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Irfan Akbar Kazi
Hakimzadi Wagan
Farhan Akbar

UMR 7235

Université de Paris Ouest Nanterre La Défense
(bâtiment G)
200, Avenue de la République
92001 NANTERRE CEDEX

Tél et Fax : 33.(0)1.40.97.59.07
Email : nasam.zaroualete@u-paris10.fr

université Paris Ouest Nanterre La Défense

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Irfan Akbar Kazi[1]
Hakimzadi Wagan[2]
Farhan Akbar[3]

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ABSTRACT

We study the changing international transmission of US monetary policy shocks to 14 major OECD countries over the period 1981Q1-2010Q4. We use a time-varying parameter factor augmented VAR approach to study the effective federal funds rate shocks together with a large data set of 265, major financial, macroeconomic and trade variables. Our main findings are as follows. First, negative US monetary policy shocks have considerable negative impact on GDP growth in the US, Canada, Japan and Sweden whereas there is positive impact on GDP growth in the most of the other member countries. Second, the transmission to GDP growth has increased in OECD countries since the early 1980s. Third, the transmission of US monetary policy shocks to major economic and financial variables varies in magnitude during financial turmoil periods than normal periods such as the gross fixed capital formation residential, turned most negative over the second quarter after the initial shock in the US, Canada, Germany, Japan, Switzerland and New Zealand mainly during 2008Q4. Asset prices, interest rates and trade channel seem to play major role in propagation of monetary policy shocks.

Keywords: Monetary policy shocks, financial markets, international transmission channels, global integration, turmoil periods, time-varying parameter factor augmented VAR.

JEL Classification Codes: F1, F4, F15, C3, C5

[1] Ph.D Candidate at Paris 10 University.Email: irfan.a.kazi@gmail.com
[2] Ph.D Candidate at Paris 1 University. Email: hakimzadi@gmail.com
[3] Ph.D Candidate at Paris 1 University. Email: farhan_a_kazi@yahoo.com

1 INTRODUCTION

There is strong evidence that the world economies have become more integrated globally over the last thirty years (Saving (2006) and Fecht et al. (2009)). The development and widespread liberalization of financial markets in the 1980s has resulted in increasing integration. The most important aspect of this financial integration is that global economies show co-movements in most of the economic variables such as inflation, unemployment, GDP growth in general and asset prices for example housing prices and stock prices in particular. Along with these facts, since 2006, the collapse of housing prices in the US as a result of collapsing residential investments, followed by a wave of crisis and sharp decrease in housing prices in Ireland, Japan and U.K. have raised the issues concerning the international transmission of these shocks across different countries. One possible explanation for this changing transmission of shocks is that transmission mechanism has evolved over time or that the size of shocks has changed. Further the increasing economic and financial integration result in "contagion effect", at the times when the prices are falling, or in times of crisis, importantly leading to global crisis.

The eruption of banking crisis during 2008 in the US as a result of "sub-prime mortgage bubble", and exceptionally loose monetary policy instance in the US from 2001 to 2006 resulted in the outbreak of global financial crisis.

However the nature of this economic and financial integration and the channels through which these shocks transmit are still not well understood. Questions such as: What factors are responsible for such co-movements? Can they be linked to particular developments in specific countries and sectors, or their nature is global for instance the two major developments in international financial system, the abandonment in the early 1970s of the Bretton Woods system of pegged exchange rates and the gradual removal of restrictions on international capital flows resulting in subsequent financial sector development in the US and its impact on world economies are still the core area of research and these are the questions that most researchers would like to answer. The main hurdle faced by the researchers in answering these questions is the lack of identification, particularly with respect to asset prices as it is difficult to associate the origin of these developments to specific country or event.

Most researchers now recognize that a key element of this inexorable trend towards globalization, rapid pace of financial markets integration on international level through asset

price co-movements and growing capital mobility is the role of US monetary policy as the driver of global financial and economic movements (Ehrmann and Fratzscher (2009)) and possibly the contagion of risk at the times of financial crisis (Carmassi et al. (2009)).

Motivated by the above discussion, the three main questions that we address are: first, how large is the impact of US monetary policy shocks on the 14 major OECD countries, and have their size and transmission changed over time? Second, what are the important channels through which US monetary policy shocks are transmitted both domestically and internationally to the OECD countries, and can we identify changes in transmission mechanism over time? Third, is there evidence of contagions effects on major financial and economic variables during financial turmoil periods and normal periods and through which channels?

For this purpose, we employ two approaches. First approach is based on factor augmented VAR approach, proposed by Bernanke et al. (2005).

The second approach is time-varying parameters factor augmented VAR approach, suggested by Koop and Korobilis (2010), which extends the constant parameter factor augmented VAR approach framework introduced by Bernanke et al. (2005).

The main contributions of this study to the literature of domestic and international transmission of contagion effects are as follows. First, while most of the previous work such as Rigobon and Sack (2003), Helbling et al. (2011) and Bagliano and Morana (2012), has just focused on stock market, credit and real shocks where as our study is based on the notion of increasing capital mobility, international role of dollar, we give one standard deviation shock to federal funds rate to provide the evidence that how the contractionary monetary policy stance has implications for OECD economies. It also points towards the fact that when Federal Reserve as the supplier of world dominant currency tightens the monetary policy and thereby limits the supply of international reserves, other banks will follow the same. Contractionary policy shocks results can impact consumption and the investment decisions in the US and thereby decreasing the demand for imported goods and shocks can spill over to other countries by foreign asset exposure or through contagion effects. Our model takes into consideration the co-movements of international variables, by including many variables for the countries under study in our data set, we allow the variables to interact with each other and there by capturing the international transmission of shocks and possible contagion effects. Second, most of the studies mentioned above applied constant parameters VAR and factor augmented VAR approaches whereas we apply time-varying parameters factor augmented

VAR approach methodology to study the international transmission of US monetary policy shocks to OECD countries.

Third, most of the studies use traditional trade channel to study the transmission mechanism where as we include major variables such as stock prices, house prices, government bond and interest rates as channels of transmission of these shocks to financial and asset markets.

Fourth, we study the impact of monetary policy shocks also over different turmoil periods including global financial crisis period, 2008-2009. We find strong evidence of the transmission of these shocks in terms of direction and magnitude to OECD countries. Linear constant-parameter approaches have failed to account for the transmission of shock volatility over different periods, thus have limitations to study the impact of global financial crisis.

The rest of the paper is structured as follows. Section 2 describes literature review. Section 3 describes empirical framework. Section 4 describes monetary policy shocks and large international data set. Section 5 explains the changing transmission of monetary policy shocks to growth and major financial variables in the US and other countries and determines the major transmission channels. Section 6 concludes.

2 LITERATURE REVIEW

This study aims to bridge two strands of the literature on the contagion effects by studying the impact of monetary policy shocks on major macroeconomic variables in general and asset market linkages in particular: first the literature on domestic financial markets and effects of monetary policy on domestic economy (section 2.1) and second, the literature on international transmission of US monetary policy shocks to other economies and asset markets (section 2.2). It also bases on the literature that attempts to explain the major elements of economic and financial linkages and monetary policy transmission process (section 2.3).

2.1 Monetary policy, economic and financial linkages

The impact of monetary policy on macro-economy in general and financial markets in particular has been the subject of long standing literature, which has regained popularity in recent years as a consequence of widespread liberalization of financial markets in the 1980s, among central banks. This is primarily due to the fact that monetary policy shocks have a highly significant and persistent impact on short term and long term interest rates, asset prices such as housing and stock prices on one hand and on the other hand they may be important transmitters of shocks, as asset prices react quickly to news (including monetary policy announcements), as suggested by Rigobon and Sack (2004) and Bernanke and Kuttner (2005), citing a few. Understanding the role of US monetary policy shocks as source of contagion

effects on financial and asset markets of OECD countries may therefore be necessary for the smooth functioning of financial markets in these countries.

Monetary policy shocks have the ability of influencing firm investment decisions by having its influence on Tobin's q, which can be easily studied through the response of share prices to this shock. At the same moment stock price responses have impact on consumer behavior through wealth effects. As an important topic of analysis, several studies have been undertaken in the context of VAR model such as Patelis (1997) and Primiceri (2005).

As an alternative to VAR approach, many researchers have performed event studies, which allows for analysis, comparatively at higher frequency than VAR literature which is normally based on quarterly and monthly data. For instance, Jensen and Johnson (1995), show that when discount rate decreases stock returns are higher and less volatile than the stock returns when the rate increases for several weeks. Thorbecke (1997), by using daily frequency shows that changes in the federal funds rate have significant effects on the US equity markets. Bomfim (2003), in his study shows that there is low volatility in the US stock markets proceeding the days of regular scheduled policy announcements where as volatility increases following the policy announcements. Bernanke and Kuttner (2005), find that effect of US monetary policy on the US stock returns is importantly related to the effect of monetary policy on expected future dividends and expected future excess returns. Dedola and Lippi (2005), while studying monetary transmission mechanism using disaggregated data of five OECD countries find that effect of monetary policy on industrial output is related to financing requirements, borrowing capacity and firm size, leading to conclude that "credit channel" variables have non negligible role.

Bernanke et al. (2005), introduce factor augmented VAR approach to incorporate a broad information set used by policy makers. They use a large data set of 120 monthly variables on the US economy to study the impact of contractionary monetary policy they find that following contractionary policy real activity declines, overall their results provide consistent measure of policy transmission. According to Leamer (2007), eight of the ten recessions in the US history were preceded by substantial problems in housing sector. Keeping in view that monetary policy shocks have remained the main reason behind the downfall of the residential investment that begun in early 2006 (Taylor (2007)), one cannot exclude that monetary policy shocks played a non negligible role in leading the way for the downturn in residential investment and the ensuing 2008 recession.

The main focus of the literature on the transmission of monetary policy shocks to study the contagion effects has been on domestic front, to the best of our knowledge there has been very

few exceptions studying the international transmission of monetary policy shocks that we will discuss in our next section.

2.2 International economic, financial and monetary linkages

This paper also belongs to the strand of literature that has studied the cross-country economic and financial linkages. In the context of studying international monetary transmission it is important to analyze open economy. Generally the framework used in this type of studies is the Mundell-Fleming-Dornbusch (MFD) model. Under the floating exchange rate regime and when the capital is perfectly mobile according to MFD model contractionary monetary policy leads to decrease in output on domestic front and increase in output on foreign front under "beggar-thy-neighbor" policy framework as the domestic economy suffers at the benefit of other foreign country. Under a fixed exchange rate regime increase in discount rate leads to monetary contraction in domestic as well as foreign front. Under flexible exchange rate regime and when there is imperfect capital mobility domestic country's monetary policy contraction decreases its price level and output but as the exchange rates move there are no output implications for the other country except that the foreign consumer prices will increase as a result of exchange rate change[4].

On empirical grounds, there are very few studies that analyze the transmission of monetary policy on international level.

Haug et al. (2005), use vector error correction model to analyze the similarity in transmission mechanisms in Australia and New Zealand and study the implications this has for the currency union between the two countries, they find similar responses for GDP and CPI however they find differences in response, in terms of magnitude for some variables for identical monetary policy shock. Eickmeier (2007), studies the transmission of the US business cycle shocks to Germany by using a large dimensional structural dynamic factor model and finds that main reactions are in monetary and trade areas. Financial markets become more important over time.

Exploring the international transmission of the US monetary policy to OECD countries is an understudied area.

Kim (2001), using VAR methodology documents evidence on international transmission of expansionary US monetary policy shocks to non US G-6 countries under a flexible exchange rate period. His findings can be summarized in two steps, first, there is short term worsening and medium and long term improvement of trade balance, the magnitude of changes in trade

[4] For the detailed explanation of this model see Hallwood and MacDonald (2000).

balance is very small compared to changes in foreign output overall his finding does not support the prediction of basic MFD model i.e. the trade balance is the major international transmission mechanism. Second the US monetary policy expansion leads to booms in non US G-6 countries, as the US is a large open economy expansionary monetary policy leads to fall in the US real interest rates which in turn decrease world real interest rates in case if the world capital market is integrated to some extent. Consequently world consumption and investment increases in effect, "overall, the basic version of Mundell-Flemming-Dornbusch (MFD) and sticky price (or sticky wage) inter-temporal models do not seem to be consistent with the evidence about all of the details of the transmission mechanism and some extended version seems necessary to match the details."

Sousa and Zaghini (2008), use structural VAR model to show that a positive monetary shock in the euro area leads to a permanent increase in price level as well as M3 aggregate, a temporary appreciation of the real effective exchange rate of the euro as well as temporary rise in real output. Ehrmann and Fratzscher (2009), study the 50 equity markets worldwide and find that the US monetary policy has been the major determinant of world equity markets. They find that on 100 basis point tightening of the US monetary policy, returns fall on average about 3.8%, ranging from a zero to more that 10% in some countries. U.S and foreign short term interest rates and foreign exchange rates are the major transmission channels. They conclude that the degree of global integration and not a country's bilateral integration is the major determinant for transmission.

Overall, the literature provides a clear and robust evidence for international economic, monetary and financial linkages. While answering for the question of causality, the US markets have been found out as major driver of global developments.

2.3 Explaining linkages

While describing cross-country (cross-market) linkages, though there is clear evidence for these linkages, but they are heterogeneous across countries and vary over time.[5] In this regard, there have been efforts to explain the magnitude of spillovers across different countries over time.

The importance of trade as a catalyst for cross-country linkages was first highlighted by Eichengreen et al. (1996), while analyzing contagious nature of currency crisis by using quarterly data set spanning from 1959 to 1993 for 20 industrialized countries. Their findings

[5] See Bekaert and Harvey (1995).

conclude that trade links rather than macroeconomic similarities were the major channels of contagion transmission across these countries under the sample period. Glick and Rose (1999), show that currency crisis affect other countries having trade ties, where as financial and economic influences do not help to explain cross country incidences of speculative attacks.[6] Forbes and Chinn (2004), test whether financial and real market linkages can explain why changes in world largest financial market have same effects on other financial markets. They find that from 1996-2000, real and financial linkages have become major factors for transmission of shocks from large economies to other economies. In this regard US factor has received importance in recent years.

Finally, some papers have also tested hypothesis to analyze the spillover effects of the US monetary policy shocks to other economies in general and financial markets in particular. Canova (2005), finds that size of countries response depends on exchange rate regime in spite of the fact that differences with de jure classification are comparatively small.

Miniane and Rogers (2007), study whether capital controls can efficiently insulate countries from the US monetary shocks. They estimate the effect of the US monetary shock on foreign country interest rates and exchange rates and see whether less open capital accounts can help countries to show systematically smaller responses. This hypothesis was rejected by the authors and concludes that exchange rate regime and degree of dollarization are the major determinants of cross country differences. Bouakez and Normandin (2010), study the impact of expansionary US monetary policy shocks on bilateral exchange rates between US and G-7 countries. Their results indicate that nominal exchange rates initially depreciate for short term then overshoot, according to variance decomposition results monetary policy shocks accounts for the major portion of the exchange rate fluctuations.

This study expands the research on international transmission of shocks with emphasis on how the US monetary policy shocks impacts OECD economies, using two most recent factor augmented VAR approach and time-varying parameters factor augmented VAR approaches, hence allowing for detailed analysis on the subject.

3 EMPIRICAL FRAMEWORK

The two empirical approaches which are frequently used to study how monetary policy shocks are transmitted to the economies of interest are structural macro models and VAR models. Structural models have been the subject of criticism in the literature because of their

[6] They use data for five different currency crises (in 1971, 1973, 1992, 1994, and 1997).

implausible identification restrictions; in this regard the work of Sims (1980), is considerable. In this framework identification is achieved by Choleski decomposition of reduced form residuals. Some researchers such as Kim (2001) and Christiano et al (1998), use this approach to study the monetary transmission.

Although VAR approach has been widely used in monetary policy analysis, recently this approach has become the subject of great criticism because of the sparse information set used in this model, which normally does not include more than eight variables to conserve degrees of freedom. Central banks normally use large information set to analyze the state of the economy before making policy decisions, so VAR approach may exclude important information pertinent in the transmission process.

3.1 Factor augmented VAR approach

To overcome the problems of sparse information set used in VAR approach, Bernanke et al. (2005), propose new framework known as factor augmented VAR approach to estimate the factors that explain most of information content used in large data sets.[7] This approach is based on two basic equations following a two step procedure as suggested by Stock and Watson (2002).

Let X_t be a N × 1 vector of rich "informational time series variables" and Y_t be a M × 1 vector of macroeconomic time series variables that are observable. Y_t includes policy instrument and may contain other observable measures of inflation and economic activity such as output so Y_t can be assumed as subset of X_t. However additional economic information may exist that may not be fully explained by Y_t, this additional economic information may be summarized in K × 1 vector of unobservable factors, F_t.[8]

The dynamics of observed and unobserved factors can be given by the following model

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \upsilon_t \quad . \tag{1}$$

Where Φ(L) is a lag polynomial of finite order d, which may contain structural priori restrictions, the error term υ_t, assumed to have mean zero and covariance matrix Q. Thus the addition of factors helps in overcoming the drawback of sparse information set used in VAR

[7] See Bernanke et al. (2005).

[8] These unobservable factors can be financial and economic indicators that cannot be captured in few variable VAR model.

models. An important step in model selection is to determine the number of unobservable factors used for policy analysis, different model selection methods may suggest an optimal number of factors on statistical grounds, however the actual number of factors required for monetary policy analysis can be different, further it requires experimentation assuming different number of factors, see for example Bernanke et al. (2005) and Korobilis and Gilmartin (2011). We run the model with two, three and five factors however qualitatively results remain same hence we opt for the two factors and two lags to keep the parsimony in factor augmented VAR approach and time-varying parameters factor augmented VAR specifications.

3.1.1 Identification of the factor augmented VAR approach

Equation (1), cannot be estimated directly as the factors are not observed. As F_t is assumed to represent information that impacts many economic and financial variables in such a situation factors can be inferred from Xt a N × 1 vector of informational variables that are assumed to be known to central bankers while making policy decisions. Hence the following relation holds between Xt and F_t

$$(2) \qquad X_t = \Lambda^f F_t + \Lambda^y Y_t + \varepsilon_t .$$

Where Λ^f and Λ^y are N × K and N × M matrix of factor loadings respectively, ε_t is N × 1 vector of error terms assumed to be weakly correlated or uncorrelated. To resolve the issue of recovering unknown factors we follow Bernanke et al. (2005), by using two-step principal component analysis (PCA). We use all the variables in Xt to obtain the first K+M principal components that can be represented by $\hat{C}(F_t, Y_t)$. As in the first step Y_t is not assumed to be observable, estimated factors are the part of space covered by $\hat{C}(F_t, Y_t)$ and not by Y_t .

To correct the dependence of estimated factors on Y_t we divide the initial data set into fast moving and slow moving variables. Fast moving variables (interest rates, exchange rate and stock prices) are those that are assumed to respond contemporaneously to monetary policy shocks, on the other hand slow moving variables (employment, industrial production and consumption) are assumed not to respond contemporaneously to monetary policy shocks. We use PCA on slow moving variables to get the matrix of slow moving variables, $C(F_t)$.

$$\hat{C}(F_t, Y_t) = \beta^f C(F_t) + \beta^y Y_t + e_t .$$

By taking the difference $\hat{C}(F_t, Y_t) - \hat{\beta} Y_t$, we get $\hat{F}_t$ (estimated factors), now the factors can be treated as observed data and equation (1) can be estimated by replacing F_t with $\hat{F}_t$. It is necessary to identify restrictions in equation (1) and (2), with respect to factors and loadings. In the next step, F_t is identified by rotating $F^* = AF_t - BY_t$, where A and B can be defined as $K \times K$, non singular and $K \times M$ respectively. We leave VAR unrestricted and impose restrictions in equation (2) we get

$$X = \Lambda^f A^{-1} F_t^* + \left(\Lambda^y + \Lambda^f A^{-1} B\right) Y_t + e_t . \quad (3)$$

We make following adjustments for the purpose of identification of factors and their loadings $\Lambda^f A^{-1} = \Lambda^f$ and $\Lambda^y + \Lambda^f A^{-1} B = \Lambda^y$, setting upper $K \times K$ and upper $K \times M$, block of Λ^f to an identity matrix and also block of Λ^y to zero respectively, for restricting the means by which $Y's$ impact the $X's$. Another important consideration should be given to variables chosen for respective blocks should not be contemporaneously responsive to Y_t as the choice of block restricts the impact of Y_t on K variables. The second step involves estimation of equation (1), by a VAR model that will be discussed in next part.

3.1.2 Estimation and identification of VAR model

In this step we estimate and identify VAR model given in equation (1), that now contains $\hat{F}_t$ and Y_t, here Y_t includes only monetary policy instrument i.e. federal funds rate as observable variable all other variables are treated as unobservable. According to Bernanke and Blinder (1992), federal funds rate is the most appropriate variable to reflect U.S. monetary policy actions.

3.2 Time-varying parameter factor augmented VAR approach

Factor augmented VAR approach approach is an excellent tool to study the transmission process; however it assumes that parameters are constant over time, such an assumption being too restrictive results in limitations of this approach. Some authors such as Primiceri (2005) and Koop et al. (2009), have emphasized that both transmission mechanism of monetary policy and variance of exogenous shocks have changed over time, this motivates the fact that multivariate models which allows for both the VAR coefficients and error covariance matrix to change overtime serves as the best tool to study the international transmission of monetary policy shocks and how the contagion transmits from the domestic economy to the other economies. While allowing parameters to vary overtime in factor augmented VAR approach it is important to include prior information or impose certain restrictions such as allowing some parameters to vary overtime period, is important to obtain plausible results. For our analysis

we use a very general specification of time-varying parameters factor augmented VAR approach given by Korobilis (2011).[9]

$$X_t = \Lambda_t^{\,f} F_t + \Lambda_t^{\,y} Y_t + \varepsilon_t \qquad (4)$$

and

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi_t \begin{bmatrix} F_t - 1 \\ Y_t - 1 \end{bmatrix} + \upsilon_t \,. \qquad (5)$$

Here ε_t is a vector of error terms, each term ε_{it}, for i = 1,.., N, follows a univariate stochastic volatility process, and $\text{var}\left(\upsilon_t\right) = \widetilde{\Sigma}_t^f$ has multivariate stochastic volatility process. [10] In terms of state space models equation (4), is called the measurement equation and equation (5), is called the state equation.

We allow the coefficients, for $(i = 1,..,N)\Lambda_t^f, \Lambda_t^y$ and Φ_t to change according to random walk. All the remaining assumptions are the same as the factor augmented VAR approach approach.[11]

3.2.1 Factor estimation and priors

We estimate the factors by using two step principal component analysis, then on the basis of these estimates, model parameters are estimated. Normally VAR has many coefficients to estimate in the absence of prior information it is difficult to obtain accurate estimates of coefficients and hence resulting in large posterior and predictive standard deviations ultimately leading to spurious estimates of impulse responses. Bayesian approach allows to use prior information on the basis that more information is preferable to less information as an alternative Bayesian approach also provides for the use of non informative priors, if someone does not wish to use informative priors, one does not has to do so, still providing a room for researchers to apply Bayesian framework.

The use of time varying parameters requires some shrinkage in the model. We use non-informative prior to provide shrinkage in the model.

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[9] The model of Korobilis (2011), is an extension of this as it contains dynamic mixture aspect and draws the index 'J' for the volatilities in the factor equation and the lower triangular matrix in the actor augmented VAR approach equation.

[10] Refer Primiceri (2005), for further details.

[11] We add more blocks to Markov Chain Monte Carlo (MCMC), algorithm for th factor augmented VAR model. For further detail on how error variance and coefficients are drawn, refer Koop and Korobilis (2010), section 3.3.1 (page no. 32) and section 3.3.2 (page no.36).

4 DATA

4.1 Monetary policy shocks

We use in our study quarterly US effective federal funds rate from 1981Q1-2010Q4, to measure US, monetary policy shocks. The data is taken from the website of Federal Reserve website, FRED - St. Louis Fed, Bank of International Settlement (BIS) and OECD national accounts.

4.2 Large international dataset

The data consists of quarterly variables from the period 1981Q1-2010Q4 for 14 major OECD countries. We tried to extend the data set on a long horizon to assess how the US monetary policy shocks result in contagion effects and transmit internationally and how the financial integration and globalization has impacted this transmission mechanism, and also we can have the benefit of comparing recent financial turmoil periods with earlier crisis periods.

Our dataset includes 265 variables, where X_t includes 19 variables for each country, encompassing a wide range of financial variables (short term, long term interest rates, all share price indices, housing price indices), variables related to real economy (GDP, personal consumption, government final consumption expenditure, gross fixed capital formation, gross fixed capital formation residential, industrial production, unemployment rate), aggregate price variables (CPI, GDP deflator), trade variables (price of imports, price of exports, import of goods and services and export of goods and services), real exchange rate and nominal exchange rate of each country per US dollar. Nominal exchange rates are defined in the way that increase reflects an appreciation of dollar.

The main challenge faced by central bankers is that their decisions taken today will affect the price level only in future whereas in short term monetary and economic statistics may be subject to certain distortions. Seasonally adjusted data allows gauging short-term developments in spite of trading-day effects and seasonal patterns where relevant hence we use seasonally adjusted time series data in our analysis. We standardized the series to have a zero mean and unit variance. More detailed description is provided in appendix A. As mentioned in literature there is no sufficient evidence on the international transmission of the US monetary policy shocks to OECD countries in light of recent global developments, and as it is the topic of hot discussions around the globe that how recent crisis has impacted economies in general and financial markets in particular.

5 EMPIRICAL RESULTS

In this section we briefly discuss the transmission of US monetary policy shocks to federal funds rate and to major financial and economic variables (main variables that depict the dynamics of key variables of interest) in the OECD countries.

5.1 Federal funds rate shocks

Principally it is important to study the movements in federal funds rate that are responses to variables other than unemployment and inflation (exogenous shocks). Figure 1, panel (a), presents the median posterior estimates of time varying standard deviation of errors from the time-varying parameters factor augmented VAR model. The high variance of shocks is associated with higher policy mistakes or major changes in monetary policy stance over that period. The period 1981-83 shows a high volatility in federal funds rate, reveals Monetarist Experiment because of oil shock and high interest rates. This finding is in line with the finding of Primiceri (2005), who employs time varying structural VAR on US quarterly data spanning from 1953Q1 to 2001Q3. His results indicate that higher variance in monetary policy shocks over 1979 to 1983 confirms Volcker regime and his monetary aggregates targeting strategy.

The periods of high volatility also coincide with periods of major financial turmoil in the US history in our sample period. 1982-84 is marked by "the Less Developed Countries Debt Crisis (LDC)," 1988-1991 "the Saving and Loan Crisis", and 2008-2009 "global financial crisis".[12] The high volatility of 1980s is also associated with changes in financial markets along with increasing competition, increased securitization, introduction of risk based capital adequacy requirements, 1987, stock market crash in 1987, Asian Financial Crisis, which started in July 1997 followed by Russian financial crisis (also called "Ruble Crisis") in 1998[13]

[12] Initially we tried to begin our data set from 1970s, to cover the four postwar financial crises as documented by Lopez-Salido and Nelson (2010) but because for many variables the series starts from 1981 so our data set begins from 1981. The International Debt Crisis of the 1980s occurred when several major Less Developed Countries (LDCs) had difficulty meeting their debt obligations, resulting in Continental Illinois failure, the largest ever bank failure in U.S. history. The Savings and Loan Crisis of the 1980s and 1990s (commonly known as the S&L crisis) was the failure of about 747 out of the 3,234 savings and loan associations in the United States.

[13] The Asian and Russian Crisis resulted in decline in world commodity prices, countries heavily dependent on the export of raw materials were among those most severely hit, Dot-com Bubble or Internet Bubble was a speculative bubble reached a climax on March 10, 2000 with the NASDAQ peaking at 5132.52 in intraday trading before closing at 5048.62, during which stock markets in industrialized nations saw their equity value

and the boom and burst of Dot-com Bubble in 2001, might have been reflected in these shocks and led to changing monetary policy transmission. Finally we notice that during the recent financial crisis, there is extraordinary increase in the variance of the shock.

We also compute the impulse responses of federal funds rate to its own shock by obtaining Cholesky residual in federal funds rate equation in the time-varying parameters factor augmented VAR; the error bands show 90% confidence interval. We have standardized the shock to one standard deviation unit; by this standardization we will further compare the transmission of the shocks of the same magnitude to other variables of interest over time. Panel (b) of Figure 1 shows the impulse responses for different quarters, revealing the fact that the impact of the shock of federal funds rate to federal funds rate peaks on effect and turns to zero almost after three to four years in 1982:Q4, 1989:Q4, 1996:Q4 where as in 2003:Q4 and 2010:Q4 the shock appears to have more persistent impact on federal funds rate though becoming statistically insignificant after seven to nine quarters.

5.2 The transmission of the US monetary policy shocks to OECD economies under constant parameter factor augmented VAR.

Panels (a-g), of Figure 2 present the impulse response functions of major financial and economic variables under constant parameter factor augmented VAR framework and then in the light of these results we further study, how these variables help in understanding the evolution and size of the US monetary policy shocks and their transmission to key variables of interest in OECD countries. Principle component based estimates use 15000 iterations of Gibbs related sampling, of which we discard 5000, initial draws, to be sure about the quantitative measure and accuracy of results.

The main purpose of using the US monetary policy shocks is to identify the source of shock and to identify the overall co-movements of major economic variables in general and financial variables in particular as key variables. Fig. 2 (a and b), gives an idea of the impact of one standard deviation shock to federal funds rate on the short term and long term interest rates respectively.

It provides clear evidence that in the US short term and long term interest rates (10 year) respond significantly, positively to the US monetary policy shock. The results show that 100 basis points tightening of US monetary policy leads to 90 % and 100 % increase in long term

rise rapidly from growth in the more recent internet sector and related fields. The period 2000 was a boom and bust cycle, one of the major contributing factor to these busts was that during 1999 and early 2000, the U.S. Federal Reserve increased interest rates six times, resulting in economic slowdown.

and short term interest rates respectively in the US and which in turn impact long term and short term interest rates in non US OECD countries because of high level of financial integration, the short term interest rates increase by between 70 and 100 basis points, subject to the country under consideration. The long term interest rates increase by 60 and 90 basis points in non US OECD countries.

Our findings echo the findings of Neri and Nobili (2010), according to them increase in federal funds rate appreciates dollar relative to other currencies, resulting in decrease in world demand which in turn reduces the prices of commodities hence resulting in increase in private final consumption and gross fixed capital formation will increase in most of the OECD countries, driving the prices on higher level, increase in short term interest rates can be interpreted as reaction of central banks which respond to contemporaneous higher price level.

There are also substantial differences in the transmission of contractionary US monetary policy shocks to non US OECD countries. The same impact in terms of magnitude and direction is found in Canada, Fig. 2 (a-I and b-I), where it is interesting to note that short term and long term interest rates respond in the same manner as in the US. Following contractionary monetary policy in the US, private final consumption expenditure decreases in Canada and increases in rest of the countries, this can be one of the reasons of increasing prices and decrease in unemployment rate in France, Germany, Norway, Sweden, Switzerland, Finland and New Zealand as can be seen in Fig. 2(f-I, II and g-I, II). For some variables the impact is even larger than the US itself for instance in Fig. 2(d-I, II and e-I, II), gross fixed capital formation reaches – 10% over the second quarter in the US where as in case of Canada and Australia it decreases to – 40% and -20% from the baseline over the same period, housing prices decrease significantly in Canada, France and Spain where the magnitude of this response is even greater than the US itself.

5.3 Understanding the changing transmission of US monetary policy shocks

Now first we try to explore how the transmission of federal funds rate shocks to GDP, gross fixed capital formation and residential investment (major macroeconomic variables) take place and evolve over time and second find out its main transmission channels by analyzing the impact of federal funds rate shocks on different other variables. Theoretically, monetary policy shocks that take place in the US can impact investment and consumption in the US,

through wealth effects, Tobin's q and changes in financing costs.[14] An appreciation of the US dollar in contractionary monetary policy can lead to increasing import demand and through trade channel positive economic effects abroad. Moreover, financial integration can play an important role to propagate the shocks to other countries for instance investors reassess their investments in other countries following the same fundamentals.[15] In our study we will see how different channels e.g. asset channel, trade channel, exchange rate channel and interest rate channel play role in the transmission of US monetary policy shocks.

In this section, hence we present the impulse response functions of selected US and other countries variables to the US monetary policy shocks, principle component based estimates use 30,000 iterations of Gibbs related sampling, of which we discard 5000, initial draws, for convergence.

In subsections 5.3.1 and 5.3.2, we will focus on "normal" times, i.e. 1985Q1, 1987Q1, 1995Q3, 2007Q2 and 2010Q4. We will try to put light on the reasons behind changing transmission of the US monetary policy shocks to OECD economies under time-varying parameters factor augmented VAR framework.

We in sub-section 5.4, will discuss on financial turmoil periods as discussed in Lopez-Salido and Nelson (2010) and also include two stock market crashes i.e. 1984Q4, 1987Q4, 1990Q4, 2001Q2 and 2008Q4 these periods are taken from following horizons, 1982Q3-1984Q4 represents LDC Debt Crisis, 1987Q4 represents Black Monday, 1988Q1-1991Q4 represents Saving and Loan Crisis, 2001Q1-2001Q4 represents the burst of Dotcom Bubble and

[14] Mishkin (2003), describes in detail the transmission channels of monetary policy, accordingly an expansionary monetary policy leads to fall in real interest rates resulting in lower cost of capital and hence investment increases leading to increase in demand and output. Consumers balance sheets can also impact their spending decisions as spending is determined by lifetime resources of the households, stock prices being the major component of financial wealth when increase rise spending. James Tobin developed Tobin's q theory which also better explains how monetary policy impact economy by its impact on valuation of stocks. Q can be defined as the as the market value of firms divided by the replacement cost of capital. In case q is high, the market value of firms is high relative to the replacement cost of capital, and new plant and equipment capital is cheap relative to the market value of firms. In case of contractionary policy money supply decrease resulting in decreasing investment in stocks so consequently falling their prices, keeping this fact in view falling stock prices and decrease in investment and output.

[15] We focus on overall transmission of monetary policy shocks rather than some specific segment of the economy, therefore we expect that exposure to foreign assets will increase the propagation of federal funds rate shocks.

subsequent recession and 2008Q1 to 2009Q2 represents recent global financial crisis. We will try to explore whether the transmission of the US monetary policy shocks differs during crisis periods from that tranquil periods.

5.3.1 The changing transmission of shocks in the US

Fig. 3 (a-c), show the impulse response functions of the US and other OECD member countries to one standard deviation shock over 1985Q1, 1987Q1, 1995Q3, 2007Q2 and 2010Q4. In the US federal funds rate shocks show the impact on wide range of variables. They decrease GDP, gross fixed capital formation and also results in decrease in gross fixed capital formation in housing.[16]

Fig. 3(a-I), shows following a contractionary monetary policy shock GDP declines in the US. This can be explained by the fact that because of high interest rates aggregate expenditure falls leading to decline in production and employment, this can explain high level of unemployment in the US and Canada. In case of US the monetary policy shocks reduce the GDP by approximately 12% relative to baseline during the initial two quarters, the negative impact on GDP peaks after about six quarters and is undone after about three years. This is in line with the theoretical priors and findings of Bjørnland and Leitemo (2009), according to their findings monetary policy shock declines output temporarily which reaches its minimum after a year and a half.

Higher interest rates result in decrease in gross fixed capital formation and fall in residential investment, Fig. 3(b-I and c-I). In the US gross fixed capital formation follows the same time path as of GDP, the most negative impact peaks after six quarters and is undone in about three to four years.

In terms of variation over time, we find that in the US the impact of negative (unexpected) US monetary policy shocks on GDP growth and gross fixed capital formation have reduced over time, this can be explained by the structural changes in financial markets or are due to the changes in the conduct of monetary policy. This shift in monetary policy transmission that we identify is similar to findings in many other studies (Boivin and Gianoni 2006 and Boivin et al. 2011).

[16] Housing prices which increase their value compared to replacement costs increase Tobin's q, hence increase housing production, increasing wealth effect results in increasing consumption and investment.

5.3.2 International financial, economic and monetary linkages

In Canada GDP declines to – 25% relative to baseline in initial period in response to the US contractionary monetary policy shock, the most negative impact is found between fifth and sixth quarter, this can be explained by the very strong positive response of short term interest rates with peak impact at 90%, after 6 quarters in 2010Q4, also in Sweden and Norway the GDP growth is depressed by US monetary policy shocks over most of the horizons under consideration which is more evident after six quarters while it has positive impact on GDP growth in France, Germany, Italy and UK, Australia, Spain, Switzerland, Finland and New Zealand where the GDP grow by about 1% to 30 % relative to baseline, Fig. 3(a-I and II). In Japan negative response of GDP growth over first 3 quarters supports the findings of Caporale and Pittis (1997), while studying the role of domestic and external factors for interest rate determination for US, Japan, Germany, France and Switzerland find that in the case of Japan they do not find the role for GDP or US interest rates, although they find that German rates are significant; in case of domestic variables, only expected inflation seems to affect interest rates and in turn GDP growth. In Canada higher interest rates, in turn tend to reduce or "crowd out" aggregate investment expenditures and consumer expenditures that are sensitive to interest rates. Gross fixed capital formation (GFC), a measure of investment in capital goods, declines in Canada, resulting in decrease in productivity and GDP growth, Fig. 3(b-I). This can be explained by the "crowding-out effect" of higher interest rates those tend to reduce aggregate investment expenditures and consumer expenditures. Gross fixed capital formation declines in Germany, Japan, Australia and Sweden by between 8% to 18% from the initial level depending on the country under consideration, refer to Fig. 3(b-II). Responses of residential investments are more scattered, they are mostly negative, decline in residential investment in Canada, Germany, Italy, UK, Japan, Australia and New Zealand is not surprising and can be explained by differences in local supply factors for instance residential construction policies, forms of finance, recessionary pressures, regulations, cross country demand factors for instance aging of population, Fig. 3(c-I and II).

5.4 What are the Channels through which financial shocks are transmitted?

5.4.1 Interest rate channel

We find that over time, the pass through of the US monetary policy shocks to interest rates has decreased in most of the countries which may have contributed to positive GDP growth in France, Germany, Italy and U.K, Australia, Spain, Switzerland, Finland and New Zealand,

Fig. 4(a-I and II). Long term interest rates on government bonds move mostly in line with US counterparts and increase after contractionary shocks, one interesting finding is that over the time this pass through to long term interest rates has reduced that can be seen over the recent period i.e. 2010 Q4 as shown in Fig. 4(b-I and II), this can be also explained by the decreasing short term interest rates in most of the OECD countries.

5.4.2 Asset channel

Asset price channel works through two transmission mechanisms, impact on Tobin's q of firm and impact on the financial wealth of households. Monetary policy shock has negative impact on share prices which fall immediately by about 20% in the US, 40% in Canada, and 30% in Australia, this finding supports the finding of Ehrmann and Fratzscher (2009), they find that equity markets in Canada and Australia react strongly to US monetary policy shocks while studying the US monetary policy transmission to 50 equity markets worldwide.

In most of the other countries stock price response to monetary policy shocks ranges from 10% to 20% however this decline in share prices is more pronounced at sixth quarter in the US, Canada, Germany, Italy, UK, Japan, Australia, Norway, Sweden, Switzerland and New Zealand after contractionary US monetary policy shocks, Fig. 4(c-I and II). This is consistent with the results found for the US in Bjørnland and Leitemo (2009) and Rigobon and Sack (2004), but with larger magnitude where former found that for every 100 basis-point increase in federal funds rate stock prices fall by 9% whereas latter found that a 25 basis-point increase in the short term interest rates results in 2.5 basis-point decline in Nasdaq index.

There can be different microeconomic and macroeconomic reasons behind this, first, US monetary policy shocks may have economic repercussions to these economies because of the spillover effect, mainly if these have very close trade links, and high degree of financial integration, in that case there are greater chances that stock markets will also be effected, another explanation, apart from this there can be microeconomic impact on individual investors and firms those are operating in national stock markets. First, if some firms finance them directly in the US; it will affect their investment decisions by changing financing costs, reduced output and expected future dividends. Second, increase in the US interest rates cause local and global financial investors to rebalance their portfolio. Third, stock price valuation of the firms those have business ties with US will change because of the impact of US monetary policy on real activity in the US.

5.4.3 Trade channel

Raising interest rates also has an effect on exchange rates, a monetary contraction leads to nominal exchange rate appreciation and an improvement of terms of trade, and consequently export industry loses competitiveness and output falls and other member countries benefits under beggar thy neighbor policy framework, resulting in currency depreciation benefiting the export sector from proportionate increase in output.[17] In other countries demand for imports decrease because of expenditure switching affect, refer to Fig. 4(d-I, II and e-I, II).[18] Nominal exchange rates are defined as national currency of each member country per US dollar, so that increase in nominal exchange rates shows appreciation of dollar. Following nominal effective exchange rate appreciation, exports increase in France, Germany, Norway, Switzerland and New Zealand, one would also expect increase in exports in Japan following considerable nominal effective exchange rate appreciation, there are different explanations for this, one reason for the negative relationship between output growth and exchange rate depreciation in some cases is low price elasticity, low responsiveness of exports and imports in the short run causing trade balance to worsen and output to contract. Second different factors affect the outcome of exchange rate changes, adjustments can take long time so short term and long term effects often differ. Third depreciation of currency sometimes may not bring desired effect on output and exports, as in some cases expenditure switching effect may not be substantial and can take longer time to occur.

All the above factors can preclude simple, predictable and definite outcomes.

[17] A protectionist policy involving the devaluation of one's currency and the construction of tariffs barriers on other countries. The goal of a beggar-thy-neighbor policy is to increase demand for a country's exports (by devaluing the currency and making a country's goods less expensive in other countries) while also reducing demand for the countries imports.

[18] Depreciation in the exchange rate can have the desired effect of improving the current account balance, over the longer term. Demand for exports picks up and domestic consumers will switch their expenditure to domestic products and away from expensive imported goods and services. Equally, many foreign consumers may switch to purchasing cheaper imported products instead of their own domestically produced goods and services.

5.5 *Is there evidence of transmission mechanism different over financial turmoil periods?*

We will now focus on the financial turmoil periods in 1984Q4 (LDC Debt Crisis), 1987Q4 (Black Monday), 1990Q4 (Saving and Loan Crisis), 2001Q2 (Burst of Dotcom Bubble) and 2008Q4 (recent global financial crisis).

In case of US we find persistent negative GDP growth and gross fixed capital formation overall horizons exception is found for 2001Q2 and 2008Q4 where after remaining negative for two quarters it showed positive growth, however after the seventh quarter GDP declines to 15% from the baseline in 2008Q4 where as in comparison to 2010Q4 (normal times) after seventh quarter the GDP declines to 2% from the baseline suggesting major fall in GDP during former quarter. In Canada GDP initially declines to 25% from baseline whereas after sixth quarter in 2008Q4 GDP declines to 24% from baseline as compared to 2010Q4 where after seventh quarter this decline was 18%, also the persistence of the shocks varies across these quarters, 2010Q4 witnessing more persistent responses of GDP than 2008Q4, Fig. 5(a-I). Negative GDP growth in the US benefits France, Germany, Italy and U.K, Australia, Spain, Switzerland, Finland and New Zealand with positive GDP growth but with less magnitude as compared to normal times, Fig. 5(a-II). Gross fixed capital formation saw a major decline during the recent financial crisis at the sixth quarter in Canada, Germany, Australia and Sweden, Fig. 5(b-I and II). In 2008Q4 there is evidence of higher gross fixed capital formation residential than normal periods depicting the major cause for burst of housing bubble in 2008 in the US, Fig. 5(c-I and II), this evidence is in accordance with Cecchetti (2008), according to him since 2000 residential prices skyrocketed resulting in housing bubble. Through Tobin's Q effects an increase in residential prices determine increase in property value over replacement costs fueling residential investment.

We find the same evidence for turmoil periods that over time US monetary policy shocks pass through to short term interest rates over first three quarters have declined to OECD countries. We find the evidence of high short term interest rates prevailing in 1990Q4 depicting the major cause of Saving and Loan Crisis Fig. 6(a-I and II), consequently higher rates on government bonds in 1990Q4 in the US over the first three quarters while other countries following the same, contagion effects may be responsible for this co-movement in other member countries, Fig. 6(b-I and II).

These findings are accompanied by declining investment in equities during that period; Fig. 6(c-I and II), shows share prices decline by between 43% to 3% from the baseline subject to country under consideration except Spain during the turmoil period. Another interesting

finding is increase in share prices during 2001Q2 in almost all countries following US because of Dotcom Bubble. According to Fig. 6(d-I and II), a contractionary monetary policy shock appreciates nominal exchange rates where maximum effect can be seen within one to two quarters followed by gradual decline, this finding supports the Dornbusch's exchange rate overshooting hypothesis, according to that increase in interest rates should instantaneously appreciate, the nominal exchange rates and then depreciate in accordance with uncovered interest rate parity (C. and Bjørnland (2009)).

Fig. 6(e-I and II), shows major decline in exports in U.S, Canada, Italy, UK, Japan, Australia, Spain, Sweden, and Finland with peak impact (negative) from baseline during 1990Q4 because of dollar appreciation over this period.

6 CONCLUDING REMARKS

In this paper we have examined the transmission of US monetary policy shocks that grapple with the three main questions: first, how large is the impact of US monetary policy shocks on the major OECD countries, and have their size and transmission changed over time? Second, what are the important channels through which US monetary policy shocks are transmitted both domestically and internationally to the OECD countries, and can we identify changes in transmission mechanism over time? Third, is there evidence of contagion effects on major financial and economic variables during financial turmoil periods and normal periods and through which channels? These questions are of basic interest for many researchers and policy analysts, as an accurate assessment of the impact of monetary policy and a good understanding of the transmission channels is pivotal to achieve financial stability and stable economic growth. Much of the empirical literature on monetary policy shocks has used VAR approach. This leads to low dimensionality and omitted variable bias issues.

In order to tackle these issues and study the monetary policy transmission in the light of questions raised, we employed factor augmented VAR approach, proposed by Bernanke et al. (2005) and time-varying parameters factor augmented VAR approach, suggested by Koop and Korobilis (2010), to amplify the changing transmission mechanism of US monetary policy. We used the quarterly data set of 265 major financial and economic variables from 14 OECD member countries from 1981:Q1 to 2010:Q4. Our main findings are as follows.

First, we find that contractionary US monetary policy shocks have considerable negative impact on GDP growth in the US, Canada, Japan and Sweden, ranging from 2% to 28% decline from the baseline, while most of the other member countries benefits, with positive

impact ranging from 8% to 51% relative to baseline, over the medium term. Overall we find that in most of the OECD countries the negative impact of (unexpected), US monetary policy shocks on GDP growth have reduced over time and also the size of the US monetary policy shocks strongly varies overtime.

Second, interest rate, asset and trade channel seem to play major role in propagation of monetary policy shocks both domestically and internationally to the OECD countries. Pass through of US monetary policy shocks to short term interest rates have reduced over short to medium term during the recent periods, in most of the OECD countries, identifying the changes in transmission mechanism over time.

Third, we find that transmission of US monetary policy shocks to US and to other OECD member countries' financial and economic variables results in contagion, both during normal and financial turmoil periods. However, transmission during turmoil periods was unusual in many respects than normal periods. In the US, Canada, Japan, Australia and Sweden the GDP response to same size shocks during turmoil periods was larger over the medium run than historical standards in 1980s, the shocks transmitted to other member countries by contagion and hence resulted in very low GDP growth during these turmoil periods. These findings are supported by persistent negative growth of gross fixed capital formation in the US, Canada, Germany, Australia and Sweden over this period. We find high share prices prevailing in 2001 signifying boom and bust of Dotcom Bubble. 2008 Financial Crisis are evidenced by decline in residential investment in the US and propagation of this shock to Canada, Germany, Japan, Switzerland and New Zealand over the recent period. US monetary policy shocks reduce share prices in most of the OECD countries; this impact is more pronounced over the turmoil period. Asset price, interest rate and trade channel again seem to play major role in propagation of monetary policy shocks during the turmoil period.

One interesting question for future research is to include Federal Reserve's communication channel to study the monetary transmission mechanism especially during the recent financial crisis.

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Appendix A: Data Description

All series were downloaded from the website of FRED - St. Louis Fed; among other sources used are BIS and OECD national accounts. All the series are seasonally adjusted. Most of the variables (Industrial production Index, Real GDP, Private Final Consumption Expenditure, Gross Fixed Capital Formation, Gross Fixed Capital Formation Residential, Government Final Consumption Expenditure, Exports of Goods and Services, Imports of Goods and Services, GDP Deflator, Consumer Price Index, Price of Commodity Imports, Price of Exports, All Share Price Index and House Price Index) are taken in growth rates, which are all found stationary after employing Augmented Dickey-Fuller Test for stationarity. In some instances where the series were available on monthly basis, quarterly values were computed by averaging the monthly observations over the quarter. Following Stock and Watson (2005), we remove the outliers, replacing them with median of the preceding five observations. The transformation codes are: 1 - no transformation (levels); 2 - first difference; 4 -logarithm 5- first difference of logarithm.

Following Bernanke et al (2005), we divide the variables into slow moving (denoted by an asterisk: * next to the variable) and fast moving variables.

Table A.1 Data included in the time-varying parameters factor augmented VAR model

#	Description	Data Span	T Code
1	Real GDP*	1981:Q1-2010:Q4	1
2	Private Final Consumption Expenditure*	1981:Q1-2010:Q4	1
3	Gross Fixed Capital Formation*	1981:Q1-2010:Q4	1
4	Gross Fixed Capital Formation Residential*	1981:Q1-2010:Q4	1
5	Govt: Final Consumption Expenditure*	1981:Q1-2010:Q4	1
6	Industrial Production*	1981:Q1-2010:Q4	1
7	Unemployment Rate*	1981:Q1-2010:Q4	1
8	Exports of Goods and Services	1981:Q1-2010:Q4	1
9	Imports of Goods and Services	1981:Q1-2010:Q4	1
10	GDP Deflator*	1981:Q1-2010:Q4	1
11	Consumer Price I ndex*	1981:Q1-2010:Q4	1
12	Price of Exports	1981:Q1-2010:Q4	1
13	Price of Imports	1981:Q1-2010:Q4	1
14	All Shares Price Index	1981:Q1-2010:Q4	1
15	House Price Index	1981:Q1-2010:Q4	1
16	Effective Federal Funds Rate	1981:Q1-2010:Q4	1
17	Short Term Interest Rate	1981:Q1-2010:Q4	1
18	Long Term Interest Rate	1981:Q1-2010:Q4	1
19	Bilateral Exchange Rate with US Dollar	1981:Q1-2010:Q4	5
20	Real Effective Exchange Rate	1981:Q1-2010:Q4	5

Appendix B: Figures

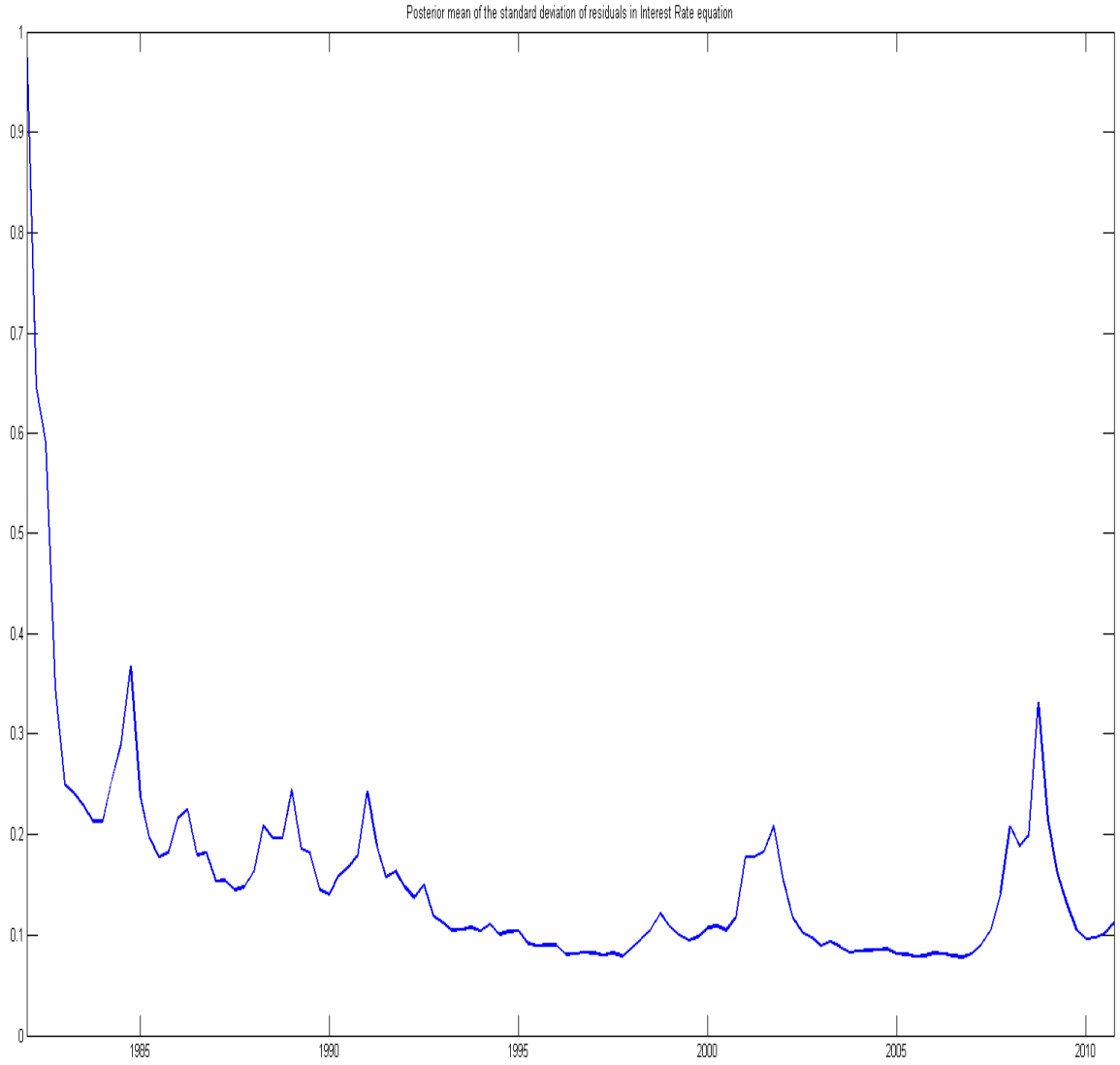
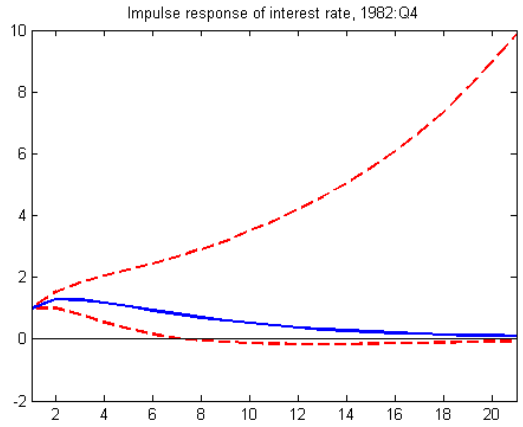
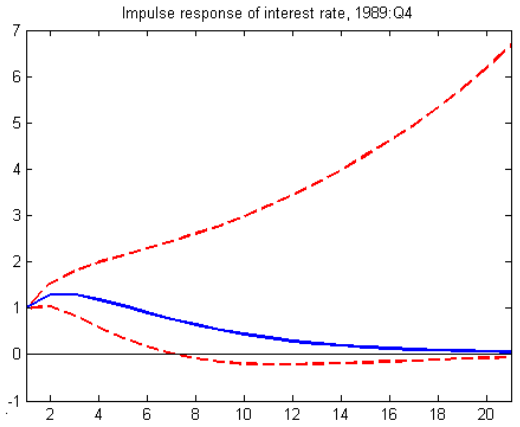
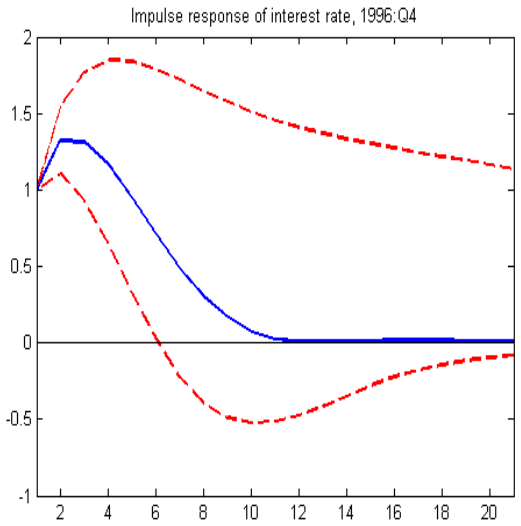
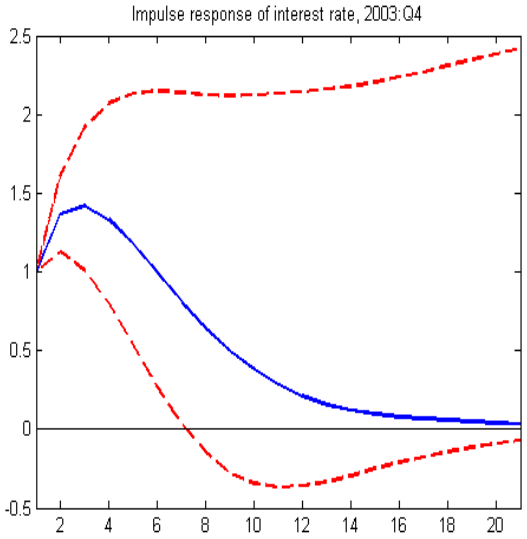


Fig. 1(a) : Posterior Mean of the Standard deviation of the residuals in Interest Rate equation.


Impulse response of interest rate, 1982:Q4


Impulse response of interest rate, 1989:Q4


Impulse response of interest rate, 1996:Q4


Impulse response of interest rate, 2003:Q4

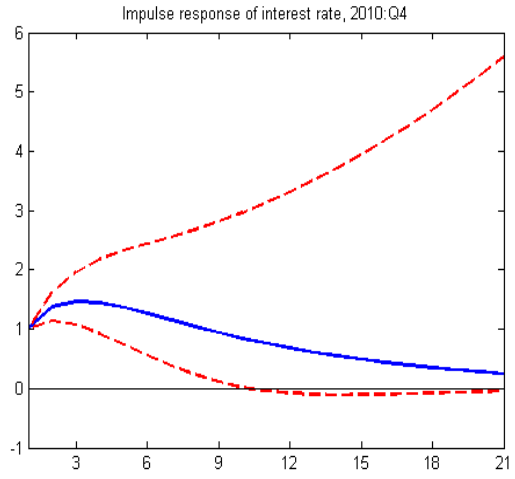

Impulse response of interest rate, 2010:Q4

Fig. 1(b).

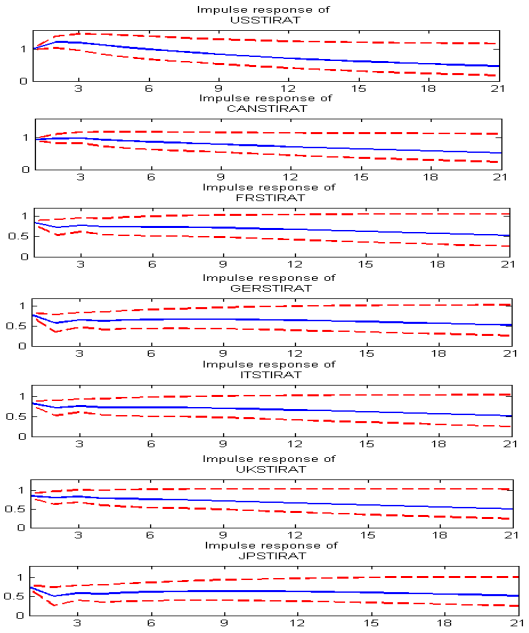


Fig. 2 (a-I).

Mnemonic: (USSTIRAT: US Short-term Interest Rate, CANSTIRAT: Canada Short-term Interest Rate, FRSTIRAT: France Short-term Interest Rate, GERSTIRAT: Germany Short-term Interest Rate, ITSTIRAT : Italy Short-term Interest Rate, UKSTIRAT : UK Short-term Interest Rate and JPSTIRAT : Japan Short-term Interest Rate).

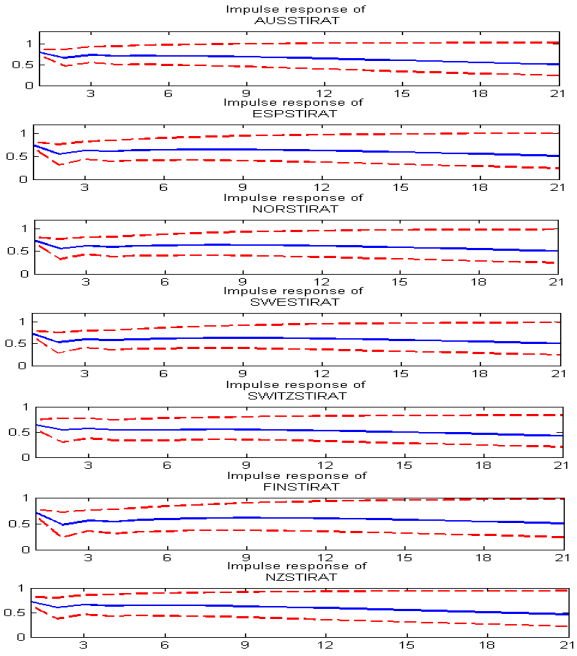


Fig. 2 (a-II).

Mnemonic: (AUSSTIRAT: Australia Short-term Interest Rate, ESPSTIRAT: Spain Short-term Interest Rate, NORSTIRAT: Norway Short-term Interest Rate, SWESTIRAT: Sweden Short-term Interest Rate, SWITZSTIRAT: Switzerland Short-term Interest Rate, FINSTIRAT: Finland Short-term Interest Rate, NZSTIRAT: New Zealand Short-term Interest Rate).

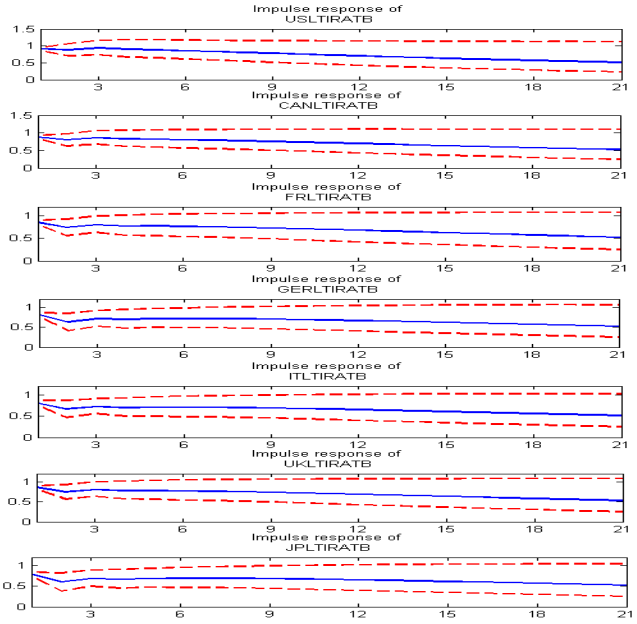


Fig. 2 (b-I).

Mnemonic: (USLTIRATB: US Long-term interest rate, CANLTIRATB: Canada Long-term interest rate, FRLTIRATB: France Long-term interest rate, GERLTIRATB: Germany Long-term interest rate, ITLTIRATB: Italy Long-term interest rate, UKLTIRATB: UK Long-term interest rate and JPLTIRATB: Japan Long-term interest rate).

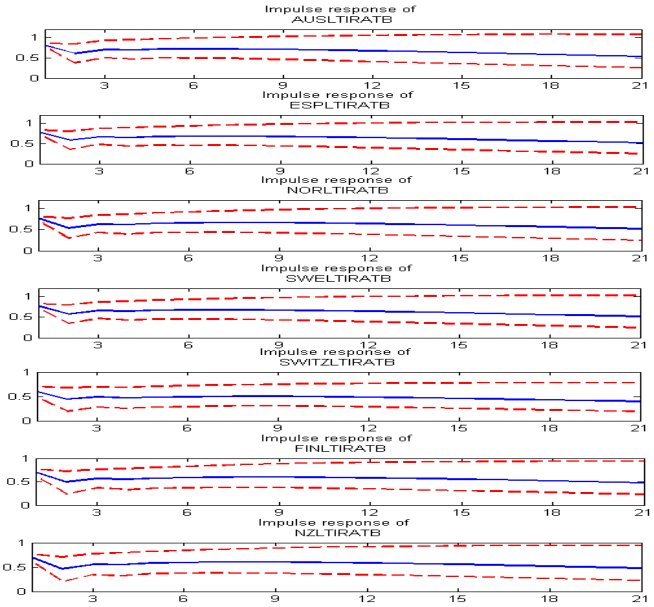


Fig. 2 (b-II).

Mnemonic: (AUSLTIRATB: Australia Long-term interest rate, ESPLTIRATB: Spain Long-term interest rate, NORLTIRATB: Norway Long-term interest rate, SWELTIRATB: Sweden Long-term interest rate, SWITZLTIRATB: Switzerland Long-term interest rate, FINLTIRATB: Finland Long-term interest rate and NZLTIRATB: New Zealand Long-term interest rate).

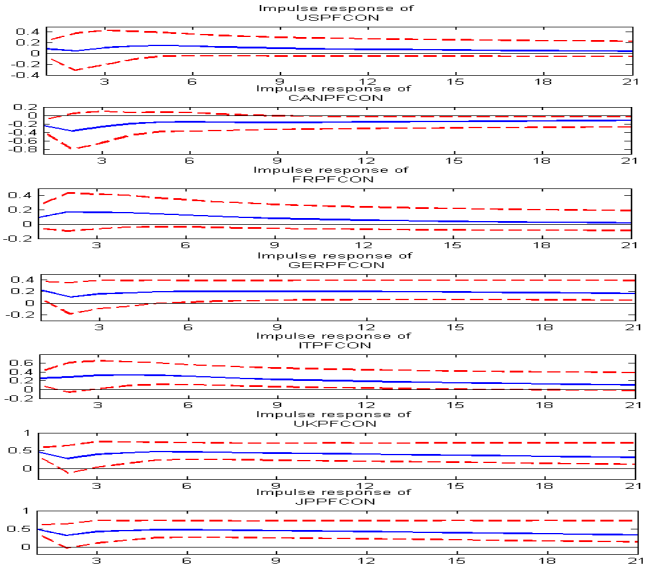


Fig. 2 (c-I).

Mnemonic: (USPFCON: US Private Final Consumption Expenditure, CANPFCON: Canada Private Final Consumption Expenditure, FRPFCON: France Private Final Consumption Expenditure, GERPFCON: Germany Private Final Consumption Expenditure, ITPFCON: Italy Private Final Consumption Expenditure, UKPFCON: UK Private Final Consumption Expenditure and JPPFCON: Japan Private Final Consumption Expenditure).

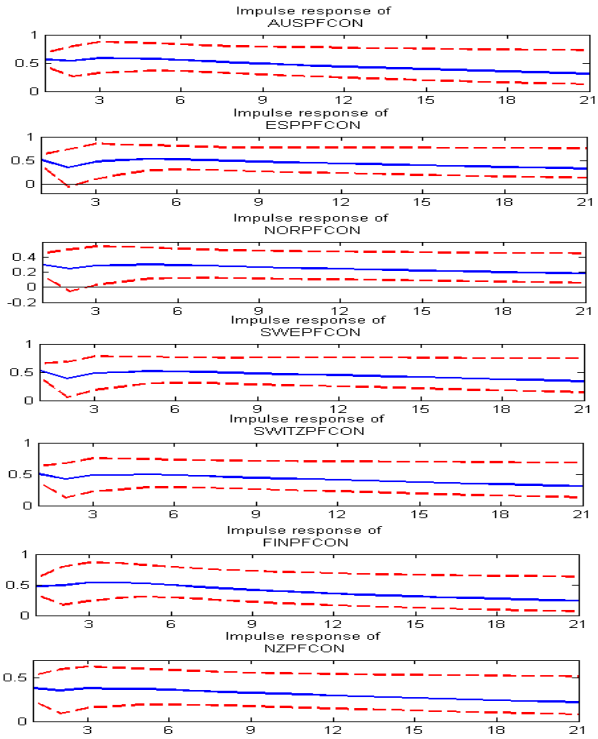


Fig. 2 (c-II).

Mnemonic: (AUSPFCON: Australia Private Final Consumption Expenditure, ESPPFCON: Spain Private Final Consumption Expenditure, NORPFCON: Norway Private Final Consumption Expenditure, SWEPFCON: Sweden Private Final Consumption Expenditure, SWITZPFCON: Switzerland Private Final Consumption Expenditure, FINPFCON: Finland Private Final Consumption Expenditure and NZPFCON: New Zealand Private Final Consumption Expenditure).

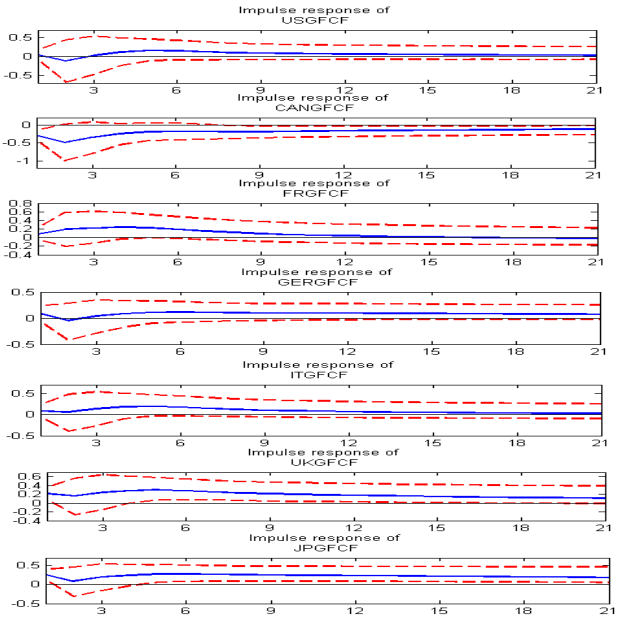


Fig. 2 (d-I).

Mnemonic: (USGFCF: US Gross Fixed Capital Formation, CANGFCF: Canada Gross Fixed Capital Formation, FRGFCF: France Gross Fixed Capital Formation, GERGFCF: Germany Gross Fixed Capital Formation, ITGFCF: Italy Gross Fixed Capital Formation, UKGFCF: UK Gross Fixed Capital Formation and JPGFCF: Japan Gross Fixed Capital Formation).

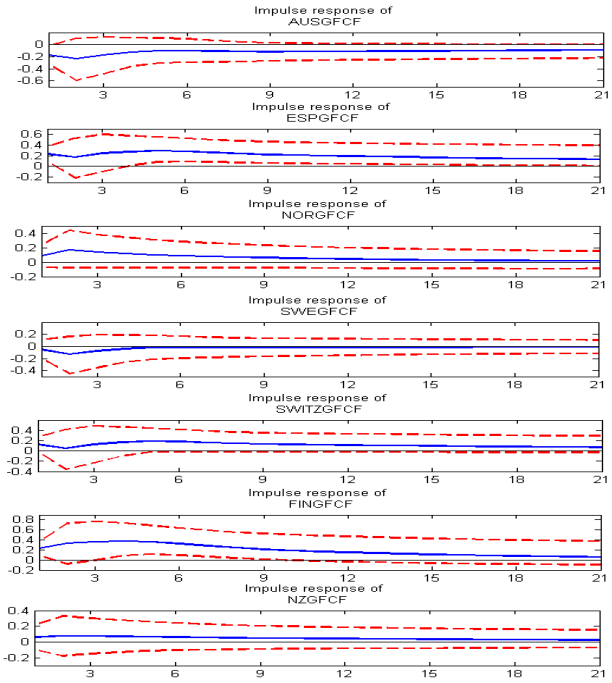


Fig. 2 (d-II).

Mnemonic: (AUSGFCF: Australia Gross Fixed Capital Formation, ESPGFCF: Spain Gross Fixed Capital Formation, NORGFCF: Norway Gross Fixed Capital Formation, SWEGFCF: Sweden Gross Fixed Capital Formation, SWITZGFCF: Switzerland Gross Fixed Capital Formation, FINGFCF: Finland Gross Fixed Capital Formation and NZGFCF: New Zealand Gross Fixed Capital Formation).

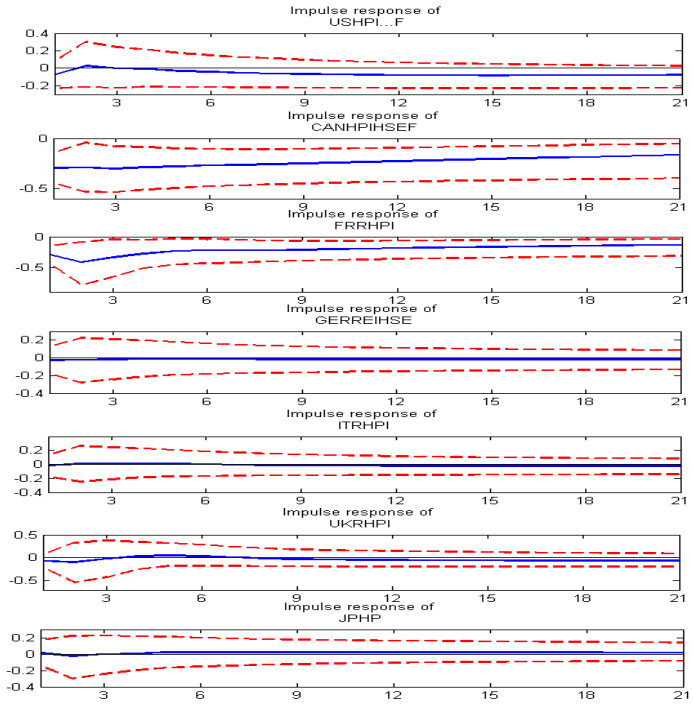


Fig. 2 (e-I).

Mnemonic (USHPI...F: US Housing Price Index, CANHPIHSEF: Canada Housing Price Index, FRRHPI: France Housing Price Index, GERREIHSE: Germany Housing Price Index, ITRHPI: Italy Housing Price Index, UKRHPI: UK Housing Price Index and JPHP: Japan Housing Price Index).

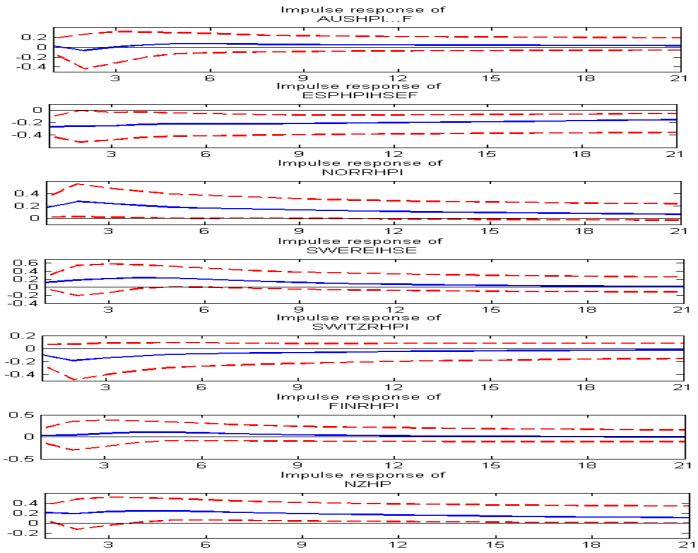


Fig. 2 (e-II).

Mnemonic: (AUSHPI...F: Australia Housing Price Index, ESPHPIHSEF: Spain Housing Price Index, NORRHPI: Norway Housing Price Index, SWEREIHSE: Sweden Housing Price Index, SWITZRHPI: Switzerland Housing Price Index, FINRHPI: Finland Housing Price Index and NZHP: New Zealand Housing Price Index).

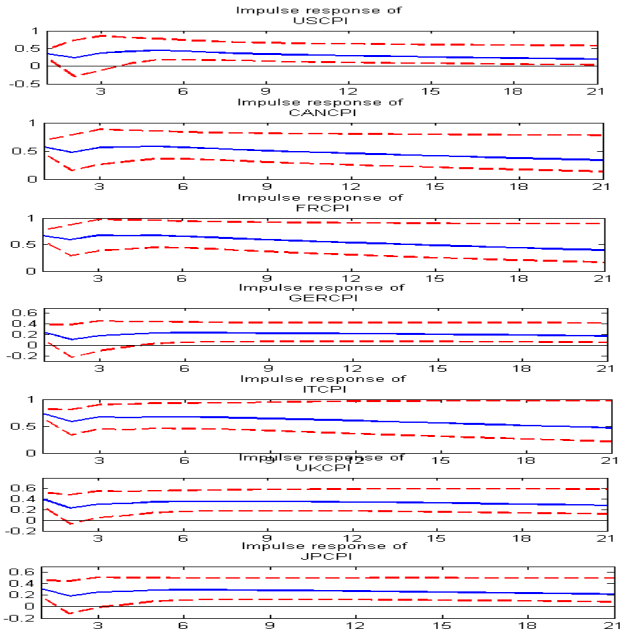


Fig. 2 (f-I).

Mnemonic: (USCPI: US Consumer Price Index, CANCPI: Canada Consumer Price Index, FRCPI: France Consumer Price Index, GERCPI: Germany Consumer Price Index, ITCPI: Italy Consumer Price Index, UKCPI: UK Consumer Price Index and JPCPI: Japan Consumer Price Index).

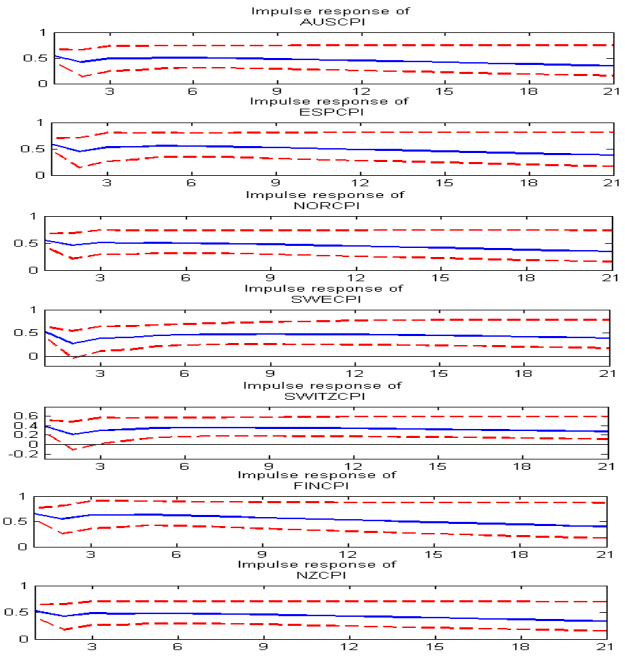


Fig. 2 (f-II).

Mnemonic: (AUSCPI: Australia Consumer Price Index, ESPCPI: Spain Consumer Price Index, NORCPI: Norway Consumer Price Index, SWECPI: Sweden Consumer Price Index, SWITZCPI: Switzerland Consumer Price Index, FINCPI: Finland Consumer Price Index and NZCPI: New Zealand Consumer Price Index).

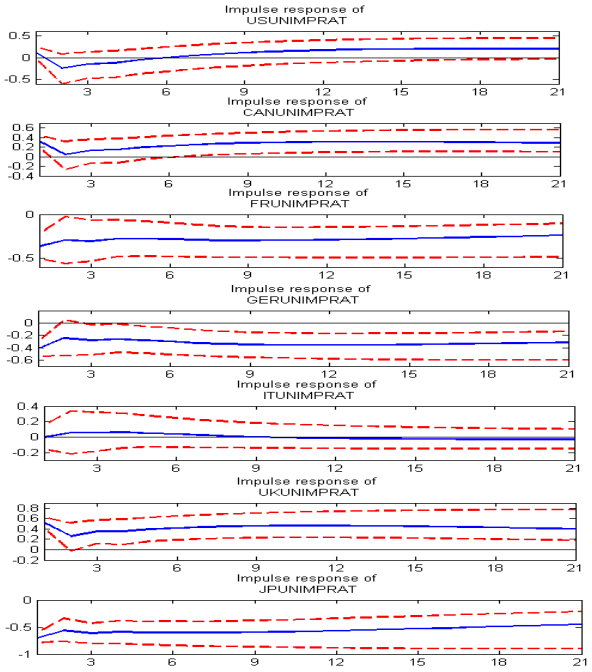


Fig. 2 (g-I).

Mnemonic: (USUNIMPRAT: US Unemployment Rate, CANUNIMPRAT: Canada Unemployment Rate, FRUNIMPRAT: France Unemployment Rate, GERUNIMPRAT: Germany Unemployment Rate, UKUNIMPRAT: UK Unemployment Rate and JPUNIMPRAT: Japan Unemployment Rate).

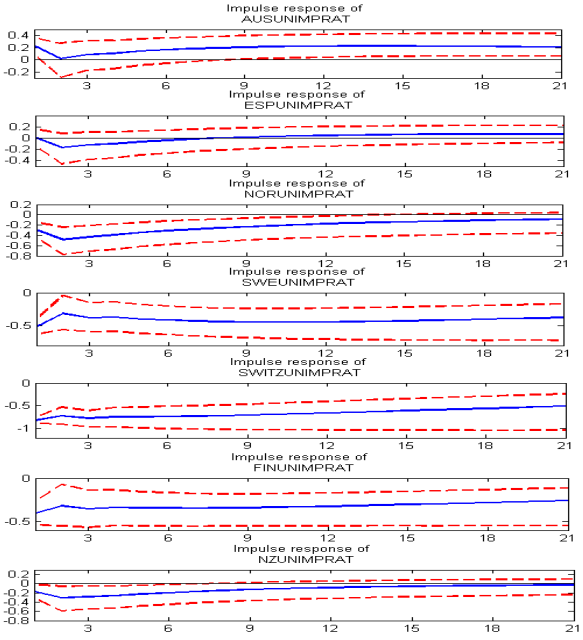


Fig. 2 (g-II).

Mnemonic: (AUSUNIMPRAT: Australia Unemployment Rate, ESPUNIMPRAT: Spain Unemployment Rate, NORUNIMPRAT: Norway Unemployment Rate, SWEUNIMPRAT: Sweden Unemployment Rate, SWITZUNIMPRAT: Switzerland Unemployment Rate, FINUNIMPRAT: Finland Unemployment Rate and NZUNIMPRAT: New Zealand Unemployment Rate).

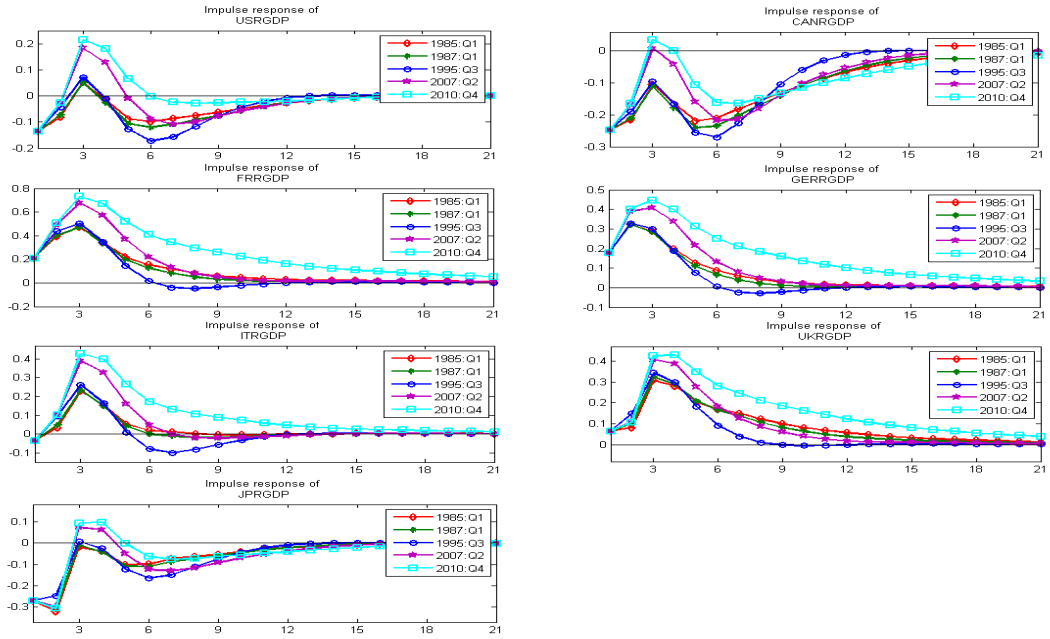


Fig. 3(a-I): Transmission of US monetary policy shocks to GDP.

Mnemonic: (USRGDP: US Real GDP, CANRGDP: Canada Real GDP, FRRGDP: France Real GDP, GERRGDP: Germany Real GDP, ITRGDP: Italy Real GDP, UKRGDP: UK Real GDP and JPRGDP: Japan Real GDP).

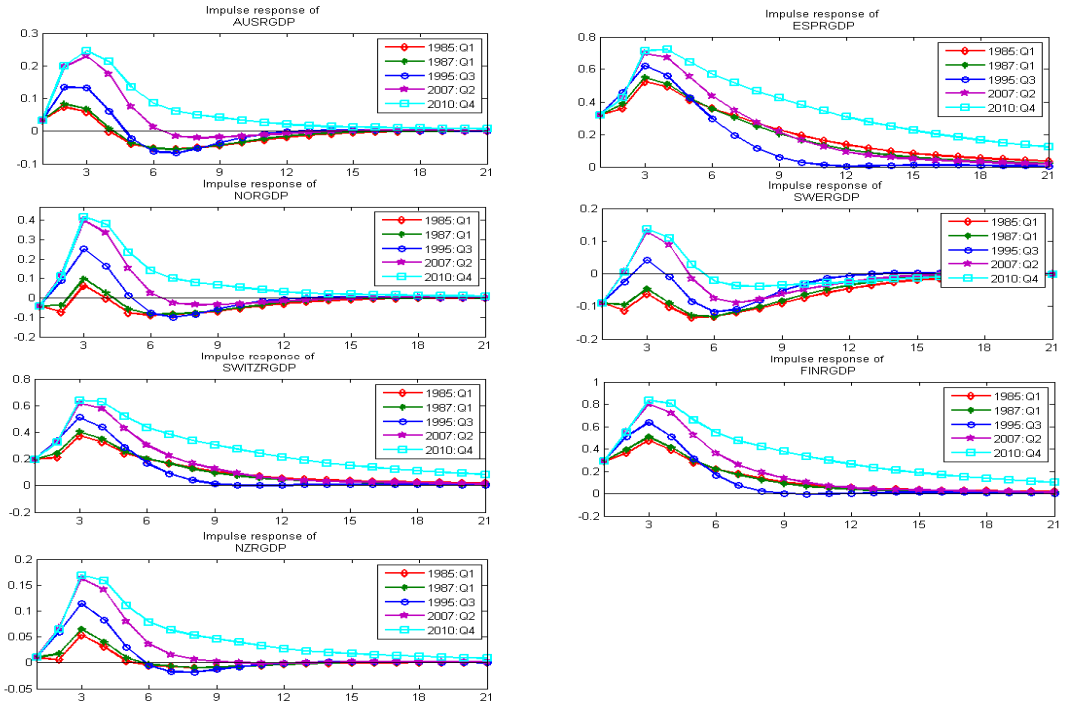


Fig. 3(a-II): Transmission of US monetary policy shocks to GDP.

Mnemonic: (AUSRGDP: Australia Real GDP, ESPRGDP: Spain Real GDP, NORGDP: Norway Real GDP, SWERGDP: Sweden Real GDP, SWITZRGDP: Switzerland Real GDP, FINRGDP: Finland Real GDP and NZRGDP : New Zealand Real GDP).

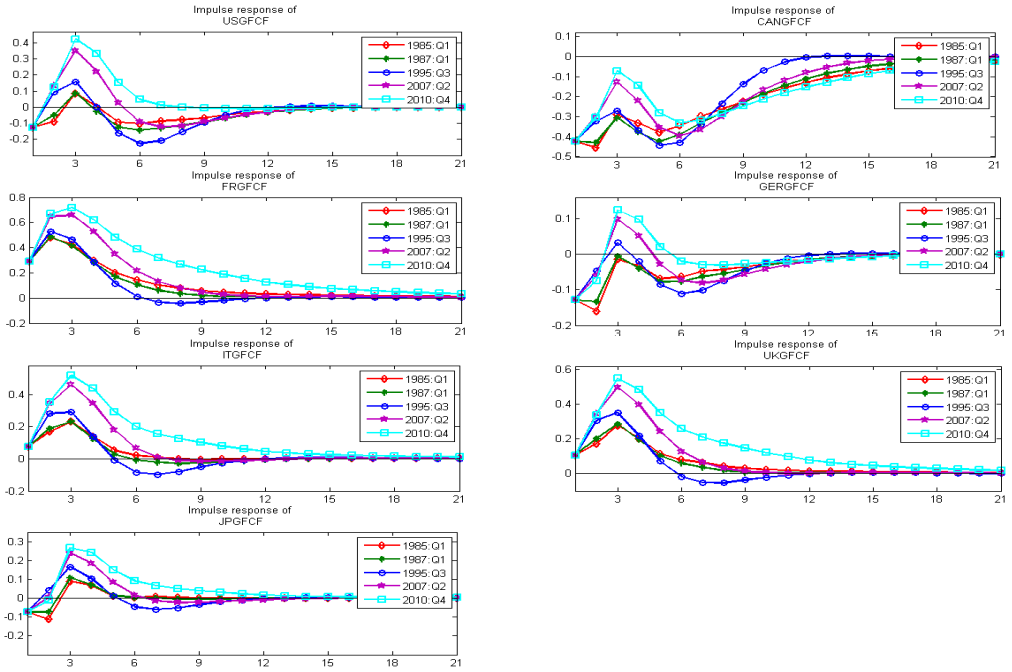


Fig. 3(b-I): Transmission of US monetary policy shocks to Gross Fixed Capital Formation.

Mnemonic: (USGFCF: US Gross Fixed Capital Formation, CANGFCF: Canada Gross Fixed Capital Formation, FRGFCF: France Gross Fixed Capital Formation, GERGFCF: Germany Gross Fixed Capital Formation, ITGFCF: Italy Gross Fixed Capital Formation, UKGFCF: UK Gross Fixed Capital Formation, JPGFCF: Japan Gross Fixed Capital Formation).

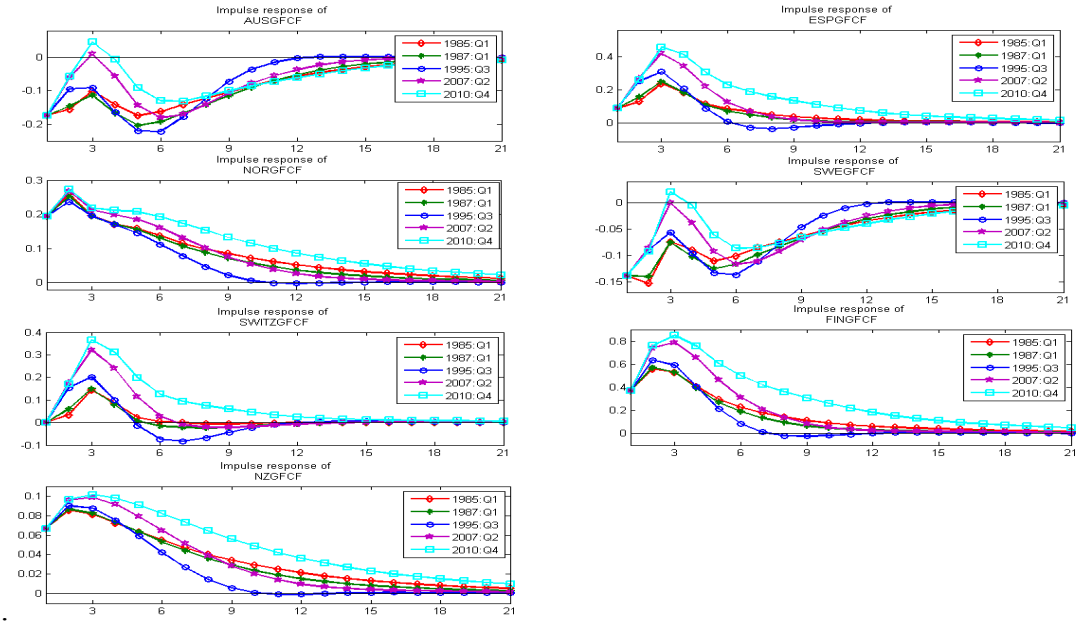


Fig. 3(b-II): Transmission of US monetary policy shocks to Gross Fixed Capital Formation.

Mnemonic: (AUSGFCF: Australia Gross Fixed Capital Formation, ESPGFCF: Spain Gross Fixed Capital Formation, NORGFCF: Norway Gross Fixed Capital Formation, SWEGFCF: Sweden Gross Fixed Capital Formation, SWITZGFCF: Switzerland Gross Fixed Capital Formation, FINGFCF: Finland Gross Fixed Capital Formation and NZGFCF: New Zealand Gross Fixed Capital Formation).

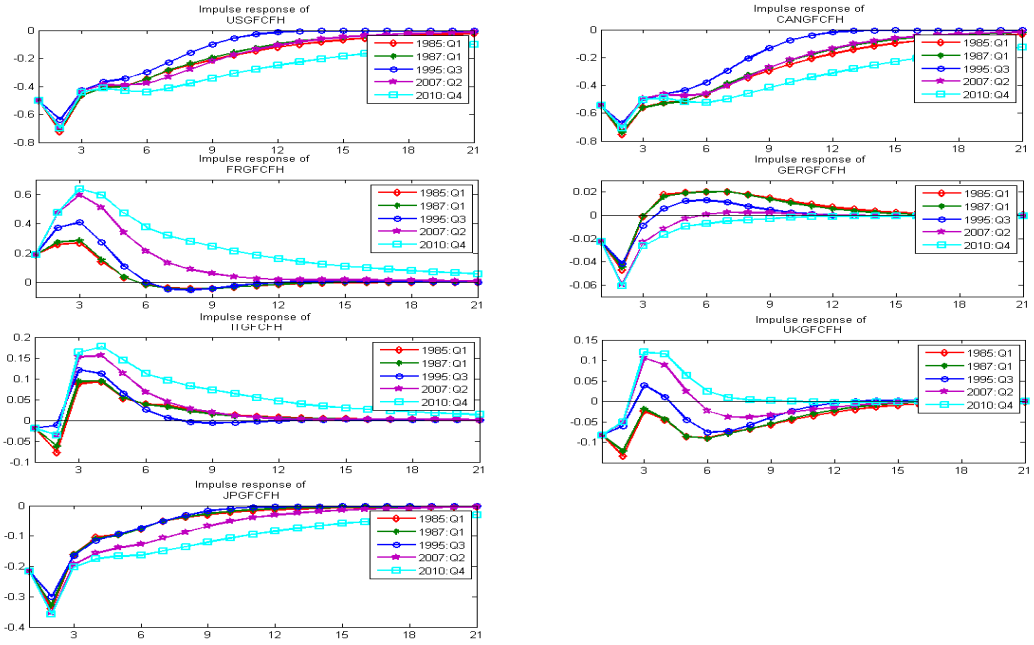


Fig. 3(c-I): Transmission of US monetary policy shocks to Gross Fixed Capital Formation Residential.

Mnemonic (USGFCFH: US Gross Fixed Capital Formation Residential, CANGFCFH: Canada Gross Fixed Capital Formation Residential, FRGFCFH: France Gross Fixed Capital Formation Residential, GERGFCFH: Germany Gross Fixed Capital Formation Residential, ITGFCFH: Italy Gross Fixed Capital Formation Residential, UKGFCFH: UK Gross Fixed Capital Formation Residential, JPGFCFH: Japan Gross Fixed Capital Formation Residential).

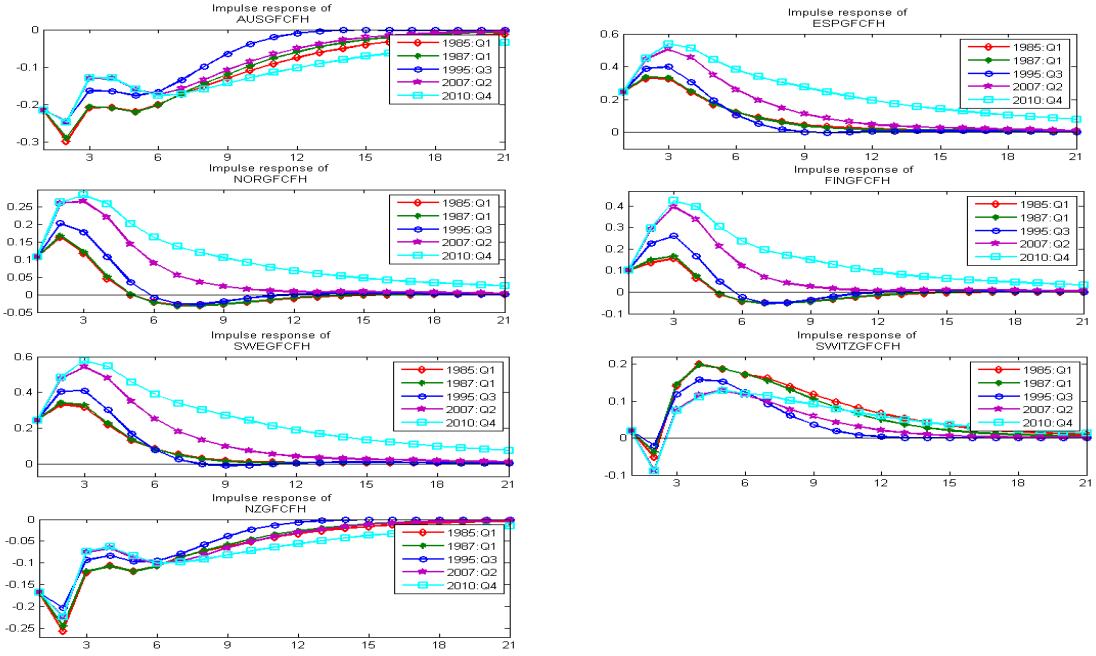


Fig. 3(c-II): Transmission of US monetary policy shocks to Gross Fixed Capital Formation Residential.

Mnemonic: (AUSGFCFH : Australia Gross Fixed Capital Formation Residential, ESPGFCFH: Spain Gross Fixed Capital Formation Residential, NORGFCFH : Norway Gross Fixed Capital Formation Residential, SWEGFCFH : Sweden Gross Fixed Capital Formation Residential, FINGFCFH : Finland Gross Fixed Capital Formation Residential and NZGFCFH : New Zealand Gross Fixed Capital Formation Residential).

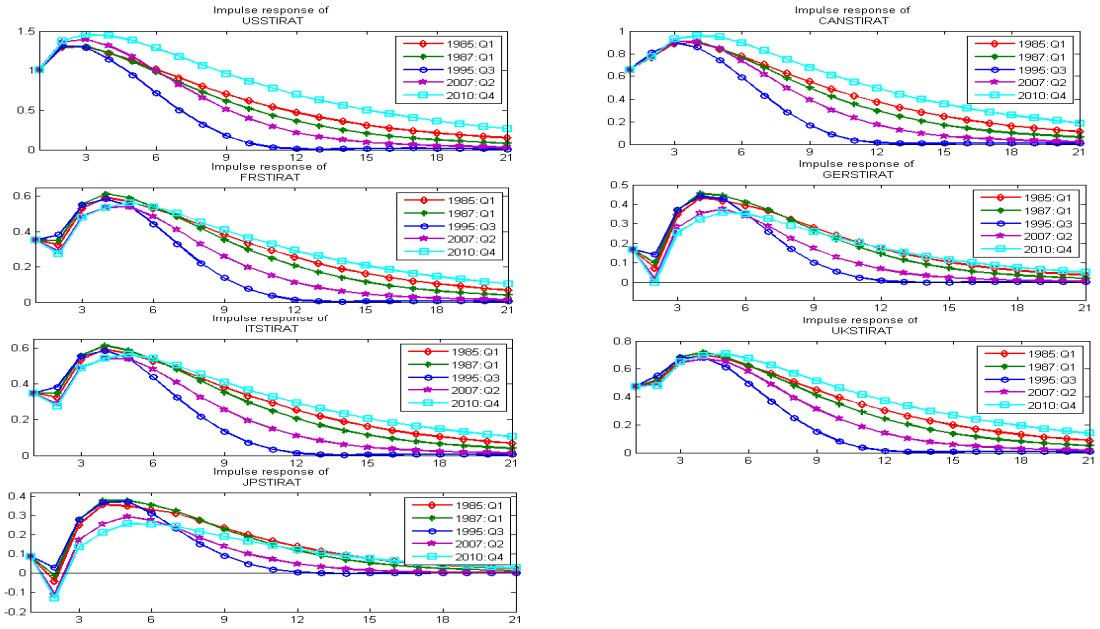


Fig. 4(a-I): Transmission of US monetary policy shocks to Short Term Interest Rates.

Mnemonic: (USSTIRAT: US Short-term Interest Rate, CANSTIRAT: Canada Short-term Interest Rate, FRSTIRAT: France Short-term Interest Rate , GERSTIRAT: Germany Short-term Interest Rate, ITSTIRAT : Italy Short-term Interest Rate, UKSTIRAT : UK Short-term Interest Rate and JPSTIRAT : Japan Short-term Interest Rate).

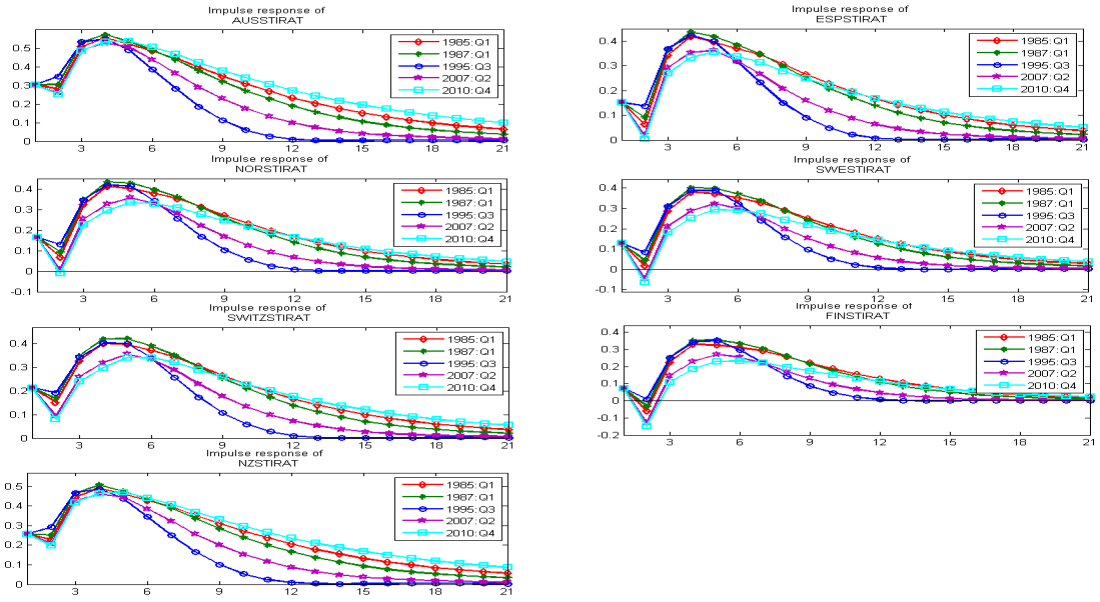


Fig. 4(a-II): Transmission of US monetary policy shocks to Short Term Interest Rates.

Mnemonic: (AUSSTIRAT: Australia Short-term Interest Rate, ESPSTIRAT: Spain Short-erm Interest Rate, NORSTIRAT: Norway Short-term Interest Rate, SWESTIRAT: Sweden Short-term Interest Rate, SWITZSTIRAT: Switzerland Short-term Interest Rate, FINSTIRAT: Finland Short-term Interest Rate, NZSTIRAT: New Zealand Short-term Interest Rate).

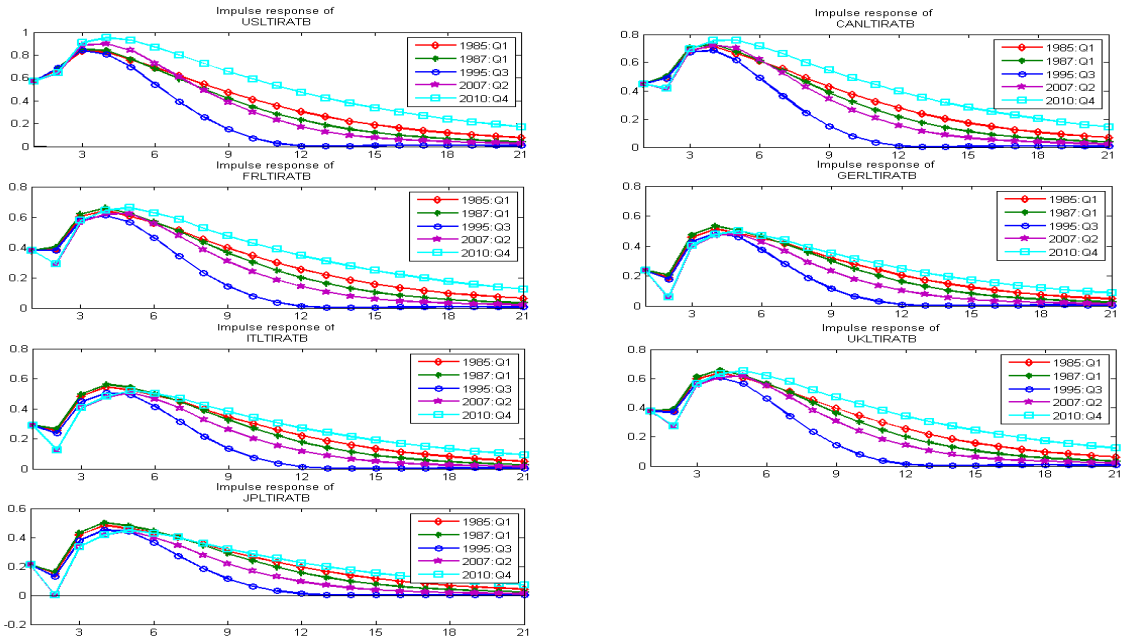


Fig. 4(b-I): Transmission of US monetary policy shocks to Long Term Interest Rtaes.

Mnemonic: (USLTIRATB: US Long-term interest rate, CANLTIRATB: Canada Long-term interest rate, FRLTIRATB: France Long-term interest rate, GERLTIRATB: Germany Long-term interest rate, ITLTIRATB: Italy Long-term interest rate, UKLTIRATB: UK Long-term interest rate and JPLTIRATB: Japan Long-term interest rate).

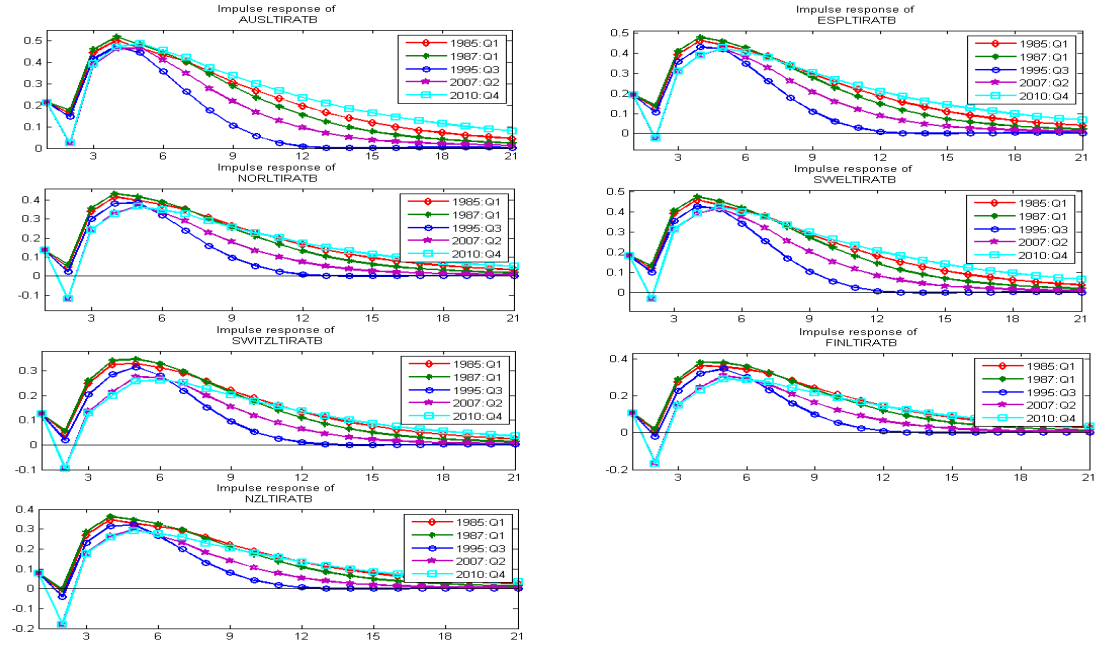


Fig. 4(b-II): Transmission of US monetary policy shocks to Long Term Interest Rtaes.

Mnemonic: (AUSLTIRATB: Australia Long-term interest rate, ESPLTIRATB: Spain Long-term interest rate, NORLTIRATB: Norway Long-term interest rate, SWELTIRATB: Sweden Long-term interest rate, SWITZLTIRATB: Switzerland Long-term interest rate, FINLTIRATB: Finland Long-term interest rate and NZLTIRATB: New Zealand Long-term interest rate).

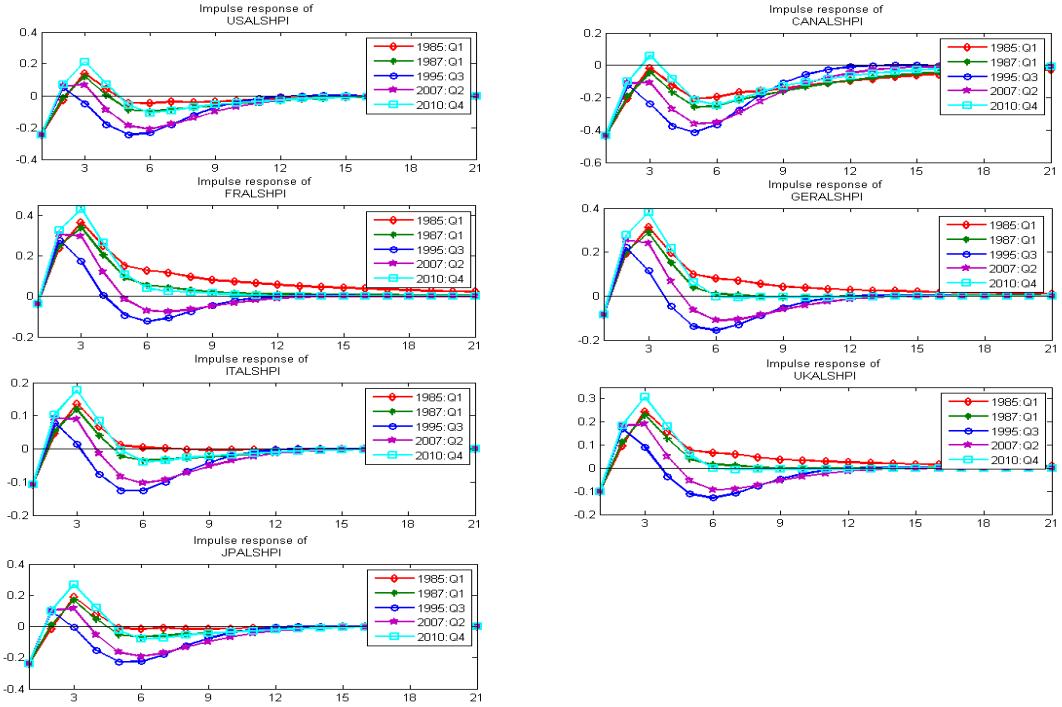


Fig. 4(c-I): Transmission of US monetary policy shocks to All Share Price Index.

Mnemonic: (USALSHPI: US All Shares Price Index, CANALSHPI: Canada All Shares Price Index, FRALSHPI: France All Shares Price Index, GERALSHPI: Germany All Shares Price Index, ITALSHPI: Italy All Shares Price Index, UKALSHPI: UK All Shares Price Index, JPALSHPI: Japan All Shares Price Index).

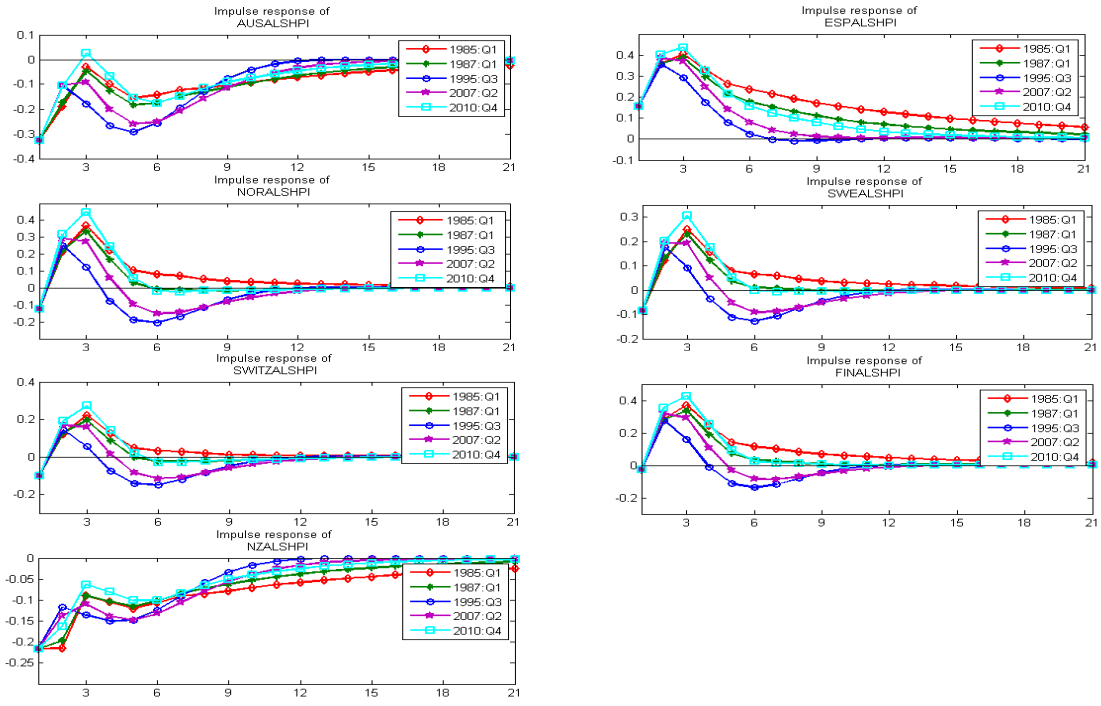


Fig. 4(c-II): Transmission of US monetary policy shocks to All Share Price Index.

Mnemonic: (AUSALSHPI: Australia All Shares Price Index, ESPALSHPI: Spain All Shares Price Index, NORALSHPI: Norway All Shares Price Index, SWEALSHPI: Sweden All Shares Price Index, SWITZALSHPI: Switzerland All Shares Price Index, FINALSHPI: Finland All Shares Price Index and NZALSHPI: New Zealand All Shares Price Index).

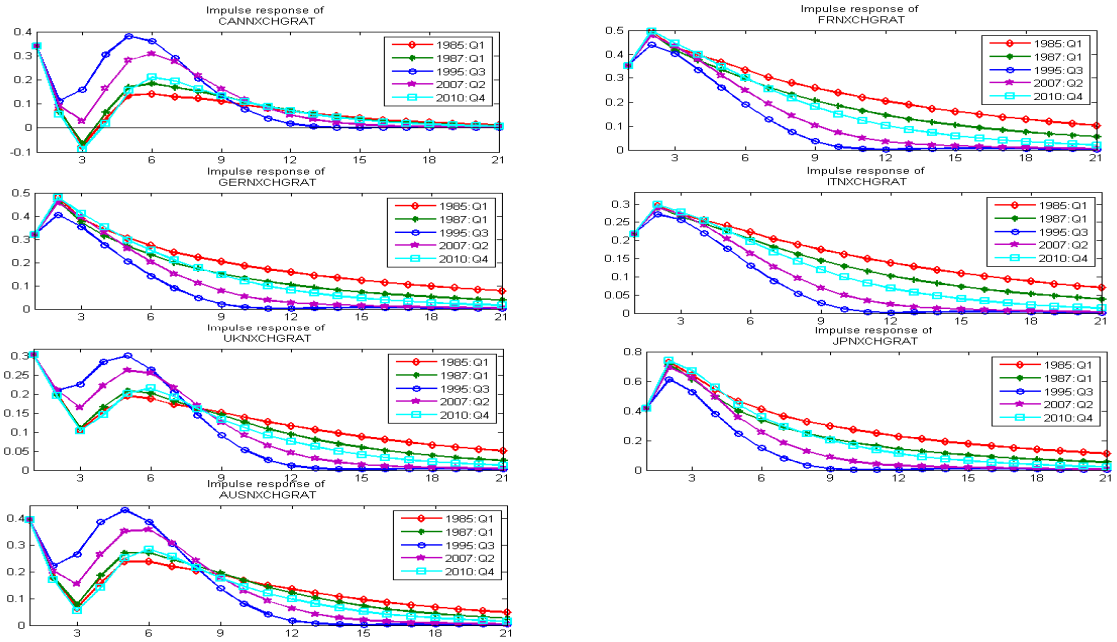


Fig. 4(d-I): Transmission of US monetary policy shocks to Nominal Exchange Rates.

Mnemonic: (CANNXCHGRAT: Canada Nominal Exchange Rate, FRNXCHGRAT: France Nominal Exchange Rate, GERNXCHGRAT: Germany Nominal Exchange Rate, ITNXCHGRAT: Italy Nominal Exchange Rate, UKNXCHGRAT: UK Nominal Exchange Rate and JPNXCHGRAT: Japan Nominal Exchange Rate).

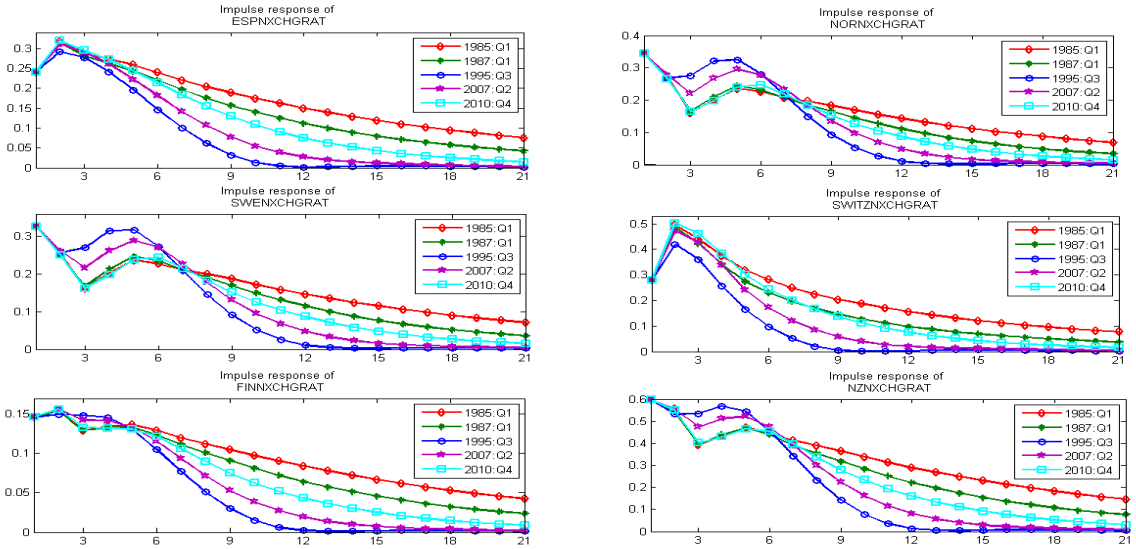


Fig. 4(d-II): Transmission of US monetary policy shocks to Nominal Exchange Rates.

Mnemonic: (AUSNXCHGRAT: Australia Nominal Exchange Rate, ESPNXCHGRAT: Spain Nominal Exchange Rate, NORNXCHGRAT: Nominal Nominal Exchange Rate, SWENXCHGRAT: Sweden Nominal Exchange Rate, SWITZNXCHGRAT: Switzerland Nominal Exchange Rate, FINNXCHGRAT: Finland Nominal Exchange Rate and NZNXCHGRAT: New Zealand Nominal Exchange Rate).

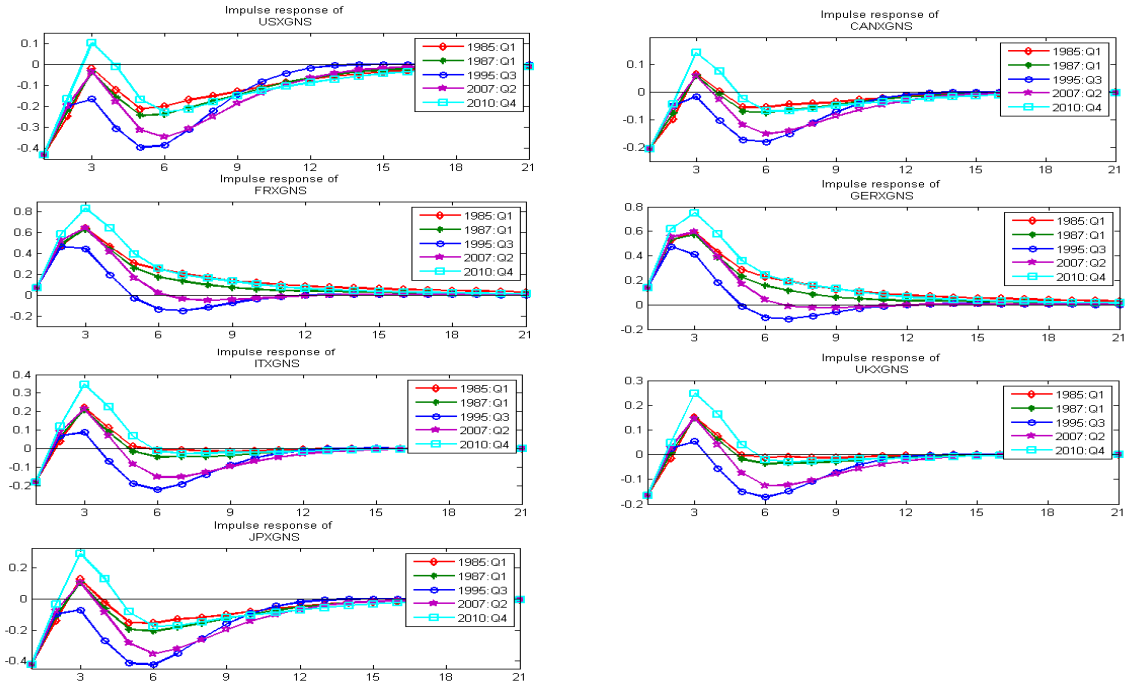


Fig. 4(e-I): Transmission of US monetary policy shocks to Exports of Goods and Services.

Mnemonic: (USXGNS: US Exports of Goods and Services, CANXGNS: Canada Exports of Goods and Services, FRXGNS: France Exports of Goods and Services, GERXGNS: Germany Exports of Goods and Services, ITXGNS: Italy Exports of Goods and Services, UKXGNS: UK Exports of Goods and Services and JPXGNS: Japan Exports of Goods and Services).

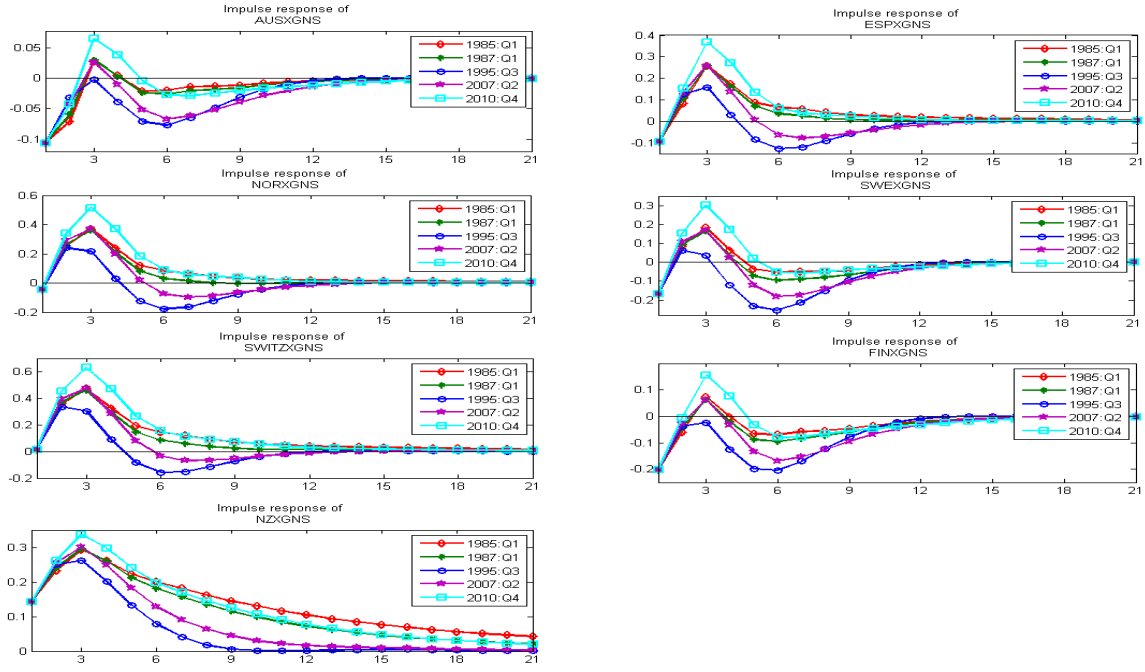


Fig. 4(e-II): Transmission of US monetary policy shocks to Exports of Goods and Services.

Mnemonic: (AUSXGNS: Australia Exports of Goods and Services, ESPXGNS: Spain Exports of Goods and Services, NORXGNS: Norway Exports of Goods and Services, SWEXGNS: Sweden Exports of Goods and Services, SWITZXGNS: Switzerland Exports of Goods and Services, FINXGNS: Finland Exports of Goods and Services, NZXGNS: New Zealand Exports of Goods and Services).

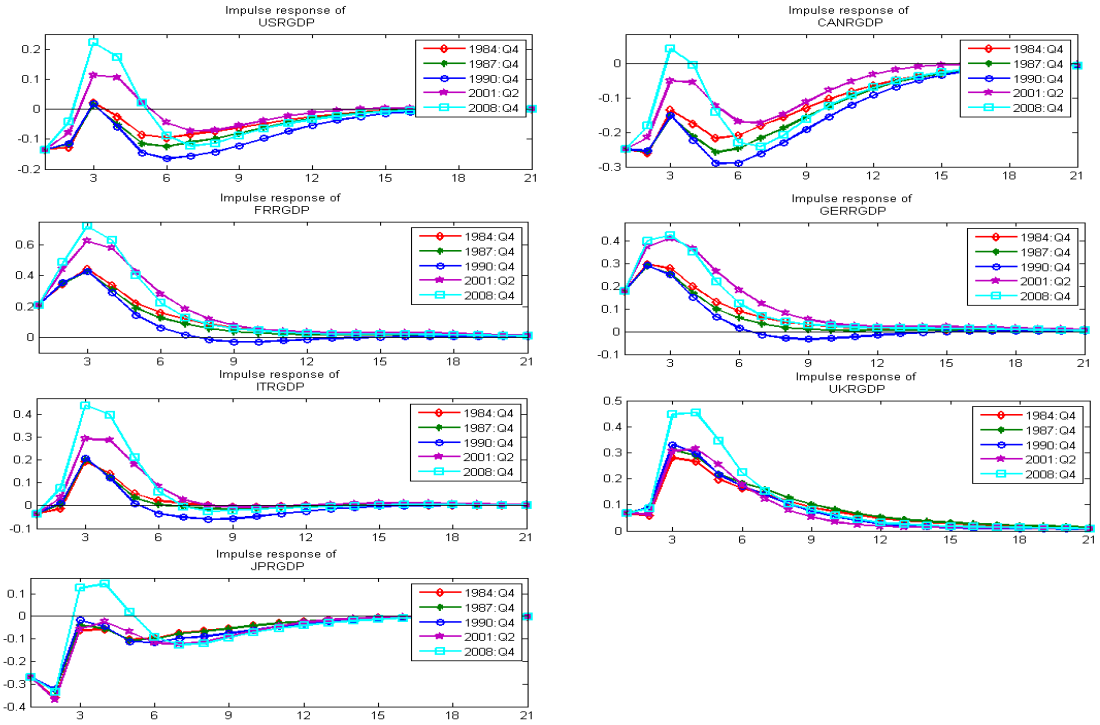


Fig. 5(a-I): Transmission of US monetary policy shocks to GDP.

Mnemonic: (USRGDP: US Real GDP, CANRGDP: Canada Real GDP, FRRGDP: France Real GDP, GERRGDP: Germany Real GDP, ITRGDP: Italy Real GDP, UKRGDP: UK Real GDP and JPRGDP: Japan Real GDP).

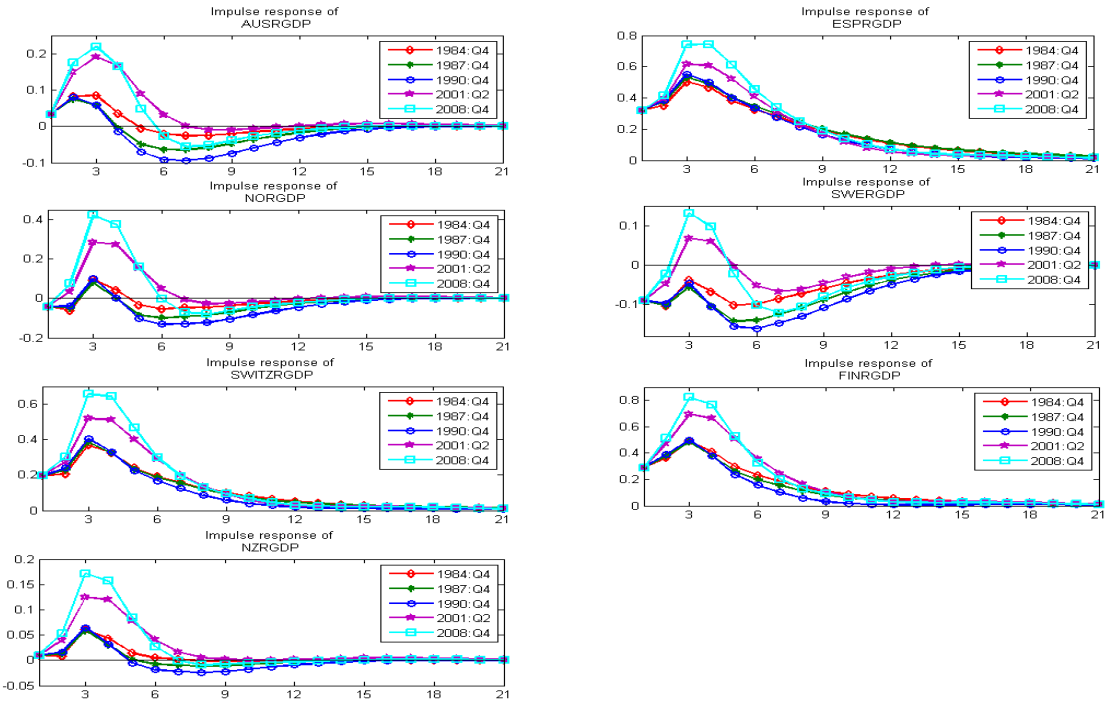


Fig. 5(a-II): Transmission of US monetary policy shocks to GDP.

Mnemonic: (AUSRGDP: Australia Real GDP, ESPRGDP: Spain Real GDP, NORGDP: Norway Real GDP, SWERGDP: Sweden Real GDP, SWITZRGDP: Switzerland Real GDP, FINRGDP: Finland Real GDP and NZRGDP: New Zealand Real GDP).

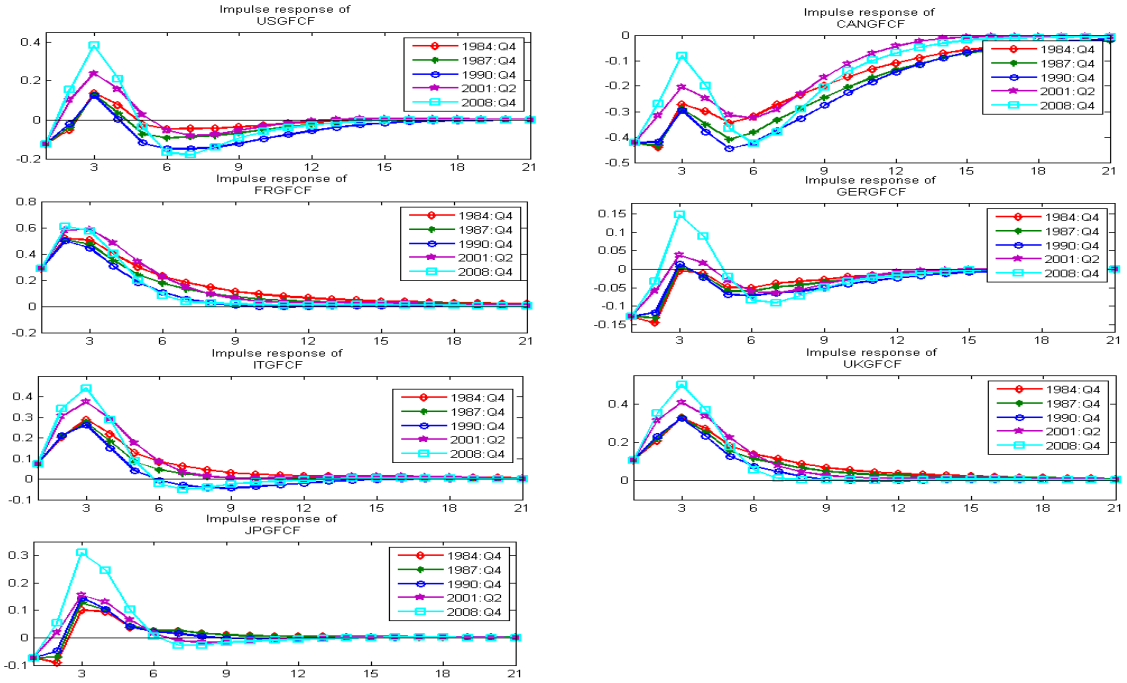


Fig. 5(b-I): Transmission of US monetary policy shocks to Gross Fixed Capital Formation.

Mnemonic: (USGFCF: US Gross Fixed Capital Formation, CANGFCF: Canada Gross Fixed Capital Formation, FRGFCF: France Gross Fixed Capital Formation, GERGFCF: Germany Gross Fixed Capital Formation, ITGFCF: Italy Gross Fixed Capital Formation, UKGFCF: UK Gross Fixed Capital Formation, JPGFCF: Japan Gross Fixed Capital Formation).

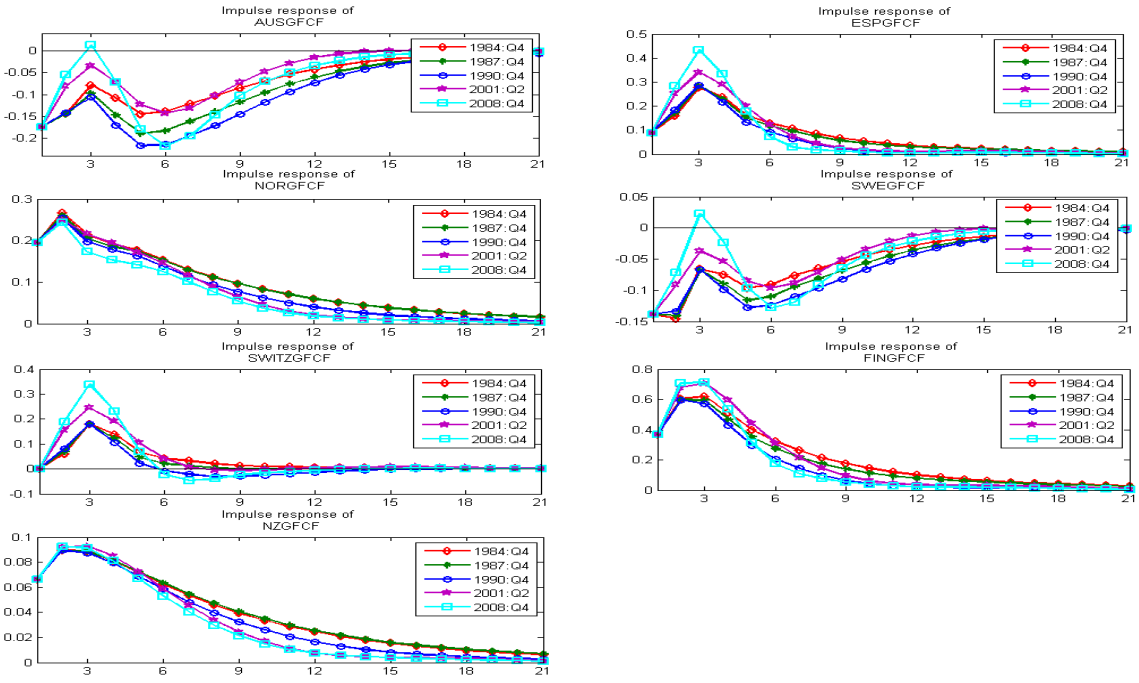


Fig. 5(b-II): Transmission of US monetary policy shocks to Gross Fixed Capital Formation.

Mnemonic: (AUSGFCF: Australia Gross Fixed Capital Formation, ESPGFCF: Spain Gross Fixed Capital Formation, NORGFCF: Norway Gross Fixed Capital Formation, SWEGFCF: Sweden Gross Fixed Capital Formation, SWITZGFCF: Switzerland Gross Fixed Capital Formation, FINGFCF: Finland Gross Fixed Capital Formation and NZGFCF: New Zealand Gross Fixed Capital Formation).

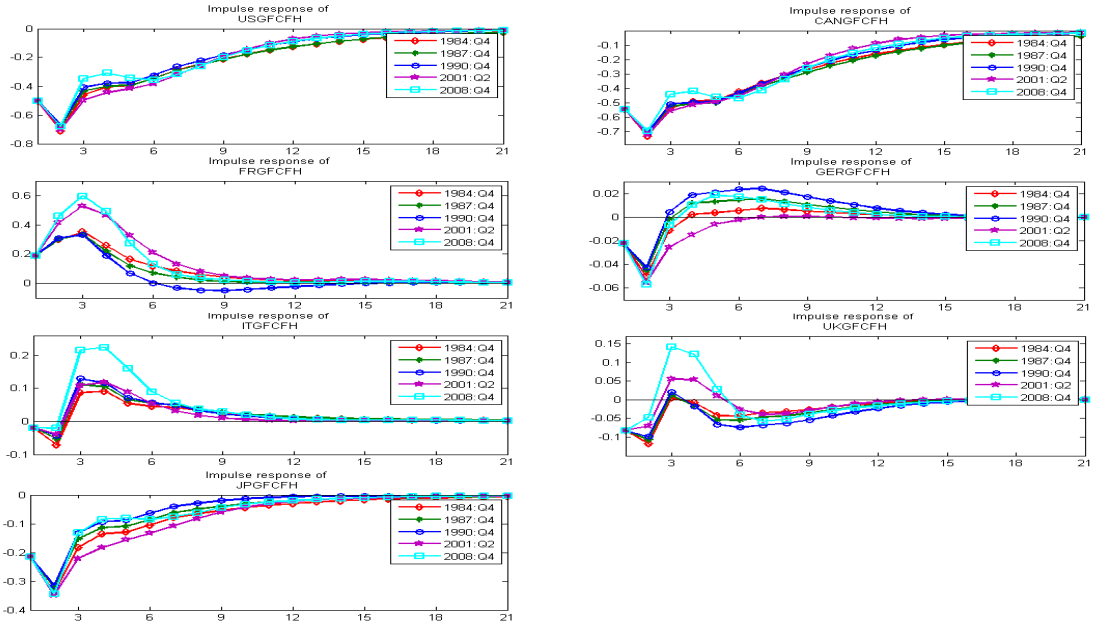


Fig. 5(c-I): Transmission of US monetary policy shocks to Gross Fixed Capital Formation Residential.

Mnemonic: (USGFCFH: US Gross Fixed Capital Formation Residential, CANGFCFH: Canada Gross Fixed Capital Formation Residential, FRGFCFH: France Gross Fixed Capital Formation Residential, GERGFCFH: Germany Gross Fixed Capital Formation Residential, ITGFCFH: Italy Gross Fixed Capital Formation Residential, UKGFCFH: UK Gross Fixed Capital Formation Residential, JPGFCFH: Japan Gross Fixed Capital Formation Residential).

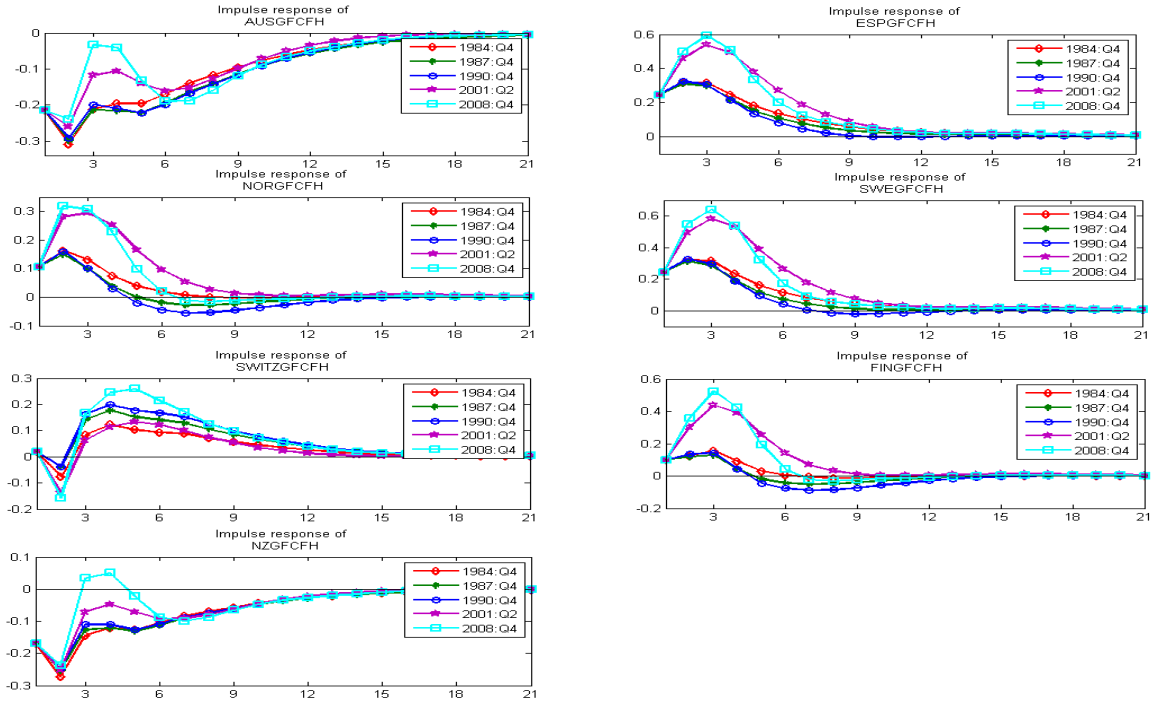


Fig. 5(c-II): Transmission of US monetary policy shocks to Gross Fixed Capital Formation Residential.

Mnemonic: (AUSGFCFH : Australia Gross Fixed Capital Formation Residential, ESPGFCFH: Spain Gross Fixed Capital Formation Residential, NORGFCFH : Norway Gross Fixed Capital Formation Residential, SWEGFCFH : Sweden Gross Fixed Capital Formation Residential, FINGFCFH : Finland Gross Fixed Capital Formation Residential and NZGFCFH : New Zealand Gross Fixed Capital Formation Residential).

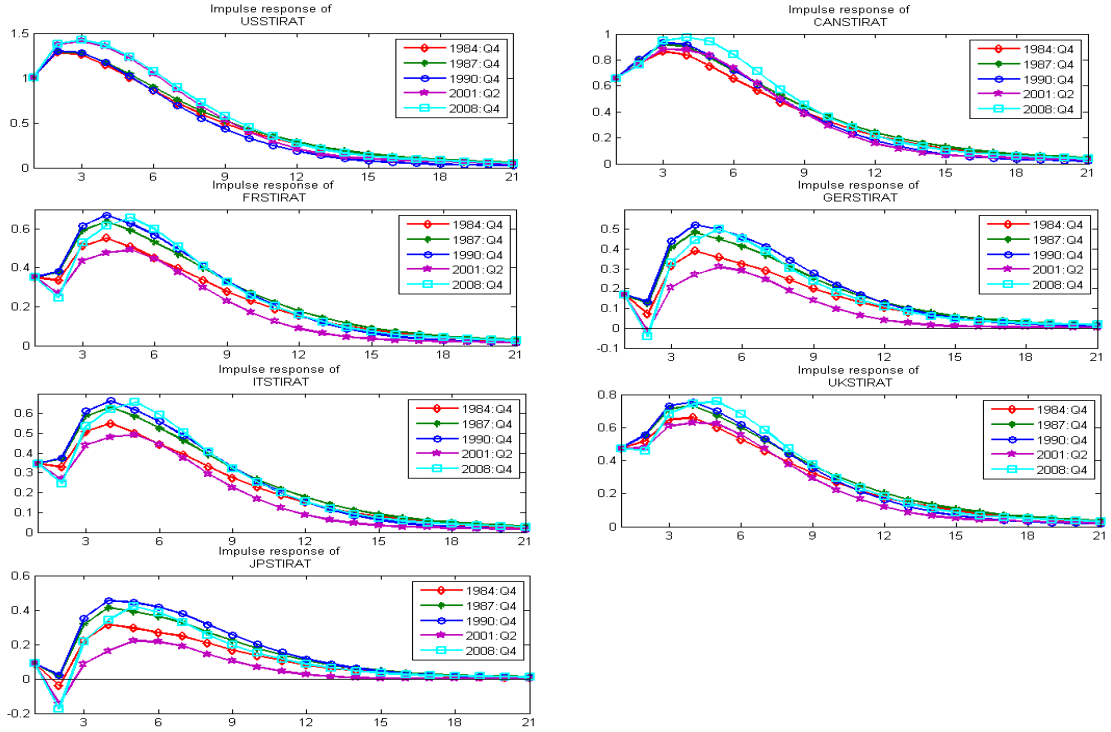


Fig. 6(a-I): Transmission of US monetary policy shocks to Short Term Interest Rates.

Mnemonic: (USSTIRAT: US Short-term Interest Rate, CANSTIRAT: Canada Short-term Interest Rate, FRSTIRAT: France Short-term Interest Rate , GERSTIRAT: Germany Short-term Interest Rate, ITSTIRAT : Italy Short-term Interest Rate, UKSTIRAT : UK Short-term Interest Rate and JPSTIRAT : Japan Short-term Interest Rate).

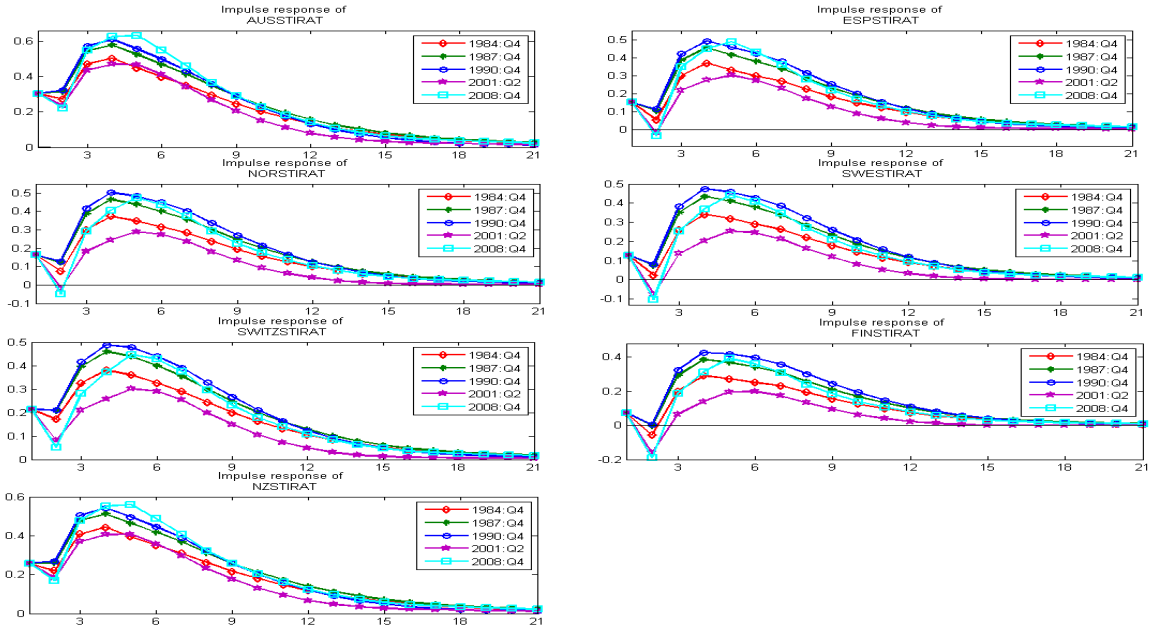


Fig. 6(a-II): Transmission of US monetary policy shocks to Short Term Interest Rates.

Mnemonic: (AUSSTIRAT: Australia Short-term Interest Rate, ESPSTIRAT: Spain Short-erm Interest Rate, NORSTIRAT: Norway Short-term Interest Rate, SWESTIRAT: Sweden Short-term Interest Rate, SWITZSTIRAT: Switzerland Short-term Interest Rate, FINSTIRAT: Finland Short-term Interest Rate, NZSTIRAT: New Zealand Short-term Interest Rate).

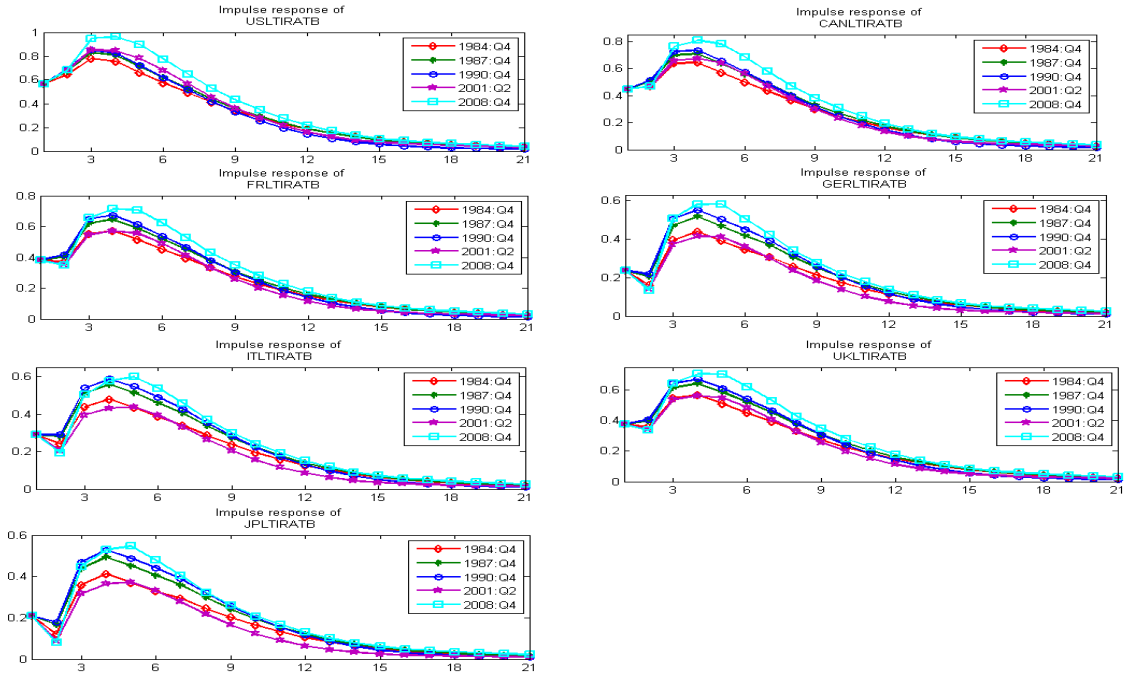


Fig. 6(b-I): Transmission of US monetary policy shocks to Long Term Interest Rtaes.

Mnemonic: (USLTIRATB: US Long-term interest rate, CANLTIRATB: Canada Long-term interest rate, FRLTIRATB: France Long-term interest rate, GERLTIRATB: Germany Long-term interest rate, ITLTIRATB: Italy Long-term interest rate, UKLTIRATB: UK Long-term interest rate and JPLTIRATB: Japan Long-term interest rate).

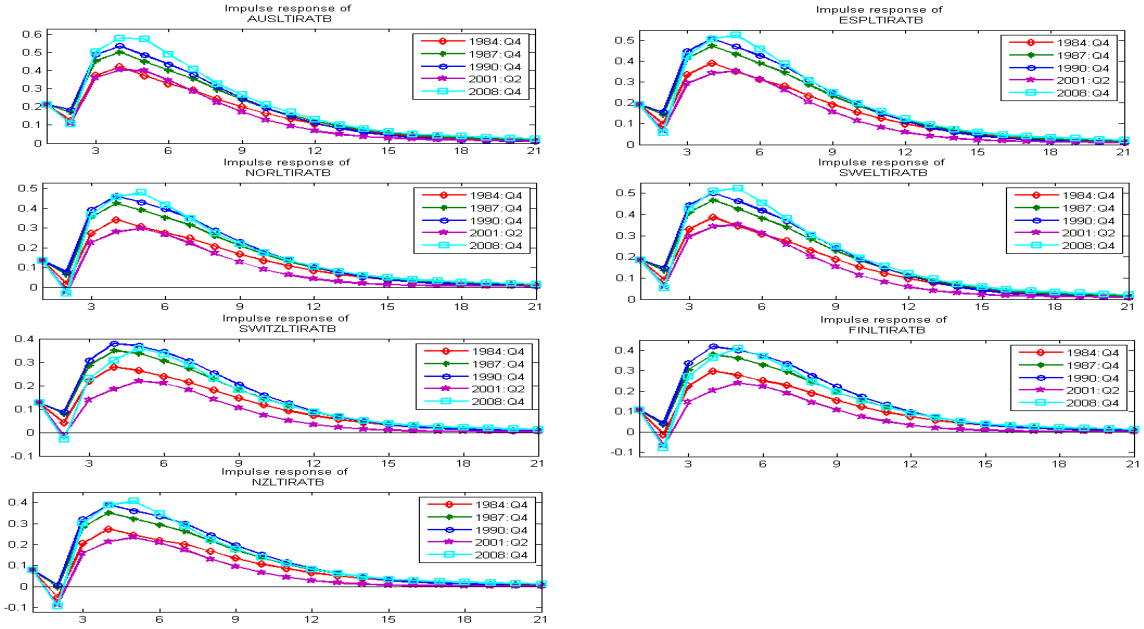


Fig. 6(b-II): Transmission of US monetary policy shocks to Long Term Interest Rtaes.

Mnemonic: (AUSLTIRATB: Australia Long-term interest rate, ESPLTIRATB: Spain Long-term interest rate, NORLTIRATB: Norway Long-term interest rate, SWELTIRATB: Sweden Long-term interest rate, SWITZLTIRATB: Switzerland Long-term interest rate, FINLTIRATB: Finland Long-term interest rate and NZLTIRATB: New Zealand Long-term interest rate).

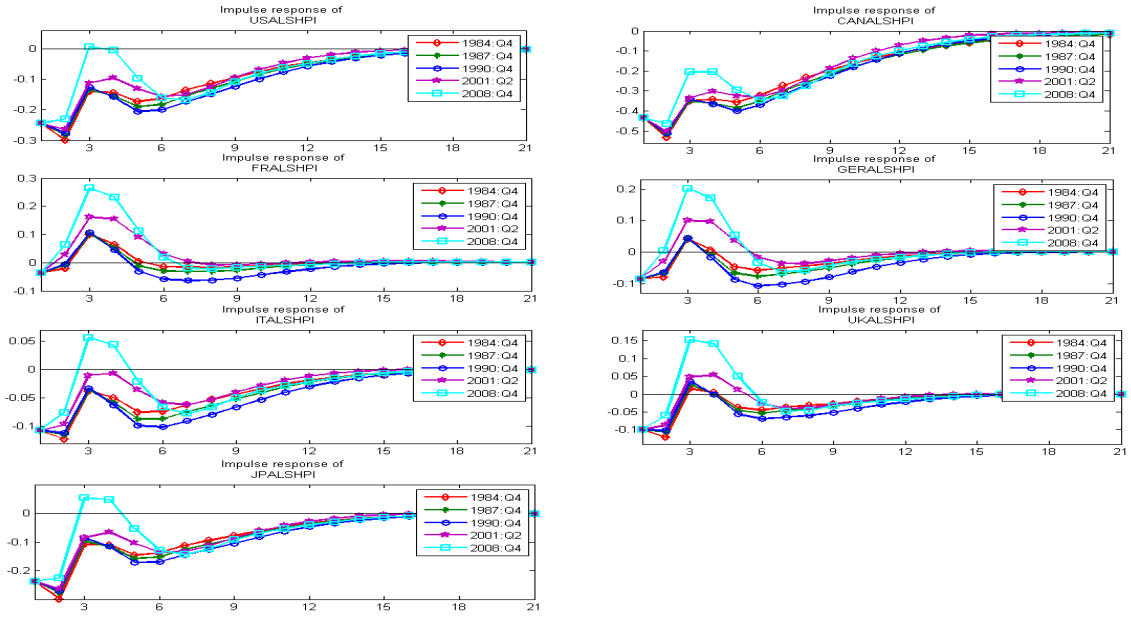


Fig. 6(c-I): Transmission of US monetary policy shocks to All Share Price Index.

Mnemonic: (USALSHPI: US All Shares Price Index, CANALSHPI: Canada All Shares Price Index, FRALSHPI: France All Shares Price Index, GERALSHPI: Germany All Shares Price Index, ITALSHPI: Italy All Shares Price Index, UKALSHPI: UK All Shares Price Index, JPALSHPI: Japan All Shares Price Index).

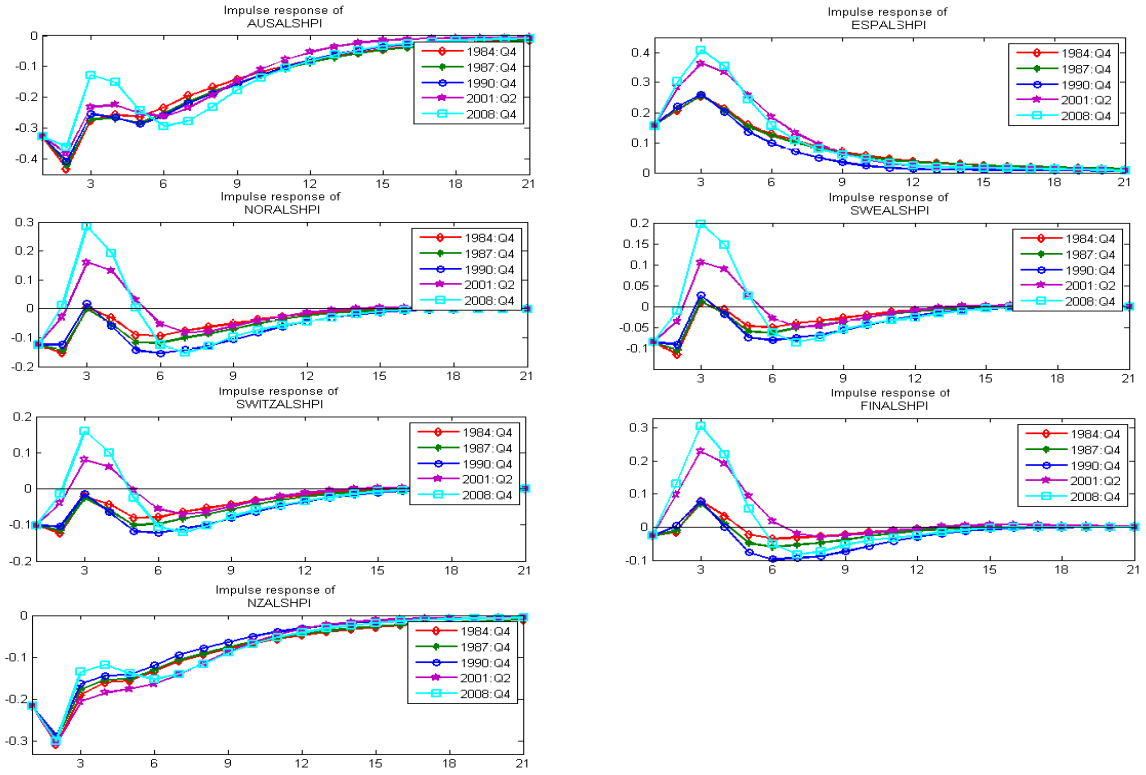


Fig. 6(c-II): Transmission of US monetary policy shocks to All Share Price Index.

Mnemonic: (AUSALSHPI: Australia All Shares Price Index, ESPALSHPI: Spain All Shares Price Index, NORALSHPI: Norway All Shares Price Index, SWEALSHPI: Sweden All Shares Price Index, SWITZALSHPI: Switzerland All Shares Price Index, FINALSHPI: Finland All Shares Price Index and NZALSHPI: New Zealand All Shares Price Index).

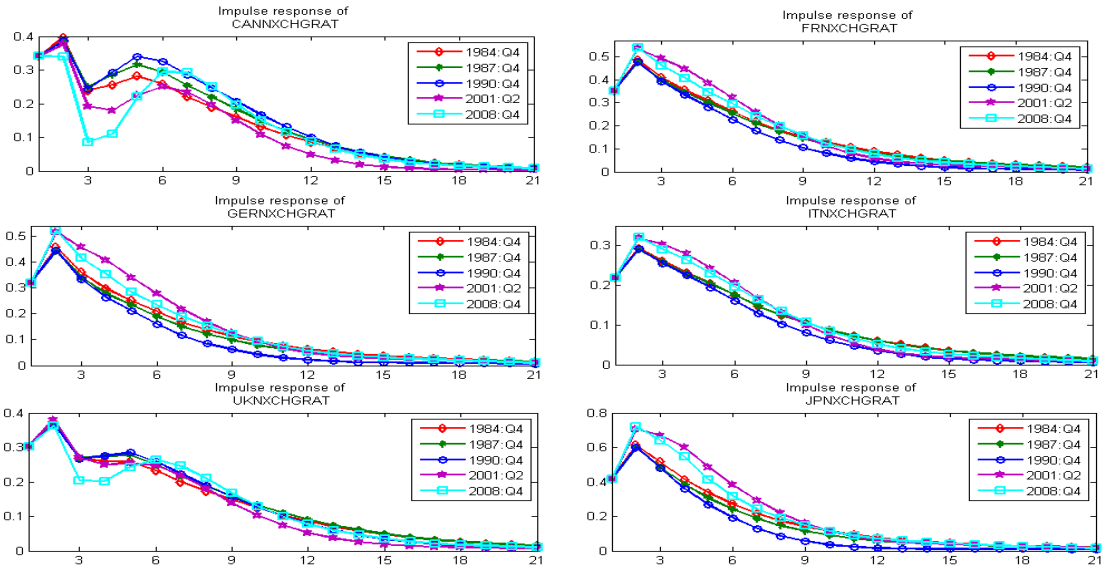


Fig. 6(d-I): Transmission of US monetary policy shocks to Nominal Exchange Rates.

Mnemonic: (CANNXCHGRAT: Canada Nominal Exchange Rate, FRNXCHGRAT: France Nominal Exchange Rate, GERNXCHGRAT: Germany Nominal Exchange Rate, ITNXCHGRAT: Italy Nominal Exchange Rate, UKNXCHGRAT: UK Nominal Exchange Rate and JPNXCHGRAT: Japan Nominal Exchange Rate).

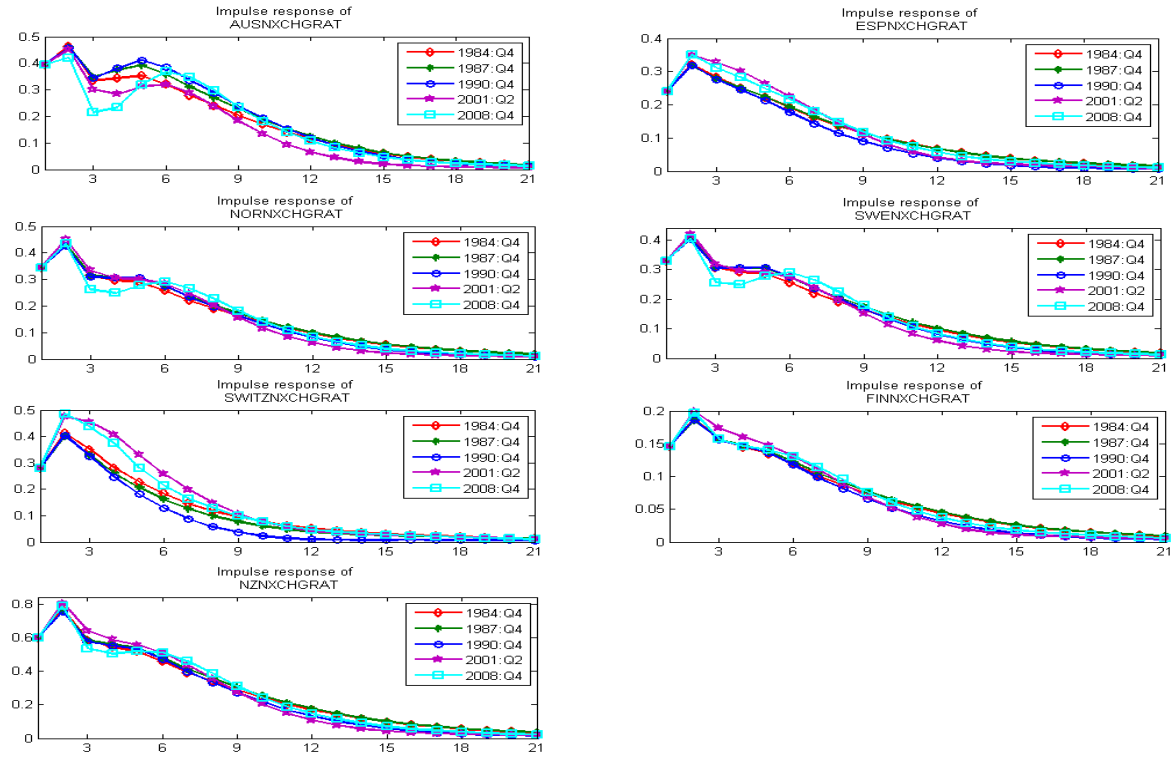


Fig. 6(d-II): Transmission of US monetary policy shocks to Nominal Exchange Rates.

Mnemonic: (AUSNXCHGRAT: Australia Nominal Exchange Rate, ESPNXCHGRAT: Spain Nominal Exchange Rate, NORNXCHGRAT: Nominal Nominal Exchange Rate, SWENXCHGRAT: Sweden Nominal Exchange Rate, SWITZNXCHGRAT: Switzerland Nominal Exchange Rate, FINNXCHGRAT: Finland Nominal Exchange Rate and NZNXCHGRAT: New Zealand Nominal Exchange Rate).

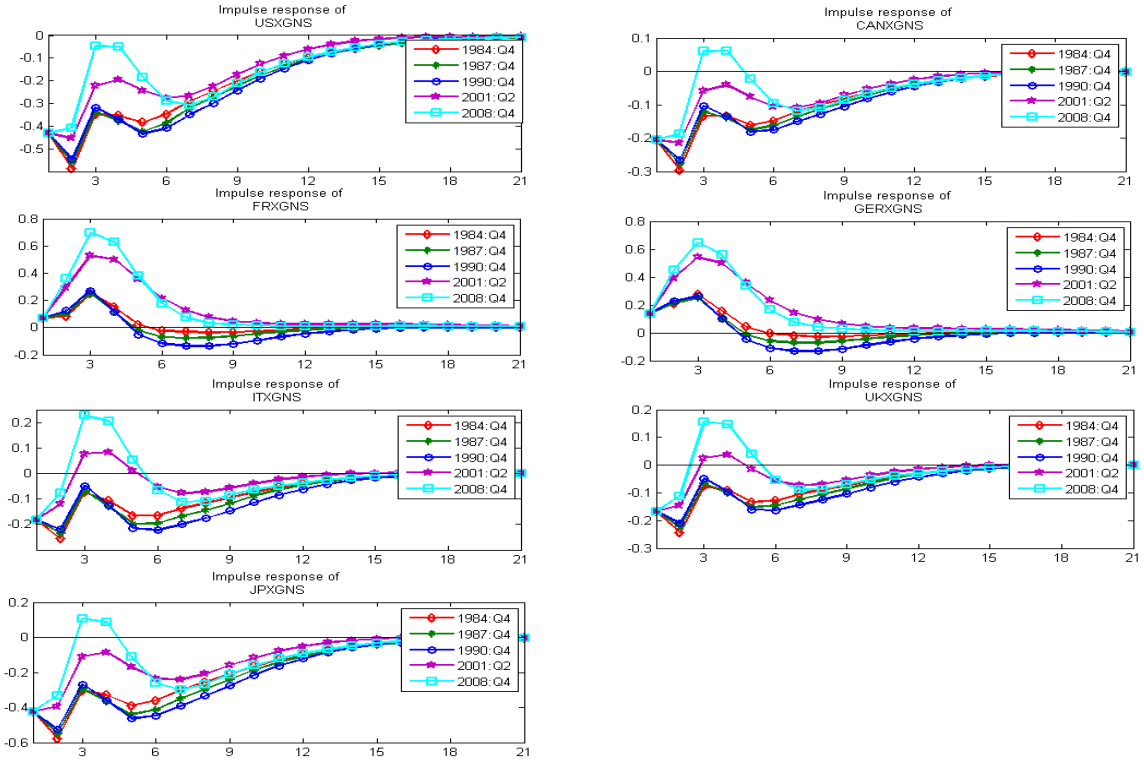


Fig. 6(e-I): Transmission of US monetary policy shocks to Exports of Goods and Services.

Mnemonic: (USXGNS: US Exports of Goods and Services, CANXGNS: Canada Exports of Goods and Services, FRXGNS: France Exports of Goods and Services, GERXGNS: Germany Exports of Goods and Services, ITXGNS: Italy Exports of Goods and Services, UKXGNS: UK Exports of Goods and Services and JPXGNS: Japan Exports of Goods and Services).

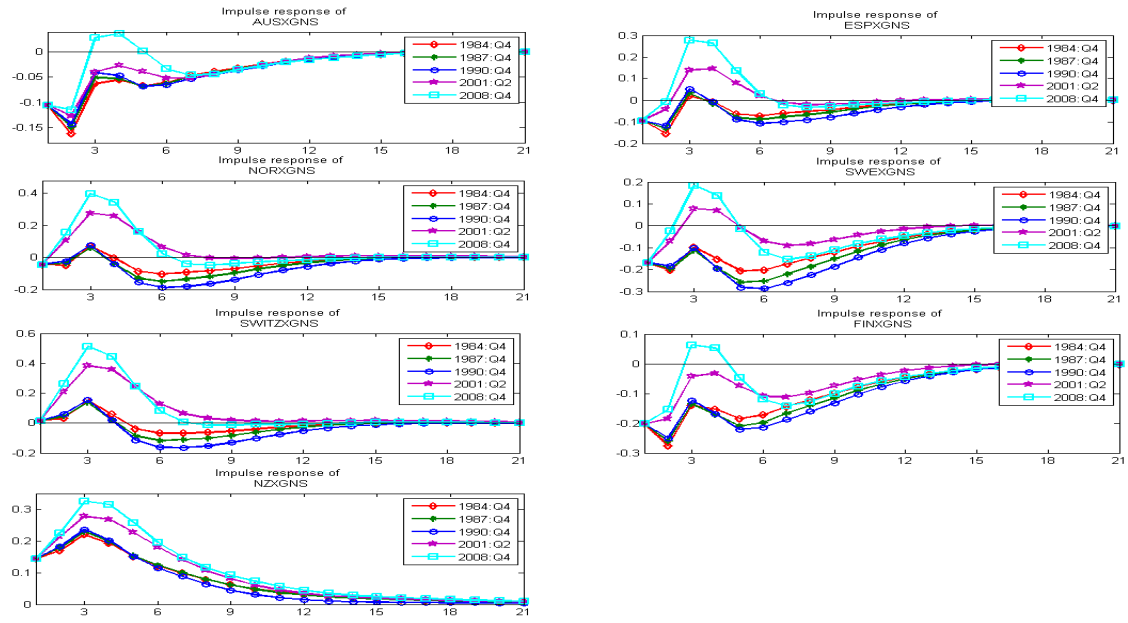


Fig. 6(e-II): Transmission of US monetary policy shocks to Exports of Goods and Services.

Mnemonic: (AUSXGNS: Australia Exports of Goods and Services, ESPXGNS: Spain Exports of Goods and Services, NORXGNS: Norway Exports of Goods and Services, SWEXGNS: Sweden Exports of Goods and Services, SWITZXGNS: Switzerland Exports of Goods and Services, FINXGNS: Finland Exports of Goods and Services, NZXGNS: New Zealand Exports of Goods and Services).