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Cross-country Transmission Effect of the U.S. Monetary Shock under Global Integration

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Abstract

Monetary policy shocks in the United States are considered a significant cause of economic fluctuations in other countries. We study empirically how the spillover effects of such shocks have changed as a result of the recent deepening of global integration. We consider shocks to the Federal Funds rate and examine how domestic production in a number of advanced, Latin American, and Asian countries were affected by these shocks during the 1990s and 2000s. We show that contractionary U.S. monetary policy shocks reduced domestic production in most of the sampled countries during the 1990s. During the 2000s, by contrast, the adverse effects were moderated. To explore the reasons behind the weakened spillover effects, we construct a DSGE model and examine the theoretical implications of the recent changes in economic structure, including global integration. In addition, we estimate response of trade and financial variables as well as policy instruments to U.S. monetary policy shocks. Our model combined with the empirical exercises suggests that, despite being enhanced by deepened trade integration, spillover effects may be decreasing due to a decline in the relative importance of the U.S. economy, and to regime switches in domestic monetary and exchange rate policy

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in non-U.S. countries. Though we empirically find a sign of short-run financial contagion during the 2000s, its effect upon the real economy was minor, possibly reflecting its low persistence.

Keywords: U.S. Monetary Policy; Spillover Effect; Financial and Trade Linkages

1 Introduction

Global integration has increasingly deepened in terms of trade and financial transactions over the current years. We display in Figure 1 the evolvements of the degree of the two classes of integration, measured by total trade volume and banks' cross border claims relative to the world GDP over time. The trade integration has increased steadily throughout the last two decades, enhancing the degree of integration in 2010 1.5 times larger than that in the early 1990s. The financial integration has also increased so that the degree of integration has doubled over the twenty years. One important consequence of such a global integration is changes in the spillover mechanism across countries. That is, a disturbance originated in one country today may be transmitted to the other countries in a different manner from the early days. Along this line, a growing attention is paid to the transmission of the U.S. monetary policy shocks in the global economy, reflecting the disproportionately large size and the interconnectedness with the rest of the world.

Theoretically, there are two main channels in the transmission of the U.S. monetary policy shock to the rest of the world. The first channel works through a change in the nominal exchange rate. The text book Mundell–Flemming–Dornbusch (MFD) model predicts that the U.S. monetary shock affects expenditure decisions of households and firms in the U.S. and non-U.S. countries. For instance, other things being equal, a contractionary U.S. monetary policy shock enhances a value of the U.S. dollar with respect to the non-U.S. currency and makes the relative price of the U.S. goods higher. As expenditure demand shifts toward non-U.S. goods, the domestic output in the non-U.S. countries increases (expenditure-switching effect). The second channel works through a change in the real interest rate. Because of its dominant role in the international financial market, the U.S. monetary policy shock affects the world interest rate. When domestic financial market is open to the U.S. and to the rest of the globe, a change in the world interest rate affects the intertemporal expenditure decisions of agents in non-US countries. A higher world interest rate stemming from the contractionary U.S. monetary policy shock therefore may dampen the domestic expenditure in the non-U.S. countries as well as that of the U.S. (expenditure-reducing effect).

The spillover effect of the U.S. monetary policy shock has been empirically explored by a good number of studies, such as Kim (2001), Canova (2005), and Mackowiak (2007). These existing studies agree that the spillover effect is an important source of business cycle fluctuations in the non-U.S. countries. The relative importance of the two channels are, however, often mixed across countries and ranges of time horizon studied. Kim

(2001) and Bluedorn and Bowdler (2006) claim that the expenditure-reducing effect generally dominates the expenditure-switching effect based on the analysis for the non-U.S. G7 countries. By contrast, Canova (2005) and Mackowiask (2007) point out that the latter effect prevails in some emerging countries. From the perspective of changes in spillover effects over time, Liu, Mumtaz, and Theophilopoulou (2011) investigate influence of the world interest rate shocks on the U.K. output and report that the former effect has been dominant until the 1990s and the effect has become nonsignificant during the 2000 and beyond. Ilzetzki and Jin (2013) study the spillover effects of shocks to the U.S. monetary policy, upon other advanced countries and observe that the former effect has been dominant before 1990 and the latter effect has taken over after 1990.[1]

In this paper, we revisit the issues of spillover effects of the U.S. monetary policy shock by shedding light on the influence of the recent deepening of global integration. To this end, we distill a time series of exogenous shocks to the Federal Funds rate in the U.S. economy by the factor augmented VAR developed by Bernanke, Boivin, and Mihov (2005) and extended by Boivin, Giannoni, and Mihov (2009).[2] We then estimate response of macroeconomic variables in the non-U.S. countries, including advanced, Latin American, and Asian countries, to the distilled U.S. monetary policy shocks following a methodology proposed by Romer and Romer (2001). To gauge the impacts of deepened global integration over the current years, we split our sample period into two sub-sample periods, from January 1990 to December 1999 and from January 2000 to December 2007. We estimate the responses for the two sub-sample periods separately. Our key finding is the changes in the spillover effects. We find that the domestic production in most of the non-U.S. countries fall in response to the contractionary U.S. monetary shocks in a statistically significant manner during the 1990s. During the 2000s, by contrast, these adverse effects are less pronounced. That is, only a limited portion of countries see statistically significant adverse consequence in the domestic production and the estimated magnitudes of the recessionary impacts across countries are reduced during the 2000s compared with the 1990s.

Why under the global integration has the spillover effects become weaker? Do tightened trade and financial linkages dampen the spillover effects instead of enhance them? To address this question, we theoretically explore implication of two other developments of global economic structure, in addition to global integration, that have advanced during the last two decades. The first development is a change in the relative significance of the U.S. economy in the global economic activities. Figure 2 displays the evolvement of the relative country size of the U.S. GDP compared with the world GDP. The rel-

[1] Along the similar line, Dées and Saint-Guilhem (2009) investigate the spillover effects of the shocks to the U.S. GDP to the rest of the world and report that a change in the U.S. GDP delivers a weaker but persistent impact on the non-U.S. economy in recent years.

[2] Boivin, Giannoni, and Mihov (2009) utilize the methodology of Bernanke, Boivin, and Mihov (2005) and distill the shocks to the U.S. monetary policy rule for the period covering from Janurary 1976 to June 2006. We construct the balanced panel following Boivin, Giennoni, and Mihov (2009) for a period that covers from Janurary 1976 to December 2007 for our estimation.

ative country size of the U.S. has been maintained around 25% throughout the 1980s and gradually declined since the early 1990s. It has fallen at even quicker rate in the subsequent periods, reaching 20% in the late 2000. From a different perspective, Figure 3 displays the relative importance of the U.S. economy in trade and financial transaction. The bilateral trade volume with the U.S. relative to the total trade volume with the rest of the world has risen from 14% in the early 1990s up to 16% in 2000 and has continuously declined throughout the 2000s to 11%. By contrast, the relative size of financial transaction with the U.S. has been maintained around 11% up to year 2000 and has risen to 13% during the latter half of the 2000s after the sharp fall to 9% in the early 2000s. Emergence of large economy and/or trading partner, such as Brazil and China, together with the global financial integration that underscores the role of the U.S. as the international financial center is the possible explanation for these changes in the relative significance of the U.S. economy in the world. The second development is the regime switches of domestic monetary and nominal exchange rate policies in the non-U.S. countries. As shown in Table 1, during the last two decades, some advanced countries have adopted inflation targeting so as to stabilize inflation expectation[3] and some Asian countries have adopted both inflation targeting policy and float nominal exchange rate regime particularly after the Asian currency crisis in the late 1990s.[4] There are also regime switches in Latin American countries. Because the U.S. monetary policy shocks are clearly source of variations in price and exchange rate in the non-U.S. countries, the endogenous policy responses to these variations matter to the transmission of the U.S. monetary policy shocks to the domestic economic activities in the non-U.S. countries.

To see how these developments affect the spillover effects, we construct a DSGE (Dynamic Stochastic General Equilibrium) model and derive the model's implications regarding these developments. Our model shows that these developments bring about two opposing consequences to the spillover effects. First, deepening of global trade integration causes a larger decline of domestic production in the non-U.S. countries in response to the same size of a U.S. contractionary monetary policy shock. On the contrary, a weakening of the bilateral relationship with the U.S., a decline in the relative country size of the U.S., or regime switches to more flexible exchange rate regime or inflation targeting regime moderates the adverse consequence on the domestic production. We also examine the implication of financial integration by considering a case when households in the two countries are more insured. The model implies that the adverse spillover effects on the domestic production in the non-U.S. countries becomes weaker though interest rate pass-through becomes quicker with financial integration. According to the model analysis, therefore, weakening of the spillover effects on domestic production is the product of changes in relative importance of the U.S., financial integration, and domestic policy regimes.

[3] See Ueda (2009) for details.

[4] Countries listed in the table 1 are only for those that are studied in our empirical exercise and therefore the coverage of the list is not comprehensive.

Having the model's prediction in hand, we ask if the explanations are consistent with the economic surroundings of our sampled countries and estimated impulse responses. We construct a country-by-country data set of trade linkage, GDP, and financial transaction as well as historical episodes for each of the sampled non-U.S. countries regarding policy regimes. We show that in most of the sampled countries, a decline of the trade relationship with the U.S. quantitatively dominates the deepening of trade integration with the rest of the world, a decline of the country size is slower than the U.S., and a financial transaction with both the U.S. and the rest of the world increases over the last two decades. In addition, we estimate the response of trade variables, financial market variables and policy instruments to the contractionary U.S. monetary policy shock. We observe the weakening of spillover effects for the most of the trade variables and financial variables. Though we find some evidence of increased financial contagion in the non-U.S. countries due to the contractionary U.S. monetary policy shock over the two decades, their propagation to the domestic productions are minor. This may be partly because financial contagion after the shock is only short-lived. Regarding estimated responses of policy instruments, we find that they are more contractionary during the 1990s than 2000s in Asian countries, suggesting that the policy responses may have caused weakening of spillover effects in these countries.

Our paper stems from two strands of the literature. The first strand discusses spillover effect of monetary policy shock in one country to the other countries.[5] A pioneering work by Kim (2001) utilizes a VAR methodology of Chrisitiano et al. (1996 and 1998) to explore how the expansionary monetary policy shock in the U.S. affects economic activities in the non-U.S. G7 countries. Subsequent work by Canova (2005) and Mackowiask (2007) investigate the spillover effect of the U.S. monetary policy shock on the non-G7 countries.[6] The second strand explores the implication of the deepening of integration in terms of financial and trade linkages to the economic activities around the globe. While existing studies agree that the integration has deepened in the current years, there is no agreement empirically yet as to what is the fruit of integration. Kose et al. (2008), discussing the globe is more integrated in current days than old days, decompose source of variations in domestic variables into a global factor common to all variables and all countries, a factor common to specific group of countries, and a country factor, and document that the proportion of variations in domestic variables accounted for by the country-specific factor has declined when current data is used for estimation. Dee and Saint-Guilhem (2009) discuss contribution of the U.S. shock to output variations in the

[5] There are several studies that discuss the international spillover of the monetary policy shock in the non-U.S. countries. Maćkowiak (2008) studies the impact of Japanese quantitative easing on East Asian countries and cast the doubts on the view that the policy has beggar-thy-neighbor effects. See also Koźluk and Mehrotra (2009) for the spillover of expansionary Chinese monetary policy shock to East Asian countries.

[6] Along the similar line, Ncube et al. (2012) discuss the impact of the U.S. monetary policy shock on the South African economy.

non-U.S. countries and show that the contribution has been declining over the years.[7]

The rest of the paper is organized as follows. The section 2 describes our estimation procedure that is employed to extract the U.S. monetary policy shocks and gauge the macroeconomic response to the shocks. It then documents the estimated response of domestic production in the non-U.S. countries to the shocks. The section 3 explores the linkages between changes in economic environment and spillover effects of the U.S. monetary policy shock using a simple open economy model. Section 4 discusses the candidate explanations for the weakened spillover effects, and the section 5 concludes.

2 Estimating Spillover Effects

2.1 Estimation Methodology

Our estimation methodology contains two steps. We first distill shocks to the U.S. monetary policy rule using the U.S. macroeconomic time series. We then estimate the response of a set of macroeconomic variables including production-related variables, trade and financial variables, and policy instruments, in the non-U.S. countries to the distilled shock series.

Obtaining the U.S. monetary policy shock series

We identify a historical time series of the U.S. monetary policy shock by making use of the factor-augmented VAR approach proposed by Bernenke, Boivin, and Eliaz (2005) and Boivin, Giannoni, and Mihov (2009). Closely following their estimation methodology, we construct a balanced panel that consists of 120 monthly macroeconomic time series running from February 1976 up to December 2007, extract the time paths of 5 latent factors from the balanced panel, and obtain a historical realization of innovations to Federal Funds rate up to December 2007 that are orthogonal to these latent factors and the own lag of the Federal Funds rate.[8] We denote the identified shock series by $\tilde{S}_t$ hereafter.[9] The time path of the Federal Funds rate together with the identified shocks

[7] See also Eickmeier et al. (2011) that estimate the consequence of favorable shock to the U.S. financial conditions index to the non-U.S. advanced countries using time-varying FAVAR and find that the degree of transmission has increased since the 1980s to the 2000s.

[8] Bernenke, Boivin, and Eliaz (2005) display the estimation results for the case when the number of latent factors is three and five. Though we choose an estimation methodology that extracts five factors from the balanced panel, our estimation results are little altered under an alternative setting where three latent factors instead of five latent factors are extracted.

[9] Because our analysis concentrates on the spillover effect of shocks to the conventional U.S. monetary policy rule, we drop a sample period beyond December 2007 where the unconventional monetary policy has been implemented. To check the robustness of our empirical analysis, however, we also conduct the analysis based on the shock series to the Federal Funds rates that are distilled from the sample period that covers the time series up to December 2012. The estimated results are little altered by the use of this alternative monetary policy shocks.

to the U.S. monetary policy rule $\tilde{S}_t$ are displayed in Figure 4.

Estimating cross-country responses to the U.S. monetary policy shock

Our sample country includes four classes of countries; G7 countries other than the U.S. plus Australia, other advanced European countries, Asian countries, and Latin American countries. To see the impact of trade and financial integration, we estimate economic dynamics of twelve macroeconomic series in these countries for the two sample periods, the 1990s and the 2000s. The first sample period covers from January 1990 to December 1999 and the second sample period covers for the January 2000 to December 2007. We drop a country from our analysis of a specific macroeconomic variable for a specific sample period when the corresponding monthly time series is not available. Our sample macroeconomic variable includes three production-related variables, industrial production index, employment, and unemployment rate, three trade-related variables, real export index, real import index, and real trade balance index, six financial variables, stock price, nominal exchange rate, long term nominal interest rate, volatility stock price, exchange rate, and long term nominal interest rate, and three policy instruments, policy rate, narrow money, and inflation rate. All of the macroeconomic series other than stock price series and interest rate series are seasonally adjusted.

Using the measure of the U.S. monetary policy shock estimated by the factor-augmented VAR approach, we estimate the impulse response functions of macroeconomic variables in the non-U.S. countries following closely the estimation methodology proposed by Romer and Romer (2004). For each of the macroeconomic variables for each country and for each sample period, we regress the macroeconomic variable x in country j on its own lags and lagged values of the U.S. monetary policy shock, $\tilde{S}_t$. Our regression equation is then given by

$$\Delta x_{j,t} = c_{j_x} + \sum_{\ell=1}^{\hat{p}} \hat{\alpha}_{j_x,\ell} \Delta x_{j,t-\ell} + \sum_{\ell=1}^{\hat{q}} \hat{\beta}_{j_x,\ell} \tilde{S}_{t-\ell} + \varepsilon_{j_x,t}, \tag{1}$$

where $\Delta x_{j,t}$ denotes the first difference of the macroeconomic variable $x_{j,t}$, c_{j_x} denotes the constant, $\hat{\alpha}_{j_x,\ell}$ denotes the estimated coefficients attached to l-th lagged macroeconomic variable $\Delta x_{j,t}$ in country j, $\hat{\beta}_{j_x,\ell}$ is the estimated coefficient attached to l-th lag of the estimated U.S. monetary policy shock, and $\varepsilon_{j_x,t}$ is the innovation that is specific to the macroeconomic variable x in country j.[10] $\hat{p}$ and $\hat{q}$ stand for the number of lags attached to the macroeconomic variable and the U.S. monetary policy shock, respectively. In all of the estimations, twelve lags for each macroeconomic variable x and thirty six lags for the U.S. monetary policy shock are included.[11] When estimated parameters are explosive,

[10] All of the response of macroeconomic variables are estimated in the log difference form, except for interest rates and the unemployment rate for which log form is employed.

[11] The difference between Romer and Romer (2004) and our specification is that numbers of lags and the use of seasonally adjusted variables. Romer and Romer (2004) make use of settings where $\hat{p} = 24$

however, shorter lags are included.

2.2 Estimation Results

To gauge the changes in domestic response to the U.S. monetary policy shock in the non-U.S. countries in details, we construct two statistics. The first statistics is a proportion of countries that experience a statistically significant increase or decrease at the significant level of 5%, or countries that see no statistically significant deviation from zero after the shock among countries that belong to the same country group. This statistics conveys information regarding signs of the responses that are statistically meaningful.[12] The second statistics computes distribution of impulse response of macroeconomic variables across countries. While the sizes and signs of domestic responses exhibit a substantial cross-country heterogeneity, this statistic conveys overall distribution of the estimated responses. To obtain the statistics, for each sampled country, we collect a value of estimated impulse response at four years after the shock and construct the distribution using the responses for the sample period covering the 1990s and the 2000s.[13][14]

Figure 5 displays the response of macroeconomic variables that capture the size of domestic production, industrial production index (IIP), employment, and unemployment rate, in the non-U.S. countries to the contractionary U.S. monetary policy shock. To highlight the heterogeneity of responses across different country group and subsample, we categorize sampled countries into five country groups, G6 + Australia, Other advanced European countries, Latin American countries, Asian countries, and all countries, and document the results for the sample covering the 1990s and the 2000s separately.[15] For each variable, the upper panel displays a proportion of countries within each country group that experience a statistically significant positive response, depicted in a black bar, significant negative response, depicted in a gray bar, and no significant difference from zero, depicted in a white bar. The lower panel displays the distribution of estimated impulse response in months around four years after the impact period across all of the

and $\hat{q} = 36$ for output and $\hat{p} = 24$ and $\hat{q} = 48$ for price level and use non-seasonally adjusted variables for estimation.

[12] To compute the confidence interval of the impulse response function of each of domestic macroeconomic variables to the shock, we assume that innovations $\varepsilon_{j_x,t}$ in the equation (1) is normally distributed and there is no measurement errors in estimating $\tilde{S}_{t-\ell}$ in the first step.

[13] We choose four years horizon for the purpose of comparison with existing studies including Kim (2001) and Canova (2005).

[14] For variables which we use its first difference in estimating the impulse response, we convert the impulse response into level by taking the cumulative sum of the impulse response over a period from the initial period up to a k period after the shock. For variables which we do use level variable in estimating the impulse response, such as unemployment rate, we do not take the cumulative sum but instead use the impulse response function itself in calculating the numbers.

[15] See Table 9 for a list of countries that are studied in this paper. Note that because the length of time series of macroeconomic variables available for the analysis differs across countries, the number of listed countries is not equal across macroeconomic variable.

sampled countries.[16] In each panel, the X-axis denotes the estimated size of impulse responses and Y-axis denotes marginal density of the corresponding size of the estimated impulse responses.

During the 1990s, for all of the three production-related variables and in each of the five country groups, the most of countries witness significant recessionary impact by the contractionary U.S. monetary policy shock. By contrast, during the 2000s, such adverse effects are observed only in a limited number of countries. The mitigation of the recessionary effects is pronounced the most in advanced countries and less so in Latin American and Asian countries. The similar observation is obtained from the cross-country distribution of estimated impulse responses. During the 1990s, estimated impulse responses in majority countries are concentrated around points below zero for IIP and employment and above zero for the case of unemployment rate, indicating that general influence of the contractionary U.S. monetary policy shock on domestic production activities in the non-U.S. countries is contractionary. During the 2000s, by contrast, the peaks of marginal densities are flattened for all of the production-related variables and they are shifted to the right for IIP and employment and to the left for unemployment rate. These findings suggest that the contractionary spillover effect is weakened.[17]

Two remarks are noteworthy regarding the estimated results. First, the results are consistent with early studies including Kim (2001) and Bluedorn and Bowdler (2011). They both document the quantitative dominance of expenditure-reducing effect on expenditure-switching effect in the transmission of the contractionary U.S. monetary policy shock to the non-U.S. countries. Our contribution regarding this point is to have shown that the same statement holds true in a broader set of countries that contains Latin American and Asian countries. Second, our result indicates that the effects of contractionary U.S. monetary policy shocks to the domestic production in the non-U.S. countries have changed over time. The adverse spillover effects have become less contractionary during the 2000s than 1990s. This finding is in line with observations made in Liu, Mumtaz, and Theophilopoulou (2011) for the U.K.[18] In the subsections below, we investigate reasons

[16] To obtain cross-country distribution of responses, we employ averaged impulse response functions over 40th month to 50th month after the shock for all of the macroeconomic variable except for the long and short term interest rate. Because the impulse responses of these variables are short-lived, we make use of averages over periods shortly after the impact period, from 1st month to 24th month.

[17] Note that our estimation results only imply that contractionary U.S. monetary policy shocks identified in the way described above may deliver adverse effect on production-related variables in the non-U.S. countries and do not indicate that a rise in the Federal Funds rate itself hampers domestic productions in these countries.

[18] Our estimation result is, in some aspects, analogous to that obtained by Ilzetzki and Ji (2013). They document that in recent years there has been switches in the relative quantitative importance of expenditure-switching effect and expenditure-reducing effect in the transmission of the U.S. monetary policy shock to abroad. That is, the contractionary U.S. monetary policy shock delivers contractionary effects in the non-U.S. countries during the early years while delivers favorable effects during the current years. Admittedly, some of our sampled countries exhibit the similar pattern of the responses as theirs. It is important to note, however, that in our analysis the most of our sampled countries see adverse

behind the changes in adverse effects of the contractionary U.S. monetary policy shock on the production activities in the non-U.S. economy.

3 Explanations for Weakened Spillover Effects and Their Theoretical Implications

Why has the spillover effects changed over time? To see the reasons, in this section, we theoretically analyze the implications of three recent developments of economic structure to the spillover effects using a plain vanilla Dynamic Stochastic General Equilibrium (DSGE) Model. The developments that we focus include a change in the relative significance of the U.S. economy in the global economic activities, the regime switches of domestic monetary and nominal exchange rate policies in the non-U.S. countries, as well as deepening of trade and financial integration. Clearly, these developments may be interrelated from each other. For instance, deepening of global integration and less reliance on the trade with the U.S. originate from the same economic reason. We however treat these developments as exogenous in the model and investigate how these exogenous developments are related to the spillover effects.

Our model is built upon the text book open economy model studied by Obstfeld and Rogoff (1996) or Corsetti and Pesenti (2001a,b). Our model consists of three countries, A, B, and C. We analyze how responses of domestic production in country B to a monetary policy shock in country A vary with degree of global integration, relative importance of the trade relationship with country A, and domestic policy regimes in country B. Admittedly, the transmission mechanism between country A and B depends on economic structure surrounding country C as well. Because of the three-country framework, our model is able to capture the third-country effects. The model answers to a question such as how an increase in country size of country C influences the monetary transmission from country A to country B.

3.1 Household

Because all of the three countries are symmetric, we describe settings for households, firms, and government sector only in country A unless otherwise noted.[19] A representative household in country A is an infinitely-lived representative agent with preference over the final consumption goods, $C_A(s^t)$ and work effort, $h_A(s^t)$, as described in the expected utility function, (2) :

consequence during both of the two sample periods and experience the mitigation of the adverse effect in the current years maintaining the qualitative aspect of the shock's effect unaltered.

[19] Only difference between country A and other two countries is that the internationally traded bond is denominated by the currency in country A. This difference, however, does not affect the spillover effects considered in the current paper.

$$U_A = \mathrm{E}_t \sum_{j=0}^{\infty} \beta^j \left[\frac{\left[C_A\left(s^{t+j}\right) - bC_A\left(s^{t+j-1}\right) \right]^{1-\sigma}}{1-\sigma} - \eta \frac{\left(h_A\left(s^{t+j}\right) \right)^{1+\xi}}{1+\xi} \right], \tag{2}$$

where s^t stands for a state in period t, $\beta \in (0,1)$ is the discount factor, $\sigma > 0$ is the inverse of intertemporal elasticity of substitution, $b \in [0,1)$ is the persistency of consumption habit, $\xi > 0$ is the inverse of the Frisch labor-supply elasticity, and $\eta > 0$ is the utility weight assigned to labor disutility.

The budget constraint for the household is

$$\begin{array}{l} P_A\left(s^t\right) C_A\left(s^t\right) \\ +B_A\left(s^t\right) + B_A^*\left(s^t\right) \end{array} \leq \begin{array}{l} W_A\left(s^t\right) h_A\left(s^t\right) + R_A\left(s^{t-1}\right) B_A\left(s^{t-1}\right) \\ +R^*\left(s^{t-1}\right) B_A^*\left(s^{t-1}\right) \left(1 - \Gamma_A\left(s^{t-1}\right)\right). \end{array} \tag{3}$$

Here $P_A\left(s^t\right)$ is the nominal price of final consumption goods $C_A\left(s^t\right)$, $W_A\left(s^t\right)$ is the nominal wage rate paid for the work effort $h_A\left(s^t\right)$. Each household is the monopolistic supplier of a differentiated work effort to domestic intermediate goods firms discussed below. Wage contracts are subject to nominal rigidity and a household chooses her wage so as to maximize her utility under the constraint.[20] Household holds two assets, domestically traded bond $B_A\left(s^t\right)$ and internationally traded bond $B_A^*\left(s^t\right)$. The former bond is in zero net supply at each country level and the latter bond is in zero net supply worldwide. For simplicity, we assume that the internationally traded bond is denominated in the currency of country A. The corresponding short-term nominal rates paid for the two bond holdings are denoted as $R_A\left(s^{t-1}\right)$ and $R^*\left(s^{t-1}\right)$, respectively.

Similarly to Laxton and Pesenti (2003) and Hirakata, Iwasaki, and Kawai (2013), there are frictions associated with the transaction of the internationally traded bond, such that

$$\Gamma_A\left(s^t\right) = \mu \left(\exp\left(\hat{\mu} B_A^*\left(s^t\right) / P_A\left(s^t\right) \right) - 1 \right) / \left(\exp\left(\hat{\mu} B_A^*\left(s^t\right) / P_A\left(s^t\right) \right) + 1 \right),$$

where μ and $\hat{\mu}$ are parameters that govern the cost of accessing the international bond market and $\Gamma_A\left(s^t\right)$ stands for size of the cost facing the household.[21]

3.2 Firms

There are two types of firms, distributors and intermediate goods producers in each of the countries. Most of our settings are borrowed from Bodenstein, Guerrieri, and Gust (2010), Laxton and Pesenti (2003) and Hirakata, Iwasaki, and Kawai (2013).

[20] See for instance Fueki, Fukunaga, Ichiue, and Shirota (2010) for the details of the nominal wage settings.

[21] Laxton and Pesenti (2003) assume that parameter value of μ and $\hat{\mu}$ are 0.05 and 0.01, respectively. As we study the recent economy after the 1990s, considering the current technological progress in financial transaction, we set the first parameter at lower value than theirs.

Distributors

The distributors purchase differentiated intermediate goods produced by the intermediate goods producers located in each country, combine the differentiated goods to produce intermediate composites, convert the intermediate composites to the final consumption goods, and sell the final consumption goods to the domestic households. They are perfectly competitive both in their input and output market.

The production technology that yields the final consumption goods $C_A(s^t)$ is given by the following equation:

$$C_A\left(s^t\right) \equiv \left[\begin{array}{l} \left(n_{AA}\right)^{\phi/(1+\phi)}\left(C_{AA}\left(s^t\right)\right)^{\phi/(1+\phi)} \\ +\left(n_{AB}\right)^{\phi/(1+\phi)}\left(C_{AB}\left(s^t\right)\right)^{\phi/(1+\phi)} \\ +\left(n_{AC}\right)^{\phi/(1+\phi)}\left(C_{AC}\left(s^t\right)\right)^{\phi/(1+\phi)} \end{array}\right]^{1+\phi}, \tag{4}$$

where $C_{AA}(s^t)$, $C_{AB}(s^t)$, and $C_{AC}(s^t)$ are intermediate composite that is converted from the differentiated intermediate goods produced in country A, B, and C, respectively. n_{AA}, n_{AB}, and n_{AC} are positive weight assigned to each intermediate composite and $\phi > 0$ is the parameter that governs substitutability across three intermediate composite.[22][23]

Each intermediate composite is produced from differentiated intermediate goods with different origin. The corresponding production technology is given by

$$\begin{aligned} C_{AA}\left(s^t\right) &\equiv \left[\int_0^1 y_{AA}\left(i,s^t\right)^{\frac{1}{1+\theta}}di\right]^{1+\theta}, \\ C_{AB}\left(s^t\right) &\equiv \left[\int_0^1 y_{AB}\left(i,s^t\right)^{\frac{1}{1+\theta}}di\right]^{1+\theta}, \text{ and} \\ C_{AC}\left(s^t\right) &\equiv \left[\int_0^1 y_{AC}\left(i,s^t\right)^{\frac{1}{1+\theta}}di\right]^{1+\theta}, \end{aligned}$$

where $y_{AA}(i,s^t)$, $y_{AB}(i,s^t)$, and $y_{AC}(i,s^t)$ is differentiated intermediate goods that is produced by the differentiated intermediate goods producer i in country A, B, and C. The parameter $\theta > 0$ governs the elasticity of substitution between differentiated intermediate goods. Taking price of these differentiated intermediate goods $p_{AA}(i,s^t)$, $p_{AB}(i,s^t)$, and $p_{AC}(i,s^t)$ as given, distributors determine how much the intermediate composite and the final consumption goods to produce.

[22] We assume that $n_{AA}+n_{AB}+n_{AC}=1$ and that the similar constraint holds for other two countries.

[23] In the current model, we denote intermediate composite that is converted from differentiated intermediate goods produced in country k and used for producing final consumption goods in country l in period t by $C_{lk}(s^t)$. The weight attached for the intermediate composite is correspondingly depicted as n_{lk}.

Intermediate goods producers

Firms in country A produce differentiated products indexed by $i \in [0,1]$. As explained above, each differentiated goods is converted by the local distributors in the destination country to the intermediate composite $C_{AA}(s^t)$, $C_{BA}(s^t)$, and $C_{CA}(s^t)$. Note that these intermediate composite are produced from the differentiated goods via the following technology:

$$\begin{aligned} C_{AA}(s^t) &\equiv \left[\int_0^1 y_{AA}(i,s^t)^{\frac{1}{1+\theta}}\, di\right]^{1+\theta}, \\ C_{BA}(s^t) &\equiv \left[\int_0^1 y_{BA}(i,s^t)^{\frac{1}{1+\theta}}\, di\right]^{1+\theta}, \text{ and} \\ C_{CA}(s^t) &\equiv \left[\int_0^1 y_{CA}(i,s^t)^{\frac{1}{1+\theta}}\, di\right]^{1+\theta}, \end{aligned}$$

where $y_{AA}(i,s^t)$, $y_{BA}(i,s^t)$, and $y_{CA}(i,s^t)$ is portion of differentiated goods produced by the differentiated intermediate goods producer i that is delivered to country A, B, and C. The demand function for the differentiated intermediate goods is derived from the optimization behavior of the distributor in each destination country, represented by

$$\begin{aligned} y_{AA}(i,s^t) &\equiv \left[\frac{p_{AA}(i,s^t)}{P_{AA}(s^t)}\right]^{\frac{-(1+\theta)}{\theta}} C_{AA}(s^t), \\ y_{BA}(i,s^t) &\equiv \left[\frac{p_{BA}(i,s^t)}{P_{BA}(s^t)}\right]^{\frac{-(1+\theta)}{\theta}} C_{BA}(s^t), \text{ and} \\ y_{CA}(i,s^t) &\equiv \left[\frac{p_{CA}(i,s^t)}{P_{CA}(s^t)}\right]^{\frac{-(1+\theta)}{\theta}} C_{CA}(s^t). \end{aligned} \tag{5}$$

where $p_{AA}(i,s^t)$, $p_{BA}(i,s^t)$ and $p_{CA}(i,s^t)$ are the nominal price of differentiated intermediate goods produced by firm i, and $P_{AA}(s^t)$, $P_{AB}(s^t)$, and $P_{AC}(s^t)$ are the nominal prices of the intermediate composite $C_{AA}(s^t)$, $C_{BA}(s^t)$, and $C_{CA}(s^t)$. All prices are denominated in the currency of destination country.

Production input of differentiated intermediate goods is labor input $h_A(i)$ provided by household in country A and the production function of firm i is given by:

$$y_{AA}(i,s^t) + y_{BA}(i,s^t) + y_{CA}(i,s^t) \leq h_A(i). \tag{6}$$

Each differentiated intermediate firm i is a monopolistic competitor in the domestic and overseas products market, setting price of its product in the destination country in reference to the demand equation given by (5) subject to the nominal rigidity associated with price adjustment. That is, firm i faces a quadratic cost à la Rotemberg (1982) in adjusting its product price, and solves the following profit maximization problem in choosing its price $p_{AA}(i,s^t)$.

$$\max_{p(i,s^{t+j})} \mathrm{E}_t \sum_{j=0}^{\infty} \beta^j \Lambda_{j-1,j} \left[\begin{array}{l} \frac{P_{AA}\left(i,s^{t+j}\right)}{P_{AA}\left(s^{t+j}\right)} y_{AA}\left(i,s^{t+j}\right) - \frac{W_A\left(s^{t+j}\right)}{P_{AA}\left(s^{t+j}\right)} y_{AA}\left(i,s^{t+j}\right) \\ -\frac{\kappa}{2}\left(\frac{P_{AA}\left(i,s^{t+j}\right)}{P_{AA}\left(i,s^{t+j-1}\right)} - 1\right)^2 y_{AA}\left(i,s^{t+j}\right) \end{array} \right].$$

Here κ is the parameter that governs size of the real cost associated with the product price adjustment and $\Lambda_{j-1,j}$ stands for the Lagrangian multiplier associated with a representative household's budget constraint. The prices of differentiated intermediate goods shipped to overseas $p_{BA}\left(i,s^t\right)$ and $p_{CA}\left(i,s^t\right)$ are also chosen subject to the similar nominal rigidity constraint (local currency pricing).

3.3 Government and Resource Constraint

Monetary Policy

The central bank in country A sets the short term nominal interest rate according to a simple Taylor rule given by

$$\ln R_A\left(s^t\right) = \begin{array}{l} (1-\rho_M)\ln R + \rho_M \ln R_A\left(s^{t-1}\right) \\ +(1-\rho_M)\left(\phi_\pi \ln \pi_A\left(s^t\right) + \phi_c \ln \frac{C_A\left(s^t\right)}{C_A\left(s^{ss}\right)}\right) + \epsilon_{r_A}\left(s^t\right) \end{array}, \tag{7}$$

where R is the short term nominal interest rate at the steady state, $\rho_M \in [0,1]$ is the autoregressive coefficient of the rate, $\phi_\pi > 1$, $\phi_c > 0$ are the policy weight attached to the inflation rate $\pi_A\left(s^t\right)$ of final consumption goods, which is defined as $P_A\left(s^t\right)/P_A\left(s^{t-1}\right)$, and output gap measured by the deviation of the final consumption goods from its steady state value denoted as $\ln(C_A\left(s^t\right)/C_A\left(s^{ss}\right))$, and $\epsilon_{r_A}\left(s^t\right)$ is an i.i.d. shock to the monetary policy rule in country A.

Evolution of bond of international capital market

The net holding of internationally traded bond in country A evolves according to the following law of motion.

$$\begin{array}{rcl} \xi_A B_A^*\left(s^t\right) & = & \xi_A R_A^*\left(s^{t-1}\right) B_A^*\left(s^{t-1}\right)\left(1-\Gamma_A\left(s^{t-1}\right)\right) \\ & & +\xi_B P_{BA}\left(s^t\right) C_{BA}\left(s^t\right)/\varepsilon_{BA}\left(s^t\right) - \xi_A P_{AB}\left(s^t\right) C_{AB}\left(s^t\right) \\ & & +\xi_C P_{CA}\left(s^t\right) C_{CA}\left(s^t\right)/\varepsilon_{CA}\left(s^t\right) - \xi_A P_{AC}\left(s^t\right) C_{AC}\left(s^t\right) \end{array} \tag{8}$$

where $\varepsilon_{BA}\left(s^t\right)$ and $\varepsilon_{CA}\left(s^t\right)$ are nominal exchange rate that is expressed in a value of currency A in terms of currency B and C, respectively. Here ξ_A, ξ_B, and ξ_c are scalers that determine the relative size of the three countries. The first term in the right hand side of the equation denotes the net return from holding internationally traded bond

$B_A^*(s^t)$ and the sum of the last four terms denotes the net trade balance between the country A and the rest of the world.

Asset market clearing condition

Asset market clearing condition is given by

$$B_A^*\left(s^t\right) + B_B^*\left(s^t\right) + B_C^*\left(s^t\right) = B_A\left(s^t\right) = B_B\left(s^t\right) = B_C\left(s^t\right) = 0.$$

Resource constraint

Resource constraints of goods produced in each of the three countries are given by

$$\begin{aligned}
\xi_A \int_0^1 y_A\left(i, s^t\right) di &= \xi_A C_{AA}\left(s^t\right) + \xi_B C_{BA}\left(s^t\right) + \xi_C C_{CA}\left(s^t\right), \\
\xi_B \int_0^1 y_B\left(i, s^t\right) di &= \xi_A C_{AB}\left(s^t\right) + \xi_B C_{BB}\left(s^t\right) + \xi_C C_{CB}\left(s^t\right), \text{ and} \\
\xi_C \int_0^1 y_C\left(i, s^t\right) di &= \xi_A C_{AC}\left(s^t\right) + \xi_B C_{BC}\left(s^t\right) + \xi_C C_{CC}\left(s^t\right).
\end{aligned}$$

3.4 Domestic Response to a Foreign Monetary Policy Shock

Using the model described above, we study how domestic response in the non-U.S. countries to a monetary policy shock in the U.S. is altered with changes in economic structure. To this end, we compute equilibrium response of macroeconomic variables in country B to a positive innovation $\epsilon_{r_A}(s^t)$ to the monetary policy rule in country A specified in equation (7).

The computed equilibrium time paths are linearly approximated around the non-stochastic steady state. The non-stochastic steady state is defined as a competitive equilibrium with $B_k^*(s^t)$ and $B_k(s^t)$ are zero for $k = A$, B, and C, such that for, all t, $\{\{C_{lk}(s^t), y_{lk}(s^t), P_{kl}(s^t)/P_k(s^t)\}_{l=A,B, \text{ and } C}, C_k(s^t), y_k(i, s^t), W_k(s^t)/P_k(s^t), h_k(s^t), R_k(s^t)\}_{k=A,B, \text{ and } C}, \varepsilon_{BA}(s^t) P_B(s^t)/P_A(s^t), \varepsilon_{CA}(s^t) P_C(s^t)/P_A(s^t)$ are constant.[24]

In the simulation exercise, we compare two distinct economies. In the first economy, which we call baseline economy, all parameters are calibrated to standard values. When the appropriate data is available, the parameter values are chosen such that the economic structures surrounding country A are consistent with the U.S. during the 1990s. In the second economy, a subset of parameter values or model settings are altered so as to characterize changes in economic structure that is focused. See Table 2 for parameter values used for baseline model.

The role of trade linkages with country A in monetary transmission

[24] The steady state condition that $B_k^*(s^t)$ for $k = A$, B, and C is zero implies that the trade is balanced for all of the three countries.

We first discuss impacts of weakened trade linkage with the U.S. on the spillover effect. A trade is a leading explanation for international business cycle comovement. Baxter and Kouparitsas (2005) empirically investigate business cycles of more than 100 countries and document that bilateral trade relationship is the only variable that accounts for the comovement in a statistically robust manner.[25] That is, other things being equal, tighter bilateral trade linkages leads to higher business cycle comovements across the two countries. The degree of bilateral trade linkage in the model is governed by parameters in aggregation equation (4) of final consumption goods such as n_{AB} and n_{AC}. For instance, a smaller value for n_{AB} implies that differentiated intermediate goods produced in country B is less needed in constructing the final consumption goods in country A. We analyze equilibrium responses under the two alternative economies together with the baseline model. In the first alternative economy, values for n_{AB} and n_{BA} are reduced to 70% of the baseline parameter values so that the bilateral trade linkage between country A and B is weaker. In the second alternative economy, a value for n_{CA}, together with a value of n_{AB} and n_{BA}, is reduced to 70% of the baseline parameter value so that the bilateral trade linkage between country A and C is weaker while that between country A and B is maintained the same as the first alternative economy. 70% is taken from Figure 3. Simulation exercise using the first economy illustrates the direct impact of weaker trade linkage with country A on economic activities in country B. Simulation exercise using the second economy illustrates the indirect impact of weaker trade linkage between country A and C on economic activities on country B.

Figure 6 displays response of domestic production $\xi_B \int_0^1 y_B(i, s^t)\, di$, short-term real interest rate $R_B(s^t)/\pi_B(s^{t+1})$, trade balance, which is measured by the sum of the last four terms of the right hand side of the equation (8) in country B divided by $C_B(s^t)$, nominal exchange rate (a value of one unit of currency in country A measured by domestic currency of country B) $\varepsilon_{BA}(s^t)$, terms of trade (price of exported goods to country A relative to that of imported goods from country A) $\varepsilon_{BA}(s^t) P_{AB}(s^t)/P_{BA}(s^t)$, and inflation rate $\pi_B(s^t)$ to a positive shock to the monetary policy rule in country A under the baseline economy as well as the two alternative economies. All of the series are expressed in terms of log-deviation from the non-stochastic steady state.

The two effects highlighted in the introduction are seen in the figure. A contractionary monetary policy shock in country A raises the domestic real interest rate and dampens production and consumption in country A. In the open economy environment, these domestic developments in country A are translated to the rest of the world through the trade and financial linkages. In particular, the rise in the real interest rate of the internationally traded bond is reflected in the domestic real interest rate in country B, hampering production and consumption in country B. Although the nominal exchange rate of currency in country B depreciates against currency in country A, making export

[25] They also study other variables including total trade in each country, sectoral structure, similarity in export and import baskets, factor endowments, and gravity variables, and find the other variables do not account for the comovement in a statistically robust manner.

goods shipped from country B cheaper compared with goods shipped from country A, the expenditure-reducing effect dominates the expenditure-switch effect, lowering production in country B. The roles of bilateral trade linkage are illustrated in the equilibrium time paths of variables under the alternative economies. With a weaker bilateral trade linkage between country B and A, less portion of domestic production and consumption in country B are affected by shocks to country A. Consequently, the adverse effect of the contractional monetary policy shock in country A is softened. As depicted in dotted line, the trade structure between country A and C also matters to the spillover effect from country A to country B. When the bilateral trade linkage between these countries is weak, a downturn in country C following the shock in country A and subsequent transmission effect from country C to country B are both diminished, mitigating the adverse consequence of the spillover effect.

The role of global trade integration in monetary transmission

We next discuss the implication of deepened trade relationship with the rest of the world to the spillover effect. To see this, we conduct simulation under the two alternative economies. The first economy illustrates the case when country B becomes more integrated with the rest of the world, which consists of country B as well as country A, such that the sum of n_{BA} and n_{BC} becomes 1.5 times larger than the baseline case.[26] 1.5 is taken from the progress of trade integration from 1990 to 2000 shown in Figure 1. The second economy illustrates the case when country C becomes more integrated such that the sum of n_{CA} and n_{CB} becomes 1.5 times larger than the baseline case. In Figure 7a, we depict the equilibrium response of macroeconomic variables in country B under the two alternative economies together with baseline economy. With a larger weight of imported goods from other countries in constructing final consumption goods, domestic economies are affected more by shocks abroad. In both of the two cases, the quantitative impacts of the contractionary monetary policy shock in country A are more pronounced than the baseline model.

Existing studies, such as Kose, Otrok, and Prasad (2008) stress that the global trade integration is accompanied with specialization of industrial production structure. To evaluate the relationship between changes in production structure and spillover effects, we construct two alternative economies with different parameter values for ϕ and study the equilibrium response of variables under the economies. The size of parameter ϕ in equation (4) captures the degree of differentiation across the three intermediate composite with distinct origin. In Figure 7b, we depict response of variables under the economy with higher elasticity (less differentiated) and lower elasticity (more differentiated) compared with baseline model. Under the premise that specialization of industrial production enhances differentiation of goods, the simulation indicates that it worsens the adverse spillover effects at the impact.

[26] Because of the assumption that $n_{BA} + n_{BB} + n_{BC} = 1$, this implies that n_{BB} falls accordingly.

The role of relative country size in monetary transmission

A relative country size in the world economy also matters to the size of spillover effect of shock originated in country A to the rest of the world. The reason why variations in the domestic real interest rate in the U.S. are transmitted to those in the non-U.S. countries stems from the fact that the size of the U.S. GDP is disproportionately large and the world interest rate is influenced by the households' intertemporal decisions in the U.S. To see the impact, we consider two alternative scenarios. In the first scenario, parameter value of ξ_A shown in equation (8) is adjusted so as to reduce the country size of country A in the world economy at the steady state from 1/4 to 1/5. The numbers are taken from Figure 2. In this case, relative country size of C and B in the world economy increase. In the second scenario, parameter value of ξ_c is adjusted so as to double the relative country size of C in the world economy at the steady state compared with baseline. In Figure 8, we compute equilibrium responses of macroeconomic variables in country B under the two alternative economies as well as baseline economy. With a smaller relative size of the country size of A, the transmission of the contractionary monetary policy shock in country A to the real interest rate of internationally traded bond are less pronounced. The developments in domestic real interest rate and domestic productions in country B become mitigated accordingly. It is important to note that the increase in relative country size of C weakens the adverse effects on domestic production in country B although initial impacts become greater than baseline model.

The role of financial transaction in monetary transmission

Households construct their portfolio from two assets, domestically traded bond and internationally traded bond. To see the role played by the financial integration in the spillover effects, we study two alternative cases, a case when the cost of accessing to the international bond market μ becomes cheaper by 1/10 only for country B and a case when such a change occurs to all of the countries. Figure 9 displays simulation results for the two alternative scenarios. As a result of the financial integration, the consumption decline is more pronounced. By contrast, the decline in work effort, which is equivalent to production, is less pronounced.

In order to illustrate the model mechanism, in the lower four panels, we display the response of holding of internationally traded bond by households in country B $B^*\left(s^t\right)/P_B\left(s^t\right)$, interest rate of internationally traded bond $R^*\left(s^t\right)$, relative price of goods produced in country A and country B $P_{AA}\left(s^t\right)/P_{AB}\left(s^t\right)$ and the real exchange rate. The last three variables are expressed in terms from deviation under each of the alternative cases from the baseline. With a smaller financial friction, households around the globe conduct inter-market arbitrage at cheaper cost than otherwise. As a result, the increase in interest rate in country A is easily transmitted to that in the domestic bond market in country B as well as in the international bond market. Because of the higher increase in the domestic interest rate, the domestic consumption in country B is dampened greater. Because of the higher return to the internationally traded bond

makes, households in country B save more in the form of the internationally traded bond $B^*(s^t)$ compared with the baseline. The households therefore consume less and work more for future consumption. As the real exchange rate of currency in country B depreciates against that in country A, the foreign demand increases from the view points of households in country B.[27][28]

The role of policy regime in monetary transmission

Lastly, we discuss implications of policy regime switch from a simple Taylor rule that is specified by equation (7) to alternative policies, a fixed exchange rate regime and a monetary policy rule that assigns a higher policy weight to inflation rate such as inflation rate targeting (hereafter IT). Conventional wisdom almost agrees, at least theoretically, that floating exchange rate regime helps insulate domestic output fluctuations from foreign monetary policy shock by allowing flexible nominal exchange rate adjustment to the shock and the fixed exchange rate regime does not. Domestic economy under a fixed exchange rate regime should therefore witness greater variations after the U.S. monetary policy shock compared with the case of otherwise. In modelling a fixed exchange rate regime, we follow Hirakata, Iwasaki, and Kawai (2012) and modify a monetary policy rule in country B to a policy specified in equation below:

$$\Delta\varepsilon_{BA}\left(s^t\right) = 0. \tag{9}$$

Policy regimes in other two countries are maintained the same as the baseline case. Changes in policy weight in the monetary policy rule also affects the spillover effects. Flood and Rose (2010), discussing the role of IT in the context of business cycle synchronization across countries, point out that a central bank following IT attains more stable inflation rate variations at a cost of a larger domestic output fluctuations. In our simulation, we maintain the functional form of the monetary policy rule and numerically increase the policy weight assigned to inflation ϕ_π from two to five. As shown in Figure 10, when the fixed exchange rate regime specified in (9) is in place, the nominal exchange rate is maintained in response to the occurrence of monetary policy shock in country A. The domestic policy rate in country B is adjusted so as to fully offset nominal exchange rate movements stemming from the shock, leaving other variables responsive to the shock. Consequently, the real interest rate rises substantially compared with the case of otherwise, suppressing domestic production and consumption. As predicted by

[27] As shown in Figure 9, the cheaper cost of financial transaction delivers lower consumption and higher labor input of households in country B. Consequently, cross-country difference in terms of consumption and labor input between countries is mitigated compared with the case of baseline model. In this sense, the cheaper cost enhances risk-sharing among households around the globe.

[28] Admittedly, there is limitation in the way that the financial integration is analyzed in the current paper. First, deepening of financial integration takes more than one forms in the actual economy. The current model specification provides only one example among them. Second, as discussed below, we do not consider effects associated with the second moment of financial variables. The linkage between the financial integration and volatilities of the asset returns, for instance, is beyond the scope of our paper.

Flood and Rose (2010), our model generates less deflationary consequence under the IT since inflation is more stabilized. In contrast to their results, however, in our model, a higher weight attached inflation rate moderates the fall in domestic production as well as deflation. Since the deflationary response is relatively stabilized under the IT regime compared with the other regimes, terms of trade appreciates greater than otherwise, giving a rise to a larger expenditure-switch effect that partly offsets the production decline.

4 Discussion regarding Explanations

Our simulation exercise in the last section provides two opposing predictions as to how spillover effects change with recent developments in economic structure. On the one hand, weaker trade linkage with the U.S. economy, decline in the relative country size of the U.S. in the globe, deepening of financial integration, and adoption of a monetary policy rule with a higher weight for inflation rate and/or more flexible exchange rate regime would reduce adverse consequence of the shock on the domestic productions in the non-U.S. economy.[29] On the other hand, deepening of global trade linkage would enhance the domestic fluctuations in response to the same shock. These model predictions suggest that estimation results obtained in section 2 are brought about by that the first effect dominates the second effect. In this section, by making use of the country-by-country data and estimated impulse function of trade and financial variables, as well as policy instruments in the non-U.S. countries, we discuss each of these candidate explanations in details.

4.1 Developments of Economic Surroundings of the Sampled Countries

Bearing the model's predictions in mind, we analyze if the four classes of recent developments of economic structure, a weaker trade linkage with the U.S., a decline in the relative country size of the U.S., deepening of financial integration, or regime switches in monetary policy or exchange rate policy, are observed on country-by-country basis for our sampled countries. In fact, the first three of the developments hold on country-by-country basis for most of our sampled countries, suggesting that they have played certain roles in mitigating the spillover effects. Admittedly, however, as shown in the above section, because there is third-country effects in the monetary transmission across countries, changes in the spillover effects to a non-U.S. country depend also on the economic surroundings of the other non-U.S. countries. The analysis here therefore provides

[29] As shown above, although quantitatively limited, our simulation exercises suggests that the reduction in the transaction cost of internationally traded bond implies wider decline in consumption but moderate decline in production in country B.

a side evidence regarding the determinants of the spillover effects.

Trade integration with the U.S. and the rest of the world

As we see in Figure 1 and 3, there are two changes in trade structure that have opposing effects on the spillover effects. Table 3 shows the size of the two secular trends regarding trade activity on country by country basis. That is, shrinkage of bilateral trade with the U.S. measured by the trade shares with the United States over the total trade, and widening of trade with the rest of the world measured by the trade activity relative to nominal GDP. These two trends are seen in almost all countries.[30] To see which of the two trends are dominant, in Table 4, we document a trade activity with the U.S. divided by the domestic GDP in the non-U.S. countries separately for the 1990s and the 2000s. While the difference of this measure over the two decades is not large in most of the countries, in particular in G6 + Australia and Asian countries, the first trend generally dominates the second trend. This suggests that from the trade perspective the importance of the U.S. becomes smaller for these countries. In the table, we also display the changes of the estimated response of production-related macroeconomic variables over the two decades on country-by-country basis. The numbers are shadowed with gray when the changes of the estimated responses over the sample periods qualitatively agrees with the theoretical prediction regarding the trade structure. Estimated differences are consistent with the theoretical prediction at least for G6 + Australia.

Country size

Table 5 documents the relative size of own GDP to the world GDP for the sampled non-U.S. countries and the U.S. The figures documented in the first two columns of the table display that about a half of the countries, including the U.S., see the decline in its relative country size from the 1990s to the 2000s. To see the relative changes between the U.S. and non-U.S. countries, we compute the difference of world share of own GDP over the two decades subtracted by the difference of the world share of the U.S. GDP. The third column of the table displays the relative size of decline in the country size for the non-U.S. countries with respect to the decline of country size of the U.S. The numbers are all positive, except for Germany and Japan. The table indicates that all of the sampled non-U.S. countries see increase in its country size with respect to the U.S., although some countries experience a decline in country size with respect to the world GDP.

Similarly to the exercise above, we display the changes of the estimated response of production-related variables over the last two decades. The numbers are shadowed with gray when the changes in the estimated responses from the 1990s to the 2000s qualitatively agree with the theoretical prediction about the relative country size. Again, the relationship between the estimated difference of impulse responses and changes in

[30] The number is shadowed when it indicates there are shrinkage of bilateral trade with the U.S., deepening of trade with the rest of the world or both.

country size is consistent with the view that such changes may have contributed to the mitigation of the adverse effects of the contractionary U.S. monetary policy shock on the non-U.S. economies.

Financial linkages

To see the role of financial linkages with the U.S. and the rest of the world, we document in Table 6 the FDI shares of the U.S. and FDIs relative to nominal GDP.[31] It is seen that the linkages with the U.S. displays a decline and those with the rest of the world displays an increase in all of the countries. The net effect of the two opposing trends are shown in Table 7. That is, for most of the countries, the financial linkages with the U.S. has become larger in the current years for country by country basis. While the decline in transaction cost in our theoretical model setting does not exactly match with the increase in the linkages of financial transaction caught by the FDI share, for almost all countries, the difference of estimated impulse responses of production-related variables across the two periods agrees with the theoretical prediction.

Regime switches

Lastly, to see the role of policy regime, we select countries that have experienced institutional changes in the domestic monetary and nominal exchange rate policy regime during either the latter 1990s, the early 2000s, or both from those listed in Table 1. We then ask if the changes in the estimated impulse response to the U.S. monetary policy shock regarding domestic production variables in the listed non-U.S. countries differ from those in the non-U.S. countries that experience no regime switches over the two decades. Table 8 documents the difference between the 1990s and the 2000s for the regime-switching countries in terms of domestic response of production variables to the contractionary U.S. monetary policy shock. To summarize, the estimated results are consistent with the theoretical prediction regarding institutional changes in some countries but not for all of the countries. On the one hand, in advanced countries, countries that have employed the IT see less adverse consequence in the wake of the contractionary U.S. monetary policy shock during the 2000s compared with the average of all countries. In Asian and Latin American countries, on the other hand, such relationship is less pronounced because the responses of the three domestic production variables disagree from each other. In these two country groups, the influence of exchange rate regime on the spillover effect is not prominent, either. In fact, this accords well with the existing studies that see a limited role of the nominal exchange rate regime in explaining the spillover effects. For instance, Canova (2005) analyzes Latin American countries with various exchange rate regime including dollarized, partially dollarized, crawling banks, and float to conclude that differentials of domestic response in these countries due to differences in exchange rate regime is minor. Maćkowiak (2007) also sees minor difference between

[31] Clearly, series for FDI captures only a limited amount of financial transaction across borders. In the current paper, however, we focus on the FDI because of the data limitation.

Hong Kong, regime with tight fixed exchange rate, and other Asian countries in the way that domestic variables respond to the U.S. monetary policy shock.[32]

4.2 Responses of Trade, Financial, and Policy Instruments to the U.S. monetary Policy Shock

In addition to the country-by-country analysis, we estimate responses of macroeconomic variables other than production-related variables in the non-U.S. countries to a contractionary shock to the U.S. monetary policy rule. The responses of these variables help outline the sources behind the changes in the spillover effects.

Response of trade variables

Figure 11 displays domestic responses of trade variables, including real export, real import, and trade balance in the non-U.S. countries to the U.S. contractionary monetary policy shock.[33] The responses of trade variables are generally in line with those of production-related variables. In particular, observation that most of the countries experience a significant decline in real export verifies that the expenditure-reducing effect dominates the expenditure-switching effect. There is a cross-country heterogeneity in the way that the trade variables respond to the shock. G6 + Australia experience the similar pattern of changes to the domestic variables over the two decades. That is, a proportion of negatively-responding countries for the trade balance decreased from the 1990s to the 2000s, indicating the trade activity helps moderate the adverse consequence of domestic production in these countries. Other advanced countries also exhibit that similar decline in the number of negatively-responding countries from the 1990s to the 2000s. In Latin American and Asian countries, moderations of adverse effect are not seen in trade balance responses. A larger portion of countries respond negatively in the current years in Latin American countries, and the composition of countries is maintained the same in Asian countries.

Response of financial variables

Figure 12 displays the estimated impulse response of nominal stock returns, nominal exchange rate, and the long term interest rate to the shock. Here the nominal exchange rates are expressed in terms of a dollar evaluated by the non-U.S. currency. The positive response indicates that a value of the non-U.S. currency depreciates against dollar

[32] One candidate explanation for the results that exchange rate regime does not seem to affect the spillover effect is that the class of regime is not the only determinants of the spillover effect. For instance, Maćkowiak (2007) discusses that Hong Kong stands out not only in terms of fixed exchange rate regime but also in terms of financial openness. Canova (2005) points out the possibility that the effective difference between the distinct institutional arrangements for exchange rate regime may be small.

[33] Similarly to the treatment in the model section, in constructing trade balance series used for estimation, we first take the difference between the export and import and divide it by the average of GDP of the sample period.

after the contractionary U.S. monetary policy shock. Estimated responses of financial variables are in line with those of production-related variables, except for the case of long term interest rate. Regarding stock price, while a bulk of countries see the negative response during the 1990s, the portion of negatively-responding countries has declined during the 2000s. Regarding nominal exchange rate, while a bulk of countries see the positive response during the 1990s, the portion of positively-responding countries has declined during the 2000s. Smaller depreciation of currencies in the non-U.S. countries against dollar may be attributed to mitigated domestic consequence of the U.S. monetary policy shock.[34] The long term interest rate exhibits qualitatively opposite responses from what are obtained for the other variables. That is, a proportion of positively-responding countries has risen from the 1990 to the 2000s. One interpretation for this observation is that the contractionary U.S. monetary policy shock causes a larger financial contagion during the 2000s than the 1990s. Combined with the estimated results regarding production-related variables, however, the real effect of such contagion on the domestic variables are minor, if not any.[35] A potential explanation is that the adverse spillover effects on the long term interest rates are short-lived. To see this, we depict the distribution of impulse response function of the long term interest rates that is averaged over three to four years after the shock. Clearly, the distribution of the impulse response function shifts to zero, indicating that increased interest rate reverts back to zero almost within these years.

Our model analysis above concentrates on a log-linearized approximation of economic dynamics after the contractionary U.S. monetary policy shock. By contrast, in practice, the shock may trigger financial contagion associated with the second moment of the asset returns. Calvo and Mendoza (2000) provide a theoretical example that the global financial integration brings about rational contagion in the financial market by solving the optimization problem of portfolio manager. Along this line, suppose that volatilities of financial assets in the non-U.S. country endogenously react to the U.S. monetary policy shock, then changes in the relationship between the volatilities of assets and the U.S. monetary policy shock may result in the weaker spillover effects of the U.S. monetary policy shock to the non-U.S. countries.

To see this, we construct a monthly series of volatility of stock return, nominal exchange rate, and long term bond for each of the sampled non-U.S. countries using generalized autoregressive conditional heteroskedasticity (GARCH) model. For this purpose,

[34]Diebold and Yilmaz (2009) construct spillover indices of stock market return and its volatility that capture the contribution of shocks originating abroad to variations of these two variables and show that the former index increases monotonically from 1995 to 2007 while the latter series rises in response to each economic event, such as East Asian crisis in 1997 or Terrorist Attack in 2001 and do not display the positive trend.

[35]From slightly different perspective, Fujiwara and Takahashi (2011) point out the presence of "macro-finance dissonance." Based on the analysis on the linkages between Asian countries and developed countries, they find that the spillover of the finical variables is strong and that of the industrial production is weak.

we construct a simple GARCH (1, 1) model for a variable X_t, which in this analysis includes a stock return, nominal exchange rate, and long term interest rate, that is specified by the following law of motion and estimate the unobservable time-varying second moments based on the model:

$$\begin{aligned} X_t &= \theta X_{t-1} + \varepsilon_t, \quad (10) \\ \varepsilon_t &= \sigma_t z_t, \text{ for } \sigma > 0, \text{ and} \\ \sigma_t^2 &= c + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2. \quad (11) \end{aligned}$$

Here, ε_t is an innovation to a variable X_t, z_t is i.i.d. innovation with zero mean and unit variance that hits the variance of a variable X_t, θ is an autoregressive parameter of a variable X_t, and c, α, and β are the non-negative parameters that govern the law of motion of time-varying volatility of a variable X_t denoted by σ_t^2. Note that (11) indicates that the volatility of the financial variable X_t is given by a one-period ahead forecast variance based on news about volatility from the previous period measured as the lag of the squared residual from the mean equation (10) and forecasted variance in the previous period.

Based on the estimated series of volatility σ_t^2, we compute the responses of these volatilities to the U.S. monetary policy shock. Figure 13 provides the evidence that the U.S. monetary policy shock influences the size of asset volatilities in a statistically significant manner.[36][37] Regarding the volatilities of stock return and the long term interest rate, the shock affects them positively throughout the two sample periods. For both of the two assets, however, a proportion of positively-responding countries has declined. This reduced volatilities of financial asset may have contributed to the weakened adverse spillover effect. The distributions of the estimated responses of volatilities for the two assets have flattened during the 2000s compared with the 1990s, indicating cross-country responses have become diverse in the current years. The shock's impact on the volatilities of nominal exchange rate disagree across countries. In Asian countries, the shock enhances the volatility in more than half of the sampled countries throughout the two decades. In other countries, except for the G6 + Australia during the 1990s, it gives no or negative impact on the volatilities.

Response of policy instruments

Figure 14 displays the response of policy instruments together with price level, measured by CPI, to the contractionary U.S. monetary policy shock. Estimated results are

[36] In computing the volatilities of long term interest rate, we employ five years government bond yield. In addition, because of the unavailability of the sufficient time series, we restrict our analysis for the 1990s on the advanced countries.

[37] Along the similar line, Shirota (2013) analyzes the determinants of cross-border credit flows and show that the importance of global factor is increasing over the years.

mixed depending on instruments and country group.[38] Among advanced countries, a larger portion of countries witness positive response of short term interest rate and negative response of narrow money to the shock during the 2000s period than the 1990s. That is, overall policy responses in the two country groups have currently become more contractionary. On the contrary, among Asian countries, a larger portion of countries witnesses a positive response of short term interest rate and a negative response of narrow money during the 1990s compared with the 2000s, suggesting that other things being equal, the endogenous policy responses more adversely affect the domestic economic activities in the country group during the 1990s.[39]

Admittedly, effective impact of the endogenous response of policy instrument on the domestic economy depends on how macroeconomic variables, in particular, price develops in the wake of the shock. The bottom two panels in Figure 14 show that the contractionary U.S. monetary policy shock generally yields deflationary impacts to the economy in the non-U.S. countries. The negative effects are more pronounced during the 2000s compared with the 1990s.[40] In Asian countries, more than half of the countries witness negative response of price level during the 1990s while a limited portion of the countries witness the negative response during the 2000s. These estimated results combined with those for policy instrument responses suggest that the developments of real interest rate and real money balance may have severely affected the domestic productions in these Asian countries during the 1990s and such effects have been diminished during the 2000s. That is, the changes in endogenous policy responses in the Asian countries to the contractionary U.S. monetary policy shock may have contributed to the recent moderation of adverse impacts of the U.S. monetary policy on these countries.

5 Conclusion

In this paper, we empirically study the spillover effects of the U.S. monetary policy shock to the rest of the world. We specifically focus on how recent developments about global

[38] Along the similar line to our study, Grilli and Roubini (1995) empirically investigate the monetary policy reactions of non-U.S. G7 countries and document that the policy rates in these countries evolve in the same direction as the U.S. monetary policy rate in response to the shock to the U.S. monetary policy rule, suggesting that the domestic policies in the non-U.S. countries endogenously react to the U.S. monetary policy shock. Kim (2001), on the contrary, claims that the endogenous policy responses of these countries are not statistically significant except for the case of Canada.

[39] Figure 14 does not document the estimation results for Latin American countries during the 1990s because of the inavaiability of the data series in the region.

[40] There is no agreement as to the qualitative impacts of the U.S. monetary policy shock on domestic inflation in the non-US countries. Mackowiak (2007), analyzing emerging countries, discusses that the contractionary U.S. monetary policy shock causes depreciation of domestic currencies and leads to inflation in the non-U.S. countries. By contrast, Chen et al. (2011), while focusing on the unconventional monetary policy, document that the expansionary shock to the policy causes inflation for most of advanced and Asian countries.

integration affect the transmission mechanism of the U.S. monetary policy. Making use of factor augmented VAR, we distill innovations to the Federal Funds rate up to 2007 and estimate the responses of a set of macroeconomic variables in the non-U.S. countries, including Advanced, Latin American, and Asian countries, to the contractionary U.S. monetary policy shock. In order to gauge the impacts of the structural changes of the economy on the spillover effects, we estimate macroeconomic responses of the non-U.S. country separately for the sample covering the 1990s and the 2000s. Our key finding is the weakening of adverse spillover effects. The contractionary U.S. monetary policy shock delivers adverse effects on the domestic production in the most of the non-U.S. economies during the 1990s. Such effects have been, however, largely diminished during the 2000s.[41]

To see the causes behind the weakening of adverse spillover effects, we examine several candidate explanations including trade and financial global integration. Those are changes in bilateral trade and financial relationship with the U.S., the relative country size of the U.S., and regime switch of domestic policies. We first construct a text book Dynamic Stochastic General Equilibrium (DSGE) model and derive theoretical implications about the linkages between these structural changes of economic environments and the spillover effects. Our model predicts that these structural changes bring about two opposing effects to the spillover effects. First, other thing being equal, a deepening of trade integration makes the non-U.S. countries more responsive to external shocks, leading to a larger decline of domestic production in these countries in response to a contractionary U.S. monetary policy shock. On the contrary, a weakening of the bilateral trade relationship with the U.S., a decline in the relative size of the U.S. economy, risk-sharing effects associated with deepening of financial integration, and switches of policy regime to more flexible exchange rate regime and/or inflation targeting rule soften such adverse consequence to domestic production. Our theoretical exercise therefore suggests that enhanced spillover effects due to global trade integration are overturned by other factors.

In addition to the theoretical analysis, we ask if these candidate explanations are consistent with the economic surroundings of our sampled countries and estimated impulse responses of non-production-related variables. We study country-by-country data and show that in most of our sampled countries, a decline of the trade relationship with the U.S. quantitatively dominates the deepening of global trade integration, a decline of the country size is slower than the U.S., and a financial transaction with both the U.S. and the rest of the world increases over the last two decades. We find that estimated response of long-term interest rate is positive and larger during the 2000s, but they die out quickly. From the estimation of policy instrument, we find that the policy responses

[41] Note that our estimation result only suggests that the changes in the domestic variables in the non-U.S. countries are mitigated over the decades in response to the same size of the contractionary U.S. monetary policy shock. Admittedly, when the original contractionary shock becomes larger, then the quantitative impacts abroad will become larger as well.

to a U.S. monetary policy shock are more contractionary during the 1990s than 2000s in Asian countries, suggesting that the policy responses may have caused weakening of spillover effects in these countries.

Our study provides some policy implications to the consequence of the monetary easings undertaken by several advanced countries in response to the current global financial crisis. The monetary easings contain unconventional quantitative measures as well as adjustments of the policy rates to a low level. Regarding the first ingredient of the monetary easings, our theoretical and empirical studies are built upon the monetary policy shocks that are identified as innovations to the nominal short-term interest rate. They are silent about the various types of credit spreads facing financial institutions, firms, and households, that were reduced by the unconventional measures. By contrast, our analysis addresses the second ingredient of the monetary easings. The estimated weakenings of adverse spillover effect is attained even if the sample period is extended to 2012.[42]

While our paper stresses the role played by a decline in the relative significance of the U.S. in the domestic economic activities in the non-U.S. countries in accounting for the weakened spillover effects of the U.S. monetary policy shock, our explanation is not mutually exclusive with alternative candidate explanations. For instance, the developments in specialization of production structure or increases in the compositional share of services sector in the economy in the non-U.S. countries may be promising alternative determinant of the spillover effects. These are left for the future researches.

[42] Admittedly, forward guidance of future time path of the short term interest rate was also an important element of policy packages launched during the financial crisis. The effect of the forward guidance is also beyond our scope. See Fujiwara, Sudo, and Teranishi (2010) and Fujiwara et al. (2013) for how commitment about future domestic short term interest rate affects economic activities in the other countries when both countries fall in the liquidity trap.

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Table 1: Regime Switches of Monetary and Nominal Exchange Rate Policy

▼Inflation Targeting Countries

Country		Start of IT framework
G7 countries + Australia	Canada	February 1991
	United Kingdom	October 1992
	Australia	April 1993
Other developed economies	Switzerland	January 2000
	Sweden	January 1993
	Norway	March 2001
Asian emerging economies	Indonesia	July 2005
	Korea	April 1998
	Philippines	Januray 2002
	Thailand	May 2000
Latin American economies	Brazil1	July 1999
	Mexico	September 1990
	Chile	January 1994
	Colombia	January 1999

▼ Countries managing foreign exchange

Country		Timing of policy change	
Asian emerging economies	Hong Kong	May 2005	1USD=7.8HKD → 1USD=7.75～7.85HKD
	India	March 1993	fixed dual exchange rate system → managed float syste
	Indonesia	August 1997	managed float system → float system
	Korea	December 1997	managed float system → float system
	Malaysia	September 1998	managed float system → fixed exchange rate system
		July 2005	fixed exchange rate system → basket system
	Thailand	July 1997	basket system → managed float system
Latin American economies	Brazil	January 1999	managed float system → float system
	Chile	September 1999	fixed exchange rate system → float system
	Colombia	September 1999	fixed exchange rate system → float system
	Mexico	January 1999	managed float system → float system

Table 2: Baseline Parameters

Parameter	Value	Description
β	.99	Quarterly subjective discount rate
θ	.2	Elasticity of substitution across differentiated products
η	5	Utility weight on disutility of labor
ξ	.5	Inverse of Frisch elasticity of labor input
ϕ	2	Elasticity of substitution across composite goods
κ	200	Cost associated with price adjustment
κ_w	50	Cost associated with wage adjustment
ϕ_w	2	Elasticity of substitution across differentiated labor
b	.8	Persistency in habit parameter
σ	1.5	Inverse of intertemporal elasticity of substitution
n_{ZZ} for $Z = A, B$, and C	5/6	Share parameter for goods produced in country Z in consumption composite in country Z
$n_{Z\hat{Z}}$ for $\hat{Z}, Z = A, B$, and C , and $\hat{Z} \neq Z$.	1/12	Share parameter for goods produced in country $\hat{Z}$ in consumption composite in country Z
ξ_A	1/4	Scale parameter for country A
ξ_B	1/20	Scale parameter for country B
ξ_C	$1 - \xi_A - \xi_B$	Scale parameter for country C
R	$1/\beta$	Policy rate at steady state
ρ_M	.9	Autoregressive parameter in monetary policy rule
ϕ_π	1.1	Policy weight on inflation rate
ϕ_c	.1	Policy weight on output gap
μ	.01	Financial friction associated with bond trade
$\hat{\mu}$	.1	Financial friction associated with bond trade

Table 3: Trade Shares with the U.S. and Trade Relative to GDP

	Trade shares with the United States		Trade activity relative to Nominal GDP	
	1990's	2000's	1990's	2000's
G7 and Australia				
Australia	11.65%	7.33%	36.84%	41.20%
Canada	76.78%	72.09%	55.76%	56.14%
France	11.50%	9.15%	45.97%	44.42%
Germany	9.59%	7.33%	47.74%	66.33%
Italy	7.25%	5.35%	37.16%	44.35%
Japan	26.29%	16.45%	15.83%	24.71%
United Kingdom	13.07%	11.27%	41.18%	40.54%
Other developed economies				
Belgium	5.85%	4.54%	109.25%	123.27%
Denmark	4.87%	4.98%	52.75%	60.51%
Finland	7.90%	5.51%	56.36%	62.09%
Netherlands	6.79%	6.21%	95.11%	112.22%
Norway	6.79%	5.80%	50.62%	51.91%
Portugal	N/A	2.73%	53.37%	55.89%
Spain	4.99%	3.93%	45.92%	42.38%
Sweden	7.51%	6.16%	51.58%	65.19%
Switzerland	7.60%	7.72%	49.69%	63.74%
Latin emerging economies				
Brazil	21.26%	15.57%	13.31%	20.11%
Chile	18.44%	15.60%	N/A	60.95%
Columbia	N/A	32.30%	N/A	32.82%
Mexico	65.51%	68.01%	12.47%	13.45%
Asian emerging economies				
China	15.51%	13.52%	34.65%	51.45%
Hong Kong	10.54%	6.20%	137.66%	172.12%
India	14.17%	8.78%	17.53%	33.99%
Indonesia	12.51%	8.29%	48.29%	46.81%
Korea	21.08%	11.87%	50.79%	76.29%
Singapore	20.03%	11.33%	215.27%	229.05%
Taiwan	22.30%	13.08%	75.97%	107.92%
Thailand	16.14%	10.08%	74.46%	120.11%

Notes:

Trade shares with the U.S. indicates the ratio of the sum of export to and import from the United States to the sum of export to and import from all of the world in each country.
Trade activity relative to nominal GDP indicates the ratio of the sum of import and export to nominal GDP for each country.

As for trade shares with the United States of 1990's, the figure for France and Germany refer to 2000, Italy, Belgium, Finland, Netherlands, Spain refer to 1991, the United Kingdom and Singapore refer to the average of 1996 and 1999, Sweden and Taiwan refer to the average from 1998 to 1999, Mexico and China refer to the average from 1993 to 1999, India and Thailand refer to the average from 1991 to 1999. As for those of 2000's, the figure for Portugal refers to the average from 2004 to 2012, Columbia refers to the average from 2006 to 2012, respectively.

As for trade activity relative to nominal GDP of 1990's, the figure for France and Spain refer to 2000, Germany, Italy, Belgium, Finland, Netherlands, Portugal refer to 1991, Japan refers to the average from 1994 to 1999, United Kingdom refers to the average of 1996 and 1999, Mexico and Indonesia refer to the average from 1993 to 1999, China refers to the average from 1992 to 1999, India and Thailand refer to the average from 1991 to 1999. As for those of 2000's, the figure for Chile refers to the average from 2003 to 2012, Columbia refers to the average from 2006 to 2012, respectively.

Table 4: Trade Linkage and Domestic Response to the U.S. Monetary Policy Shock

	Trade with the United States relative to GDP		Difference	Response of IIP	Response of Employment	Response of Unemployment Rate
	1990s	2000s	2000s - 1990s	2000s - 1990s	2000s - 1990s	2000s - 1990s
G7 and Australia						
Australia	4.3%	3.0%	-	NA	0.22	-0.90
Canada	42.8%	40.5%	-	-0.49	0.05	-1.17
France	5.3%	4.1%	-	0.26	NA	-1.61
Germany	4.6%	4.9%	+	0.50	0.62	0.72
Italy	2.7%	2.4%	-	0.27	NA	-1.31
Japan	4.2%	4.1%	-	-0.02	0.16	-1.17
United Kingdom	5.4%	4.6%	-	0.09	0.01	-0.06
Other developed economies						
Belgium	6.4%	5.6%	-	0.64	NA	-1.31
Denmark	2.6%	3.0%	+	-0.10	NA	-0.60
Finland	4.4%	3.4%	-	1.02	0.08	-0.19
Netherlands	6.5%	7.0%	+	0.22	NA	-0.60
Norway	3.4%	3.0%	-	NA	0.57	0.40
Portugal	NA	1.5%	NA	NA	NA	0.16
Spain	2.3%	1.7%	-	NA	NA	-0.51
Sweden	3.9%	4.0%	+	NA	0.30	-0.47
Switzerland	3.8%	4.9%	+	NA	NA	-2.01
Latin emerging economies						
Brazil	2.8%	3.1%	+	-0.25	-0.10	0.20
Chile	NA	9.5%	NA	-0.06	0.17	-1.92
Columbia	NA	10.6%	NA	0.07	NA	NA
Mexico	8.2%	9.1%	+	-1.28	NA	-0.11
Asian emerging economies						
China	5.4%	7.0%	+	NA	NA	NA
Hong Kong	14.5%	10.7%	-	NA	-0.36	-0.40
India	2.5%	3.0%	+	NA	NA	NA
Indonesia	6.0%	3.9%	-	0.05	NA	NA
Korea	10.7%	9.1%	-	0.17	-0.18	-1.27
Singapore	43.1%	25.9%	-	0.25	NA	NA
Taiwan	16.9%	14.1%	-	NA	0.00	-0.36
Thailand	12.0%	12.1%	+	NA	0.22	NA

Notes:

Trade shares with the U.S. indicates the ratio of the sum of export to and import from the United States to the sum of export to and import from all of the world in each country. Difference indicates the difference of trade with the U.S. relative to GDP over the two decades.

Response of IIP, employment, and unemployment rate are the difference over the two decades of the estimated impulse response at the quarter four years after the contractionary U.S. monetary policy shock. The numbers are shadowed when response becomes less adverse during the 2000s for countries that sees a decline in trade relationship with the U.S. over the two decades.

Table 5: Relative Importance of Own GDP to the U.S. GDP

	Share of GDP relative to world GDP		Difference	Response of IIP	Response of Employment	Response of Unemployment Rate
	1990's	2000's	2000s - 1990s	2000s - 1990s	2000s - 1990s	2000s - 1990s
US	23%	22%	-2%			
G7 and Australia						
Australia	1.33%	1.71%	+	NA	0.22	-0.90
Canada	2.24%	2.48%	+	-0.49	0.05	-1.17
France	5.12%	4.35%	+	0.26	NA	-1.61
Germany	7.67%	5.70%	-	0.50	0.62	0.72
Italy	4.29%	3.55%	+	0.27	NA	-1.31
Japan	15.50%	9.54%	-	-0.02	0.16	-1.17
United Kingdom	4.38%	4.32%	+	0.09	0.01	-0.06
Other developed economies						
Belgium	0.88%	0.78%	+	0.64	NA	-1.31
Denmark	0.58%	0.52%	+	-0.10	NA	-0.60
Finland	0.44%	0.41%	+	1.02	0.08	-0.19
Netherlands	1.33%	1.31%	+	0.22	NA	-0.60
Norway	0.51%	0.66%	+	NA	0.57	0.40
Portugal	0.39%	0.38%	+	NA	NA	0.16
Spain	2.09%	2.28%	+	NA	NA	-0.51
Sweden	0.91%	0.77%	+	NA	0.30	-0.47
Switzerland	1.00%	0.86%	+	NA	NA	-2.01
Latin emerging economies						
Brazil	2.25%	2.54%	+	-0.25	-0.10	0.20
Chile	0.23%	0.30%	+	-0.06	0.17	-1.92
Columbia	0.33%	0.38%	+	0.07	NA	NA
Mexico	1.56%	1.80%	+	-1.28	NA	-0.11
Asian emerging economies						
China	2.59%	7.19%	+	NA	NA	NA
Hong Kong	0.49%	0.40%	+	NA	-0.36	-0.40
India	1.29%	2.06%	+	NA	NA	NA
Indonesia	0.58%	0.85%	+	0.05	NA	NA
Korea	1.53%	1.67%	+	0.17	-0.18	-1.27
Singapore	0.26%	0.32%	+	0.25	NA	NA
Taiwan	0.91%	0.74%	+	NA	0.00	-0.36
Thailand	0.47%	0.44%	+	NA	0.22	NA

Source: IMF

The difference denotes the changes in relative significance of own GDP to the U.S. GDP. That is, the difference of world share of own GDP over the two decades subtracted by the difference of that for the U.S.

Response of IIP, employment, and unemployment rate are the difference over the two decades of the estimated impulse response at the periods four years after the contractionary U.S. monetary policy shock. The numbers are shadowed when estimated response becomes less adverse during the 2000s for countries that see an increase in own GDP relative to the U.S. GDP over the two decades.

Table 6: FDI Shares of the U.S. and FDIs Relative to GDP

	FDI shares of the United States		FDIs relative to Nominal GDP	
	1990's	2000's	1990's	2000's
G7 and Australia				
Australia	20.42%	19.70%	42.78%	65.92%
Canada	53.82%	46.44%	41.39%	70.37%
France	19.11%	14.14%	26.17%	76.97%
Germany	26.47%	15.77%	17.23%	61.26%
Italy	10.66%	6.85%	15.48%	32.64%
Japan	52.71%	47.14%	6.53%	13.92%
United Kingdom	39.43%	32.03%	50.22%	105.67%
Other developed economies				
Belgium	N/A	N/A	N/A	N/A
Denmark	8.64%	5.09%	49.92%	102.73%
Finland	14.36%	5.96%	20.76%	78.31%
Netherlands	45.42%	42.52%	74.18%	184.55%
Norway	19.81%	11.75%	25.38%	57.65%
Portugal	4.15%	0.90%	24.94%	65.57%
Spain	9.58%	8.11%	23.45%	72.28%
Sweden	13.97%	13.52%	39.81%	123.21%
Switzerland	36.14%	32.16%	63.61%	202.66%
Latin emerging economies				
Brazil	N/A	35.16%	N/A	33.24%
Chile	N/A	N/A	56.81%	84.34%
Columbia	N/A	N/A	N/A	N/A
Mexico	46.61%	30.24%	10.93%	32.34%
Asian emerging economies				
China	N/A	3.74%	N/A	26.31%
Hong Kong	N/A	N/A	N/A	N/A
India	11.57%	11.06%	3.71%	11.56%
Indonesia	N/A	12.24%	N/A	14.05%
Korea	N/A	17.64%	N/A	20.58%
Singapore	N/A	N/A	N/A	N/A
Taiwan	N/A	N/A	N/A	N/A
Thailand	N/A	N/A	N/A	N/A

Notes:
FDI shares of the U.S. indicates the ratio of the sum of inward FDI from the U.S. and outward FDI to the U.S. to the total of inward and outward FDI in each country. FDIs relative to nominal GDP indicate the ratio of the inward FDIs to nominal GDP for each country.

As for FDI shares of the U.S. of 1990's, the figure for Denmark refers to the average of 1998 and 1999, Portugal refers to the average from 1995 to 1999, Chile and India refer to the average from 1997 to 1999, respectively.

As for FDI shares of the U.S. of 2000's, the figure for France, Italy, Denmark and Norway refers to the average from 2000 to 2011, Brazil refers to the average from 2001 to 2011, Korea refers to the average from 2001 to 2012, Australia refers to the average from 2005 to 2012, Portugal refers to the average from 2007 to 2009, China refers to the average from 2004 to 2011, Indonesia refers to the average from 2007 to 2011, respectively.

As for FDIs relative to nominal GDP of 1990's, the figure for Denmark refers to the average of 1998 and 1999, Portugal refers to the average from 1995 to 1999, Chile and India refer to the average from 1997 to 1999, respectively.

As for FDIs relative to nominal GDP of 2000's, the figure for France, Italy, Denmark, Norway, and Indonesia refers to the average from 2000 to 2011, Brazil and Korea refer to the average from 2001 to 2012, China refers to the average from 2004 to 2011, respectively.

Table 7: Financial Linkage and Domestic Response to the U.S. Monetary Policy Shock

	FDI of the United States relative to Nominal GDP		Difference	Response of IIP	Response of Employment	Response of Unemployment Rate
	1990's	2000's	2000s - 1990s	2000s - 1990s	2000s - 1990s	2000s - 1990s
G7 and Australia						
Australia	13.92%	22.31%	+	NA	0.22	-0.90
Canada	27.11%	44.07%	+	-0.49	0.05	-1.17
France	4.22%	9.64%	+	0.26	NA	-1.61
Germany	1.79%	5.96%	+	0.50	0.62	0.72
Italy	1.11%	1.60%	+	0.27	NA	-1.31
Japan	2.49%	4.88%	+	-0.02	0.16	-1.17
United Kingdom	18.72%	29.67%	+	0.09	0.01	-0.06
Other developed economies						
Belgium	N/A	N/A		0.64	NA	-1.31
Denmark	4.31%	5.23%	+	-0.10	NA	-0.60
Finland	2.98%	4.67%	+	1.02	0.08	-0.19
Netherlands	33.69%	78.48%	+	0.22	NA	-0.60
Norway	5.03%	6.77%	+	NA	0.57	0.40
Portugal	1.03%	0.59%	-	NA	NA	0.16
Spain	2.25%	5.86%	+	NA	NA	-0.51
Sweden	5.56%	16.66%	+	NA	0.30	-0.47
Switzerland	22.99%	65.17%	+	NA	NA	-2.01
Latin emerging economies						
Brazil	N/A	11.69%		-0.25	-0.10	0.20
Chile	N/A	N/A		-0.06	0.17	-1.92
Columbia	N/A	N/A		0.07	NA	NA
Mexico	5.10%	9.78%	+	-1.28	NA	-0.11
Asian emerging economies						
China	N/A	3.74%		NA	NA	NA
Hong Kong	N/A	N/A		NA	-0.36	-0.40
India	0.43%	1.28%	+	NA	NA	NA
Indonesia	N/A	1.72%		0.05	NA	NA
Korea	N/A	3.63%		0.17	-0.18	-1.27
Singapore	N/A	N/A		0.25	NA	NA
Taiwan	N/A	N/A		NA	0.00	-0.36
Thailand	N/A	N/A		NA	0.22	NA

Notes:

Response of IIP, employment, and unemployment rate are the difference over the two decades of the estimated impulse response at the quarter four years after the contractionary U.S. monetary policy shock. The numbers are shadowed when estimated responses become less adverse during the 2000s for countries that see an increase in financial transaction with the U.S.

Table 8: Response of Production-Related Variables and Regime Switches

Changes in Estimated Response to U.S. Monetary Policy Shock

	Difference from 1990 to 2000		
	IIP	Employment	Unemployment
Average of Countries that adopt IT (Advanced)	NA	0.571	-0.801
Average of Countries that adopt IT (Asia)	0.109	-0.181	-1.269
Average of Countries that adopt IT (Latin)	-0.088	-0.104	0.201
Average of Countries that adopt IT (All)	0.011	0.095	-0.668
Average of Countries that adopt Floating (Asia)	0.109	-0.364	-1.269
Average of Countries that adopt Floating (Latin)	-0.379	0.035	-0.610
Average of Countries that adopt Floating (All)	-0.216	-0.037	-0.699

Note: Numbers are shadowed if the numbers are greater (smaller) than the averaged number of all sampled countries for IIP and employment (for unemployment rate).

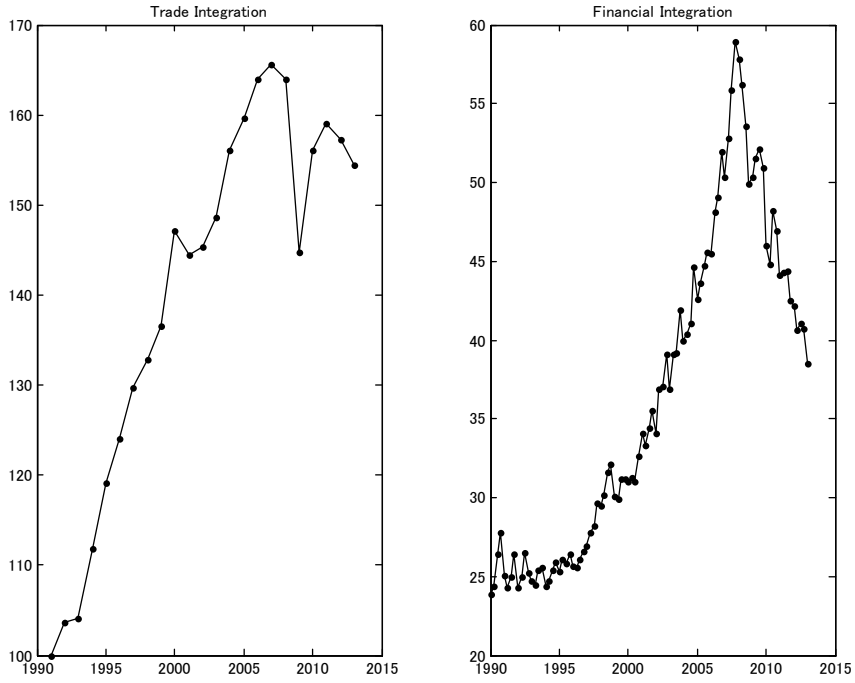
Table 9: List of Countries used for Estimation

	1990's	2000's
IIP	BEL BRA CAN CHI COL DEN FIN FRA GBR GER INA IRL ITA JPN KOR MEX NED SIN	ARG BEL BRA CAN CHI COL DEN FIN FRA GBR GER INA IND IRL ITA JPN KOR MEX NED POR SIN SPN
Employment	AUS BRA CAN CHI FIN GBR GER HKG JPN KOR NOR SWE TPE	AUS BRA CAN CHI FIN GBR GER HKG JPN KOR NOR SWE TPE
Umployment Rate	AUS BEL BRA CAN CHI DEN FIN FRA GBR GER HKG IRL ITA JPN KOR MEX NED NOR POR SPN SUI SWE TPE	AUS BEL BRA CAN CHI DEN FIN FRA GBR GER HKG IRL ITA JPN KOR MEX NED NOR POR SPN SUI SWE TPE
Real Export	ARG AUS BEL BRA CAN CHN FIN FRA GBR GER INA IND ITA JPN KOR MEX NOR SPN SUI SWE TPE	ARG AUS BEL BRA CAN CHN FIN FRA GBR GER INA IND ITA JPN KOR MEX NOR SPN SUI SWE
Trade Balance	AUS BEL BRA CAN FIN FRA GBR GER INA IND ITA JPN KOR MEX NOR SPN SWE	AUS BEL BRA CAN FIN FRA GBR GER INA IND ITA JPN KOR MEX NOR SPN SWE
Stock / Volatility of Stock Return	ARG AUS CAN CHI EUR GBR GER HKG INA IND JPN KOR PER PHI SPN SUI THA TPE	ARG AUS BRA CAN CHI CHN EUR GBR GER HKG INA IND JPN KOR MAS MEX NZL PER PHI SIN SPN SUI THA TPE
Exchange Rate / Volatility of Exchange Rate	AUS BRA CAN CHI CHN COL FIN GBR HKG INA JPN KOR MAS MEX NOR PHI SIN SWE THA TPE	AUS BRA CAN CHI CHN COL FIN GBR HKG INA JPN KOR MAS MEX NOR PHI SIN SWE THA TPE
Long Term Interest Rate	AUS BEL BRA CAN COL DEN FIN FRA GBR GER HKG IRL ITA JPN KOR MEX NED NOR POR SIN SPN SUI SWE	AUS BEL BRA CAN COL DEN FIN FRA GBR GER HKG IRL ITA JPN KOR MEX NED NOR POR SIN SPN SUI SWE TPE
Volatirity of Long Term Interest Rate	AUS CAN DEN FRA GBR GER SPN SWE	AUS CAN DEN FRA GBR GER HKG ITA KOR MEX NOR PHI SIN SPN SUI SWE THA
Policy Rate	AUS CAN DEN GBR JPN NOR PHI SIN SUI SWE TPE	BRA CAN CHI CHN COL DEN EUR GBR HKG IND ISL JPN KOR NOR PER PHI SIN SUI SWE THA TPE
Narrow Money	AUS BEL BRA CAN CHN FIN GBR HKG INA IND IRL JPN KOR MAS NED SIN SUI TPE	AUS CAN DEN GBR INA JPN MAS NOR SIN SUI SWE
Inflation	ARG BEL BRA CAN CHI COL DEN FRA GBR GER HKG INA IND ITA JPN KOR MAS MEX NED POR SIN SPN SUI SWE TPE	ARG BEL BRA CAN CHI COL DEN FRA GBR GER HKG INA IND ITA JPN KOR MAS MEX NED POR SIN SPN SUI SWE

Notes:

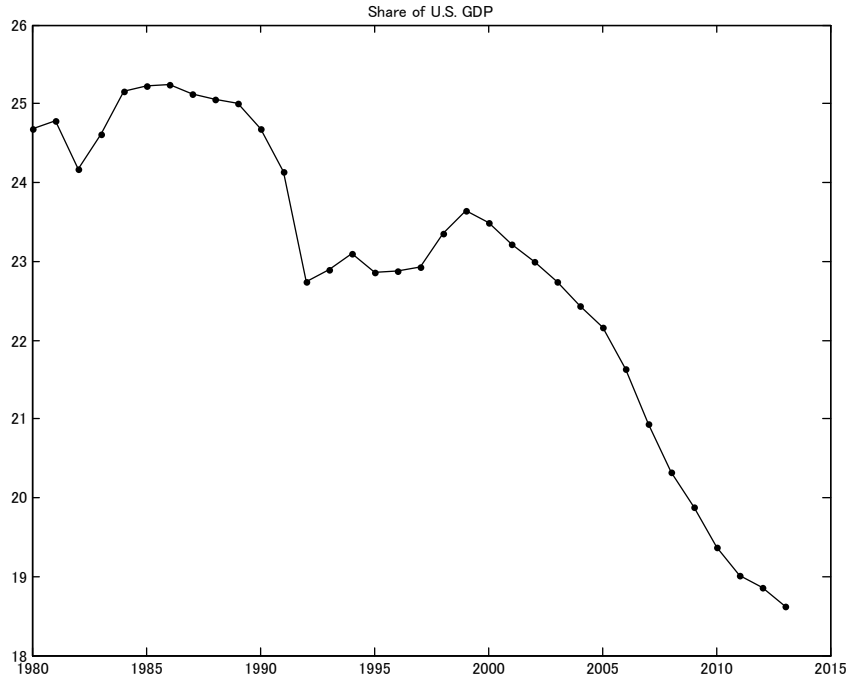
Abbreviations used in the chart follow the country codes recognized by the International Olympic Committee. Each abbreviation represents a country or an area as follows: **ARG** for Argentina, **AUS** for Australia, **BEL** for Belgium, **BRA** for Brazil, **CAN** for Canada, **CHI** for Chili, **CHN** for China, **COL** for Colombia, **DEN** for Denmark, **EUR** for Euro area, **FIN** for Finland, **FRA** for France, **GBR** for the United Kingdom, **GER** for Germany, **HKG** for Hong Kong, **INA** for Indonesia, **IND** for India, **IRL** for Ireland, **ISL** for Iceland, **ITA** for Italy, **JPN** for Japan, **KOR** for Korea, **MAS** for Malaysia, **MEX** for Mexico, **NED** for Netherland, **NZL** for New Zealand, **NOR** for Norway, **PER** for Peru, **PHI** for Philippine, **POR** for Portugal, **SIN** for Singapore, **SPN** for Spain, **SUI** for Switzerland, **SWE** for Sweden, **THA** for Thailand and **TPE** for Taiwan.

Figure 1: Trade and Financial Integration



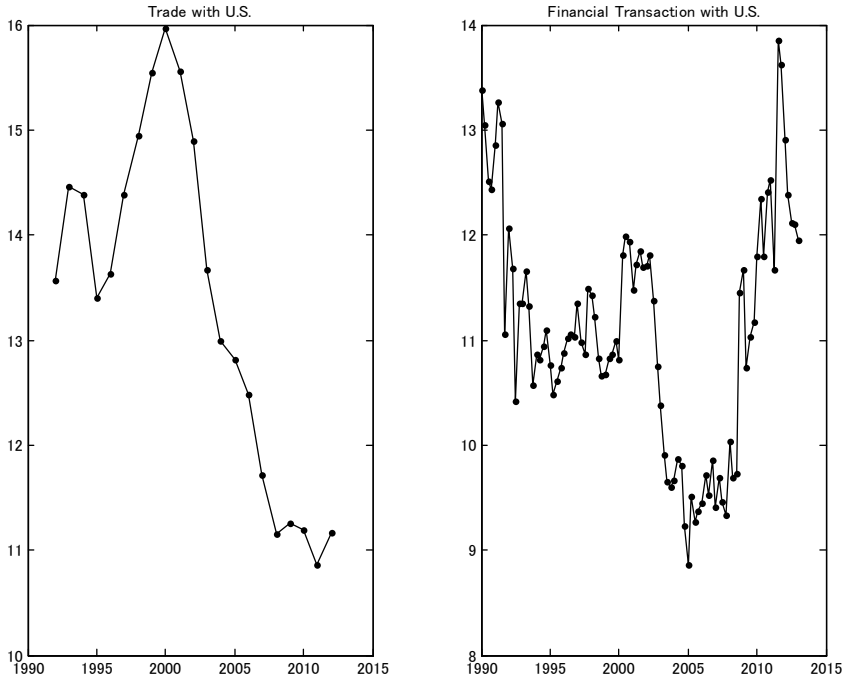
Note: Degree of trade integration is defined as the world import volume relative to world GDP and degree of financial integration is defined as the global banks' cross-border claims relative to world GDP. The data are taken from IMF, BIS, and HAVER.

Figure 2: Share of the U.S. GDP over the World GDP



Note: The data are taken from IMF.

Figure 3: Relative Importance of Trade and Financial Transaction with the U.S.



Note: Relative importance of trade with the United States in the world trade is defined as the ratio of the sum of import to and export from the United States relative to the sum of world import and world export. Relative importance of financial transactions with the United States in cross-border claims is defined as the amount of holdings of U.S. banks' cross-border claims relative to overall cross-border claims around the globe. The data are taken from IMF, BEA, and BIS.

Figure 4: Time path of Federal Funds Rate and Extracted U.S. Monetary Policy Shocks

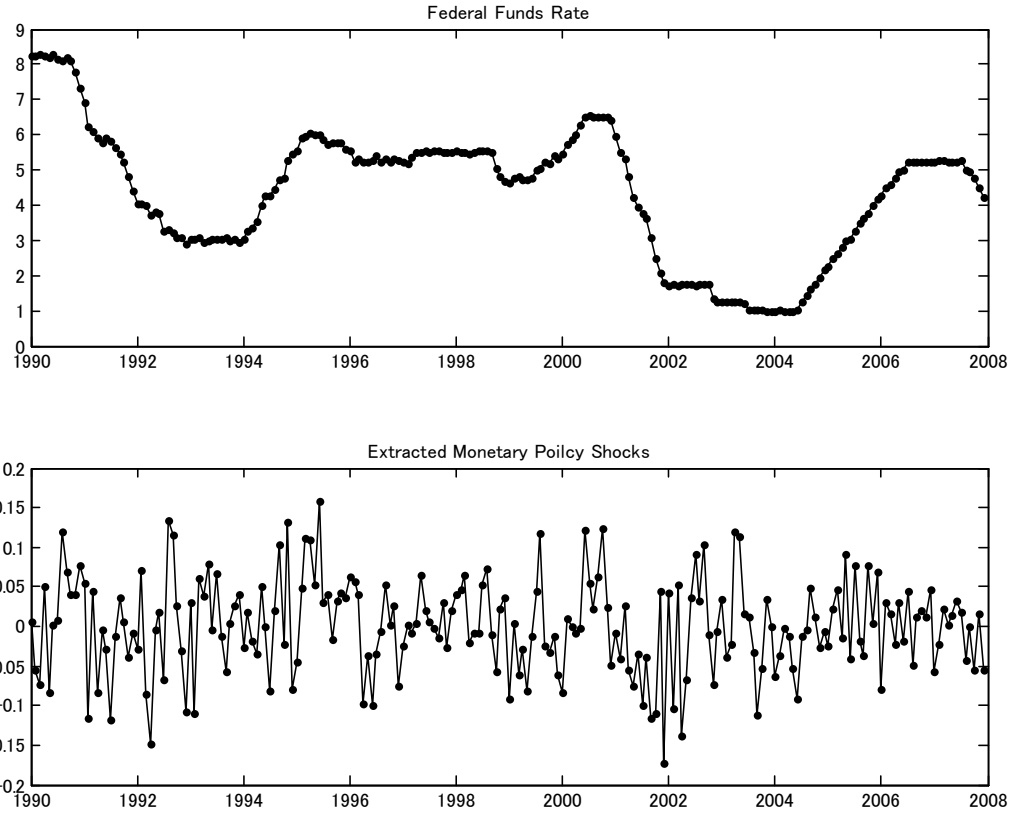
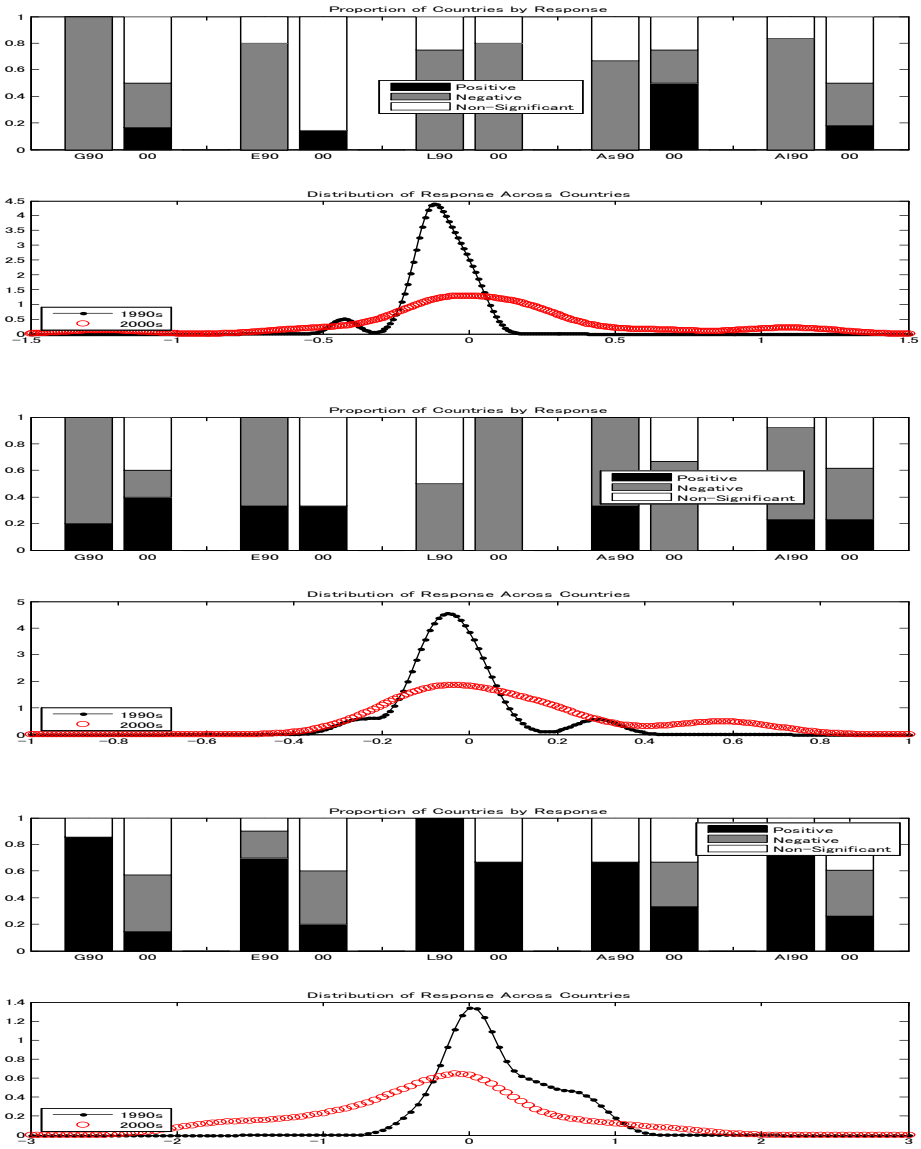
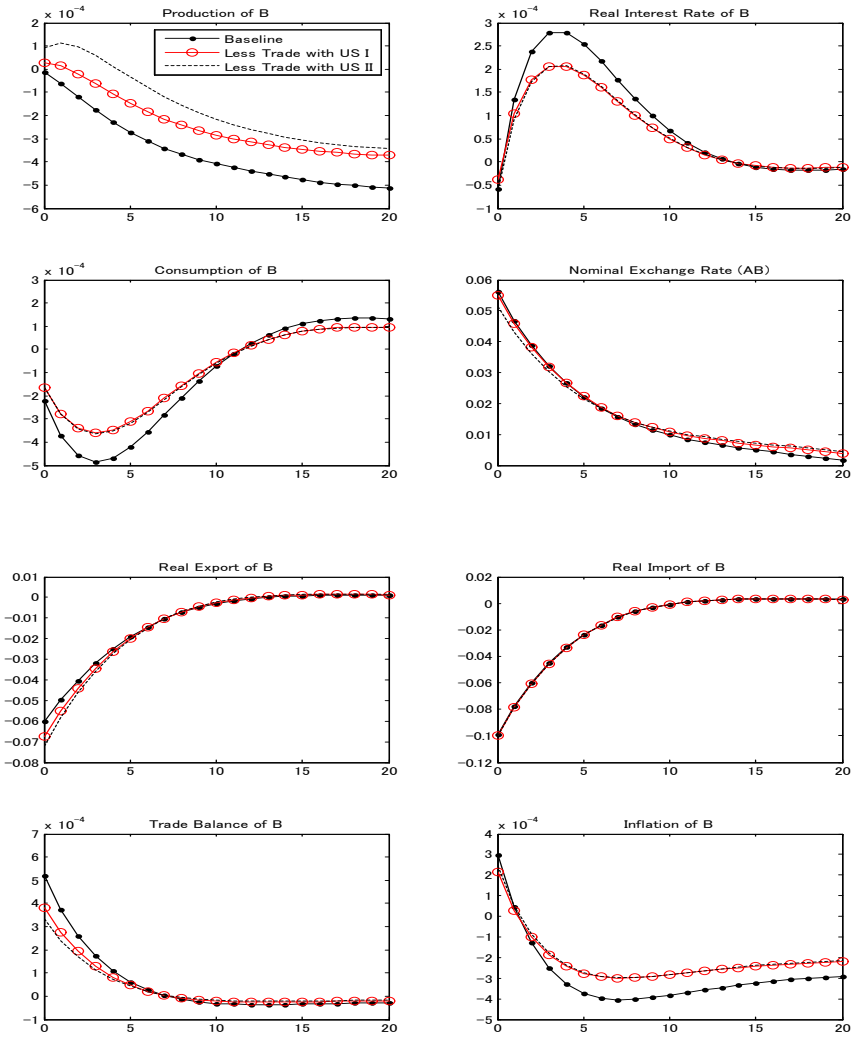


Figure 5: Response of IIP, Employment, Unemployment Rate



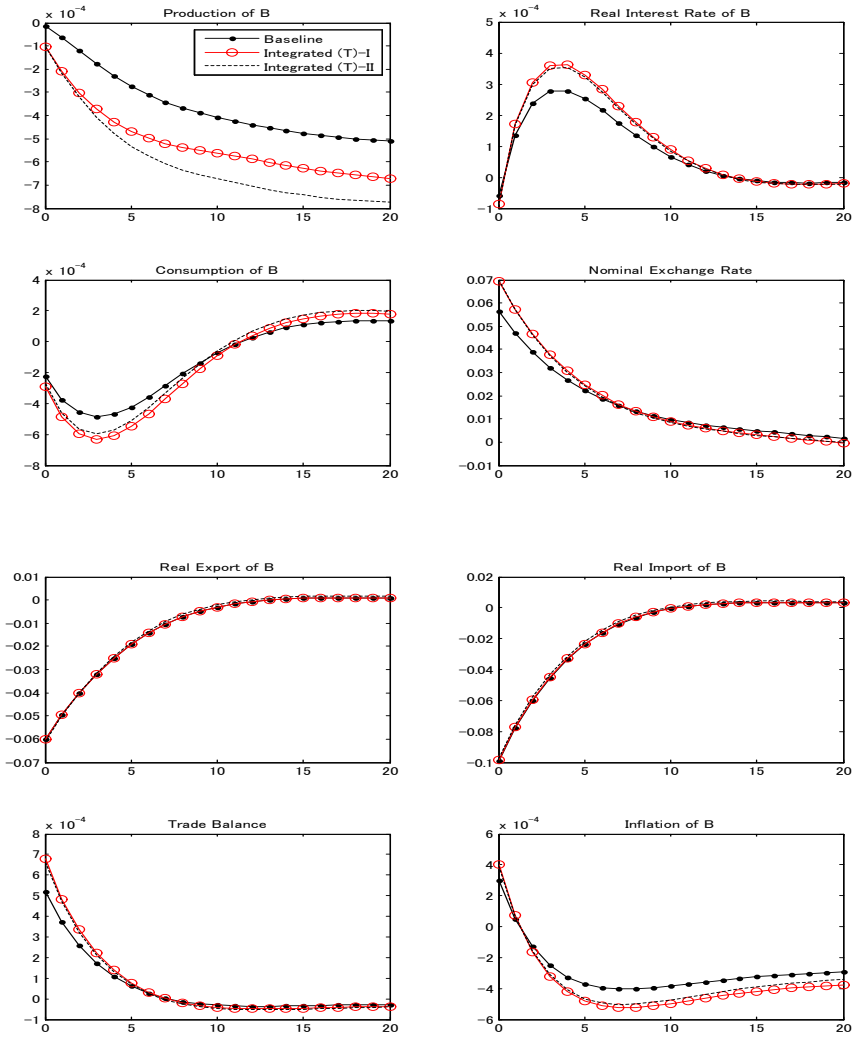
Note: Estimation results for IIP, employment, and unemployment rate are reported. For each variable, a bar graph depicts proportion of countries whose corresponding macroeconomic variable exhibit statistically increase (black) or decrease (grey) at 5%, or non-significance (white) after the contractionary U.S. monetary policy shock by different country groups and by estimation period. Lower graph depicts distribution of impulse response functions of macroeconomic variable four years after the shock across all sample countries for the sample period of the 1990s (solid black line) and the 2000s (red line with circle).

Figure 6: Domestic Response When Trade with the U.S. Shrinks



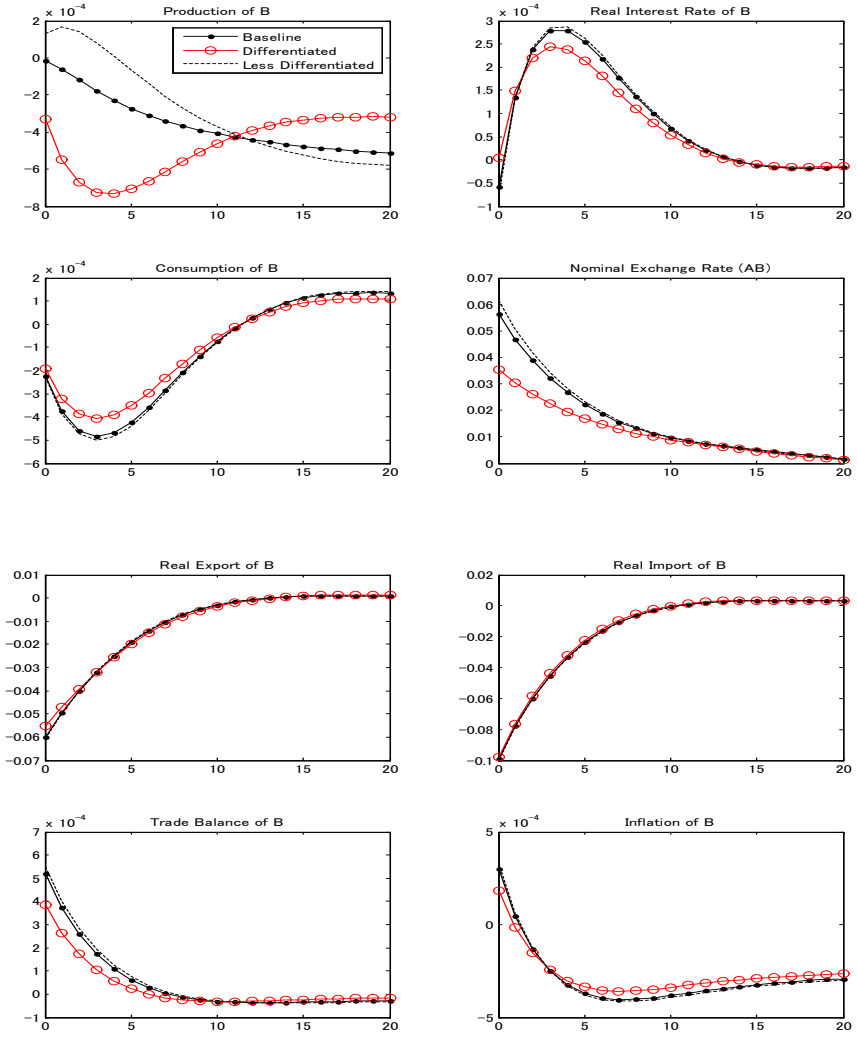
Note: Figure displays the domestic response of production, short-term real interest rate, real consumption, nominal exchange rate, real export, real import, trade balance, and inflation rate in country B to a positive shock to the monetary policy rule in country A under the baseline economy, the economy where trade relationship between country A and B is smaller, and the economy where trade relationship between country A and C is smaller compared with the case of baseline economy.

Figure 7a: Domestic Response When Trade Integration Deepens



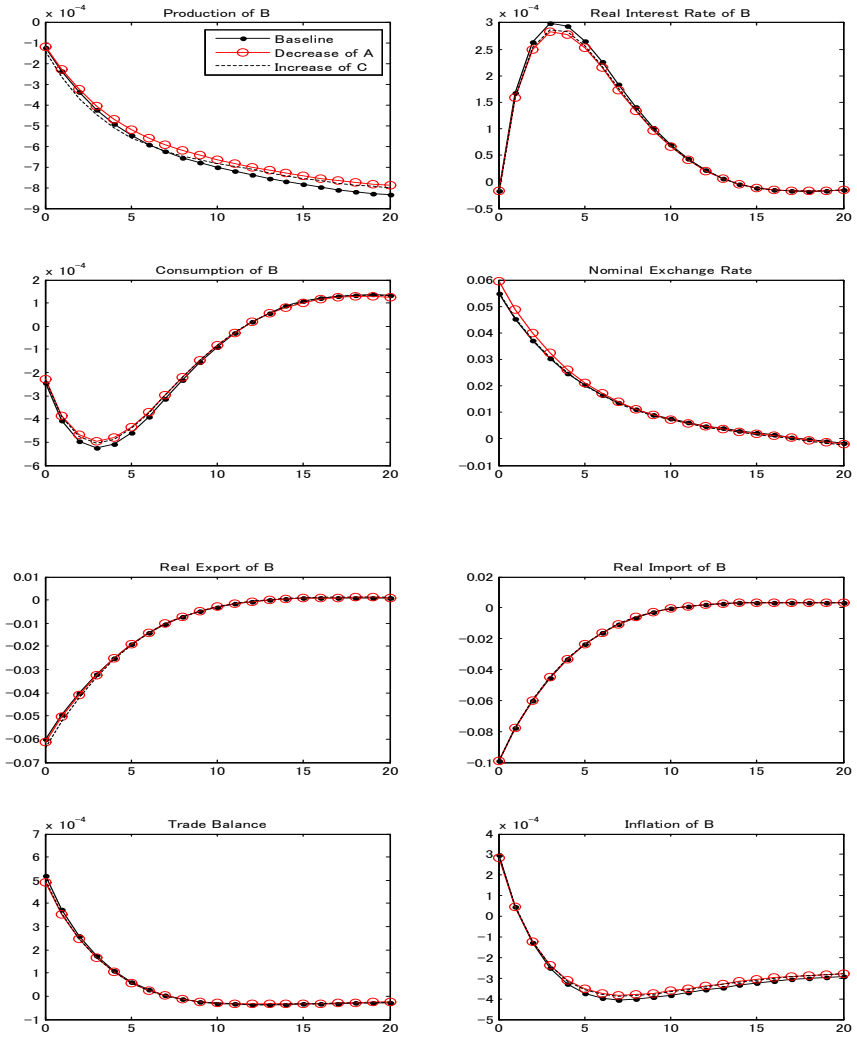
Note: Figure displays the domestic response of production, short-term real interest rate, real consumption, nominal exchange rate, real export, real import, trade balance, and inflation rate in country B to a positive shock to the monetary policy rule in country A under the economy where all parameters are calibrated to benchmark value, the economy where share of traded goods relative to GDP in country B is larger than baseline model and the economy where the share of traded goods relative to GDP in country C is larger than baseline model.

Figure 7b: Domestic Response When Trade Integration Deepens



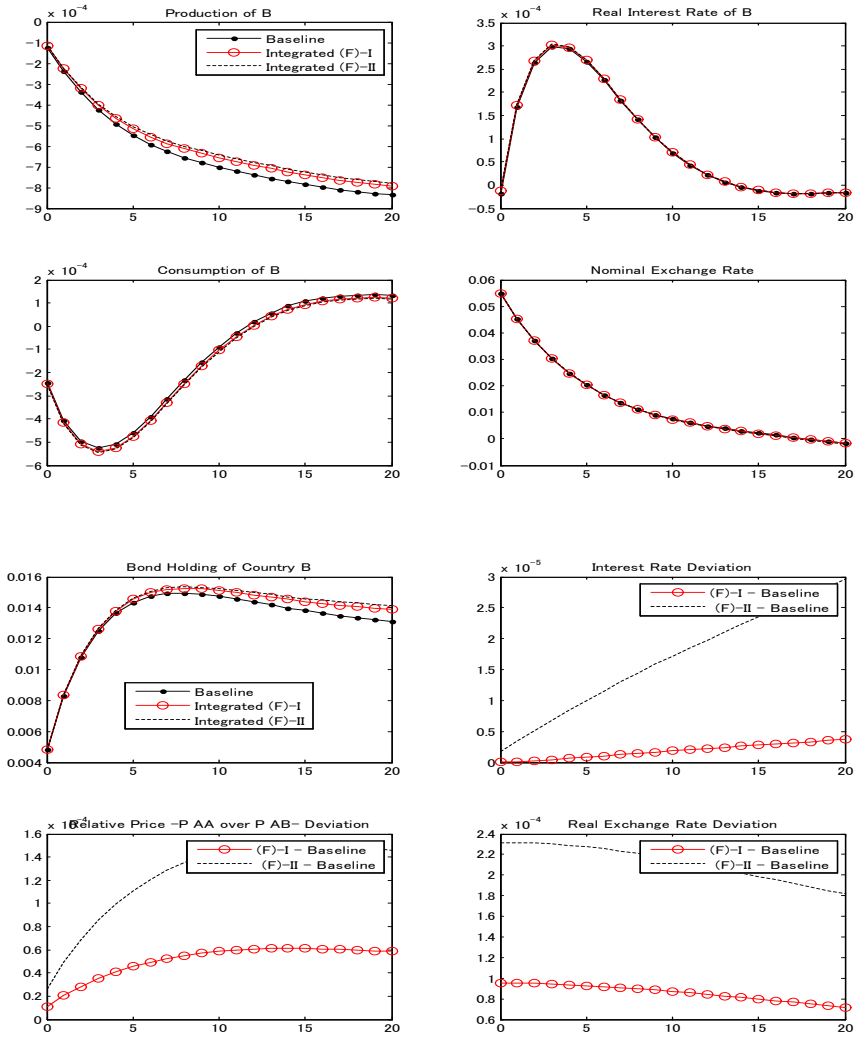
Note: Figure displays the domestic response of production, short-term real interest rate, real consumption, nominal exchange rate, real export, real import, trade balance, and inflation rate in country B to a positive shock to the monetary policy rule in country A under the baseline economy, the economy where goods produced in each country is highly differentiated, and the economy where goods produced in each country is less differentiated compared with the case of baseline model.

Figure 8: Domestic Response When Relative Size of the U.S. Shrinks



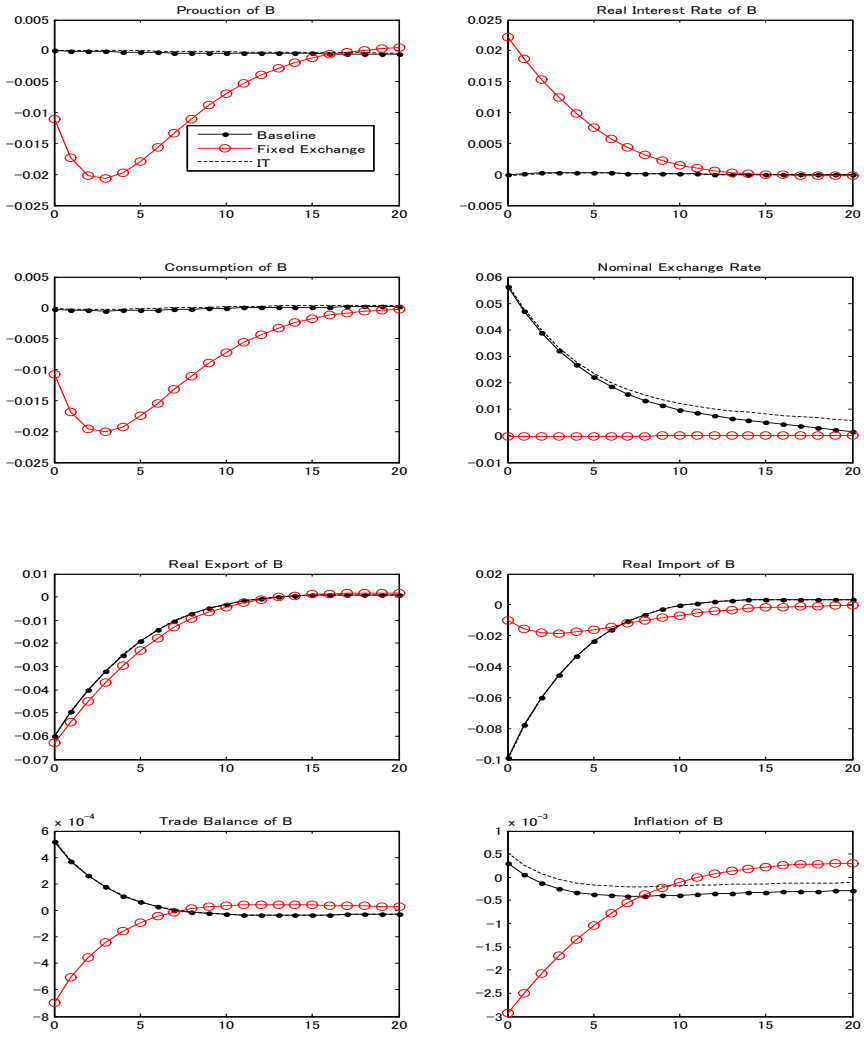
Note: Figure displays the domestic response of production, short-term real interest rate, real consumption, nominal exchange rate, real export, real import, trade balance, and inflation rate in country B to a positive shock to the monetary policy rule in country A under the baseline economy, the economy where country size of A becomes smaller, and the economy where country size of C becomes larger compared with the case of baseline model.

Figure 9: Domestic Response When Cost of Accessing International Market is Small



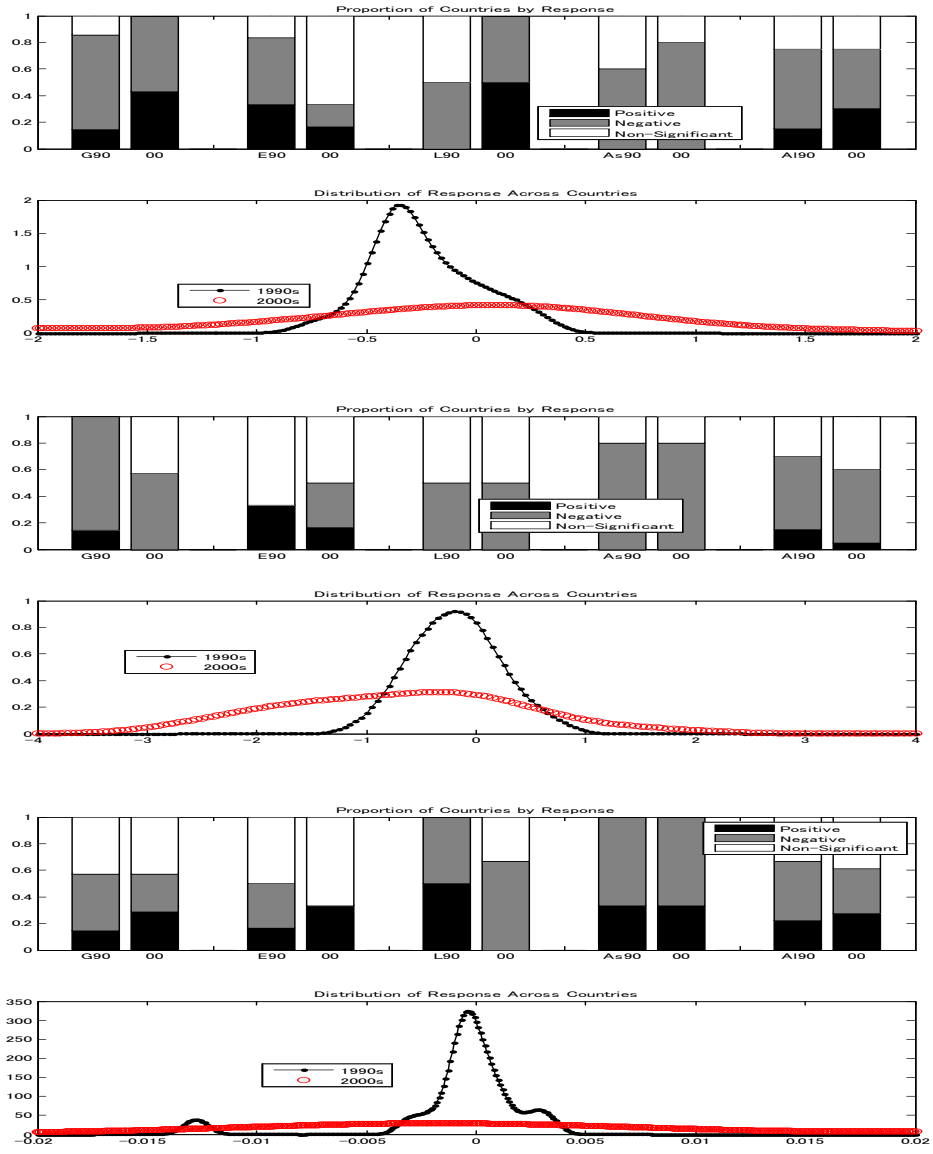
Note: Figure displays the domestic response of production, short-term real interest rate, real consumption, nominal exchange rate, internationally traded bond holding in country B and those in country A,interest rate of internationally traded bond, relative price of goods produced in A and B in country A, and real exchange rate to a positive shock to the monetary policy rule in country A under the baseline economy, the economy where country B faces less cost in accessing the global financial market, and the economy where all countries face less cost in accessing the global financial market. The bottom three panels display the deviation from the baseline model.

Figure 10: Domestic Response When Alternative Policy is Adopted



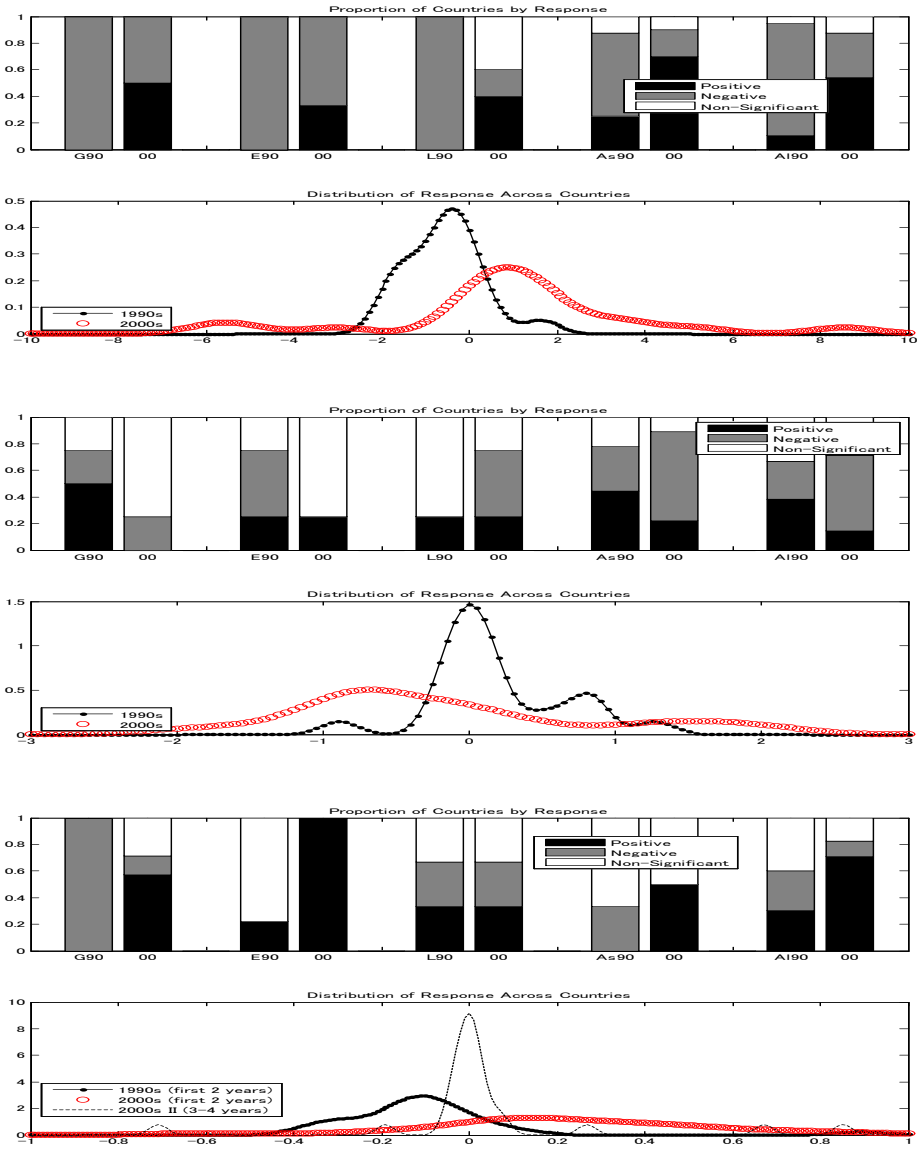
Note: Figure displays the domestic response of production, short-term real interest rate, real consumption, nominal exchange rate, real export, real import, trade balance, and inflation rate in country B to a positive shock to the monetary policy rule in country A under the baseline economy, the economy where country B adopts a monetary policy that maintains the nominal exchange rate instead of Taylor rule, and the economy where country B adopts monetary policy that assigns a higher weight on inflation rate.

Figure 11: Response of Export, Import, and Trade Balance



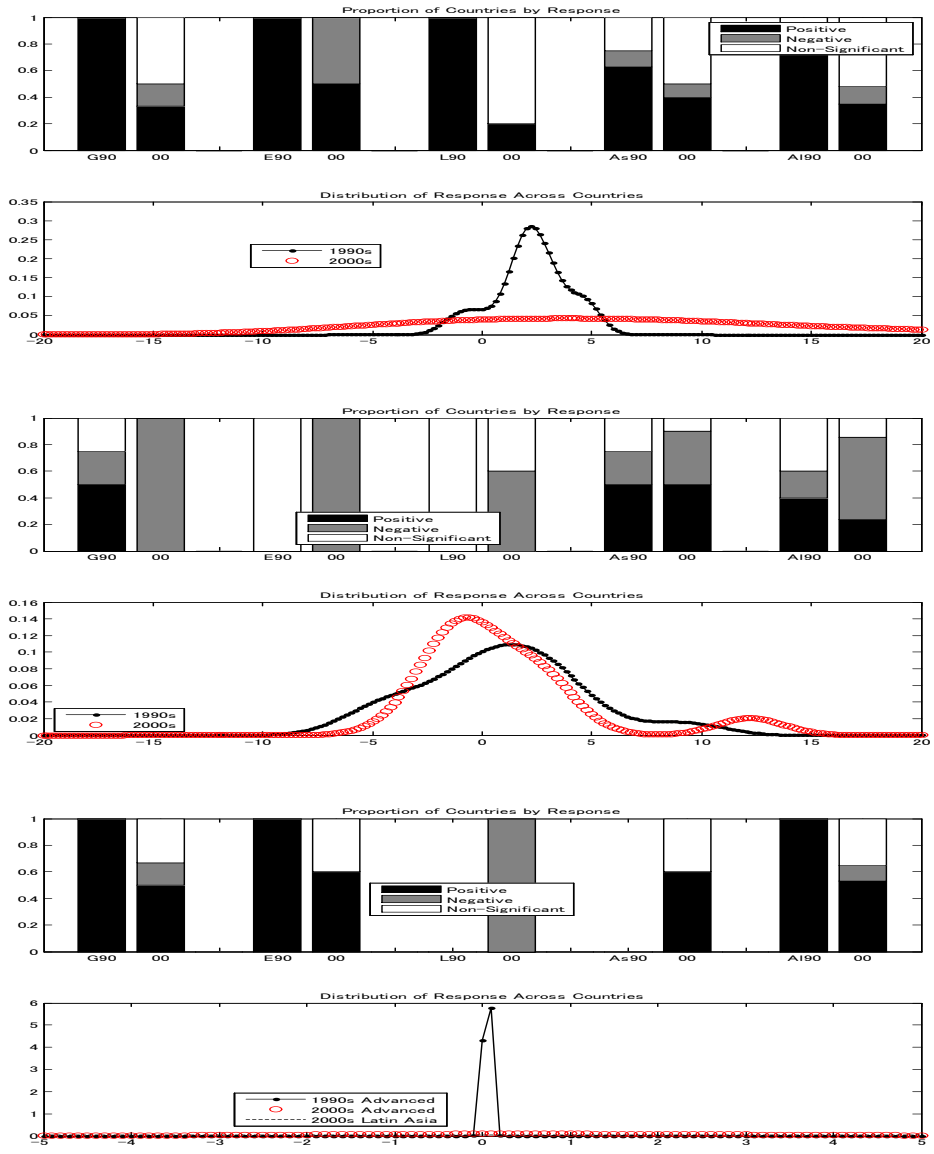
Note: Estimation results for real export, real import, and trade balance are reported. For each variable, a bar graph depicts proportion of countries whose corresponding macroeconomic variable exhibit statistically increase (black) or decrease (gray) at 5%, or non-significance (white) after the contractionary U.S. monetary policy shock by different country groups and by estimation period. Lower graph depicts distribution of impulse response functions of macroeconomic variable four years after the shock across all sample countries for the sample period of the 1990s (solid black line) and the 2000s (red line with circle).

Figure 12: Response of Stock Price and Exchange Rate, and Long Term Interest Rate



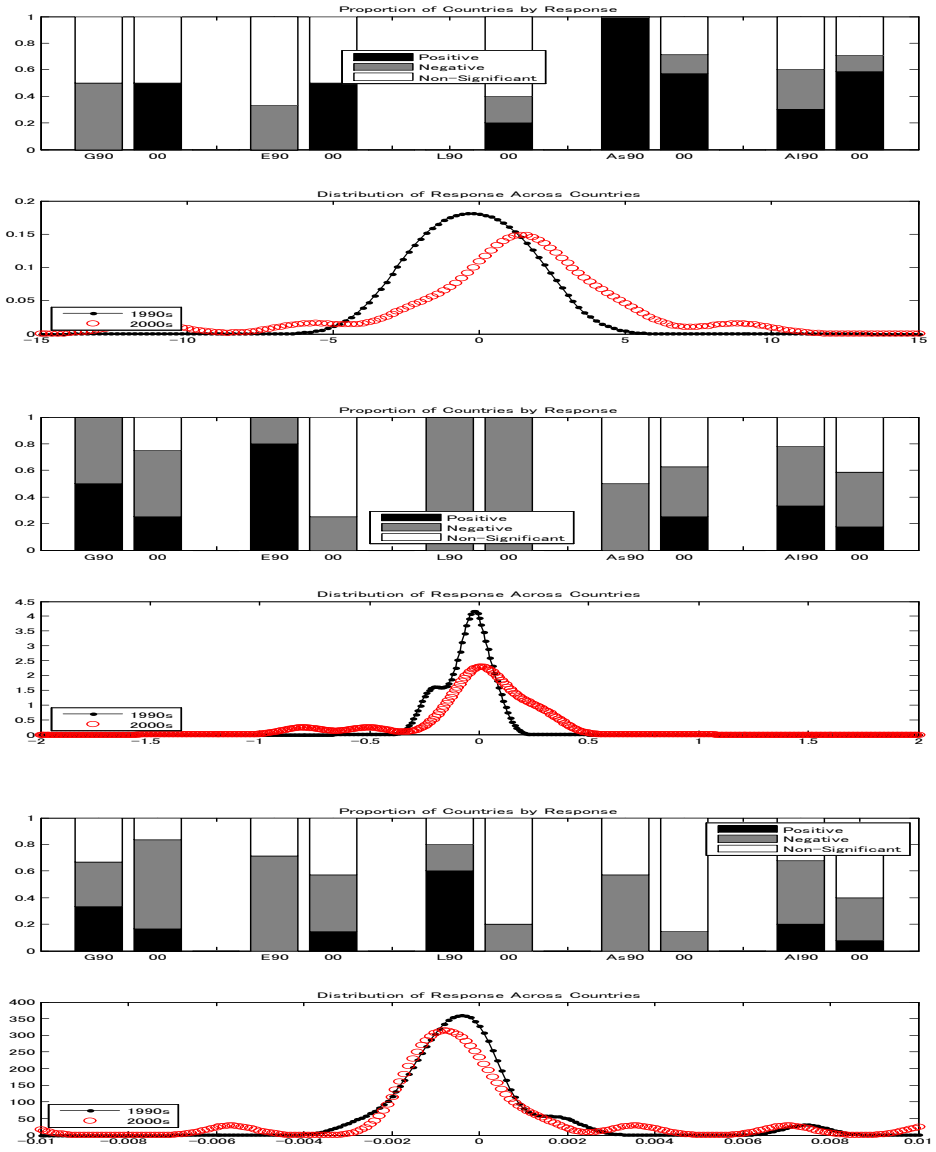
Note: Estimation results for stock return, exchange rate, and long-run interest rate are reported. For each variable, a bar graph depicts proportion of countries whose corresponding macroeconomic variable exhibit statistically increase (black) or decrease (gray) at 5%, or non-significance (white) after the contractionary U.S. monetary policy shock by different country groups and by estimation period. Lower graph depicts distribution of impulse response functions of macroeconomic variable after the shock across all sample countries for the sample period of the 1990s (solid black line) and the 2000s (red line with circle).

Figure 13: Response of Volatility of Stock Price, Exchange Rate, and Long Term Interest Rate



Note: Estimation results for volatility of stock return, exchange rate, and long term interest rate are reported. For each variable, a bar graph depicts proportion of countries whose corresponding macroeconomic variable exhibit statistically increase (black) or decrease (gray) at 5%, or non-significance (white) after the contractionary U.S. monetary policy shock by different country groups and by estimation period. Lower graph depicts distribution of impulse response functions of macroeconomic variable four years after the shock across all sample countries for the sample period of the 1990s and the 2000s.

Figure 14: Response of Policy Rate, Narrow Money, and Inflation Rate



Note: Estimation results for short-term policy rate, monetary aggregate, and inflation are reported. For each variable, a bar graph depicts proportion of countries whose corresponding macroeconomic variable exhibit statistically increase (black) or decrease (gray) at 5%, or non-significance (white) after the contractionary U.S. monetary policy shock by different country groups and by estimation period. Lower graph depicts distribution of impulse response functions of macroeconomic variable four years after the shock across all sample countries for the sample period of the 1990s (solid black line) and the 2000s (red line with circle).