

The International Transmission of The U.S. Monetary Policy Shock
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This paper studies the effect of a U.S. contractionary monetary policy on foreign economies using a VAR model. There are two main findings. First, a contractionary U.S. monetary policy shock induces an increase in interest rate and total output level in foreign countries. This is due to a large capital inflow into the foreign countries following an expectation of a long-run increase in foreign interest rates. Secondly, a U.S. contractionary policy stimulates significant fluctuations in foreign sectoral output levels. There are clear differences in cross-sector and cross-country responses due to differences in foreign trade sectors. Overall, a U.S. monetary policy shock explains a significant amount of fluctuations in foreign economies.

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Monetary policy shocks; International transmission; VAR; Interest rate channel; Trade balance channel

1. Introduction

Globalization has brought the world economy closer and closer together over the past few decades. It is almost impossible to discuss any country's economy in isolation. Given that the U.S. is a large, open economy with close trade relations with many countries, a U.S. monetary policy shock is likely to stimulate a certain degree of economic fluctuation around the world. Based on economic structure of a foreign, non-U.S. country, as well as its trade relation with the rest of the world, different foreign countries respond differently to a U.S. monetary policy shock. Many studies have looked at the effect of a U.S. monetary policy shock to foreign economies both theoretically and empirically. However, none of the studies try to disaggregate a foreign, non-U.S. economy to look at the response from each sector of the economy. Hence, I try to complete two objectives in this paper. First, I look at the international mechanism through which a U.S. monetary policy shock is transmitted to the foreign countries. Second, I look at how different sectors in foreign countries respond to a U.S. shock.

The traditional Mundell-Fleming-Dornbusch (MFD) model is a standard textbook model to explain international monetary policy transmission mechanism. Through interest rate and exchange rate differentials, the MFD model predicts that an expansionary domestic monetary policy would lead to a decrease in total output level in foreign countries. Literature based on intertemporal model, however, have more mixed predictions. Obstfeld and Rogoff (1995) found that, in the long run, an expansionary domestic monetary could cause deterioration on foreign welfare due to debt and trade deficit. However, in the short run, foreign consumption will be positively stimulated. Svensson and Wijnbergen (1987), on the other hand, found that depending on the elasticity of consumption, the international spillover effect of a monetary policy shock can be either positive or negative.

Given the ambiguous predictions from theoretical models, some researchers try to identify the transmission channel based empirical evidence. Most of the empirical analysis used vector autoregression (VAR) model. For example, Kim (2001) and Canova (2005). Their researches show that a U.S. monetary policy shock have opposite effects on developed and developing countries. However, both of their researches show that the interest rate differential plays the biggest role in international transmission of the shock. Their findings, even though opposite, show that the MFD model gives better prediction of the international monetary policy spillover effect than the intertemporal model.

For my first research question, I am not trying to answer the question regarding which model is the better fit. Instead, I add to the work already done by Kim (2001) and Canova (2005) by providing more empirical evidence on the effect of a U.S. monetary policy shock on foreign countries. Moreover, I am going to focus on whether the U.S. shock transmits to foreign countries via interest rate channel or trade balance channel.

There is no literature that I can refer to address the second part of my research question. However, given that a U.S. shock has significant impact on foreign interest rates,

we should expect heterogeneous responses from different sectors of a foreign economy at least due to a domestic interest rate fluctuation. Many researches have already proven these heterogeneous responses. For example, Ganley and Salmon (1997), Hayo and Uhlenbrock (1999), Dale and Haldane (1995), Dedola and Lippi (2000) and Gertler and Gilchrist (1994).

This paper contributes to the existing literature in two ways: first of all, it adds more empirical evidence on the international transmission mechanism. Secondly, it explores a new area that the other researches have not done before: how does a U.S. monetary policy shock affect foreign sectoral output levels.

There are several main findings from this research. First of all, a U.S. monetary policy shock accounts for a significant amount of fluctuations in foreign economies. To be more specific, a contractionary U.S. monetary policy induces a positive effect on foreign total output and demand. Neither the trade channel nor the interest rate channel plays an important role in the transmission mechanism. Instead, the world capital channel explains how the U.S. policy shock transmits to foreign countries. Secondly, a U.S. monetary policy shock accounts for a significant amount of fluctuations in foreign sectoral output levels. There are clear heterogeneous cross-country and cross-sector responses. For countries whose export sectors mainly consist of agricultural products, their agriculture sectors would be significantly negatively affected due to the contractionary U.S. shock. For countries whose export sectors depend heavily on manufacture products, their manufacture sectors would be significantly positively affected.

2. Literature Review

There is a large amount of empirical literature that study the international transmission mechanism of a monetary policy shock. Most of them uses a VAR approach. For example, Betts and Devereus (1999) studied the monetary policy transmission

mechanism in a two-country setting. Their methodology extends the MFD model by including a long run budget constraint. By incorporating the theory into the VAR model, they found that a positive U.S. monetary policy shock has positive spillover effects on foreign output levels. Following Kim (2001), I choose to use a VAR that is not based on any theory. Since the prediction of a theoretical model is often subject to the author's selection of variables. Hence the results are sensitive to little changes in the model. Moreover, I am not trying to test whether or not a particular theory could explain international transmission. Instead, I try to suggest a possible transmission mechanism based on empirical results.

In addition to the standard VAR, some authors have proposed a factor-augmented VAR (FVAR) approach (for example, Mumtaz and Surico(2009) and Bernanke, Boivin and Elias(2005)). One of the criticism for the standard VAR model is that, the degree of freedom rises exponentially as the number of input variable increases. Hence, a VAR typically do not employ more than six variables (Bernanke et al. (2005)). The largest problem with a small set of VAR identification scheme is that: the model is not able to capture all the information that directly affect the value of variables included in the VAR. On the other hand, FVAR uses a small set of estimated indexes that can effectively summarize a large amount of time series information. Hence more information can be included in the analysis without sacrificing any degree of freedom. This paper did not choose to use FVAR mainly for two reasons. First, even though FVAR allows the incorporation of more information, it is still uncertain exactly how many time series variables should be included to take into account all the factors that might affect the variables of interest. Secondly, FVAR is a comparatively new concept compared to the standard VAR. The setup of a standard VAR identification scheme that could identify the international effect of a monetary policy shock has already been tested by many researchers. Hence the standard VAR better serves the purpose for this research.

The two literatures that are the most closely related to my research on international transmission mechanism is by Kim (2001) and Canova (2005). Canova (2005) studied the responses of eight Latin American countries to a contractionary U.S. monetary policy shock. He found that the output level in Latin American countries increases due to the U.S. shock. This is due to a higher increase in interest rate in Latin American countries compared to the increase in the U.S. federal funds rate after the shock. This interest rate differential induces a capital inflow into the Latin American countries, which then stimulates an increase in total output and demand.

Kim (2001), on the other hand, studied the effect of a U.S. expansionary monetary policy shock on the other G-6, non-U.S. countries on an aggregate level. His conclusion is quite opposite to what Canova (2005) found. Kim found that an expansionary U.S. shock induces a positive spillover effect on the other countries. This is due to a decrease in the world real interest rate after the expansionary U.S. shock. One of the draw backs of Kim's study is that, he did not look at the responses at a country-level. The aggregate level response conceals many cross-country response differentials that might worth look deeper into.

As I have mentioned earlier, there is no literature that discusses the effect of a U.S. monetary policy shock on foreign sectoral output levels. However, there are a few literatures that study the heterogeneous responses of domestic sectoral output levels to a domestic monetary policy shock. For example, Ganley and Salmon (1997) studied responses of 24 sectors in the U.K. economy after an unexpected monetary tightening. They found that the construction sector shows a more significant and rapid decline in output than the other sectors, whereas the service sector shows a much more muted response. Hayo and Uhlenbork (1999) studied the responses of the industries within mining and manufacturing sectors in Germany. They found that, almost half of the industries response significantly differently to a contractionary U.S. monetary policy shock compared to their corresponding aggregate sector-

level responses. These empirical researches prove the heterogeneous responses from different sectors to a domestic policy shock, which suggests that there might be similar heterogeneous responses from domestic sectoral output levels to a foreign monetary policy shock.

3. VAR Model:

Since I study the fluctuations of international economic indicators given a U.S. monetary policy shock, the economic variables I choose to study is likely to affect each other both contemporaneously and with lags. Hence a VAR model is the most suitable to study the international transmission effect.

I assume that the international shock can be described by a structural VAR model as following:

$$Ay_t = B_1y_{t-1} + B_2y_{t-2} + \dots + B_p y_{t-p} + e_t$$

Where the main diagonal terms on A is 1. B_i are $k \times k$ matrices. (k denotes the number of variables). e_t is a $k \times 1$ matrix of the error term.

I assume that the error term has a mean of zero, and there is no correlation across time. What I am interested in is the covariance matrix of the error term, which indicates the effect of an external shock on the other variables. The covariance matrix can be calculated by:

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

In order to calculate Σ , I transform the structural VAR into a reduced form by multiplying both sides of the VAR equation by A^{-1} . I then end up with a reduced form VAR:

$$y_t = A^{-1}B_1y_{t-1} + A^{-1}B_2y_{t-2} + \dots + A^{-1}B_p y_{t-p} + A^{-1}e_t$$

The covariance matrix of the reduced VAR is:

$$\mu = E(A^{-1}e_t e_t' (A^{-1})') = A^{-1}\Sigma(A^{-1})'$$

The value for μ can be found using OLS method. In order to recover Σ , I follow the method proposed by Sim (1980) using Cholesky decomposition identification, where A^{-1} is assumed to be a lower triangle matrix:

$$A^{-1} = \begin{pmatrix} a_{11} & \cdots & 0 \\ a_{21} & \ddots & 0 \\ a_{31} & \cdots & a_{kk} \end{pmatrix}$$

By using this method to recover Σ , the order of the variables determines that the first variable I choose is only affected by some historical values and its own contemporaneous shock; the last variable is affected by some historical values and contemporaneous shocks from all the other variables; and the variables in between are affected by some historical values and the contemporaneous shocks from all the variables ordered before them.

4. VAR Identification scheme

Upon choosing the basic VAR identification scheme, I found that, when studying the international transmission mechanism of a U.S. shock, the measure of U.S. real activity, inflation rate, money supply, and the slope of term structure are very often included in the VAR model (Kim,2001; Sim,1980; Canova, 2005 and Betts and Devereux (1999), Bernanke and Gertler (1995)). Most researchers believe that these variables have high predictive power to the changes in the U.S. monetary policy. However, they are not the only variables that the U.S. federal government takes into consideration when making monetary policy changes. As I have mentioned before, the U.S. government takes into account hundreds of economic activity measures that it is unrealistic to include all of them into the VAR model. Moreover, the degree of freedom increases exponentially for each additional variable in the VAR model. As a result, having too many variables in a VAR model would reduce its predictive power.

In order to have a VAR model that could capture most of the effects on a U.S. monetary policy shock, at the same time conserve the degree of freedom and maintain the

precision of estimates, I choose to follow the model developed by Kim (2001). In his research, Kim experimented with various VAR models. I use the model with the least number of variables while giving similar responses as the other models with larger scales. I also modify the models to suit the purpose of my research.

In Kim's model, industrial production (IP), consumer price index (CPI), commodity price (PC) are assumed to have contemporaneous effects on the U.S. federal funds rate, and M1 is assumed to be contemporaneously affected by all the other variables. The ordering of his model is as following: {IP, CPI, PC, FFR, M1}. I dropped M1 from my model. Since in recent years, M1 plays an insignificant role in monetary policy formulation in the U.S. Dropping an unnecessary variable can help to increase the precision of my results. Moreover, I found that including M1 in the model does not change the final results, hence dropping it can increase the precision of estimation without sacrificing accuracy of the results.

In order to estimate the effect of a U.S. monetary policy shock on the foreign economy, I extend the basic VAR model to include foreign economic indicators. Each foreign variable is added into the basic VAR model one at a time. I assume that the U.S. monetary policy has a contemporaneous effect on foreign economic indicators. Kim (2001) also experimented with the assumptions that the U.S. monetary policy does not have a contemporaneous effect on the foreign variables. He obtained similar results from these two identifications.

The foreign board economic indicators I study include: interest rate, real GDP, exchange rate, export and import levels, inflation rate, and yield on 10-year government bond. The foreign sectoral output includes: output for agricultural, manufacture, construction, and service sector. All the variables are logged except for the interest rate. All the logged variables are also first-differenced to eliminate the unit-root problem (Based on Dicky-Fuller test). I did not impose a uniform number of lags for all the regressions. Instead, I find the

optimal number of lags for each regression based on Akaike information criteria. This method gives me a better forecast estimates than the other alternatives.

My VAR analysis consists of two parts. The first part is the analysis of the effect of a U.S. contractionary monetary policy shock on foreign economic indicators. I only study the period 1984-2007. Since the U.S. monetary policy act the most effectively during this period. The second part studies how the output in foreign agricultural, manufacture, construction and service sectors react to the shock. The countries I study are: Australia, France, Germany, Hungary, New Zealand, Uruguay, Finland, Greece, Canada, and Chile. Due to data shortage, I used all the available for this set of VAR analysis. Please see the Appendix A for more detailed description of data. I report the impulse responses for 30 periods with a 68% confidence level.

5. Regression Results and Transmission Mechanism

5.1 Economic Indicators

Based on Mushin(1995), there are two major channels through which an increase in the U.S. interest rate can affect the other countries: interest rate channel and trade balance channel. The interest rate channel works as following: Since the U.S. is a large, open economy, an increase in the U.S. interest rate might induce a world-wide interest rate increase. Consumers increase their spending through income effect if they are savors; however, they will reduce their spending if they are borrowers. Through substitution effect, all consumers will save their current spending until future periods because the relative price of consumption becomes more expensive in the current period. The current investment will also decrease due to higher opportunity cost. As a result, a contractionary U.S. monetary shock leads to a world-wide decrease in real GDP.

The trade balance channel, on the other hand, predicts opposite effects from a contractionary U.S. policy. If foreign countries maintain a fixed exchange rate, the government would respond instantaneously to a U.S. monetary shock to maintain the exchange rate level. As a result, the foreign economic indicators will not experience any observable effects. If foreign countries maintain a floating exchange rate, a relative increase in the U.S. interest rate will cause a depreciation in foreign currencies, which will deteriorate foreign countries' terms of trade and make their exports more competitive. As a result, demand for output in foreign countries will increase, which might cause an increase in price if supply could not react in time to an increase in demand. Import level in the foreign countries will also increase due to increase in demand.

I study the international transmission mechanism by first of all analyzing whether or not the interest rate channel is the major transmission channel. If it is, we should expect an immediate increase in foreign interest rate and a gradual decrease in foreign real GDP. Figure 1 shows the response of foreign interest rates for 30 periods given a contractionary U.S. monetary policy shock. Most countries experience an immediate boost in interest rate. Australia and Finland are the only countries that experience an immediate drop in interest rate. However, their interest rates either jump back to the zero level immediately (Australia), or gradually increase to positive level.

Figure 2 shows the response of foreign real GDP to a U.S. monetary policy shock. Most countries experience an immediate increase in real GDP compared to the previous year, and the increase last for several periods. Hungary, Germany and Chile are the only countries that experience a decrease in real GDP. However, for Hungary and Germany, the real GDP either increases back to the zero level quickly (Hungary), or increases significantly to a positive level (Germany). Chile is the only country that experiences a long-lasting negative GDP effect. Since the real GDP in most countries shows a significant improvement, this goes

against the prediction based on the interest rate channel. Hence, we can conclude that the interest rate channel is not the major transmission channel for a U.S. monetary policy shock.

Next, I look at whether or not the trade channel could explain the international transmission mechanism. Under fixed exchange rate regime and perfect capital mobility, we would expect the economic indicators to show either no change, or small changes that quickly go back to the zero level. As figures 2 shows, the real GDP level shows significant fluctuations for all countries except for Canada. This result matches my expectation, since none of the countries I study maintains a fixed exchange rate. Under flexible exchange rate and imperfect capital mobility, we should expect to see an increase in real GDP, a drop in foreign exchange rate against the U.S. dollar, and an increase in foreign export sector due to more competitive prices of foreign products. My analysis of real GDP based on figure 2 points out that most countries respond by an immediate significant GDP hike.

Figure 3 shows the response of foreign exchange rate against the U.S. dollars. Only 2 of the countries do not experience any significant effect on foreign exchange rate. For most countries, the effect is not only significantly positive, but also last for a long time. This result contradicts with what the trade balance channel predicts. Hence, the international monetary transmission mechanism does not work through the trade channel, either.

Due to exchange rate appreciation, it is then not surprising that the change in total export to the U.S. do not contribute to the total increase in foreign real GDP (See Appendix B for Impulse Response Graph). My next concern is whether the contractionary U.S. monetary policy shock could induce a depreciation of the foreign exchange rate against all the other countries; hence induce an increase in foreign GDP due to an increase in total export to the rest of the world. Figure 4 shows the response of foreign exchange rate against a weighted average of the world currency. Only two countries (Germany and Greece) show an immediate significant currency depreciation. Figure 5 shows the response of foreign export to

the rest of the world. Out of 10 countries, 4 countries experience a significant increase in export level. However, response of export quickly fades away. 5 of the countries shows a significant decrease in export level (including Germany and Greece). Hence, in general, there is no strong evidence that the change in foreign export level contributes to increase in foreign total GDP.

If the rise in foreign real GDP is not due to a better performance in foreign country's trade sector, then it is mostly likely that it is due to an increase in total domestic demand. If this is the case, we would expect an increase in foreign inflation rate and a possible increase in foreign import level.

Figure 6 shows the response of inflation rate in foreign countries. 4 out of 10 countries experience a significant increase in inflation rate. For the 4 countries that experience a decrease in inflation rate, Chile, France and New Zealand experience a gradual increase in inflation rate in the long run. Hence, a U.S. monetary shock would induce inflation in foreign countries in the short or long run. Moreover, the effect persists for a long period for most of the countries.

Figure 7 shows the response of foreign total imports. 6 out of 10 countries experience a significant increase in import level. Among the three countries whose import level decreases immediately after the shock, import levels in France and Greece increase to above zero level immediately after the drop, and the import level in Germany increases back to zero quickly. Hence, a U.S monetary contraction improves the import levels in most of the foreign countries.

Figure 6 and 7 together present a strong evidence that a U.S. policy shock induces a significant increase in total demand within most of the foreign countries. Since neither the trade balance channel nor the interest rate channel explains the international transmission mechanism, the question of which channel is at work still remains. In order to narrow down

the range of possible answers, we have enough evidence to reframe the original question into: how does a U.S. contractionary policy shock induce an increase in foreign aggregate demand.

Canova (2005) also found similar response from 8 Latin American countries after a contractionary U.S. monetary policy shock. He found an increase in Latin American interest rate that is greater in magnitude than the increase in the U.S. interest rate. As a result, Latin American countries experience positive capital inflows, which stimulates local aggregate demand after a two-quarter delay. Moreover, the inflow of capital is spent mainly on non-tradable goods and services. My next step is to look at whether the U.S. monetary policy shock also stimulates a similar capital inflow into the foreign countries I study.

Figure 7 shows the combined responses of U.S. federal funds rate and foreign interest rate after a U.S. monetary policy shock. We can see that the responses of foreign interest rate for most countries increase in magnitude. However, there is no strong evidence that the foreign interest rate increases at a higher magnitude than that of the U.S. Nonetheless, for most of the countries, their interest rate exceeds the U.S. interest rate after certain periods of time. The mechanism of the international transmission works as following: given that the U.S. is a big, open economy, the federal funds rate can be seen as the world interest rate. Given the appreciation of the foreign exchange rate in the long run, investors would expect the foreign interest rate to exceed the U.S. interest rate in the long run. This fulfills the uncovered interest rate parity condition. Given the expectation for future rise in interest rate, foreign countries will experience a capital inflow, which will stimulate local demand and total GDP.

Another evidence that shows investors' expectation on a long run increase in foreign interest rate is the rising yields of 10-year government bonds. Figure 9 shows the response of the yields of foreign 10-year government bonds after the U.S. monetary policy shock. Except for Greece and Hungary, all the other countries show an immediate rise in yield. Hence, we

can conclude that the increase in foreign output level is stimulated by a large capital inflow due to investors' expectation of a long-term interest rate rise.

I also looked at the importance of a U.S. monetary policy shock on the fluctuations in foreign economic variables. Table 1 presents forecast error variance decomposition for foreign interest rate, exchange rate against the U.S. dollar, import, export and inflation level for each of the foreign countries 20 months after the shock. The standard variation figures are presented in parenthesis. The U.S. shock does not seem to have strong influences over foreign import and export levels—a U.S. shock accounts for on average 2% of fluctuations in the import level and 1.4% in the export level.

On the other hand, a U.S. shock seems to account for a moderate amount of fluctuations in interest rate, foreign exchange rate, and inflation rate. On average, 10.41% of fluctuations in interest rate, 4.46% of fluctuations in exchange rate, and 6.31% of fluctuations in inflation are due to a U.S. shock. These figures show that U.S. shock is an important component in foreign economic fluctuations. Moreover, they also prove my analysis that the U.S. shock affects foreign countries through the world capital market, instead of the trade balance channel.

5.2 Sector Output

Except for the effect of a U.S. shock on the broad foreign economic indicators, I also explore the responses from each of the main economics sectors to a U.S. monetary shock. The four sectors that I study individually are: agricultural sector, manufacture sector, construction sector, and service sector. Figures 10-13 reports the impulse response graphs for each of the fluctuation in sectoral output for each country. In order to assist the comparison of fluctuations across sectors and countries, I summarize the results from the impulse response graphs in Table2. I choose to focus on the responses from the first 5 periods. The arrows in

Table 2 represents the direction of the most significant responses from each sector after a U.S. monetary shock. The percentage points represent an approximation of the magnitude of responses based on the impulse response graph, and the duration represents the number of quarters after which a U.S. monetary shock has no effect on foreign sectoral output.

Just by looking at the directions of arrows, we can see that most of the sectoral output levels respond positively to a contractionary U.S. monetary policy shock. This is expected, since the real GDP for most of the countries also increases. To analyze the direction and magnitude of effects in more detail, I look at the overall effects on direction, magnitude and duration on both cross-sector level and cross-country level.

The two channels that are most widely studied in explaining the effect of a monetary policy shock on different sectors of the domestic economy are interest rate channel and credit channel (Dedola and Lippi, 2000). The interest rate channel states that, a monetary policy contraction will trigger a decrease in both investment and consumption for durable goods. Hence, firms that are more capital intensive or produce mainly durable goods are more sensitive to a monetary policy contraction. The credit channel, on the other hand, sees firm's access to financial markets as critical to its vulnerability to a monetary policy shock. A firm with more difficulty in borrowing from the financial market are more sensitive to a shock. This corresponds to findings by Gertler and Gilchrist (1994), who found that output from small firms drop significantly more than that of big firms after an unexpected monetary policy contraction, since smaller firms face more credit constraints.

To analyze the cross-sector responses to a U.S. monetary policy shock, I started by analyzing whether or not the interest rate channel is the main channel through which the U.S. monetary shock transmits to foreign sectoral output levels. If it is, we would expect manufacture and construction sectors to exhibit the highest levels of responses—the same as findings by Ganley and Salmon (1997). Since these two sectors produce durable goods, and

are in general more capital intensive than the other sectors. However, by comparing sectoral responses for each country, we can see that in general, the agricultural sector respond the most significantly to a U.S. shock. Hence the interest rate channel does not explain the transmission mechanism. The credit channel seems to not at work, either. Since for most of the countries, government heavily subsidizes the agriculture sector. Which means the agriculture sector should have the least credit constraint. Hence it should be the least vulnerable under credit channel, which is opposite to what my result shows.

In terms of the cross-country reaction to the U.S. policy shock for each sector, we can see that there is clear heterogeneity. Yet, Dedoay and Lippi (2000) found that, given an unexpected monetary policy shock, the responses of each of the 21 manufacturing sectors in 5 OECD countries (France, Germany, Italy, the UK, and the U.S.) are similar. My results clearly contradict with their findings. Since there are also clear heterogeneous within-sector reactions between France and Germany.

In general, I cannot reconcile my results with what had been found by previous researchers. This might be due to the fact that all the existing literatures look at changes in sectoral output levels due to a domestic monetary policy shock. Even though a U.S. monetary policy shock induces similar changes in foreign interest rate, the channel through which the shock affect foreign sectoral output levels is different. There are two possible reasons to explain why the channels are different. First, a contractionary domestic monetary policy would cause a dampening effect on domestic output level. However, as is discussed in the previous section, an increase in domestic interest rate in response for a U.S. increase rate hike would stimulate domestic output level. Second, a contractionary domestic monetary policy discussed by existing literature is a response to an over-heated domestic economy. However, the increase in interest rate I discuss is a response to a U.S. monetary policy shock.

By comparing the heterogeneous responses at the cross-country level, it is clear that the increase in foreign total output after the U.S. shock affect the foreign sectoral output levels through the trade channel. This is not to say, however, that the net export sector is the driving force for the increase in foreign total output level. As I have discussed in the last section, there is no significant evidence which shows the export sector to play an important role. However, it is still possible that the export sector behaves differently among the 4 sectors of the economy, which result in a zero net export effect.

Among the countries I study, the main export product for Australia and Chile consists of raw material; the main export for France, Germany, Hungary, Finland, Greece, and Canada consists of manufacturing products such as machinery and automobiles, and the main export for New Zealand and Uruguay consists of agricultural products (globalEDGE). From Table 2, we can see that for countries whose main export is agricultural products, their agriculture output level decreases significantly. For all the countries whose main export is manufacturing products, their manufacture output level increases significantly. These heterogeneous responses might be due to the substitutability of the products. Since the agricultural products require low technology and is highly substitutable, when the foreign exchange rate appreciates, importers will quickly switch to other sources of agricultural products at lower prices. Hence the countries that depends heavily on export of agricultural products are the most vulnerable to a U.S. shock. The manufacture products, on the other hand, are much less substitutable because of the high level of technology involved. Given that a U.S. monetary contraction is very likely a policy response to an over-heated U.S. economy, as well as its subsequent stimulation of foreign total demand, it is reasonable that countries whose export sector depends heavily on manufacture products would experience an increase in total manufacture output level.

At the cross-sector level, we can see that the magnitude of responses to a U.S. contractionary policy shock is the most pronounced in the agricultural sector. Moreover, the duration of the responses is also the longest in the agricultural sector. This might be due to the fact that the agricultural sector is the most sensitive to a change in broad economic condition. The service sectors in all countries show a significant positive reaction. This might be due to the fact that the service sector is very demand elastic—as people’s wealth increases, they are more likely to increase their spending on products that could increase their life qualities.

I also analyze the importance of a U.S. monetary shock to the fluctuations in foreign sectoral output levels. Table 3 shows the error decomposition variance at the 10th quarter. For Canada and Chile, the decomposition variation for the 10th month is shown. Overall, a U.S. monetary shock has moderate effects on all the sectoral output levels in foreign countries. On average, it explains about 4.9% of the agricultural fluctuation, 6.684% of the manufacture fluctuation, 5.384% of the construction fluctuation, and 7.59% of the service fluctuation.

Overall, a U.S. contractionary monetary policy shock will, in general, induce significant positive changes in foreign sectoral output levels. The direction and magnitude of changes vary on cross-sector and cross-country levels. Due to the differences between a domestic and a foreign monetary policy shock, we cannot use the interest rate channel or the credit channel to explain the effect of a U.S. shock on foreign sectoral output levels. Nonetheless, I found that the trade channel plays an important role in cross-country response differences. The U.S. monetary policy has a significant negative effect on the foreign agricultural sector if the foreign country’s export depends heavily on agriculture. The U.S. shock has a significant positive effect on foreign manufacture sector if it is the main export product in a foreign country. On the cross-sector level, the U.S. shock induces the most

significant response from the agricultural sector, and the most muted response from the service sector. This is due to the volatility and demand characteristics among different sectors.

6. Conclusion

I used the VAR approach to study the international effects of a U.S. contractionary monetary policy shock. Overall, I find strong evidence that a U.S. policy shock stimulates significant fluctuations in foreign economies. My research is divided into two parts. In the first part, I study the international transmission mechanism of a U.S. policy shock. In the second part, I study the heterogeneous foreign sectoral responses to a U.S. monetary policy shock.

Based on my VAR results, I found that a U.S. shock induces an increase in total demand and output level in most of the foreign countries. Neither interest rate channel nor trade balance channel could explain the international transmission mechanism. Instead, there is strong evidence that the shock is transmitted through the world capital market—the U.S. shock induces an expectation of a rising foreign interest rate in the long run, which induces a significant capital inflow into the foreign countries. As a result, foreign total demand and output level also increases.

The U.S. shock also induces significant fluctuations in foreign sectoral output levels. I found cross-country and cross-sector differences in their responses to the U.S. shock. These differences cannot be explained by the transmission mechanism of a domestic shock studied by other researchers. Instead, based on my VAR results, the trade channel plays a significant role in the transmission process. It also explains some cross-country differences in responses. Looking at cross-sector level, the agricultural sector exhibits the most significant reactions, whereas the service sector exhibits the most muted reactions.

My research shows that, when making monetary policy decisions, the government cannot take into account the domestic economic situation only. Instead, it needs to consider the foreign economic situations and predict the movement of foreign monetary policy, especially in countries with large economic power, such as the U.S. Only by doing so, can the government form an optimal monetary policy for the well-being of domestic economy.

Reference

- Obstfeld, Maurice and Kenneth Rogoff (1995). "Exchange Rate Dynamics Redux," *Journal of Political Economy*, Vol. 103, No. 3 (Jun., 1995), pp. 624-660
- Svensson, Lars E.O. and Sweder van Wijnbergen (1987). "Excess Capacity, Monopolistic Competition and International Transmission of Monetary Disturbances," *National Bureau of Economics Research*, Working Paper No.2262
- Kim, Soyoung (2001). "International Transmission of U.S. Monetary Policy Shocks: Evidence from VAR's," *Journal of Monetary Economics*, Volume 48, Issue 2, Pages 339-372
- Canova, Fabio (2005). "The Transmission of U.S. Shocks to Latin America," *Journal of Applied Econometrics*, J. Appl. Econ. 20: 229-251
- Ganley, Joe and Chris Salmon (1997). "The Industrial Impact of Monetary Policy Shocks: Some Stylised Facts," *Bank of England*, ISSN 1368-5562
- Hayo, Bernd and Birgit Uhlenbrock (1999). "Industry effects of monetary policy in Germany," *ZEI working paper*, No. B 14-1999
- Dale, Spencer and Andrew G. Haldane (1995). "Interest Rates and the Channels of Monetary Transmission: Some Sectoral Estimates," *European Economic Review*, 39 (1995) 1611-1626
- Dedola, L. and F. Lippi (2000). "The Monetary Transmission Mechanism: Evidence from the Industries of Five OECD Countries," *Banca D'ITALIA*, number 389
- Gertler, Mark and Simon Gilchrist (1994). "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms," *The Quarterly Journal of Economics*, Vol. 109, No. 2 (May, 1994), pp. 309-340
- Betts, Caroline and Michael B. Devereux (1999). "The International Effects of Monetary and Fiscal Policy in British Columbia Vancouver, Canada, V6T 1Z1
- Mumtaz, Haroon and Paolo Surico (2009). "The Transmission of International Shocks: A Factor-Augmented VAR Approach," *Journal of Money, Credit and Banking*, Supplement to Vol. 41, No. 1 (February 2009)
- Bernanke, Ben S., Jean Boivin and Piotr Elias (2005). "Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach," *The Quarterly Journal of Economics*
- Sims, C.A. (1980). "Macroeconomics and Reality", *Econometrica*, 48 (1980), pp. 1-48
- Bernanke, Ben S and Mark Gertler (1995). "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *National Bureau of Economics Research*, Working Paper No.5146

Mishkin, Frederic S. (1995). "Symposium on the Monetary Transmission Mechanism"
The Journal of Economic Perspectives, Vol. 9, No. 4 (Autumn, 1995), pp. 3-10

International Business Knowledge. (n.d.). Retrieved May 05, 2017, from
<https://globaledge.msu.edu/>

Figure 1
Responses of foreign nominal interest rates

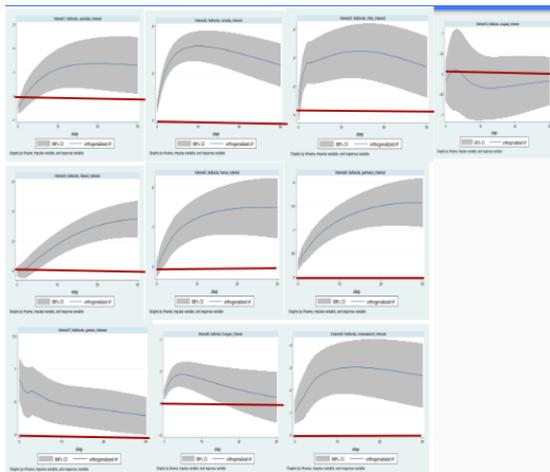


Figure 2
Responses of foreign real GDP

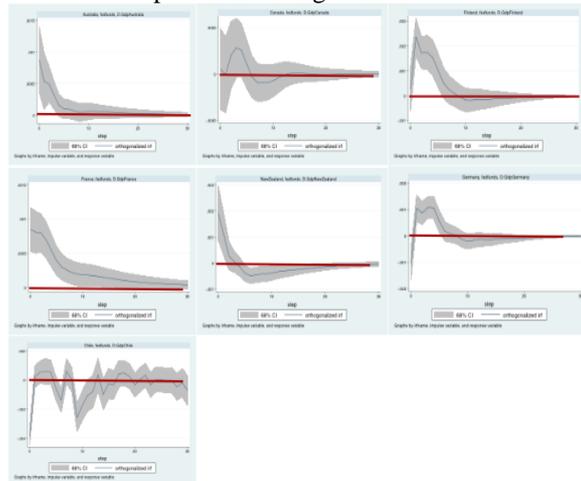


Figure 3
Responses of foreign exchange rate against the U.S.

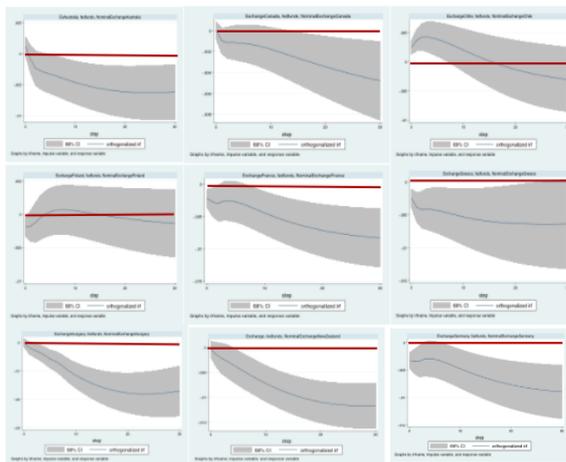


Figure 4
Responses of foreign exchange rate against the world

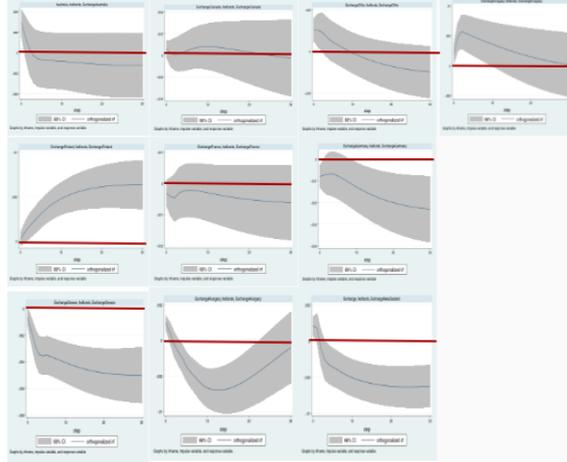


Figure 5
Responses of foreign exports



Figure 6
Responses of foreign inflation rate

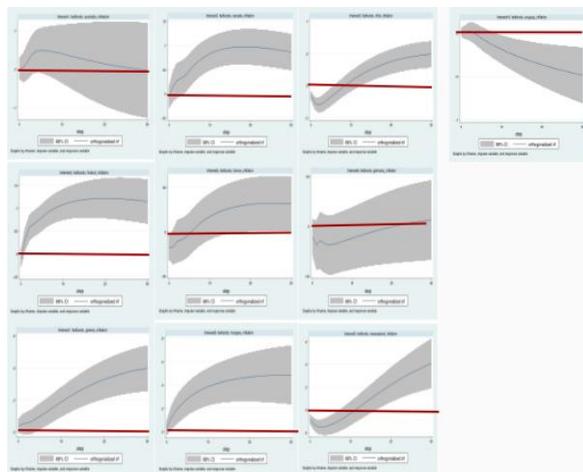


Figure 7
Responses of foreign imports



Figure 8
Responses of FFR and foreign nominal interest rates

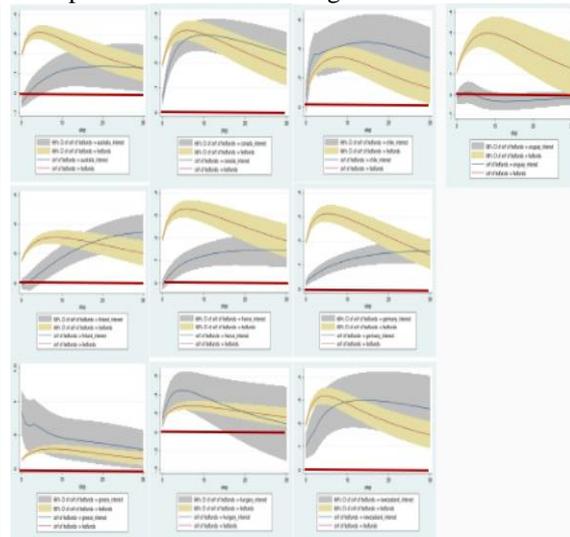


Figure 9
Responses of foreign 10-year government bonds

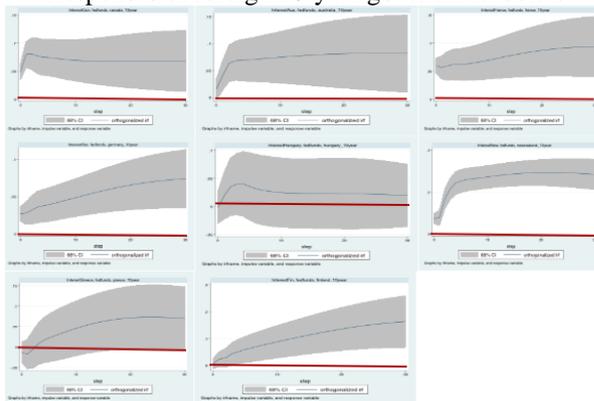


Figure 10
Agriculture output effect

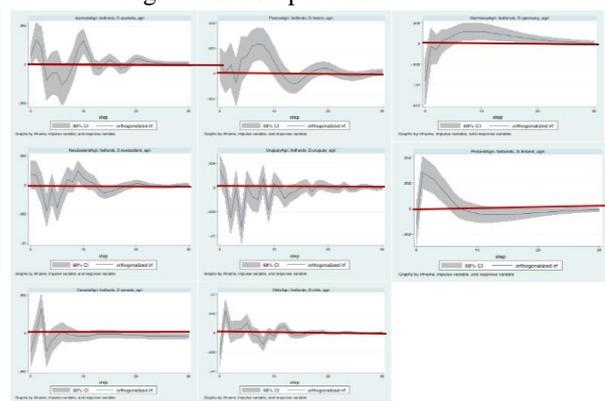


Figure 11
Manufacture output effect

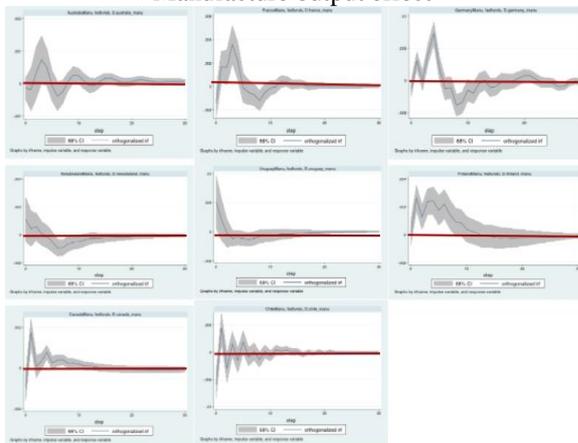


Figure 12
Construction output effect

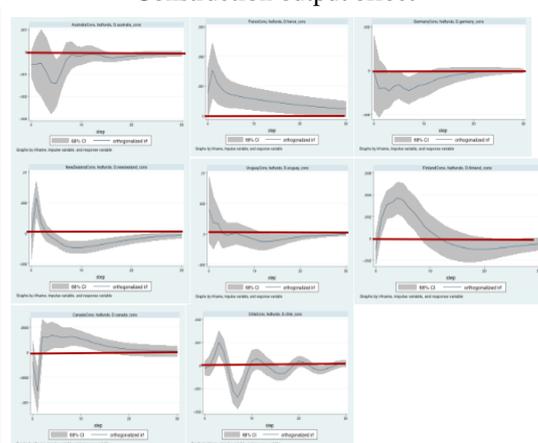


Figure 13
Service output effect



Table 1
FEDV for foreign economic indicators

Country	Steps	Interest Rate	GDP	Exchange Rate	Export	Import	Inflation
Australia	20 months	0.031(.045)	0.038(.033)	0.032(.042)	0.010(.009)	0.038(.020)	0.007(.025)
France	20 months	0.089(.069)	0.114(.063)	0.034(.043)	0.007(.010)	0.007(.008)	0.012(.023)
Germany	20 months	0.182(.079)	0.082(.046)	0.035(.044)	0.010(.013)	0.012(.013)	0.003(.010)
Hungary	20 months	0.081(.088)	0.049(.031)	0.180(.104)	0.037(.024)	0.034(.023)	0.077(.058)
New Zealand	20 months	.095(.071)	0.038(.031)	0.065(.054)	0.012(.013)	0.005(.005)	0.078(.045)
Uruguay	20 months	0.031(.066)	N/A	N/A	0.021(.020)	0.017(.017)	0.027(.039)
Finland	20 months	0.115(.081)	0.092(.057)	0.001(.001)	0.012(.012)	0.025(.017)	0.161(.091)
Greece	20 months	0.096(.086)	0.216(.088)	0.030(.043)	0.007(.007)	0.050(.024)	0.082(.066)
Canada	20 months	0.331(.099)	0.004(.010)	0.014(.028)	0.016(.013)	0.010(.012)	0.080(.061)
Chile	20 months	0.317(.186)	0.325(.088)	0.011(.016)	0.006(.009)	0.008(.005)	0.045(.033)
Average		13.67%	10.64%	4.46%	1.38%	2.04%	6.32%

Table 2
Foreign sectoral level responses

	Agriculture			Manufacture			Construction			Service		
	Direction	Reaction	Duration (quarter)	Direction	Reaction	Duration (quarter)	Direction	Reaction	Duration (quarter)	Direction	Reaction	Duration (quarter)
Australia	↑	0.25%	11	0	0	0	↓	-0.13%	8	0	0	0
France	↑	0.10%	10	↑	0.38%	9	↑	0.15%	22	↑	0.13%	5
Uruguay	↓	-0.56%	10	↑	0.50%	1	0	0	0	↑	0.40%	6
Finland	↑	0.29%	5	↑	0.26%	9	↑	0.38%	9	↑	0.17%	10
Canada	↑	0.16%	1	↑	0.17%	2.5	↓	-0.06%	3.75	↑	0.03%	7.5
Germany	↓	-0.80%	18	↑	0.55%	12	↓	-0.10%	11	↑	0.10%	10
New Zealand	↓	-0.40%	10	↓	-0.10%	9	↑	0.52%	3	0	0.00%	21
Chile	↑	0.55%	3	↓	-0.55%	1.75	↑	0.10%	2.25	↑	-0.09%	2.75
Greece	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hungary	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average duration			8.5			5.53125			7.375			7.78125

Table 3
FEDV for Foreign sectoral level responses

Country Name	Steps	Agriculture	Manufacture	Construction	Service
Australia	10 quarters	.024(.028)	0.010(.016)	0.015(.021)	0.000(.003)
France	10 quarters	0.027(.024)	0.056(.039)	0.036(.037)	0.123(.079)
Germany	10 quarters	0.035(.033)	0.213(.082)	0.018(.025)	0.198(.078)
Hungary	10 quarters	0.023(.026)	0.050(.039)	0.096(.067)	0.027(.035)
New Zealand	10 quarters	0.047(.040)	0.010(.011)	0.037(.025)	0.015(.020)
Uruguay	10 quarters	0.109(.057)	0.023(.028)	0.010(.019)	0.042(.064)
Finland	10 quarters	0.078(.060)	0.132(.091)	0.134(.097)	0.196(.107)
Greece	10 quarters	0.063(.055)	0.055(.043)	0.067(.043)	0.073(.062)
Canada	10 quarters	0.022(.014)	0.039(.024)	0.026(.019)	0.022(.014)
Chile	10 quarters	0.066(.040)	0.080(.051)	0.102(.064)	0.062(.036)
Average		4.92%	6.68%	5.38%	7.59%

Appendix A

Data

I use monthly data to test the effect of a U.S. monetary policy shock on foreign economic indicators. The U.S. monthly data include: U.S. industrial production, U.S. consumer price index, U.S. producer price index (to substitute for the commodity price), and the effective federal funds rate. All the data are obtained from the FRED. Except for the U.S. federal funds rate, all the data are seasonally adjusted.

For foreign economic indicators, the data from the International Financial Statistics are: foreign export, foreign import, and exchange rate against the world (real). The data from the FRED are: exchange rate against the U.S. (nominal), yield for 10-year government bond, and foreign real GDP. The data for foreign inflation rate and interest rates for most countries is from OECD Data. Due to data availability, PPI from the IMF Data is used in place of CPI for Uruguay and Australia. For New Zealand, the food price index from the New Zealand statistics website is used. For Uruguay, long term interest rate data from the European central bank is used.

I use quarterly data to test the effect of a U.S. monetary policy shock on foreign sectoral output levels. The U.S. data is the same set of data as the U.S. monthly data, except that they are adjusted to be quarterly data. The foreign sectoral output data are all from the official statistics website for each country. For Canada and Chile, monthly sectoral output data is used due to availability. The data is available upon request.

Appendix B

