative real effective exchange rates contradicts with the model's prediction. The effect of monetary shocks to the real exchange rates is conformable to the model's prediction only for U.S./U.K. and U.S./France pairs, resulting in a real depreciation of home currency in response to the monetary shocks. This result is in contrary to the results as found in Mussa (1986).

The implied negative effect of supply shocks to relative prices as predicted by the model is observed only for U.S./France pair. The effect of demand shocks on relative prices leads to decrease in home country's relative price to foreign's, which contradicts the predictions of the model. The effect of monetary shocks, however, is consistent with the model for all country pairs resulting in a rise in the U.S. relative price in response to monetary shocks in the U.S.. All shocks have persistent effect on relative price levels as suggested by our long-run characteristics of the model.

The impulse responses for the U.S. against three countries France, Germany, and Italy appear somewhat problematic with regard to their conformability with the model's predictions. The reason can potentially be fact that these three countries are members of euro, and there was a regime change in these countries by participating in common euro currency beginning 1999, which certainly have effects on macroeconomic adjustment. In order to control the effect of this regime change, a dummy of regime change was introduced into the VAR estimation. , and with this new specification the impulse responses did not change significantly but the effect of monetary shocks to explain relative real effective exchange rates come closer to the model's predictions (Figure 2).

Figure 2: Impulse Responses (Regime Change)

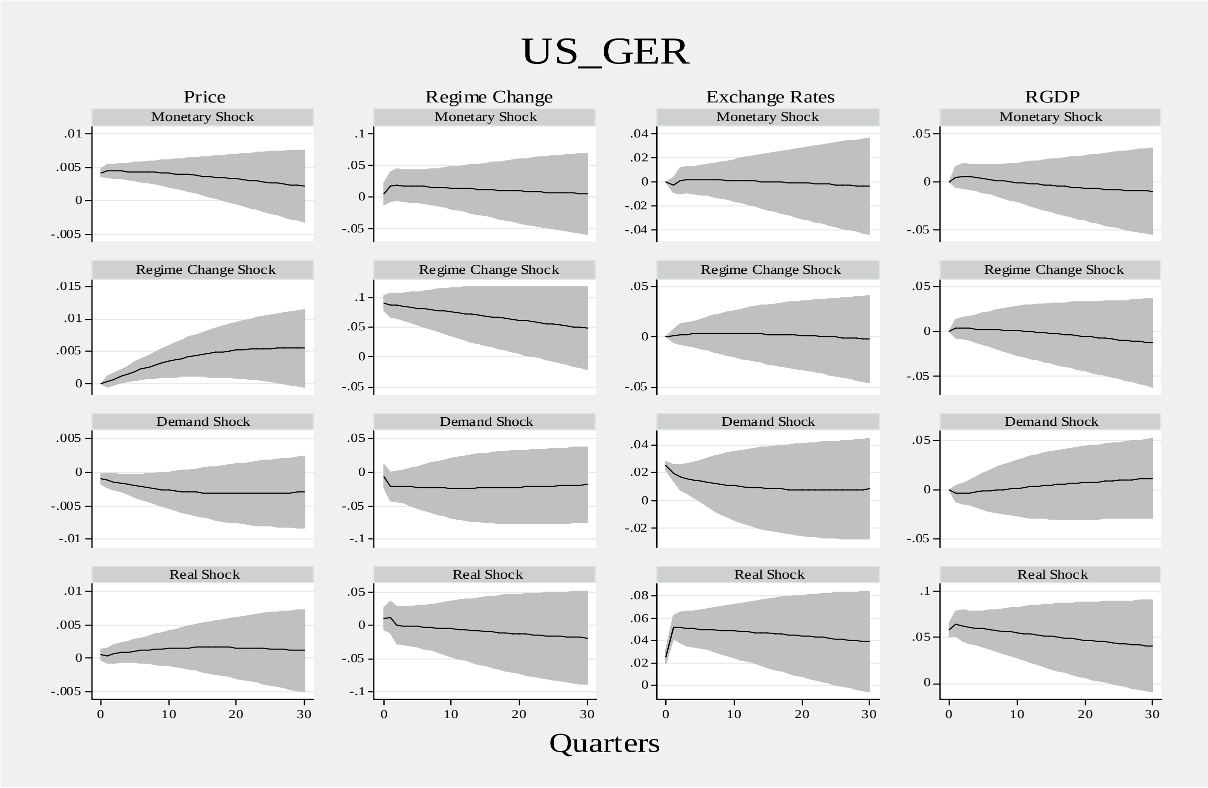
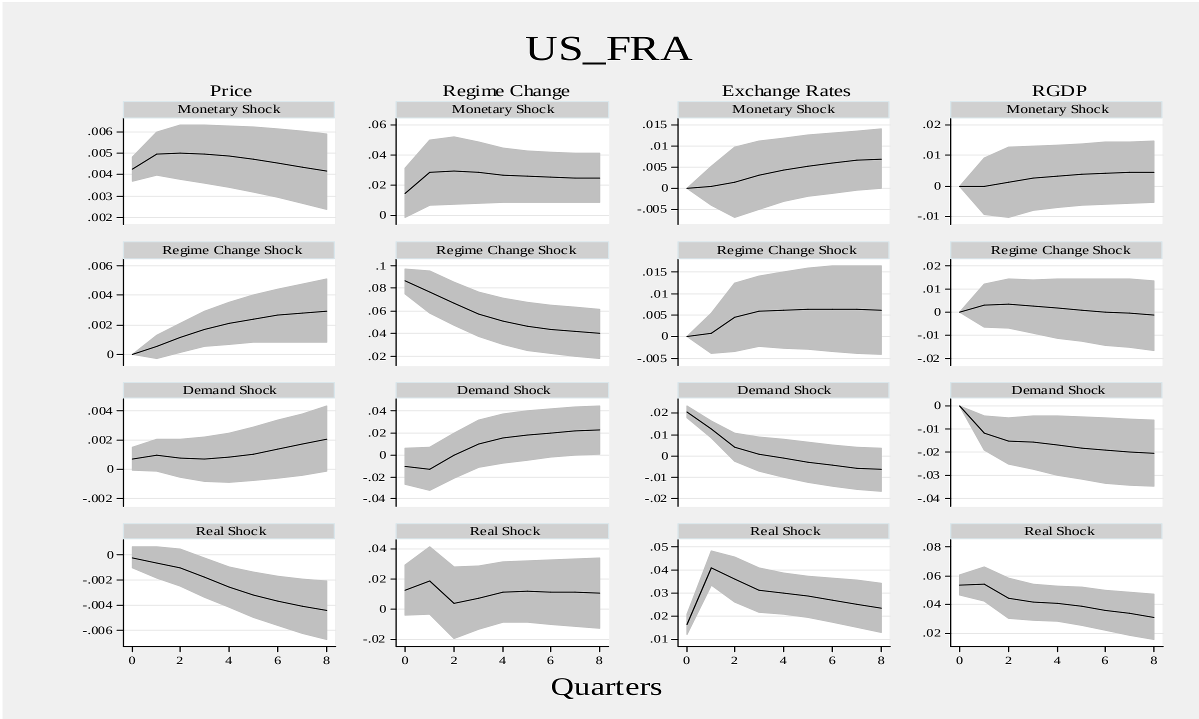
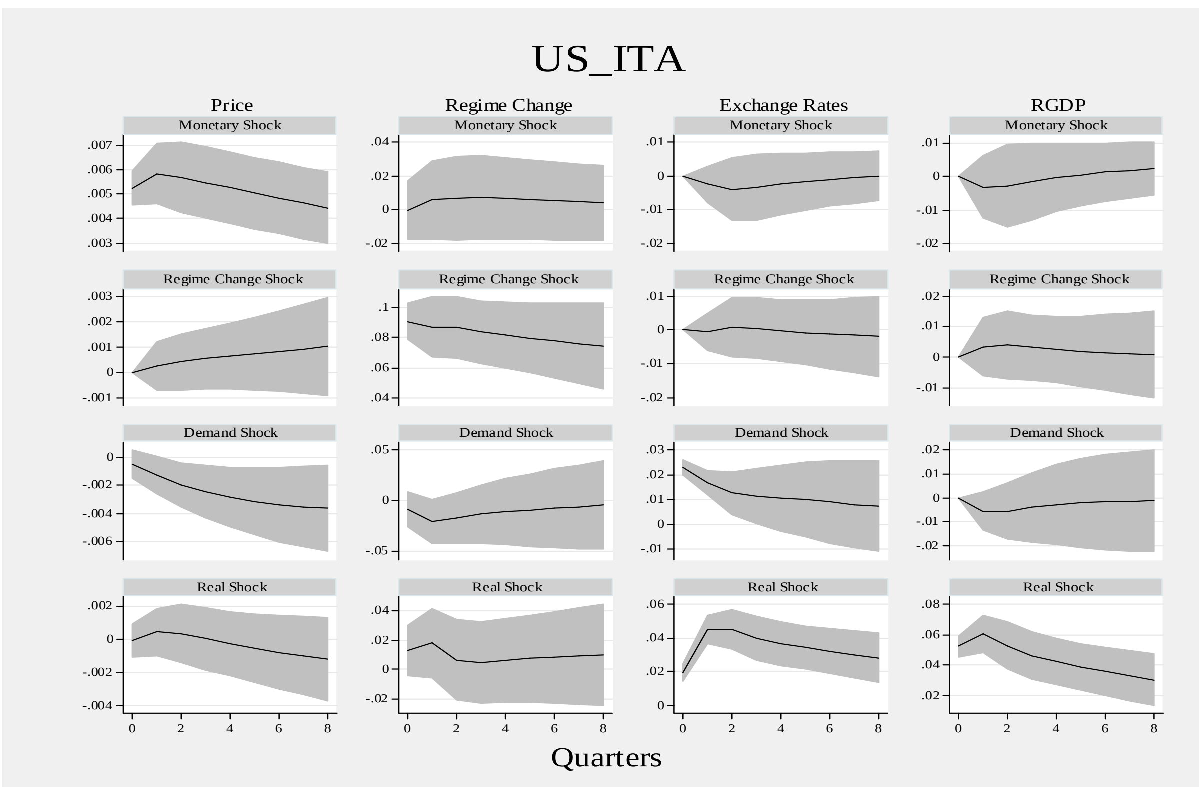


Figure 2(continued)





The variance decompositions in Table 3 demonstrate the proportion of movement of three variables included in the VAR specification as resulted from three different shocks.

Table 3. Variance Decompositions

Qtr.	RGDP			REER			Price		
	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock
0	0.97	0.03	0.01	0.14	0.85	0.02	0.03	0.00	0.97
1	0.96	0.03	0.00	0.23	0.76	0.01	0.03	0.01	0.97
2	0.95	0.03	0.02	0.24	0.75	0.01	0.03	0.01	0.96
3	0.92	0.05	0.03	0.24	0.75	0.01	0.02	0.03	0.95
4	0.89	0.07	0.04	0.22	0.76	0.02	0.02	0.07	0.92
5	0.89	0.08	0.03	0.22	0.76	0.02	0.01	0.11	0.88
6	0.89	0.08	0.03	0.23	0.76	0.02	0.01	0.15	0.84
7	0.89	0.08	0.03	0.25	0.73	0.02	0.01	0.19	0.80
8	0.90	0.07	0.02	0.28	0.71	0.02	0.02	0.22	0.76
9	0.91	0.07	0.02	0.29	0.69	0.01	0.02	0.24	0.74
10	0.92	0.07	0.02	0.30	0.69	0.01	0.02	0.25	0.72
15	0.95	0.04	0.01	0.39	0.61	0.01	0.04	0.26	0.70
20	0.97	0.03	0.01	0.46	0.54	0.01	0.05	0.25	0.70
25	0.98	0.02	0.00	0.51	0.48	0.00	0.07	0.25	0.68
30	0.98	0.01	0.00	0.55	0.45	0.00	0.08	0.26	0.66
35	0.99	0.01	0.00	0.58	0.42	0.00	0.09	0.26	0.65
40	0.99	0.01	0.00	0.60	0.39	0.00	0.10	0.26	0.64

US/CAN Pair

Table 3 – Continued

Qtrs.	RGDP			REER			Price		
	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock
0	0.79	0.20	0.02	0.08	0.92	0.00	0.04	0.00	0.96
1	0.86	0.13	0.01	0.40	0.57	0.02	0.02	0.00	0.98
2	0.91	0.09	0.01	0.50	0.47	0.03	0.01	0.01	0.98
3	0.93	0.06	0.01	0.58	0.40	0.03	0.00	0.03	0.97
4	0.94	0.05	0.00	0.63	0.35	0.02	0.00	0.05	0.95
5	0.95	0.04	0.00	0.67	0.31	0.02	0.00	0.06	0.94
6	0.96	0.03	0.00	0.70	0.28	0.02	0.00	0.06	0.94
7	0.96	0.03	0.01	0.72	0.26	0.02	0.00	0.07	0.93
8	0.96	0.03	0.01	0.73	0.25	0.02	0.00	0.07	0.92
9	0.96	0.02	0.01	0.74	0.24	0.03	0.00	0.08	0.92
10	0.96	0.02	0.01	0.75	0.23	0.03	0.00	0.09	0.90
15	0.97	0.02	0.01	0.76	0.21	0.02	0.01	0.12	0.87
20	0.98	0.01	0.01	0.78	0.20	0.02	0.01	0.14	0.85
25	0.98	0.01	0.01	0.79	0.19	0.02	0.01	0.15	0.84
30	0.99	0.01	0.01	0.80	0.19	0.01	0.01	0.16	0.83
35	0.99	0.01	0.00	0.81	0.18	0.01	0.02	0.16	0.82
40	0.99	0.01	0.00	0.81	0.18	0.01	0.02	0.17	0.82

US/GER Pair

Table 3 – Continued

Qtrs.	RGDP			REER			Price		
	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock
0	0.97	0.03	0.01	0.63	0.37	0.01	0.03	0.00	0.97
1	0.96	0.03	0.01	0.80	0.14	0.06	0.04	0.01	0.96
2	0.96	0.04	0.01	0.84	0.12	0.04	0.04	0.06	0.90
3	0.96	0.03	0.01	0.85	0.11	0.03	0.05	0.15	0.80
4	0.95	0.05	0.01	0.89	0.09	0.03	0.06	0.22	0.72
5	0.92	0.06	0.02	0.91	0.06	0.02	0.08	0.24	0.67
6	0.92	0.06	0.02	0.93	0.05	0.02	0.10	0.26	0.64
7	0.93	0.06	0.02	0.94	0.04	0.01	0.12	0.26	0.62
8	0.93	0.06	0.01	0.95	0.04	0.01	0.12	0.27	0.61
9	0.93	0.05	0.01	0.95	0.04	0.01	0.13	0.28	0.60
10	0.94	0.05	0.01	0.95	0.04	0.01	0.13	0.29	0.58
15	0.95	0.03	0.01	0.93	0.06	0.01	0.14	0.31	0.55
20	0.96	0.03	0.01	0.91	0.08	0.01	0.13	0.31	0.55
25	0.97	0.03	0.01	0.91	0.09	0.01	0.13	0.32	0.56
30	0.97	0.02	0.01	0.91	0.09	0.00	0.12	0.32	0.56
35	0.97	0.02	0.01	0.91	0.08	0.00	0.12	0.32	0.55
40	0.98	0.02	0.01	0.91	0.09	0.00	0.12	0.32	0.55

US/FRA Pair

Table 3 – Continued

Qtrs.	RGDP			REER			Price		
	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock
0	0.80	0.15	0.04	0.08	0.91	0.00	0.15	0.04	0.80
1	0.87	0.11	0.02	0.39	0.59	0.01	0.23	0.05	0.72
2	0.91	0.07	0.02	0.49	0.50	0.01	0.26	0.06	0.68
3	0.93	0.06	0.01	0.56	0.42	0.02	0.25	0.10	0.65
4	0.94	0.05	0.01	0.64	0.35	0.01	0.26	0.12	0.62
5	0.94	0.05	0.01	0.69	0.30	0.01	0.26	0.15	0.59
6	0.94	0.05	0.01	0.73	0.26	0.01	0.25	0.19	0.55
7	0.95	0.04	0.01	0.75	0.24	0.01	0.24	0.24	0.53
8	0.95	0.04	0.01	0.77	0.22	0.01	0.22	0.27	0.51
9	0.95	0.04	0.01	0.78	0.21	0.01	0.21	0.30	0.49
10	0.95	0.03	0.01	0.79	0.20	0.01	0.19	0.32	0.49
15	0.96	0.03	0.01	0.82	0.18	0.01	0.12	0.41	0.47
20	0.97	0.02	0.01	0.83	0.16	0.00	0.08	0.46	0.46
25	0.97	0.02	0.01	0.84	0.15	0.00	0.06	0.49	0.45
30	0.98	0.02	0.01	0.85	0.15	0.00	0.05	0.51	0.45
35	0.98	0.01	0.01	0.85	0.14	0.00	0.04	0.52	0.44
40	0.98	0.01	0.01	0.86	0.14	0.00	0.03	0.53	0.44

US/ITA Pair

Table 3 – Continued

Qtrs.	RGDP			REER			Price		
	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock
0	0.82	0.15	0.03	0.21	0.77	0.02	0.01	0.03	0.96
1	0.85	0.14	0.02	0.51	0.48	0.01	0.02	0.02	0.96
2	0.86	0.12	0.01	0.56	0.44	0.00	0.03	0.03	0.94
3	0.87	0.11	0.02	0.60	0.40	0.00	0.05	0.04	0.91
4	0.88	0.09	0.02	0.63	0.36	0.01	0.07	0.06	0.88
5	0.90	0.08	0.02	0.68	0.31	0.01	0.07	0.08	0.85
6	0.92	0.07	0.02	0.71	0.28	0.01	0.07	0.10	0.83
7	0.93	0.06	0.01	0.73	0.27	0.01	0.07	0.11	0.82
8	0.94	0.05	0.01	0.74	0.25	0.01	0.07	0.12	0.81
9	0.94	0.05	0.01	0.76	0.24	0.01	0.07	0.12	0.81
10	0.95	0.04	0.01	0.77	0.23	0.00	0.07	0.13	0.80
15	0.96	0.03	0.01	0.81	0.19	0.00	0.06	0.12	0.81
20	0.97	0.02	0.01	0.83	0.17	0.00	0.06	0.13	0.81
25	0.98	0.02	0.00	0.84	0.16	0.00	0.06	0.13	0.81
30	0.98	0.01	0.00	0.85	0.15	0.00	0.05	0.13	0.81
35	0.98	0.01	0.00	0.86	0.14	0.00	0.05	0.13	0.81
40	0.99	0.01	0.00	0.86	0.14	0.00	0.05	0.14	0.81

US/JAP Pair

Table 3 – Continued

Qtrs.	RGDP			REER			Price		
	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock	Supply Shock	Demand Shock	Monetary Shock
0	0.68	0.18	0.15	0.04	0.95	0.01	0.40	0.03	0.58
1	0.81	0.11	0.08	0.33	0.65	0.02	0.46	0.04	0.50
2	0.87	0.08	0.05	0.44	0.54	0.01	0.46	0.04	0.50
3	0.89	0.07	0.04	0.50	0.49	0.01	0.46	0.07	0.47
4	0.91	0.05	0.04	0.54	0.44	0.02	0.45	0.07	0.48
5	0.93	0.04	0.03	0.59	0.39	0.02	0.44	0.07	0.49
6	0.94	0.04	0.03	0.64	0.35	0.02	0.43	0.06	0.50
7	0.94	0.03	0.03	0.67	0.31	0.02	0.44	0.06	0.51
8	0.95	0.03	0.02	0.71	0.28	0.02	0.45	0.05	0.50
9	0.96	0.02	0.02	0.74	0.25	0.01	0.44	0.05	0.51
10	0.96	0.02	0.02	0.76	0.23	0.01	0.44	0.05	0.51
15	0.97	0.01	0.01	0.82	0.17	0.01	0.46	0.04	0.50
20	0.98	0.01	0.01	0.84	0.15	0.01	0.47	0.03	0.50
25	0.98	0.01	0.01	0.86	0.14	0.01	0.47	0.03	0.50
30	0.99	0.01	0.01	0.87	0.13	0.01	0.48	0.03	0.49
35	0.99	0.01	0.01	0.88	0.12	0.00	0.48	0.03	0.49
40	0.99	0.00	0.00	0.88	0.11	0.00	0.48	0.03	0.49

US/UK Pair

The results show that the movement in relative real GDP for all country pairs is mainly attributed to the supply shocks. In the first quarter of the relative U.S./Canada GDP, for instance, 96 percent variation of this output is explained by the supply shocks whereas only three percent and one percent variations are explained by demand and monetary shocks, respectively.

The effects of demand and monetary shocks almost vanish at the end of the period, and therefore all movement in relative real GDP is explained entirely by supply shocks.

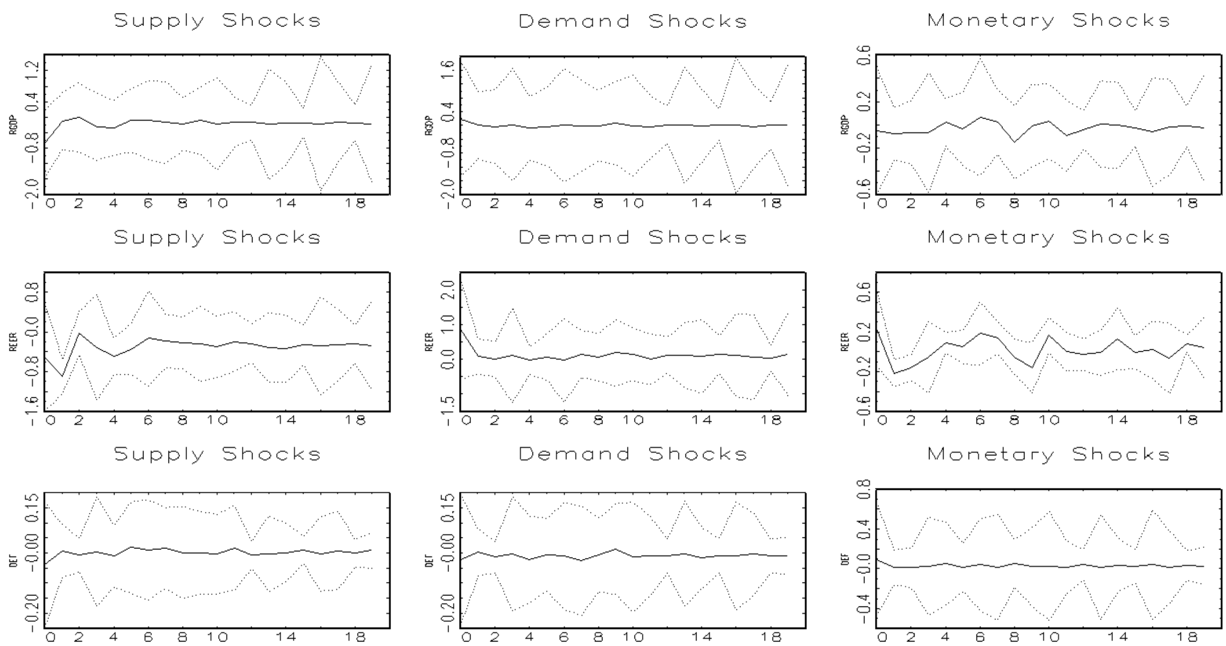
The movement in real effective exchange rates, on the other hand, is mainly governed by demand shocks. Except for the U.S./Germany country pair, more than 90 percent of variation in exchange rates in all country pairs is attributed to demand shocks. The monetary shocks do not play a major role to cause movement in relative real effective exchange rates.

Monetary shocks are dominant to explain relative price movement. More than 95 percent variation in relative price is attributed to monetary shocks for all country pairs except for U.S./Italy and U.S./UK country pairs. The demand shock, however, contributes for the most of the variation in later periods for the fluctuations of relative price level.

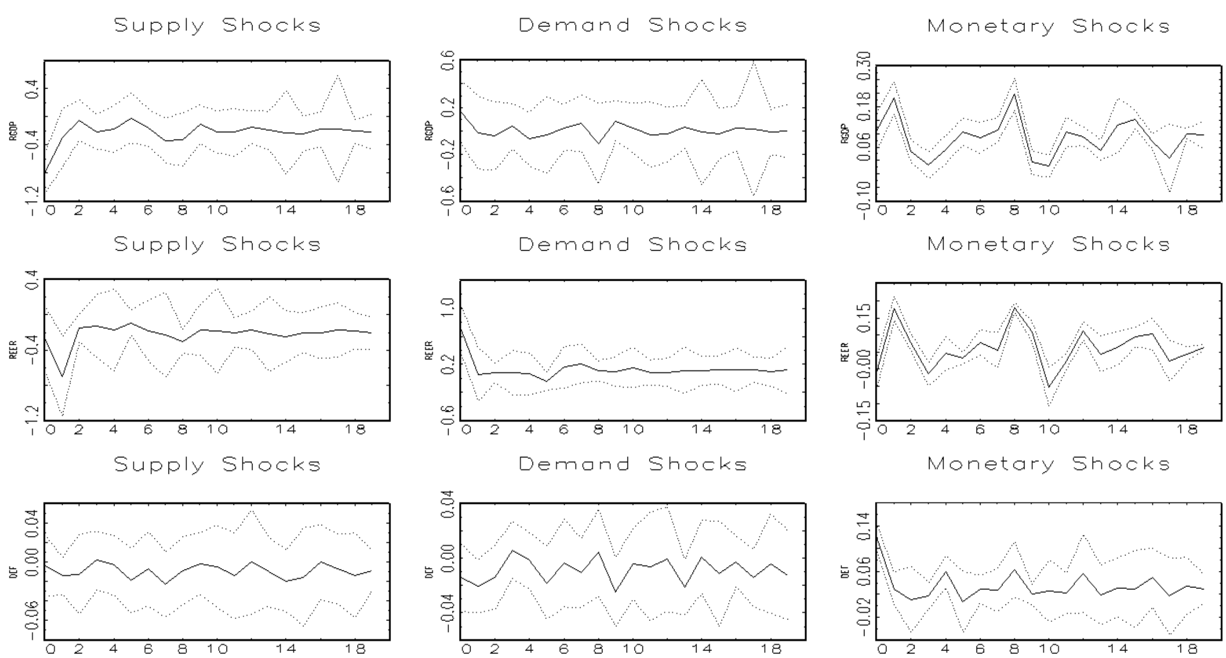
The impulse responses after applying sign restrictions from short-run dynamics of the model have been reported in Figure 3. The impulse responses demonstrate that output adjustment process is negative for all country pairs following supply shocks and vanishes after few quarters. The important thing to note here is that the impulse responses display the effects of supply shocks on the growth rate differential of real GDP between two countries, which suggests that after supply shocks in the domestic economy, the gap in growth rate differential between the U.S. and other countries narrows down. The demand and monetary shocks produces the similar convergent effect for real GDP but for most of the country pairs the impulse responses lies on the negative territory, which contradicts with the model's prediction.

Figure 3: Impulse responses (with short-run sign restrictions)

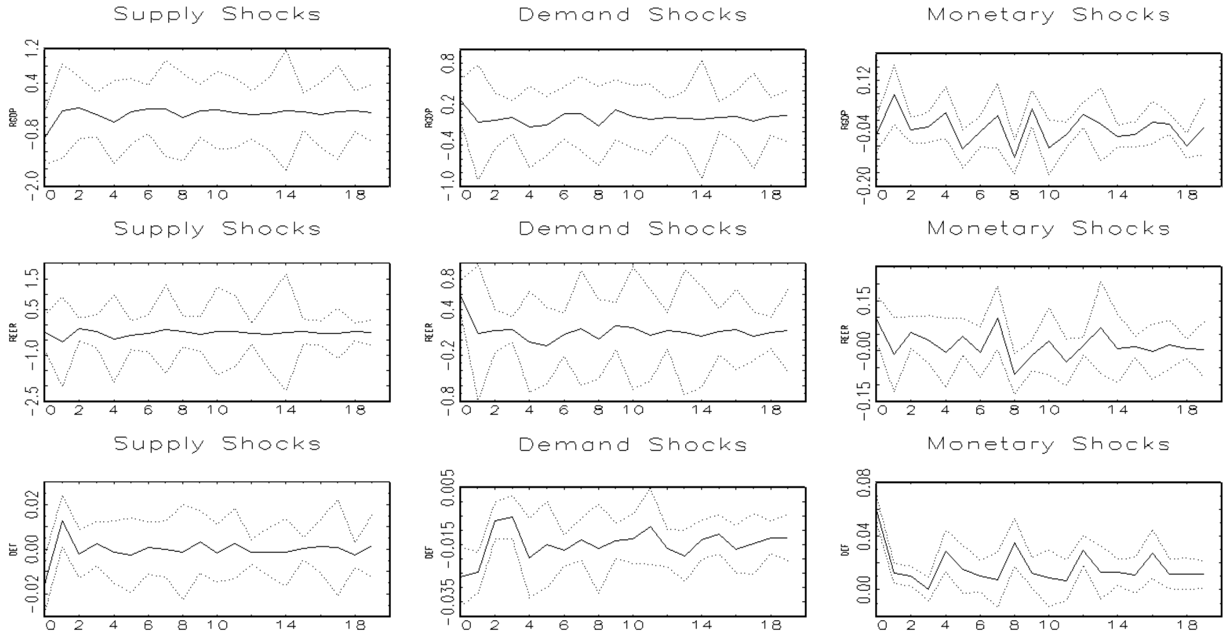
US_JAP Pair



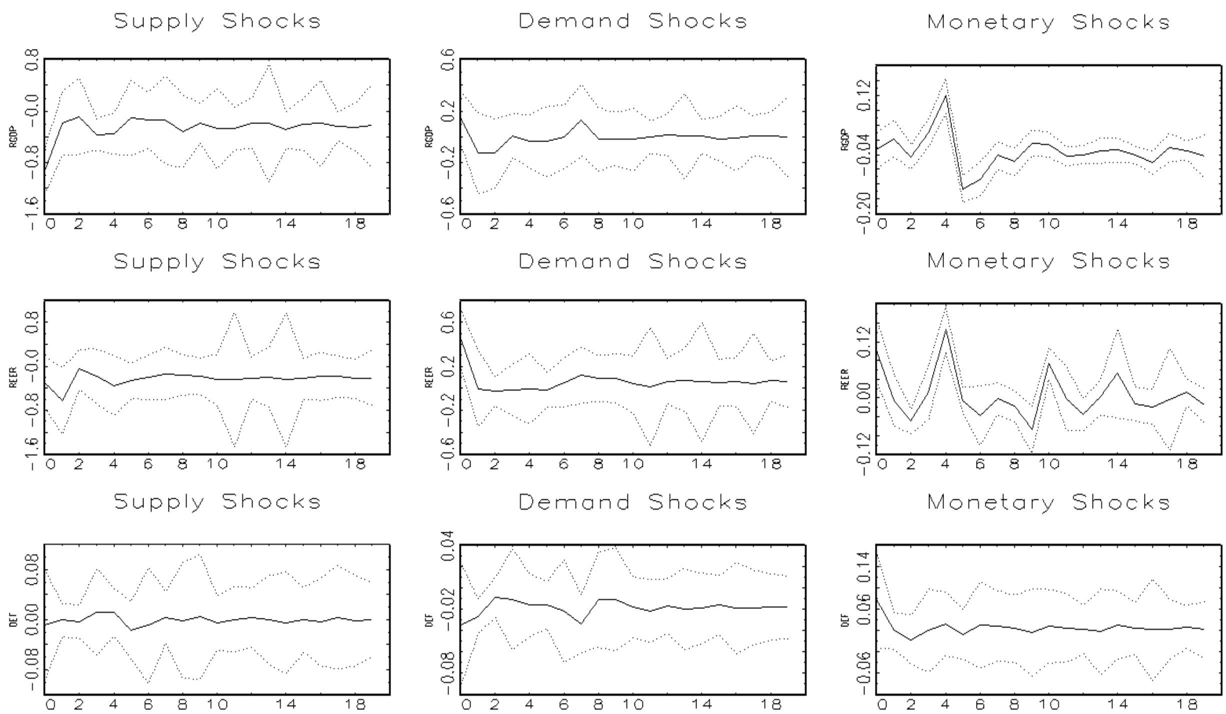
US_UK Pair



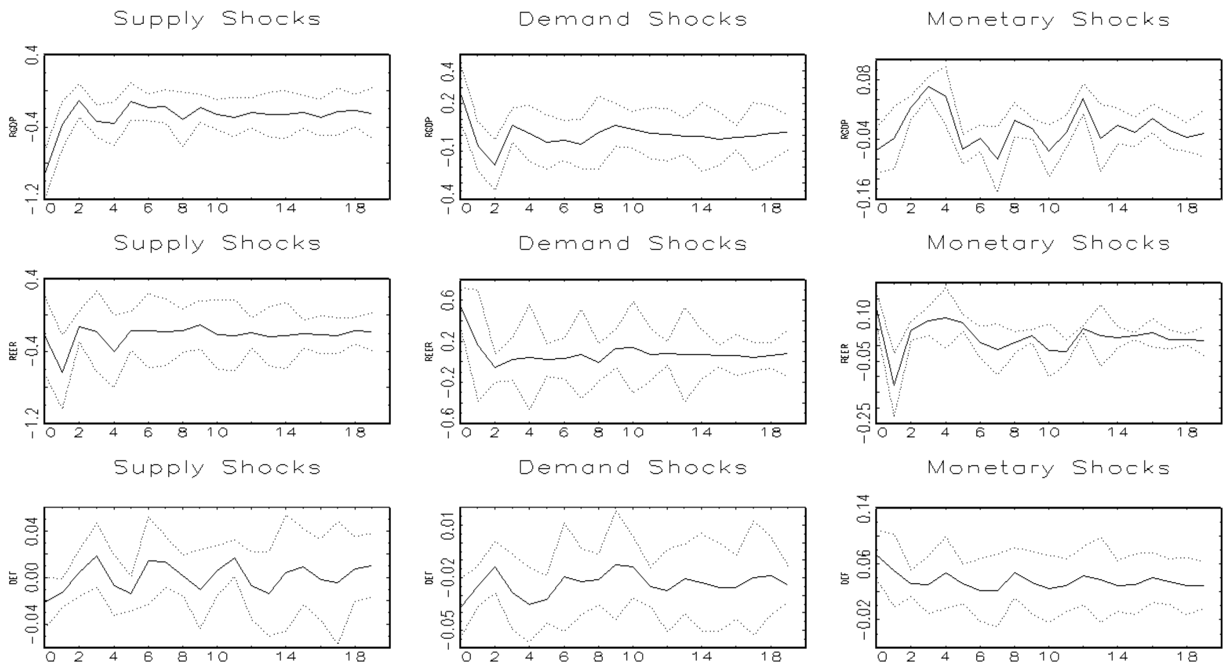
US_GER Pair



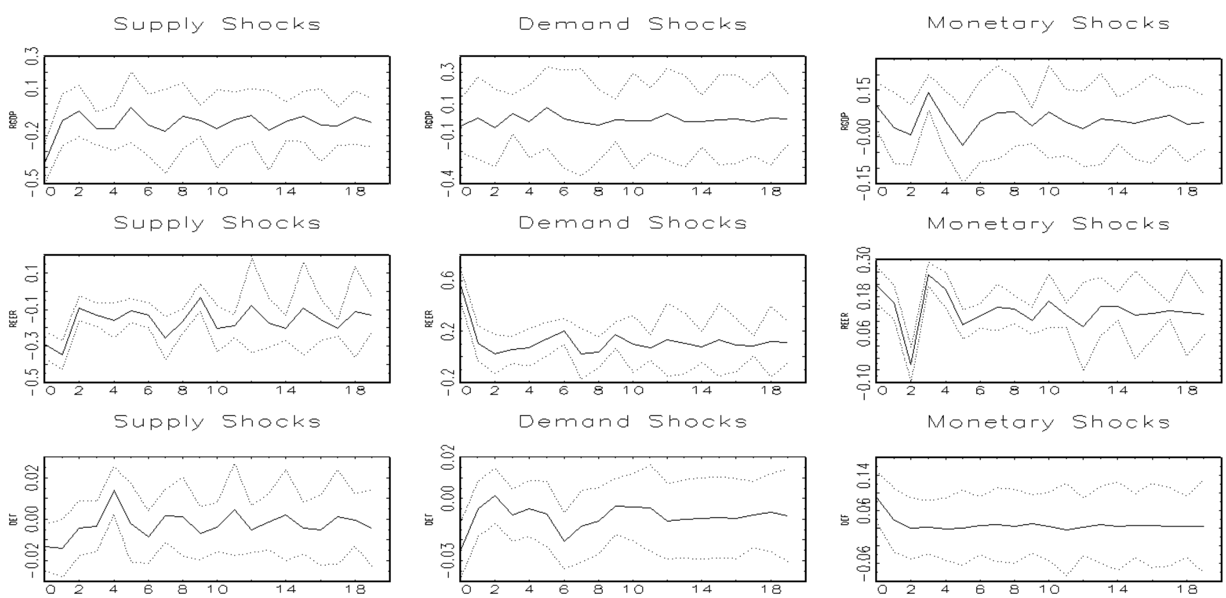
US_FRA Pair



US_ITA Pair



US_JAP Pair



For inflation rate differential, the supply shocks and monetary shocks caused positive adjustment process whereas demand shocks generated negative adjustment process for most of the country pairs. This suggests that the inflation in the U.S. remains to be lower than the inflation in other countries after supply and monetary shocks in the U.S. economy, and the opposite happens when demand shocks hit the U.S. economy. The inflation rates in both countries, however, are equalized after few quarters as shown by the convergence of the impulse responses at zero level after some quarters.

The dynamics of relative real effective exchange rates is noteworthy here. The impulse responses suggest that in most of the country pairs the appreciation rate in the U.S. from a supply shock is smaller than the appreciation rate of the foreign economy, whereas the depreciation rate of the U.S. currency is greater than the depreciation rate of the foreign currency, following demand and monetary shocks in most of the country pairs. The gap remains to be larger at the beginning and comes to the convergence at the latter periods. Following the supply shocks, the effective exchange rates temporarily falls below the long-run values as indicated by negative impulse responses for exchange rates. This indicates that not only the monetary shocks but also real shocks are attributed to generate exchange rate overshooting.

5. Conclusion

We study the effects of the U.S. real and nominal shocks on key macroeconomic variables in G-7 countries by estimating structural VAR model. The impulse responses of U.S. real GDP relative to the rest of other countries to the supply shocks are consistent with the predictions of the model, resulting in a rise in U.S.'s real GDP compared to other countries' following the supply shocks in the U.S. The relative real GDP persistently increases in response to supply shocks whereas it exhibits hump-shape in response to demand and monetary shocks.

The responses of effective exchange rates to supply shocks are also consistent with the model's predictions. The relative real effective exchange rates depreciate in all country pairs when there is a positive supply shock in the U.S. The supply shock effects on real exchange rates remains persistent for a longer period of time. In response to demand shocks, however, the exchange rates do not appreciate as contrary to the model's prediction. The effect of monetary shocks to the real exchange rates is conformable to the model's prediction in most of the country pairs resulting in real depreciation of home currency in response to the monetary shocks in the U.S..

The responses of relative prices in the U.S. relative to the prices in other countries, on the other hand, do not show consistent prediction with the model. The expected negative effect of supply shocks to relative prices as predicted by the model is observed only for U.S./Canada pair. The effect of monetary shocks, however, are consistent with the model for all country pairs resulting in a rise in the U.S.'s relative prices in response to monetary shocks in the U.S..

The variance decompositions show that the movement in relative real GDP for all country pairs is mainly attributed to the supply shocks. The movement in real effective exchange rates, on the other hand, is mainly governed by demand shocks, whereas monetary shocks are dominant to explain relative price movement.

After applying sign restrictions in disequilibrium dynamics, the gap in growth rate differential in real GDP between the U.S. and other countries narrows down following a supply shocks in the U.S., but following the demand and monetary shocks the growth rate of real GDP in the U.S. economy is higher than the growth rate of real GDP in rest of the countries. For the differential in inflation rates, the domestic inflation falls shorter than the foreign inflation after supply shocks in the U.S., and the opposite happens when demand and monetary shocks hit the

U.S. economy. The exchange rates demonstrate a noteworthy behavior following the supply shocks, resulting in most of the country pairs a smaller appreciation rate in the U.S. than the appreciation rate in the foreign economy at the beginning and this effect dyes out after few quarters. This suggest that not only monetary and demand shocks cause exchange rate overshooting but supply shocks are also attributable for exchange rate overshooting.

While this study provides fresh account of explaining transmission effects of U.S. real and nominal shocks beyond international borders, the study is not free of shortcomings. The effects of U.S. shocks on international macroeconomic variables through terms trade and interest rate differentials have been ignored in this study. By addressing this issue, a realistic transmission mechanism of the effects of shocks from one country to other countries is expected.

CHAPTER 3

INTERNATIONAL TRANSMISSION OF U.S. FINANICAL SHOCKS

1. Introduction

The world had recently been passed through a severe economic crisis that led to a severe contraction in output and hardship for millions of people around the globe. While there is no doubt that the unfettered expansion of the US housing market was behind the trigger of this crisis, the question still unresolved is how a trouble in such a small sector of the economy can actually pushed the entire world into such a big chaos. This question indeed led us to ponder over how the financial crisis emerged in the U.S. transmitted its effects all over the U.S. and in the entire world. We investigate this question by estimating a vector autoregression (VAR) model and identify the U.S. financial shocks and observe their effects on domestic as well as on the G-7 macroeconomic variables. In our benchmark estimation, we closely observe the behavior of stock prices and federal funds rate for a daily data starting from 1957. This basic specification is then extended to observe the effects of U.S. financial shocks to other U.S. and international macroeconomic variables. The identification strategy we apply in this study for the VAR estimation is similar to Kim (2001).

The benchmark results show that the financial shocks in the stock market has no any definite effect on the behavior of federal funds rate, which is customary believe that Federal Reserve does not respond to stock market volatility in the very short-run. The effect of monetary policy shocks, however, exerts a negative effect on stock prices, and the effects die out after 10 days. Other U.S. macroeconomic variables also exhibit expected responses following the shocks on the U.S. financial system. The positive innovation to U.S. financial stress index (FSI), for example, has negative impact on U.S. real GDP and industrial production. The difference between asset and liabilities, which can be defined as capital requirements, on the other hand, also respond negatively with financial shocks, which support the evidence that banks face dire capital crunch following the crisis. The international transmission effect of U.S. financial shocks is also in line with the expectation, leading to a decline in the real GDP in the rest of G-7 countries following a financial stress in the US. This shock also leads to a decline in the interest rates in all other countries, showing that other countries follow the U.S. policy of reducing interest rates after crisis happens in the U.S.. The stock prices decline in other countries as well when the U.S. economy is hit by financial shocks.

Rest of the paper is organized as follows: Section 2 describes the literatures. Section 3 provides an account of methods used to address the research question posed. Results are discussed in Section 4. Section 5 concludes.

2. Literatures

Past studies have shown that the volatility in aggregate economy is tightly linked with the volatility in financial sector. The nature of link is procyclical (Borio (2007), Goodhart (1996), and Minsky (1992)) resulting in a decline in economic activities when financial crisis hits the economy. The economy may often distort when there is an abrupt correction mechanism is pursued.

One of the possible reasons why an economy fluctuates in conjunction with the development in financial sector is because of the significant role of financial accelerator which reinforces the effects of financial cycles on the real economy by changing the values of collateral that ultimately affect the willingness of the financial system to make available of the credit. (Bernanke and Gertler (1995), Bernanke, Gertler, and Gilchrist (1999), and Kiyotaki and Moore

(1997). The financial shocks, according to this hypothesis, are transmitted their effects into the economy by changing the creditworthiness of the borrowers.

The effect of financial accelerator, however, varies with the characteristics of financial system (Rajan and Zingales (2003)). The financial system where the finance is based on the principle that the buyers and sellers act independently without having strong relationship between them will have more absorbing capacity for any financial stress than the financial system where the parties are more dependent and made their transaction based on their relationship.

Other studies focus on the role of changes in lenders' balance sheets as a mechanism to affect the real sector of the economy after financial crisis. According this approach, the crisis changes the level of capital in the banking system, which affects the lending ability of banks and then the overall aggregate macroeconomic activities are affected (Bernanke and Lown (1991), Kashyap and Stein (1995), and Gambacorta and others (2007)). Banks become reluctant and unable too, in this situation to extend their loans.

The transmission effect of financial shocks is not only confined to a single country; it has a tremendous cross-border effect as evidenced by the global spillover effect we witnessed recently. The past two decades have characterized by a substantial cross-border financial integration leading to a smooth transmission of financial shocks from one country to another. When accounted for direct wealth effect and indirect expectation-driven effect, shocks that originate in a large foreign stock market may have non-trivial effects on other open economies that may go up to about 10 to 20% of aggregate output fluctuations (Milani (2010)). Such effects would become even larger when valuation channel of external adjustment is taken account of (Obstfeld (2004) and Ghironi et al. (2006)). According to this approach, the two-way holdings of foreign assets have substantially increased in recent years due to increased financial integration across countries and valuation of such assets changes significantly due to a change in exchange rate and asset prices leading to the scope for analyzing the transmission effects of financial shocks to other economies through valuation channel of external adjustment. Other studies have taken account of international equity trading in which households are allowed to choose a portfolio of both home and foreign equities and such a situation lead to the vulnerability of income and profit situations of domestic economies when financial shocks occurs even in other economy (Engel and Matsumoto (2006)).

In view of such a tremendous role of financial sector to affect macroeconomic activities, a great deal of debate has surfaced recently regarding whether central banks should include stock prices in their monetary policy rule so that the financial sector would be appropriately addressed in monetary policy-making[8]. Svensson (2000) claims that exchange rate cannot be directly included into the monetary policy rule because output has already been included. Smets and Wouters (2002), however, find it worthwhile to include exchange rate in monetary feedback rule when economy becomes more open. Rogoff (2004, 2006) make aware of not including exchange rate into the rule as it can lead to the possible speculation. Moreover, exchange rates are more volatile and thus cannot be a good candidate for fitting it to the policy rule. For the same reason including asset prices has also become questionable.

The role of financial cycles to a change in the path of economic activities is not free of controversy, however. The emphasis on the role of assets prices as a predictor of aggregate economic activities during 1990s emerged as a result of the disappointment over the failure of monetary aggregates to forecast the turbulence during 1970s and 1980s. The relationship

[8] Literatures attempting to address this issue include Svensson (2000), Taylor (2001), Smets and Wouters (2002), Rogoff (2004, 2006), Nistico (2005), and Castelnivo and Nistico (2010), among others.

between financial sector and real economy has, therefore, been considerably unstable depending on when the relationships were attempted to be established and also for what countries. (Stock and Watson (1993)).

Bernanke and Gertler (2001), on the other hand, have a view that central bankers should respond to asset prices only when the volatility in asset prices only affect the central banks' inflation forecasting. When inflation targeting is in place for an economy, which is in fact a preferred policy regime for most of the central banks at present, it already accounts for asset price volatility for the monetary policy implication. When the predictive content of asset prices for inflation has been accounted for through inflation targeting, there should be no need of additional response of monetary policy to asset price fluctuations.

The literatures above suggest that there is an unresolved question how financial sector vulnerability in one country can affect domestic and international macro economy, and this study is an attempt of answering this question.

3. Methodology

3.1 The VAR Model

As being a purely empirical work, this study explores the effects of U.S. financial shocks on the U.S. macroeconomic variables as well as on the macroeconomic variables of G-7 countries by estimating a vector autoregressive (VAR) model. We follow the approach adopted by Kim (2001), according to which we estimate a benchmark VAR for domestic variables at first and then add foreign variables one-by-one in other VAR specifications. The model is as follows:

The economy is described by a following structural equation

$$K(L)x_t = e_t \qquad (1)$$

where x_t is $n \times 1$ data vector which includes the variables described below and K(L) a matrix polynomial in lag operator L. e_t is a $n \times 1$ vector of structural innovations where Var(e_t) = Ω. Ω is a diagonal matrix with variances of structural innovations on the diagonal.

The following reduced-form model is estimated

$$x_t = Q(L)x_{t-1} + u_t \quad (2)$$

where K(L) is a matrix polynomial in lag operator L and $Var(u_t) = \sum$.

Assuming that B be the contemporaneous coefficient matrix and $K_0(L)$ be the coefficient matrix in $K(L)$ without the contemporaneous coefficient matrix B, such that

$$K(L) = B + K_0(L) \quad (3)$$

Then the structural model is linked to the reduced-form model as

$$Q(L) = -B^{-1} K_0(L) \quad (4)$$

The structural innovations and reduced-form disturbances, and their variance-covariance matrices are linked as

$$Bu_t = e_t \quad (5)$$

$$B\Sigma B' = \Omega \quad (6)$$

The identification is achieved by Cholesky decomposition of variance-covariance matrix of reduced-form residuals $\sum$, which makes B matrix as triangular matrix.

3.2 Data

The major source of data is International Financial Statistics (IFS) published by International Monetary Fund (IMF). The study is confined only to G-7 countries (United States, United Kingdom, Canada, France, Germany, Italy, and Japan). This confinement is relevant in the sense that these countries have closer economic ties, and the shocks generated in any of these countries have significant impact on other economies in the this group. We first analyze the co-movement between federal funds rate and stock prices, and the source of data for this analysis is St. Louis Fed's daily federal funds rate (FFR) and SP500 Index (SP500) starting from January 7, 1957 through September 23, 2010. For all other estimations, we use quarterly data ranging from 1993Q4 to 2010Q1. The starting point for the data was chosen as 1993Q4 because U.S. financial stress index, one of the major variables in the study, is available starting from this date. Next, we estimate the VAR model for U.S. macroeconomic variables, which includes the variables real GDP (RGDP), GDP deflator (DGDP), Federal Funds Rate (FFR), financial stress index (FSI), U.S. share price index (SP), Industrial Production Index (seasonally adjusted) (IP), Consumption (CONS), Investment (INV), Claims on Private Sector (CPS), and international variables such as Terms of Trade (TT), Foreign Exchange Reserves (FEX), Security Holdings of Non-residents (SEC_NR) (which is available only up to 2007Q3), and Real Effective Exchange Rates (REER). The international macroeconomic variables for G-7 countries include real GDP (RGDP), short-term interest rates (R), and share price index (SPI), with corresponding country names for each of the variables. The source of all these data is International Financial Statistics (IFS). For exchange rates, we use effective exchange rates in place of ordinary exchange rates between two countries. Effective exchange rates are obtained by suitably weighing the exchange rate index for the country itself and the index of 20 other industrial countries. The justification for using such rates comes from the fact that our sample includes major industrial countries and such rates truly reflect the exchange rate behavior among these countries.

The financial shock in the U.S. is measured by St. Louis Fed's Financial Stress Index (FSI). This measure has been constructed by using principal components analysis, according to which financial stress is extracted by assuming that it is a primary factor influencing a co-movement of a group of variables (there are 18 variables in consideration and among them are effective federal funds rate, Baa-rated corporate, J.P. Morgan Emerging Markets Bond Index Plus, 3-month London Interbank Offering Rate–Overnight Index Swap Spread, Corporate Baa-rated bond minus 10-year Treasury, Chicago Board Options Exchange Market Volatility Index, to name a few). All these 18 variables capture some aspect of financial stress, and when the level of financial stress in the economy changes, these variables are likely to move together. It is assumed that financial stress is the most important factor in explaining the comovement of these 18 variables. Higher values of the FSI indicate a greater degree of financial stress in the economy and vice versa.

Table 1: Unit Root Test#

U.S. Macroeconomic Variables				International Macroeconomic Variables					
Var.	ADF Stat.	Var.	ADF Stat.	Var.	ADF Stat.	Var.	ADF Stat.	Var.	ADF Stat.
RGDP	-2.98	INV	-3.81	RGDP_CAN	-3.24	R_CAN	-3.90	SP_CAN	-3.14
DGDP	-3.08	CPS	-2.68	RGDP_FRA	-2.54	R_FRA	-2.89	SP_FRA	-2.34
FFR	-1.46	TT	-1.51	RGDP_GER	-2.73	R_GER	-2.89	SP_GER	-2.92
FSI	-3.67	FEX	-3.03	RGDP_ITA	-2.46	R_ITA	-3.72	SP_ITA	-2.91
SP	-2.75	SEC_NR	-1.84	RGDP_JAP	-3.52	R_JAP	-5.29	SP_JAP	-3.59
IP	-2.39	REER	-3.03	RGDP_UK	-3.10	R_UK	-3.61	-	-

#All variables are in log difference except FFR and FSI. Short-term interest rates for rest of G-7 countries are in first difference. Tests were conducted in the specification with intercepts and 5 lags
Critical values for 1%, 5%, and 10% are, respectively, -3.54, -2.91, and -2.59.

Before estimating VAR, all these variables were tested for unit roots (results are reported in Table 1). Ng and Perron (1998)'s lag length test supported for 5 lags for unit root tests (Schwert's criteria sets 10 as the maximum lag, and t-value for last equation in ADF test for 5 lags is 2.00).

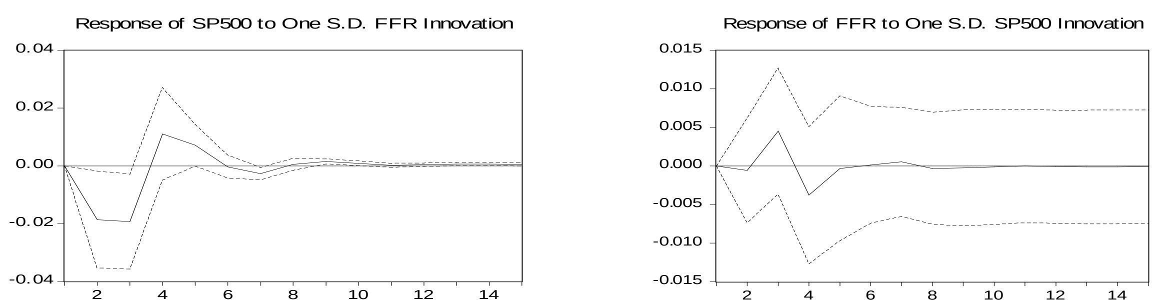
4. Empirical Results

4.1 Interplay between Federal Funds Rate and Stock Prices

We start out our analysis by observing the behavior of federal funds rate and U.S. stock prices. The interaction between these two variables can be characterized as the first interrelationship that we can analyze between financial sector and the macro economy in the United States. The behavior is observed by estimating a VAR for the daily data starting from January 7, 1957 to September 23, 2010. An identification strategy to estimate the VAR is Cholesky decomposition, according to which we assume federal funds rate do not have contemporaneous effect on stock prices in one specification and other way around in another specification as shown below.

$$\begin{bmatrix} 1 & 0 \\ b_{21} & 1 \end{bmatrix}\begin{bmatrix} FFR_t \\ SP_t \end{bmatrix} = K_0(L)\begin{bmatrix} FFR_{t-1} \\ SP_{t-1} \end{bmatrix} + \begin{bmatrix} e_{t,FFR} \\ e_{t,SP} \end{bmatrix} \text{ and } \begin{bmatrix} 1 & 0 \\ b_{21} & 1 \end{bmatrix}\begin{bmatrix} SP_t \\ FFR_t \end{bmatrix} = K_0(L)\begin{bmatrix} SP_{t-1} \\ FFR_{t-1} \end{bmatrix} + \begin{bmatrix} e_{t,SP} \\ e_{t,FFR} \end{bmatrix} \quad (7)$$

Figure 1: Interplay between Federal Funds Rates and Stock Prices



The results are shown in Figure 1. Stock prices respond negatively to the monetary shock (that is, the shock on federal funds rate), and the effect of shocks dies out after about ten days. This result is consistent with the evidence that stock market responds immediately with decreasing stock prices when there is an announcement of raising federal funds rate by the Fed and an increase in stock prices with Fed's policy announcement of lowering interest rates. The second panel of the figure, however, demonstrates that the response of Fed is not definite when there a shock in stock prices. This is in consistent with Fed's behavior that the Fed is reluctant to react stock market variations immediately but Fed adopts the policy of wait and see until the Fed feels that stock market vulnerability may affect its implicit inflation target (as suggested in Bernanke and Gertler (1999, 2001)). The behavior of like this has implication for the ordering of the variables in our extended system below, where there is a logical reason why we put stock market variables after federal funds rate.

4.2 Transmission Effects to Other U.S. Macroeconomic Variables

We now extend our analysis to observe the effects of U.S. financial shocks to U.S. macroeconomic variables. For the identification of financial shocks, we again adopt a recursive scheme as suggested by Sims (1980) and applied in Kim (2001). We apply this approach in the basic system first and add new variables one-by-one in the extended systems so that the impulse responses of the variables in the basic system does not change even in the extended system which validates that the financial shocks were appropriately identified.

Basic Scheme

The system with domestic macroeconomic variables comprises real GDP (RGDP), GDP deflator (DGDP), Federal Funds Rate (FFR), financial stress index (FSI) and U.S. share price index (SP). Two recursive frameworks are used taking account of two different financial variables FSI and SP, and the ordering of the variables in the basic system are (RGDP, DGDP, FFR, FSI) and (RGDP, DGDP, FFR, FSI, SP) as shown in the following specifications:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 \\ b_{41} & b_{42} & b_{43} & 1 \end{bmatrix} \begin{bmatrix} RGDP_t \\ DGDP_t \\ FFR_t \\ FSI_t \end{bmatrix} = K_0(L) \begin{bmatrix} RGDP_{t-1} \\ DGDP_{t-1} \\ FFR_{t-1} \\ FSI_{t-1} \end{bmatrix} + \begin{bmatrix} e_{t,RGDP} \\ e_{t,DGDP} \\ e_{t,FFR} \\ e_{t,FSI} \end{bmatrix} \quad (8)$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ b_{51} & b_{52} & b_{53} & b_{53} & 1 \end{bmatrix} \begin{bmatrix} RGDP_t \\ DGDP_t \\ FFR_t \\ FSI_t \\ SP_t \end{bmatrix} = K_0(L) \begin{bmatrix} RGDP_{t-1} \\ DGDP_{t-1} \\ FFR_{t-1} \\ FSI_{t-1} \\ SP_{t-1} \end{bmatrix} + \begin{bmatrix} e_{t,RGDP} \\ e_{t,DGDP} \\ e_{t,FFR} \\ e_{t,FSI} \\ e_{t,SP} \end{bmatrix} \quad (9)$$

The specifications above indicate that the real sector reacts sluggishly to monetary policy and financial shocks (federal funds rate, financial stress index, and stock price index) (first and second equations). It is a customary assumption that real GDP and prices respond to monetary shocks with a lag (Christiano et al. (1996, 1998)). For instance, within the quarter firms do not change their output and prices in response to unexpected changes in monetary policy due to adjustment costs. The argument for the sluggish response of real sector to financial sector, on the other hand, comes from the fact that when the response of monetary policy to financial sector is not immediate (as evidenced by the analysis in the first part of this section) the real sector also responds sluggishly to the financial variables. This assumption is also consistent with the belief that monetary authority is reluctant to react financial sector developments promptly but rather wait for some time and appropriately respond when needed (Bernanke and Gertler (1999, 2001)). The financial variables as being an asset price or the proxy of asset prices, however, react immediately to changes in all the other variables in the system (third, fourth and fifth equations).

The inclusion of financial stress index in the specification above requires more theoretical justification. Cecchetti et al. (2002) simulate a similar model as Bernanke and Gertler (1999, 2001) and find that a central bank that recognizes a bubble in the dynamics of the stock market should react to it. This conclusion was based on simply adding a reaction to stock prices in Taylor rule that helps reduce overall volatility in the economy. Bjornland and Leitemo (2009), on the other hand, analyze the interdependence between US monetary policy and the S&P 500 using structural vector autoregressive (VAR) methodology. Bjornland and Leitemo (2009) uses the similar short-run identification strategy as used in this study. The study found a great interdependence between the interest rate setting and real stock prices. Real stock prices immediately fall by seven to nine percent due to a monetary policy shock that raises the federal funds rate by 100 basis points. A stock price shock increasing real stock prices by one percent leads to an increase in the interest rate of close to 4 basis points. Also in support for the necessity of stock market behavior to be accounted for when analyzing the dynamics of aggregate economy, Castelnuovo E. and S. Nistico (2010), in an estimation of DSGE model, find that there is a significant impact of stock prices on real activity and business cycles, and their estimation also identify a significant and counteractive Fed response to stock-price fluctuations.

Table 1: Results on Cross Validation

Dependent Variables in VAR	Root Mean Squared Error (RMSE)		Mean Absolute Error (MAE)		F-Statistics*	
	Model with FSI	Model without FSI	Model with FSI	Model without FSI	Model with FSI	Model without FSI
RGDP	0.968	0.975	0.502	0.437	9.93 (0.00)	2.53 (0.01)
DGDP	0.855	0.852	0.302	0.306	2.23 (0.03)	2.43 (0.03)
FFR	3.521	4.018	2.643	3.559	350.88 (0.00)	273.35 (0.00)
FSI	1.427	-	1.035	-	46.51 (0.00)	-

* the numbers in parentheses are p-values for F-statistics

To substantiate this view, we also conduct a cross-validation of our VAR estimation. For this analysis, we divide our entire sample into two subsamples and we choose a breaking point for this division as 2002Q2, which is supported by Qu and Perron (2007)'s test of structural changes in multivariate regressions. This breaking point deserves relevance also based on the fact that the famously known dot-com bubble crashed around this time leading to the financial crisis and then to 2001 recession. We then estimate a VAR for subsample period prior to this breaking point and use the estimated parameters thus obtained to forecast the variables for the second subsample. The assessment of forecast is judged based on the root mean squared errors (RMSE) and mean absolute errors (MAE). The forecast assessment as shown in Table 1 in the Appendix justifies for the VAR model with FSI, as RMSE and MAE are mostly smaller in this model than they are in the model without FSI. The results are also supported by F-test.

Table3: Variance Decompositions with Order Change and with-and-without FSI

Qtrs.	Shocks										
	Benchmark Model				Model with Order Change of FSI and FFR				Model without FSI		
	RGDP	DGDP	FFR	FSI	RGDP	DGDP	FSI	FFR	RGDP	DGDP	FFR
	Variance Decomposition of RGDP										
2	56.5	7.6	*27.7*	**8.2**	56.5	7.6	**6.5**	29.4	93.1	0.7	*6.2*
5	40.2	13.7	*25.4*	**20.7**	40.2	13.7	**19.2**	26.9	77.5	4.4	*18.1*
10	27.0	41.8	*15.8*	**15.5**	27.0	41.8	**14.6**	16.6	70.5	10.8	*18.7*
15	28.1	40.7	*15.8*	**15.5**	28.1	40.7	**14.6**	16.7	71.6	10.2	*18.2*
20	25.5	45.0	*14.7*	**14.7**	25.5	45.0	**13.9**	15.6	70.3	10.9	*18.8*
	Variance Decomposition of DGDP										
2	7.0	87.9	*0.0*	**5.1**	7.0	87.9	**5.1**	0.0	0.4	99.5	*0.0*
5	12.6	81.2	*0.7*	**5.5**	12.6	81.2	**5.7**	0.6	15.7	84.1	*0.1*
10	13.0	75.4	*3.6*	**8.0**	13.0	75.4	**8.0**	3.6	19.7	74.9	*5.3*
15	12.7	75.9	*3.3*	**8.2**	12.7	75.9	**8.1**	3.3	24.2	69.1	*6.7*
20	12.6	75.5	*3.6*	**8.4**	12.6	75.5	**8.3**	3.6	26.5	65.4	*8.1*

In addition, the variance decomposition with different ordering of the variables and the models with-and-without FSI in Table 3 also justifies for the financial variable to be one of the variables that should be included in the VAR specification. First taking account of order change between FFR and FSI (which has drawn much controversy), as an example, the contribution of financial shocks to explain RGDP and DGDP have increased in our benchmark estimation, the model we have used in our estimation (compare bold-faced numbers). When comparing the model that includes FSI with the one that does not contain FSI, we have compared the efficacy of monetary policy shocks to affect RGDP and GDP and find that the model performs better with the model with FSI because the contribution of monetary policy shocks to affect these two variables has increased, at least at the beginning of the quarters, which is in line with the goal that central banks set in the short-run (compare italic numbers).

Figure 2: Responses to the Shocks in Financial Stress Index (FSI)

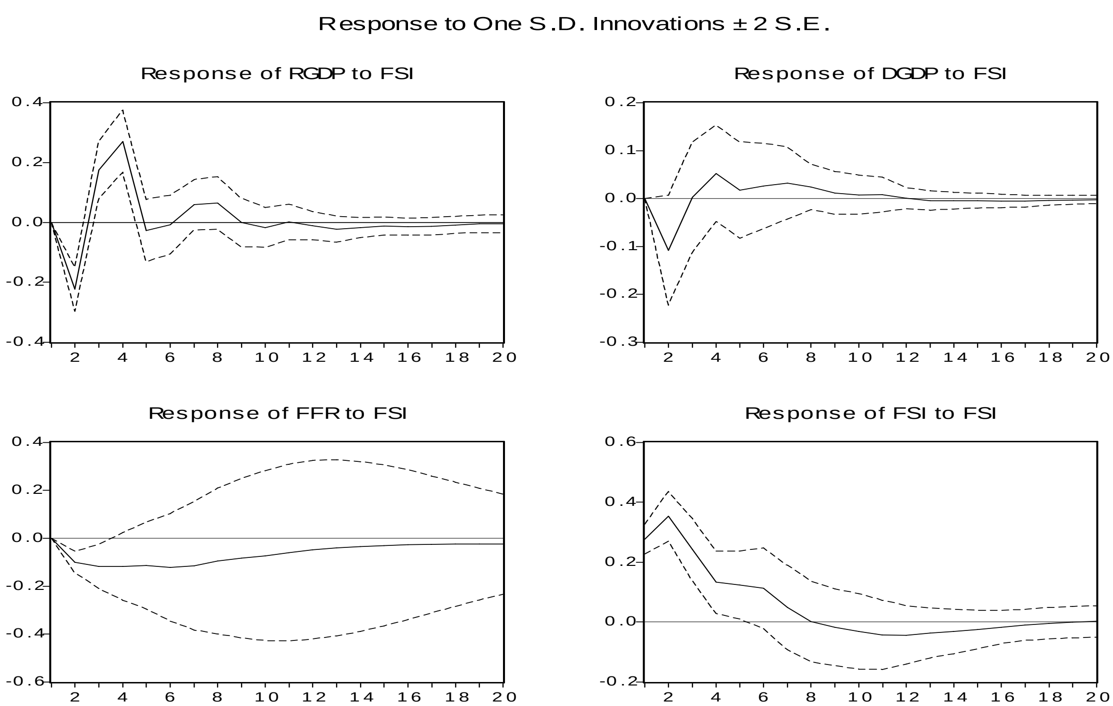
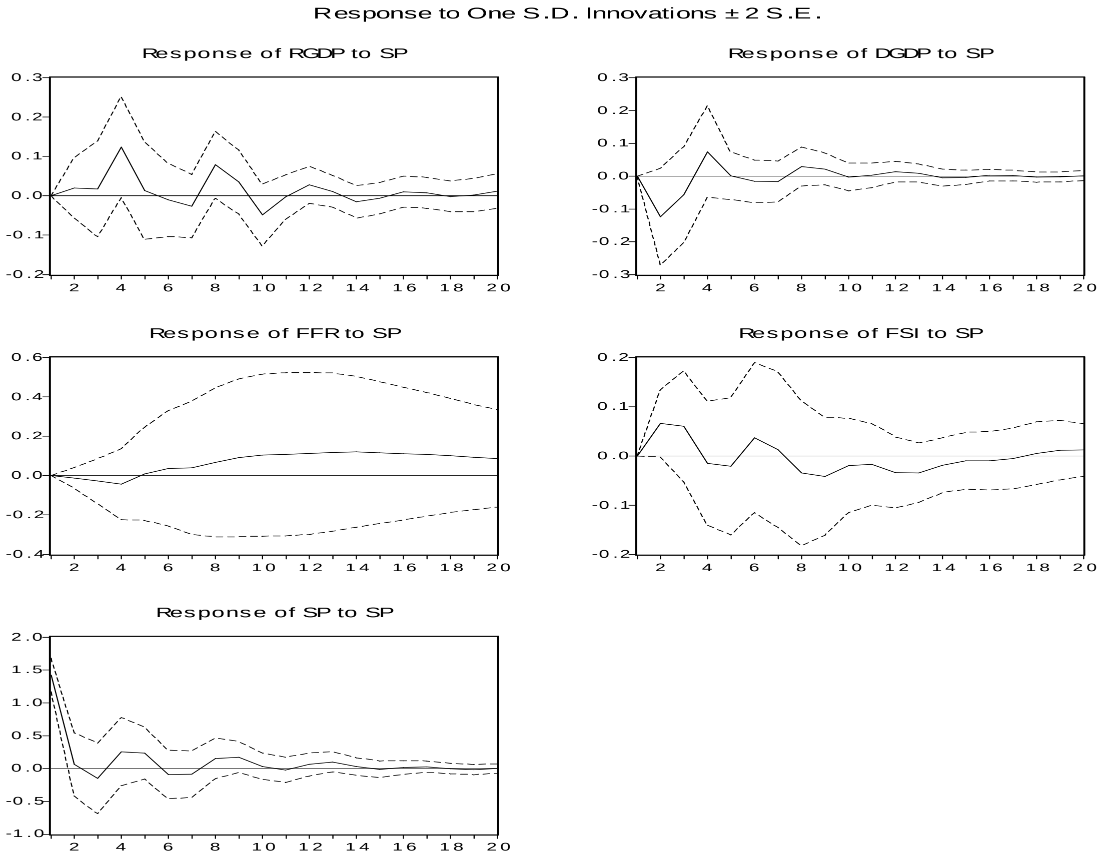


Figure 3: Responses to the shocks in Stock Prices



Figures 2 and 3 display the estimated impulse responses to an unexpected temporary financial stress index. The results are consistent with the general expectation that the economy is negatively affected when it is hit by financial shocks. The innovation to FSI, for example, has contractionary effect on real GDP and the impact is immediate. The FFR, on the other hand, declines after the economy is hit by financial shocks, which is the same phenomenon we observe during and after the crisis. The prices and federal funds rate have also declined. The effects do not change much when there is an innovation to either financial stress index or in stock prices.

Responses of Other U.S. Macroeconomic Variables

In order to observe the impulses responses of other U.S. macroeconomic variables the similar identification strategy is applied as above but all other U.S. macroeconomic variables are placed one-by-one in between DGDP and FFR as in equation (4) shown below. This specification assumes that other macroeconomic variables are also contemporaneously exogenous to monetary policy and financial shocks.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ b_{51} & b_{52} & b_{53} & b_{53} & 1 \end{bmatrix} \begin{bmatrix} RGDP_t \\ DGDP_t \\ USMV_t \\ FFR_t \\ FSI_t \end{bmatrix} = K_0(L) \begin{bmatrix} RGDP_{t-1} \\ DGDP_{t-1} \\ USMV_{t-1} \\ FFR_{t-1} \\ FSI_{t-1} \end{bmatrix} + \begin{bmatrix} e_{t,RGDP} \\ e_{t,DGDP} \\ e_{t,USMV} \\ e_{t,FFR} \\ e_{t,FSI} \end{bmatrix} \tag{10}$$

where, USMV stands for U.S. domestic macroeconomic variables, such as Industrial Production (IP), Investment (INV), Claims on Private Sector (CPS), and international variables such as Terms of Trade (TT), Foreign Exchange Reserves (FEX), Security Holdings of Non-residents (SEC_NR), and Real Effective Exchange Rates (REER).

Figure 4 reports the impulse responses of other U.S. domestic macroeconomic variables. The responses are also in line with general expectation. Industrial production (IP) and Banks' Asset Liability Ratio (BALR) falls on the negative territory after the financial shocks. The difference between asset and liabilities, which can be defined as capital requirements, on the other hand, also respond negatively to financial shocks, which support the evidence that banks face capital crisis after the negative shocks in the economy. Claims on private sector or private loans (CPS) and investment (INV) exhibit mixed responses over the quarters ahead following the shocks.

Figure 4: Responses of Other Macroeconomic Variables

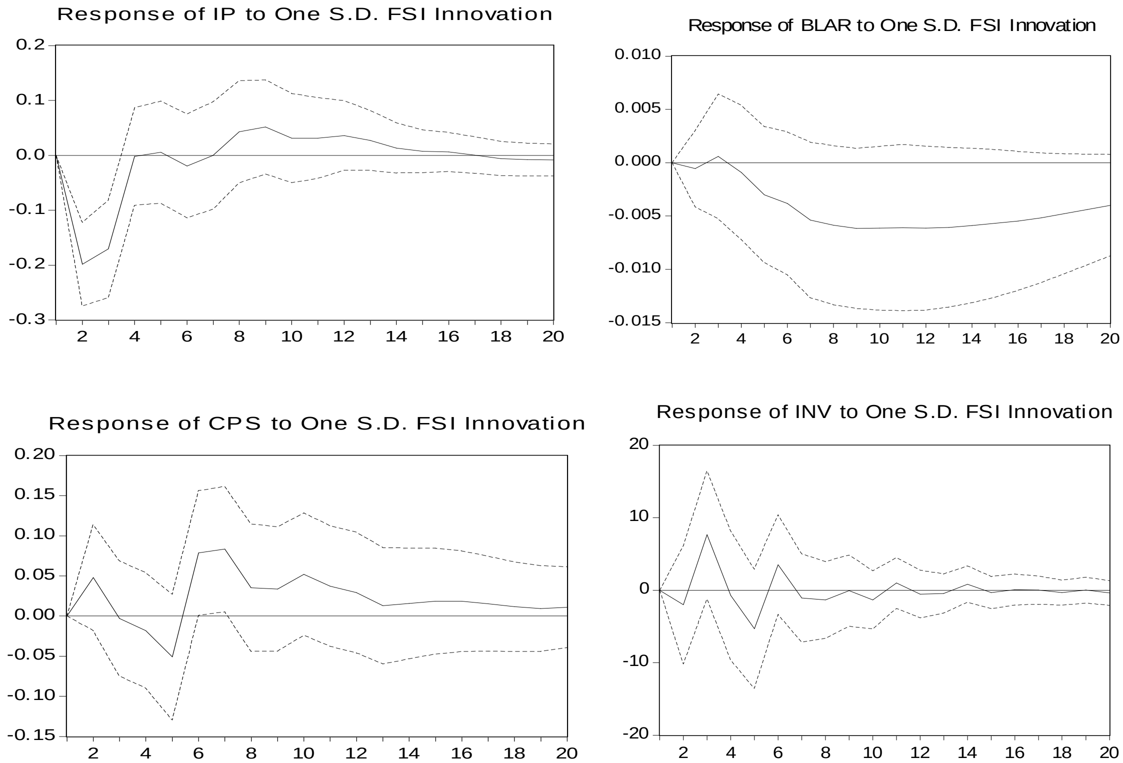
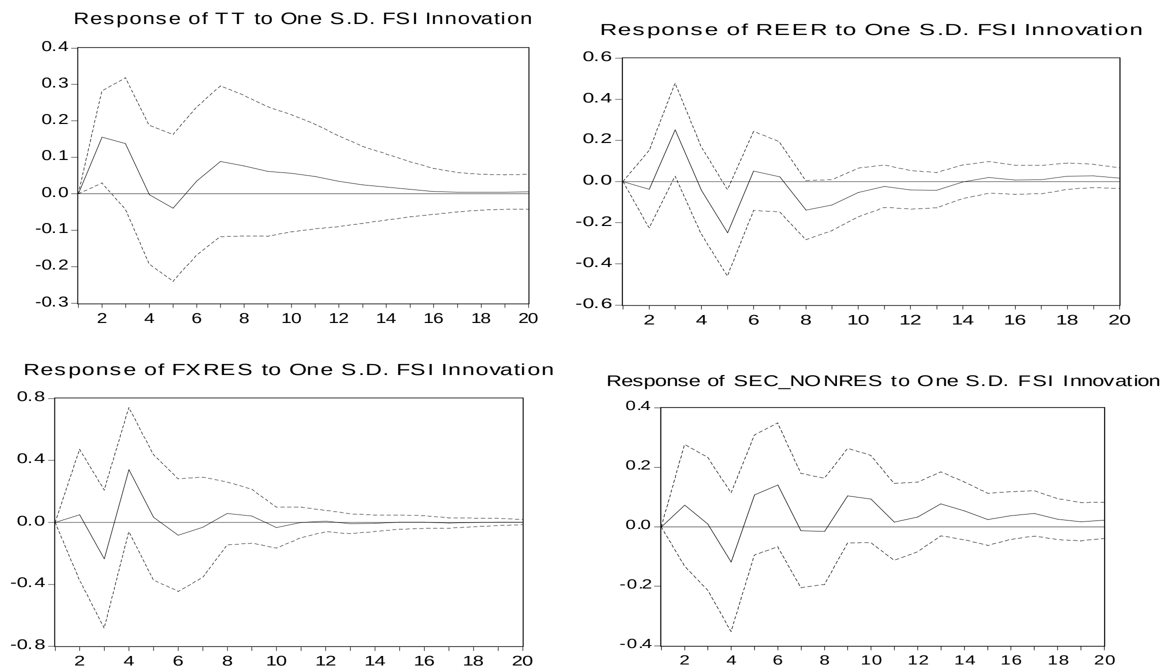


Figure 5: Reponses of U.S. International Macroeconomic Variables



The financial shocks in the U.S., however, do not affect negatively for international macroeconomic variables of the U.S. (Figure 5). The results show that the terms of trade (TT), the log of ratio of export prices to import prices, has temporarily improved following the financial shocks. This results may be attributed to the declining imports due to reduced income in the U.S.. Foreign exchange reserves (FEX) and the holdings of U.S. securities by foreigners (SEC_NR) do not exhibit any definite pattern following the shocks. The exchange rates temporarily appreciates until two quarters but after that follows the similar pattern as foreign exchange reserves and the holdings of U.S. securities by foreigners.

4.3 Transmission Effects to Foreign Macroeconomic Variables

The analysis is now extended to the foreign macroeconomic variables in G-7 countries. Same as before, foreign macroeconomic variables take the position in between DGDP and FFR in the VAR specification as in equation (5).

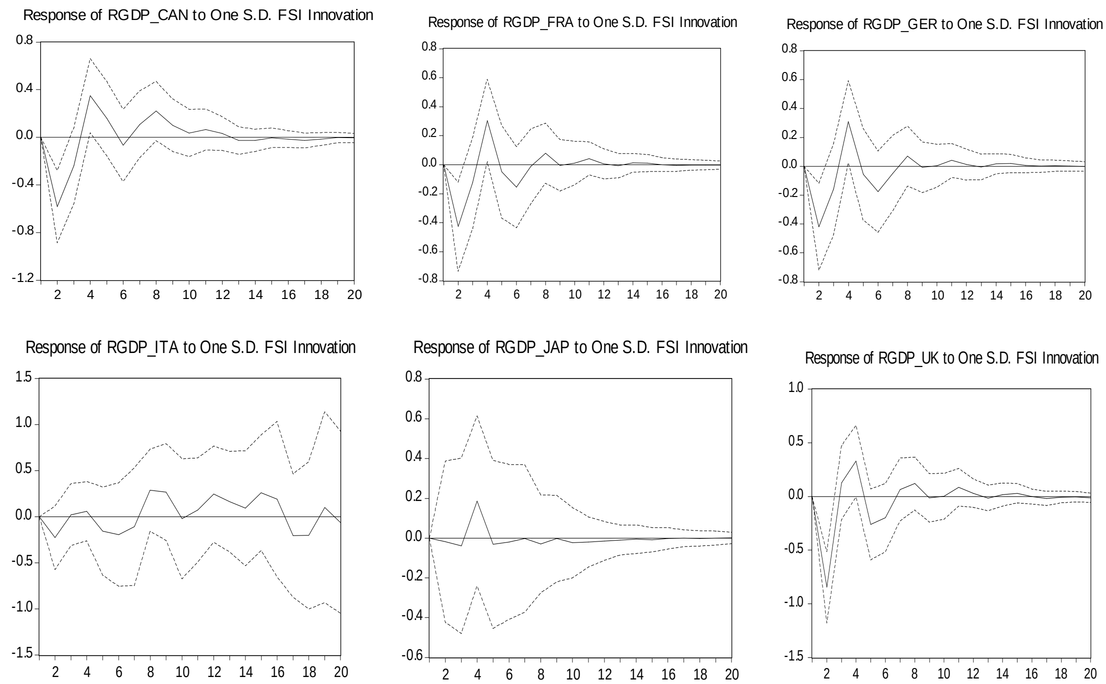
$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ b_{51} & b_{52} & b_{53} & b_{53} & 1 \end{bmatrix} \begin{bmatrix} RGDP_t \\ DGDP_t \\ FMV_t \\ FFR_t \\ FSI_t \end{bmatrix} = K_0(L) \begin{bmatrix} RGDP_{t-1} \\ DGDP_{t-1} \\ FMV_{t-1} \\ FFR_{t-1} \\ FSI_{t-1} \end{bmatrix} + \begin{bmatrix} e_{t,RGDP} \\ e_{t,DGDP} \\ e_{t,FMV} \\ e_{t,FFR} \\ e_{t,FSI} \end{bmatrix} \tag{11}$$

where FMV stands for Real GDP (RGDP), Short-term Interest Rates (R), and Share Prices (SP) for Canada, France, Germany, Italy, Japan, and UK.

Figure 6 shows the responses of real GDP, interest rates, and share prices after the financial crisis in the U.S.. The real GDP in the rest of G-7 countries decline immediately when financial crisis hits the U.S. economy. The decline in real GDP, however, does not last for a long period of time.

Figure 6: Responses of G-7 Macroeconomic Variables

(i) RGDP



(ii) Interest Rates

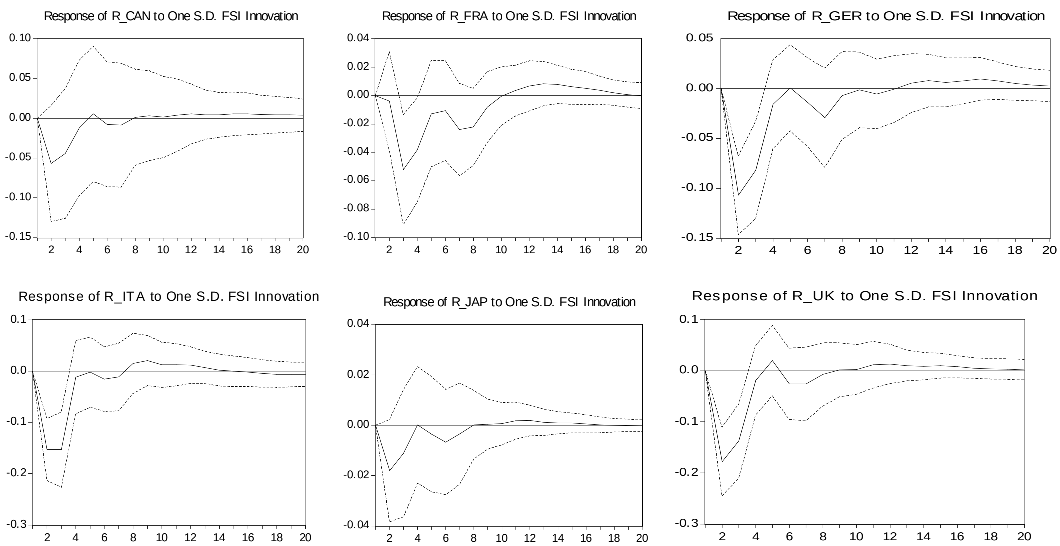
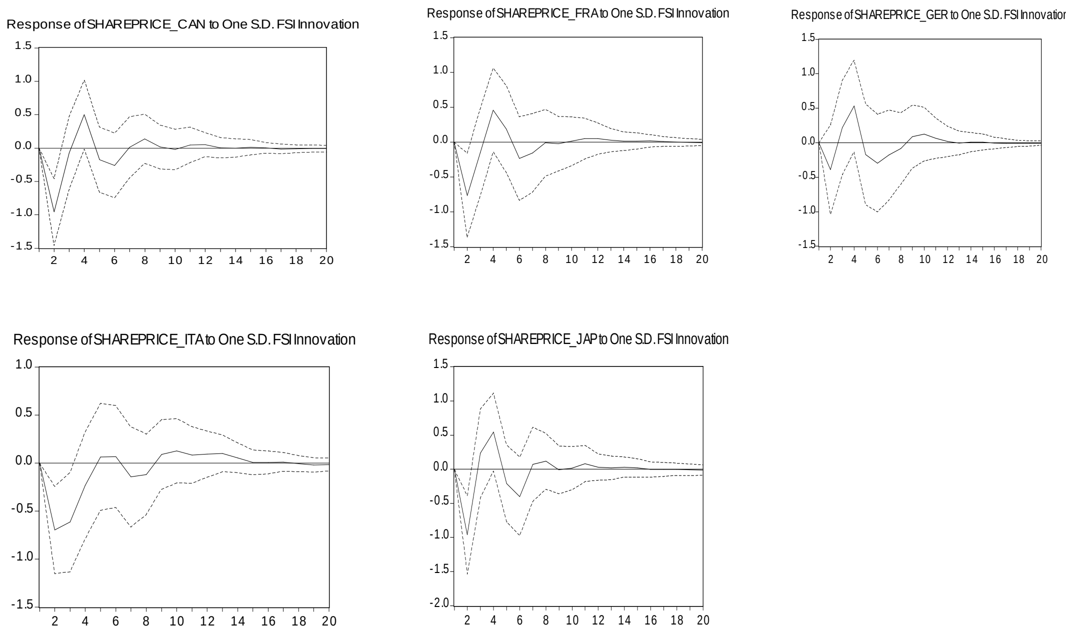


Figure 6 - Continued

(iii) Share Prices



The interest rates persistently decline following the financial shocks in the U.S. The decline in interest rates is consistent with the belief that the central banks in other countries pursue the same U.S. policy of reducing interest rates as a cushion to defend their economies from adverse effects that may come from exchange rates appreciation.

Share prices also follow the similar trend as interest rates when there is an financial stress in the U.S.. The G-7 countries are financially most integrated, it is therefore customary to believe that share markets move in the same directions in these countries when one country is hit by financial crisis.

The variance decompositions in Table 4 demonstrate the proportion of movement of the variables included in the VAR specification in the basic system as resulted from different shocks.

Table 4: Variance Decompositions – Basic System

Qtrs.	RGDP				DGDP			
	RGDP	DGDP	FFR	FSI	RGDP	DGDP	FFR	FSI
1	100.0	0.0	0.0	0.0	2.9	97.1	0.0	0.0
2	46.0	6.3	29.2	18.5	4.4	92.8	0.0	2.8
3	40.0	7.5	27.9	24.6	4.5	92.7	0.0	2.8
4	33.1	6.3	24.7	35.9	4.4	91.2	1.1	3.3
5	32.5	7.7	24.5	35.3	4.3	90.2	2.1	3.3
6	32.4	7.7	24.6	35.3	4.3	89.9	2.3	3.4
7	27.5	21.3	20.8	30.4	4.3	89.5	2.5	3.6
8	27.3	21.1	20.8	30.8	4.3	89.3	2.6	3.8
9	27.1	21.3	21.0	30.6	4.3	89.2	2.7	3.8
10	27.1	21.2	21.0	30.7	4.4	89.2	2.7	3.8
11	27.1	21.3	21.0	30.6	4.4	89.1	2.7	3.8
12	27.0	21.3	21.2	30.5	4.4	89.1	2.7	3.8
13	26.8	21.7	21.3	30.3	4.4	89.1	2.7	3.8
14	26.6	21.9	21.4	30.1	4.4	89.1	2.7	3.8
15	26.4	22.1	21.6	29.9	4.4	89.1	2.7	3.8
16	26.1	22.5	21.8	29.6	4.4	89.1	2.7	3.8
17	25.9	22.9	22.0	29.3	4.4	89.1	2.7	3.8
18	25.7	23.2	22.2	29.0	4.4	89.0	2.7	3.8
19	25.5	23.4	22.4	28.7	4.4	89.0	2.8	3.8
20	25.3	23.6	22.5	28.5	4.4	89.0	2.8	3.8

Table 4 - Continued

FFR				FSI			
RGDP	DGDP	FFR	FSI	RGDP	DGDP	FFR	FSI
2.0	2.0	96.0	0.0	8.5	4.4	0.5	86.7
0.6	20.0	75.3	4.1	10.2	12.4	0.2	77.1
1.0	31.3	63.8	3.9	10.7	14.1	1.3	74.0
1.7	32.5	62.4	3.3	8.2	32.4	2.7	56.7
2.3	36.7	58.2	2.7	5.9	47.7	3.6	42.8
2.6	39.6	55.4	2.4	5.0	52.8	4.0	38.2
2.9	41.5	53.4	2.2	4.8	54.1	4.5	36.6
3.2	42.7	52.1	2.0	4.7	54.5	5.1	35.7
3.3	43.6	51.3	1.8	4.6	54.8	5.5	35.1
3.5	44.3	50.6	1.7	4.6	54.8	5.6	35.0
3.6	44.7	50.1	1.5	4.6	54.7	5.6	35.1
3.7	45.0	49.9	1.4	4.5	54.6	5.6	35.2
3.8	45.2	49.7	1.4	4.5	54.6	5.6	35.2
3.8	45.3	49.6	1.3	4.5	54.7	5.7	35.1
3.9	45.4	49.5	1.3	4.4	54.8	5.9	34.9
3.9	45.4	49.5	1.2	4.4	54.8	6.1	34.6
4.0	45.4	49.4	1.2	4.4	54.9	6.3	34.4
4.0	45.4	49.4	1.2	4.4	54.9	6.5	34.2
4.1	45.4	49.4	1.1	4.4	54.9	6.7	34.1
4.1	45.4	49.4	1.1	4.4	54.9	6.8	33.9

The results show that the movement of U.S. real GDP is significantly governed by financial shocks, which ranges from 18.5 to 28.5 percent up to twenty quarters. The financial shocks, however, do not cause significant variations in inflation and federal funds rate. The contribution of financial shocks for the variation of inflation remains at around 3 percent for entire twenty quarters, whereas it is 1 to 4 percent variation in federal funds rate during this period. The smaller contribution for the variance of federal funds rate is consistent with what has been observed in our analysis at the beginning for the interplay between federal funds rate and stock prices where the shocks on stock prices do not have any definite effect on federal funds rate.

Table 5: Variance Decompositions - U.S. Other Macroeconomic Variables

Qtrs.	IP					BLAR				
	RGDP	DGDP	IP	FFR	FSI	RGDP	DGDP	BLAR	FFR	FSI
1	1.7	62.8	35.5	0.0	0.0	0.1	20.4	79.5	0.0	0.0
2	15.5	41.1	25.5	0.4	17.5	0.6	23.0	76.4	0.0	0.0
3	21.4	36.1	19.7	0.3	22.5	2.5	24.9	72.2	0.3	0.1
4	20.8	38.9	19.9	0.9	19.5	2.7	23.5	73.4	0.3	0.1
5	18.3	46.0	17.2	1.6	16.9	2.7	21.2	75.0	0.5	0.6
6	16.0	52.4	15.1	1.5	14.9	2.4	19.5	76.3	0.6	1.1
7	15.9	52.9	15.1	1.4	14.8	2.4	18.3	76.8	0.5	2.0
8	15.8	52.7	15.0	1.4	15.1	2.4	16.6	77.7	0.4	2.8
9	15.7	52.2	15.1	1.6	15.5	2.4	15.1	78.5	0.4	3.6
10	15.7	51.9	15.2	1.7	15.6	2.3	13.8	79.3	0.4	4.2
11	15.7	51.7	15.1	1.7	15.7	2.2	12.7	79.9	0.4	4.7
12	15.7	51.6	15.0	1.7	15.9	2.1	11.9	80.2	0.4	5.2
13	15.7	51.6	15.0	1.7	16.0	2.1	11.3	80.5	0.4	5.7
14	15.6	51.6	15.0	1.7	16.0	2.1	10.8	80.6	0.4	6.1
15	15.6	51.6	15.0	1.7	16.0	2.1	10.5	80.6	0.4	6.5
16	15.6	51.7	15.0	1.7	16.0	2.0	10.2	80.5	0.4	6.9
17	15.6	51.7	15.0	1.7	16.0	2.0	9.9	80.4	0.5	7.2
18	15.6	51.7	15.0	1.8	16.0	2.0	9.7	80.3	0.5	7.5
19	15.6	51.7	15.0	1.8	16.0	2.0	9.6	80.2	0.6	7.7
20	15.6	51.6	14.9	1.8	16.0	1.9	9.4	80.0	0.8	7.8

Table 5 – Continued

CPS					INV				
RGDP	DGDP	CPS	FFR	FSI	RGDP	DGDP	INV	FFR	FSI
18.5	0.6	80.9	0.0	0.0	15.6	5.8	78.7	0.0	0.0
15.9	2.5	75.8	4.4	1.3	13.3	15.7	69.2	1.3	0.4
14.4	15.7	65.0	3.8	1.1	11.1	17.7	61.5	4.0	5.7
18.1	17.8	58.4	4.8	1.0	11.1	17.9	61.4	4.0	5.7
17.2	17.6	54.4	9.0	1.8	10.9	17.4	59.7	4.0	7.9
16.9	19.9	50.6	9.0	3.6	13.6	17.1	56.8	3.9	8.6
15.3	20.4	48.1	11.0	5.2	13.5	17.1	56.8	3.9	8.7
14.6	22.4	46.1	11.6	5.3	13.7	17.0	56.6	4.0	8.7
14.6	22.2	46.2	11.6	5.4	14.3	16.9	56.2	4.0	8.7
14.7	21.7	45.9	11.8	5.9	14.6	16.8	55.8	4.0	8.7
14.6	21.3	45.9	12.1	6.1	14.6	16.7	55.8	4.0	8.8
14.8	21.2	45.6	12.3	6.1	14.6	16.8	55.7	4.0	8.8
14.9	21.1	45.3	12.7	6.0	14.8	16.7	55.6	4.0	8.8
15.1	21.0	45.0	13.0	6.0	14.9	16.7	55.5	4.0	8.9
15.1	21.0	44.6	13.4	5.9	14.9	16.7	55.5	4.1	8.9
15.0	21.2	44.1	13.8	5.9	14.9	16.7	55.5	4.1	8.9
14.9	21.5	43.6	14.2	5.8	14.9	16.7	55.5	4.1	8.9
14.8	21.6	43.2	14.6	5.8	14.9	16.7	55.5	4.1	8.9
14.8	21.8	42.8	15.0	5.7	15.0	16.7	55.4	4.1	8.9
14.7	22.0	42.4	15.3	5.6	15.0	16.7	55.4	4.1	8.9

As demonstrated in Table 5 for other U.S. macroeconomic variables, industrial production shares significant proportions of variations resulting from financial shocks, which is around 16 percent for most of the quarters and second after price shocks. Financial shocks have contributed moderately for the variations in banks' capital position and in private loans. The movement in investment attributed to financial shocks is nearly one-tenth among the contributions of other shocks.

Table 6: Variance Decompositions - U.S. International Variables

Qtrs.	TT					REER				
	RGDP	DGDP	TT	FFR	FSI	RGDP	DGDP	REER	FFR	FSI
1	0.4	7.9	91.7	0.0	0.0	0.6	7.1	92.3	0.0	0.0
2	4.2	3.9	88.2	0.9	2.9	0.7	31.9	67.1	0.2	0.1
3	13.2	9.1	70.6	3.5	3.6	1.4	29.8	64.6	0.6	3.7
4	20.0	11.6	58.3	7.3	2.8	1.7	31.7	62.4	0.6	3.5
5	24.0	10.3	53.1	10.0	2.6	1.9	31.6	59.5	0.7	6.4
6	25.7	12.0	49.0	10.9	2.4	2.4	31.5	58.7	1.0	6.4
7	27.4	12.1	46.8	11.1	2.6	2.4	31.6	58.6	1.0	6.4
8	28.8	11.8	45.6	11.0	2.8	2.4	32.6	56.9	1.0	7.1
9	29.6	11.5	45.0	10.9	2.9	2.3	32.6	56.3	1.1	7.7
10	30.1	11.5	44.5	10.9	3.0	2.3	32.6	56.2	1.1	7.8
11	30.5	11.5	44.2	10.8	3.1	2.3	33.1	55.7	1.1	7.7
12	30.8	11.4	44.0	10.7	3.1	2.3	33.9	54.9	1.2	7.7
13	31.0	11.3	44.0	10.6	3.1	2.3	34.2	54.6	1.3	7.7
14	31.1	11.3	44.0	10.6	3.1	2.3	34.2	54.4	1.4	7.7
15	31.2	11.2	44.0	10.5	3.1	2.3	34.4	54.2	1.5	7.7
16	31.2	11.2	44.0	10.5	3.1	2.3	34.5	54.0	1.6	7.7
17	31.2	11.3	43.9	10.5	3.0	2.3	34.5	53.9	1.6	7.7
18	31.2	11.3	43.9	10.6	3.0	2.3	34.5	53.9	1.7	7.7
19	31.1	11.4	43.8	10.6	3.0	2.3	34.4	53.9	1.7	7.7
20	31.0	11.5	43.8	10.7	3.0	2.3	34.4	53.9	1.7	7.7

Table 6 – Continued

FXRES					SEC_NONRES				
RGDP	DGDP	FXRES	FFR	FSI	RGDP	DGDP	SEC_NONRES	FFR	FSI
0.1	0.9	99.0	0.0	0.0	0.5	1.9	97.5	0.0	0.0
0.4	6.7	89.4	3.5	0.0	12.4	1.6	85.1	0.2	0.7
0.3	8.1	87.3	3.5	0.9	13.4	5.2	80.5	0.3	0.6
0.8	9.9	83.5	3.4	2.5	14.4	7.5	75.4	0.7	2.0
0.9	12.1	81.2	3.4	2.4	12.5	6.6	76.1	2.0	2.8
0.9	13.0	80.3	3.4	2.5	13.3	6.4	73.7	2.2	4.5
0.9	13.9	79.4	3.4	2.4	12.8	8.2	72.5	2.1	4.3
0.9	14.0	79.2	3.4	2.5	14.2	8.5	71.0	2.2	4.2
0.9	14.1	79.2	3.4	2.5	14.0	8.3	70.3	2.4	5.0
0.9	14.1	79.1	3.4	2.5	13.9	8.3	69.8	2.4	5.7
0.9	14.1	79.1	3.4	2.5	14.0	8.6	69.4	2.4	5.6
0.9	14.2	79.0	3.4	2.5	14.4	8.6	68.9	2.4	5.7
0.9	14.2	79.0	3.4	2.5	14.4	8.5	68.5	2.4	6.1
0.9	14.2	79.0	3.4	2.5	14.4	8.5	68.3	2.4	6.3
0.9	14.2	79.0	3.4	2.5	14.5	8.5	68.1	2.5	6.3
0.9	14.2	79.0	3.4	2.5	14.6	8.5	67.9	2.5	6.4
0.9	14.2	79.0	3.4	2.5	14.6	8.5	67.8	2.6	6.6
0.9	14.2	79.0	3.4	2.5	14.6	8.5	67.7	2.6	6.6
0.9	14.2	79.0	3.4	2.5	14.7	8.5	67.6	2.7	6.6
0.9	14.2	79.0	3.4	2.5	14.7	8.5	67.5	2.7	6.6

Table 6 shows the variance decomposition for U.S. international macroeconomic variables. The contribution of financial shocks to cause variation in international macroeconomic variables is trivial, which is no more that 10 percent for all variables under analysis. The variation in terms of trade, for example, is only 3 percent, whereas it is 8 percent for real exchange rates owing to financial shocks. The other domestic shocks govern a significant proportion of variations in international variables. Thirty one percent variation in terms of trade is attributed to the shocks in real GDP and price shocks contributes as much for the variation in exchange rates at the end of twentieth quarter.

In Tables 7 – 9, we report variance decompositions for international macroeconomic variables for G-7 countries. The numbers in the tables are the proportions of variations on the variables under analysis resulting from only financial shocks, thus one should not be confused that the numbers do not add up to 100 percent for each quarter.

Table 7: Variance Decompositions - G-7 Real GDP (Shocks to U.S. FSI)

Qtrs.	RGDP_CAN	RGDP_FRA	RGDP_GER	RGDP_ITA	RGDP_JAP	RGDP_UK
1	0.0	0.0	0.0	0.0	0.0	0.0
2	11.3	4.8	4.6	1.4	0.0	19.4
3	12.0	5.0	5.1	1.2	0.0	18.7
4	14.8	6.1	6.3	1.2	0.6	18.6
5	14.2	6.1	6.3	1.7	0.5	18.2
6	13.8	6.4	6.7	2.5	0.5	18.5
7	13.7	6.2	6.5	2.7	0.5	17.7
8	14.5	6.2	6.6	4.3	0.5	17.8
9	14.7	6.2	6.5	5.7	0.5	17.6
10	14.7	6.2	6.5	5.6	0.5	17.5
11	14.7	6.2	6.5	5.7	0.6	17.6
12	14.7	6.2	6.5	6.7	0.6	17.5
13	14.7	6.2	6.5	7.1	0.6	17.5
14	14.7	6.2	6.5	7.2	0.6	17.5
15	14.7	6.2	6.5	8.2	0.6	17.5
16	14.7	6.2	6.5	8.8	0.6	17.5
17	14.7	6.2	6.5	9.4	0.6	17.5
18	14.7	6.2	6.5	10.0	0.6	17.5
19	14.7	6.2	6.5	10.1	0.6	17.5
20	14.6	6.2	6.5	10.1	0.6	17.5

Table 7 demonstrates that financial shock in the U.S. has some role for the variation in real GDP of rest of G-7 countries. Nearly ten to fifteen percent variation in real GDP in Canada, for example, is dictated by the financial shocks in the U.S.. Also, nearly as much variation in real GDP in the U.K. is governed by the same U.S. financial shocks. The effect on rest of other countries' real GDP is moderate.

Table 8: Variance Decompositions - G-7 Interest Rates (Shocks to U.S. FSI)

Qtrs.	R_CAN	R_FRA	R_GER	R_ITA	R_JAP	R_UK
1	0.0	0.0	0.0	0.0	0.0	0.0
2	1.7	0.0	17.0	17.1	1.7	22.0
3	2.2	5.7	23.3	25.9	2.2	30.5
4	2.2	7.7	22.0	25.2	2.2	27.4
5	2.1	7.6	19.0	24.2	2.2	23.4
6	1.9	7.1	16.0	21.4	2.4	20.3
7	1.9	7.3	15.7	21.1	2.4	20.0
8	1.9	7.8	15.3	20.9	2.4	20.0
9	1.9	7.8	15.0	20.8	2.4	20.0
10	1.9	7.8	14.7	20.7	2.4	19.9
11	1.9	7.7	14.6	20.6	2.4	19.9
12	1.9	7.8	14.6	20.6	2.4	19.9
13	1.9	7.9	14.5	20.4	2.4	19.9
14	1.9	7.9	14.5	20.3	2.4	19.8
15	1.9	8.0	14.4	20.1	2.4	19.7
16	1.9	8.0	14.3	19.9	2.4	19.7
17	1.9	8.0	14.3	19.8	2.4	19.6
18	1.9	7.9	14.2	19.6	2.4	19.5
19	1.9	7.9	14.1	19.5	2.4	19.4
20	1.9	7.8	14.1	19.4	2.4	19.4

Financial shocks in the U.S. are also a significant factor to govern nominal short-term interest rates in G-7 countries. The U.K. demonstrates the similar trend as with real GDP for the interest as well, where nearly 20 percent variation comes from financial shocks in the U.S.. Interest rates in Japan is less responsive to the financial shocks in the U.S., potentially for the reason that the interest rates in Japan are at very low levels compared to other countries during the sample period and there is no room for it to move even though U.S. financial shocks put pressure on it.

Table 9: Variance Decompositions - G-7 Share Prices (Shocks to U.S. FSI)

Qtrs.	SP_CAN	SP_FRA	SP_GER	SP_ITA	SP_JAP
1	0.0	0.0	0.0	0.0	0.0
2	8.4	4.7	1.1	4.2	8.0
3	8.1	4.5	1.3	5.9	8.4
4	9.8	5.6	2.5	6.0	10.2
5	8.9	5.1	2.4	5.4	9.2
6	9.2	5.3	2.7	4.9	10.1
7	9.0	5.4	2.9	4.9	10.0
8	9.1	5.4	2.9	5.0	10.0
9	9.0	5.3	2.9	5.0	9.9
10	9.0	5.3	3.0	5.1	9.9
11	9.0	5.3	3.0	5.1	9.9
12	9.0	5.3	3.0	5.1	9.9
13	9.0	5.3	3.0	5.2	9.9
14	9.0	5.3	3.0	5.2	9.9
15	9.0	5.3	3.0	5.2	9.9
16	9.0	5.3	3.0	5.2	9.9
17	9.0	5.3	3.0	5.2	9.9
18	9.0	5.3	3.0	5.2	9.9
19	9.0	5.3	3.0	5.2	9.9
20	9.0	5.3	3.0	5.2	9.9

For share prices, Canada and Japan dominate other countries in responding to financial shocks in the U.S.. Nearly ten percent variations in the share prices of these countries are governed by U.S. financial shocks. The variations in share prices in Italy and France amount only about 5 percent where it is only 3 percent in Germany that results from financial shocks in the U.S..

5. Conclusion

In view of the fact that the financial crisis originated in the U.S. recently led to a global catastrophe, the study on transmission effects of this crisis worldwide has now been on the center of investigation. With an objective to provide a complementary analysis to the existing literatures, this study estimates a VAR model to identify the financial shocks in the U.S. and observe their effects on U.S. and international macroeconomic variables. As a starting point, we analyze the interaction between Federal Reserve's monetary policy-making and the development in the U.S. financial sector by estimating a two variable VAR for federal funds rate and U.S. stock prices for daily data starting from 1957. The benchmark results show that the financial shocks in the U.S. stock market does not exhibit any definite effect on the behavior of federal funds rate, but the effect of monetary policy shocks exerts a negative effect on stock prices. Other U.S. macroeconomic variables also exhibit expected responses following the shocks in the U.S. financial system. The positive innovation to U.S. financial stress index (FSI), for example, has negative impact on U.S. real GDP and industrial production. The U.S. international variables also also negatively after the financial shocks in the U.S.. The international transmission effect of U.S. financial shocks is also in line with the expectation, leading to a decline in the real GDP in the rest of G-7 countries following a financial stress in the U.S. This shock also leads to a decline in the interest rates in all other countries, and the stock market in other countries also move in tandem with U.S. market following the shock.

Since this study is a preliminary attempt to identify the U.S. financial shocks and their transmission effects on the dynamics of domestic and international macroeconomic variables, the study is not far from criticism. One of the major issues that should be taken account of is the degree of exogeneity between monetary policy and stock market behavior. There is a great deal of debate among economists regarding whether stock market behavior should be included in monetary policy rule or not, and there is no complete agreement available as of now. In this study also, for example, if the ordering of the variables is changed such that financial variables (FSI and SP) come before FFR, making financial variables more exogenous to FFR, the results show that the response of RGDP do not change following the shocks on FFR (monetary policy shocks) but the FSI responded positively, as opposed to negative response of FFR to the financial shocks. This result indicates that more works need to be done to resolve the issue of exogeneity between monetary policy and financial sector to capture the better transmission mechanism that relates financial sector and macro economy.

CHAPTER 4

SUMMARY AND CONCLUSION

The purpose of this dissertation is to study the effects of U.S. real, nominal shocks, and financial shocks on key macroeconomic variables in G-7 countries. We estimate VAR models and the results are found to be consistent with the predictions of standard macroeconomic models. The impulse responses of U.S. real GDP relative to the rest of other countries to the supply shocks, for example, results in a rise in U.S.'s real GDP compared to other countries' following the supply shocks in the U.S.. There is persistence in relative real GDP after the supply shocks whereas it exhibits hump-shape in response to nominal shocks such as demand and monetary shocks.

The real effective exchange rates also demonstrate the consistent behavior following the supply shocks. The relative real effective exchange rates depreciate in all G-7 country pairs when there is a positive supply shock in the U.S.. The effect of monetary shocks to the real exchange rates also matches the model's prediction in most of the country pairs resulting in real depreciation of home currency in response to the monetary shocks in the U.S.. As contrary to the model's prediction, the exchange rates, however, do not appreciate when U.S. economy is hit by demand shocks. The effect of monetary shocks are consistent with the model for all country pairs resulting in a rise in the U.S.'s relative prices in response to monetary shocks in the U.S.. The behavior of prices after the supply shocks is not as expected. The expected negative effect of supply shocks to relative prices as predicted by the model is observed only for U.S./Canada pair.

The analysis of variance decompositions confirm that that the movement in relative real GDP for all country pairs is mainly attributed to the supply shocks. The movement in real effective exchange rates, on the other hand, is mainly governed by demand shocks, whereas monetary shocks are dominant to explain relative price movement.

After the sign restrictions, the gap in growth rate differential in real GDP between the U.S. and other countries narrows down following a supply shocks in the U.S., but following the demand and monetary shocks the growth rate of real GDP in the U.S. economy is higher than the growth rate of real GDP in the rest of the countries. For the differential in inflation rates, the domestic inflation falls shorter than the foreign inflation after supply shocks in the U.S., and the opposite happens when demand and monetary shocks hit the U.S. economy. The exchange rates demonstrate a noteworthy behavior following the supply shocks, resulting in most of the country pairs a smaller appreciation rate in the U.S. than the appreciation rate in the foreign economy at the beginning and this effect dyes out after few quarters. This suggest that not only monetary and demand shocks cause exchange rate overshooting but supply shocks are also attributable for exchange rate overshooting.

We also estimate a VAR to identify U.S. financial shocks and observe their effects on key U.S. and international macroeconomic variables. The interaction between Federal Reserve's monetary policy-making and the development in the U.S. financial sector is analyzed at the beginning by estimating a two variable VAR for federal funds rate and U.S. stock prices for daily data starting from 1957. In consistent with the behavior of Federal Reserve in responding stock market, the results show that the financial shocks in the U.S. stock market does not cause any definite effect on the behavior of federal funds rate. The effect of monetary policy shocks, however, exerts a negative effect on stock prices.

All other U.S. macroeconomic variables also exhibit expected responses following the shocks in the U.S. financial system. The U.S. real GDP and industrial production, for example, are negatively affected by a positive innovation to U.S. financial stress index (FSI). The banks' capital position deteriorates following the shocks. Private loans and investment demonstrate mixed effects. The international transmission effect of U.S. financial shocks to G-7 countries are also in line with the expectation, resulting in a decline in the real GDP in the rest of G-7 countries following a financial stress in the U.S.. Foreign interest rates and stock prices both decline when U.S. experiences financial shocks. All these effects indicate that the macroeconomic variables in G-7 countries move in tandem with each other when the U.S. undergoes a financial shock.

Since this study is a preliminary investigation to identify the U.S. real, nominal, and financial shocks and their transmission effects on the dynamics of domestic and international macroeconomic variables, the study is not far from criticism. The effects of U.S. shocks on international macroeconomic variables through terms trade and interest rate differentials have been ignored in this study but by addressing this issue, a realistic transmission mechanism of the effects of shocks from one country to other countries is expected. In analyzing the effects of financial shocks on real sector, one of the major issues that should be taken account of is the degree of exogeneity between monetary policy and stock market behavior. There is a great deal of debate among economists regarding whether stock market indicator should be included in monetary policy rule or not, and a complete agreement is still far-fetched. In this study also, for example, if the ordering of the variables is changed such that financial variable (FSI) are placed before FFR, that is, making financial variables more exogenous to FFR, the results show that even though the response of RGDP do not alter that much following the shocks on FFR (monetary policy shocks) but the response of FSI changes and it is now positive as opposed to negative response of FFR to the financial shocks before. This result indicates that more works need to be done to resolve the issue of exogeneity between monetary policy and financial sector to capture the better transmission mechanism.

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ABSTRACT

INTERNATIONAL TRANSMISSION OF U.S. NOMINAL, REAL, AND FINANCIAL SHOCKS

by

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Major: Economics

Degree: Doctor of Philosophy

This dissertation identifies real, nominal, and financial shocks in the U.S. and observes their effects on U.S. as well as G-7 macroeconomic variables. First, the real and nominal shocks in the U.S. are identified by using long-run implications of an open economy stochastic macroeconomic model, and the effects of these shocks are observed in real GDP, real effective exchange rates, and the prices for the U.S. relative to each of six other G-7 countries. While Blanchard and Quah's long-run identification strategy is used to identify the shocks, short-run implication of the model are also exploited, as a prima facie evidence, by applying appropriate sign restrictions in the contemporaneous coefficient matrix in the VAR estimation. Consistent with the model's predictions, a positive supply shock results in an increase in relative U.S. real GDP and a real depreciation of U.S. currency whereas nominal shocks in the U.S. lead to an increase in relative U.S. real GDP and relative U.S. prices. The application of short-run dynamics with proper sign restrictions produces exchange rate overshooting following the U.S. real shocks. Second, A VAR is estimated to provide empirical evidence on the international transmission of U.S. financial shocks on the U.S. as well as on the rest of G-7 macroeconomic

variables. A shock to the U.S. financial sector causes a negative and immediate impact on U.S. real GDP and industrial production. Banks' capital position deteriorates immediately whereas exchange rates and foreign exchange reserves situations worsen after few quarters of shocks hitting the U.S. economy. The international transmission effects demonstrate that transmits a negative effect on real GDP and stock prices in the rest of G-7 countries. The U.S. shocks also lead to a decline in the interest rates in all other countries, showing that other countries follow the U.S. policy of reducing interest rates after a trigger of the crisis in the U.S..

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