International Spillover Effects of the Quantitative Easing Policy -An Examination of the U.S. and Japan with the TVP-VAR Approach-

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Abstract

Series of the U.S. quantitative easing policies, responding to the ongoing financial crisis and its aftermath, are reported to substantially modify the international capital flow and to significantly influence on the oversea asset prices and economies. Japan is among the heavily influenced economies so that its financial markets and policy authorities responded strongly to the changing crisis situations and the U.S. policy actions. We focus on the changing nature of the international spillovers between the U.S. and Japan. The credit contraction got deepened and eased in both economies. Several major financial institutions got bankrupted and/or rescued in the U.S. The Japanese exports declined rapidly, partially due to the disruption in the trade credit market, and recovered afterwards. Those events are considered to have caused the significant structural changes in the international and domestic financial flows, which in turn have caused variations in the inter-relationships among the macroeconomic variables. In order to grasp these variations, we adopt the time-varying-parameter estimation for the two-country VAR model, which includes both the real and financial sides of the two economies.

Keywords: U.S. quantitative easing policies, TVP-VAR, International spillovers effect

JEL classification: E44; E52; E58

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1 Introduction

Series of the U.S. monetary policy actions, its quantitative easing (QE) policies in particular, responding to the ongoing financial crisis and its aftermath stagnation are considered to substantially modify the international capital flow and to significantly influence on the oversea economies, asset prices, and so on. It is observed and reported that those policy actions have had large influences on the world economies and financial markets under the special conditions generated by the crisis.

Japan was heavily influenced by the world financial crisis originated in the U.S., though its financial institutions were relatively intact. Its export declined about 40% in the fourth quarter of 2008 and the first quarter of 2009 compared with a year earlier. This extreme decline was partially due to the disruption in the trade credit market. The Japanese banks stopped accepting the letter of credit issued by the U.S. banks for the U.S. importers, since many U.S. banks were in severe distress. This shock to its export-related industries was so large that the damage was propagated to its entire economy. Therefore, it was natural that the Japanese financial markets and policy authorities responded strongly to the changing crisis situations and the U.S. policy actions.

We focus on the changing nature of the international spillovers between the U.S. and Japan. The credit contraction got deepened and eased in both economies. Initially, the U.S. money market stopped functioning due the extremely high counter-party risks. Losing the short-term funding, major financial institutions were pushed to the edge in the U.S. so that some got bankrupted and others rescued: severe credit contraction followed. The Federal Reserve tried to inject funds to financial institutions through various instruments and initiated its QE policy in order to counter the credit crunch.

The Japanese export‘s rapid decline was mainly due to the disruption in the trade credit market. The Japanese banks avoided the counter-party risks by refusing to accept the letters of credit issued to the U.S. importers by the U.S. banks. Therefore, the U.S. policy actions to recover the U.S. financial institutions' soundness could help the trade credit and the Japanese exports.

Those events are considered to have caused the significant structural changes in the international and domestic financial flows, which in turn have caused variations in the inter-relationships among the macroeconomic variables of the two economies. In order to grasp these variations, we adopt the time-varying-parameter estimation to the two-country VAR model, which includes both the real and financial sides of the two economies. Ijiri(2016) , Ijiri(2017) and Ijiri and Matsubayashi(2019) showed that the policy effects of the Japanese QE has changed over time.

This paper is organized as follows. The next section briefly summarizes the U.S. and the Japanese QE policies. The third section surveys the preceding literatures and describes the estimation models. The fourth section reports the empirical results on the U.S. monetary base(MB) shock. The fifth section reports those on the Japanese MB shock. The final section concludes.

2 The U.S. and the Japanese QE

Both the U.S. Federal Reserve and the bank of Japan implemented the quantitative easing (QE) policies in response to the financial crisis and its aftermath. In this section, we briefly look at their policy actions as a preparation for the later discussion. Because we will utilize the TVP-VAR approach, we compare the sizes of impulse responses among the sub-periods of their QE policies.

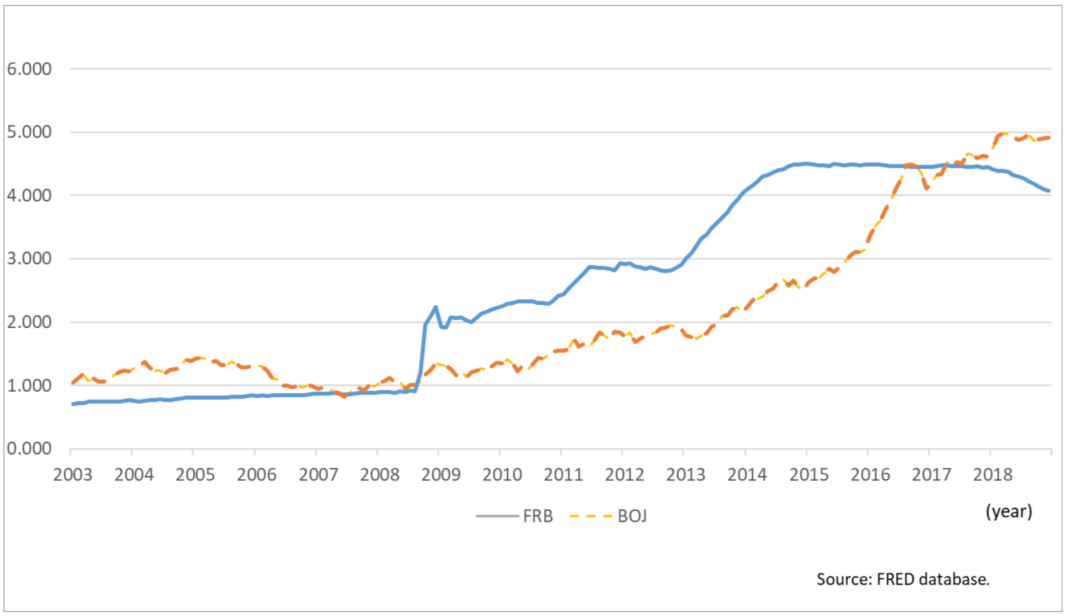

Figure 1: The asset sizes of the Federal Reserve System and the bank of Japan

2.1 The U.S. QE policy

In the first stage, midst the crisis around the fall of 2018, the Federal Reserve responded to the sudden stop situation in the domestic short-term financial markets by introducing the various liquidity facilities. Because the "shadow banking" institutions, which depended heavily on the short-term borrowing in the credit market, did not have access to its discount window, the Fed had to create these facilities. They called these operations as the credit easing. The amount of credit easing increased rapidly but then decreased as the crisis situation eased.

In the second stage, the Fed initiated the large-scale asset purchase, the quantitative easing (QE) policy, in order to support not only the financial markets but also the macroeconomic conditions. Its QE period, which is our sample period, is categorized into four sub periods according its policy operation regimes; QE1, QE2, Maturity Extension Program (MEP), and QE3.

The Fed started the QE1 by purchasing the mortgage-backed securities (MBS) and the Agency bonds in November 2008, then added purchasing the Treasury bonds, and continued this operation until June 2010. Shortly after, in the November 2010, it started the QE2 and purchased the long-term Treasury bonds in order mainly to raise the inflation until the June 2011. Inflation rebounded somewhat but the unemployment rate stayed in the high level so that the Fed introduced the MEP in the September 2011 and continued it until the December 2012. It tried to lower the long-term interest rate to stimulate the aggregate demand without raising inflation expectations. Before the end of the MEP, the Fed started the QE3 in the September 2012, by continuing the purchase of the Treasury bonds and adding the purchase of the MBS without the fixed target purchase amount. This " open end " framework was reported to influence the financial market highly and continued until the October 2014.

After the QE3, the asset size of the Fed was sustained at the same high level until the December 2017, by reinvesting the repayments of the matured securities. Its asset size was gradually decreased afterwards until recently. On the other hand, it started to raise the federal funds rate target gradually since

2.2 The Japanese QE policy

In Japan, BOJ implemented the QE policy, the large scale purchase of the Japanese Government bonds (JGB), in the early 2000s before the last world financial crisis. It exited from that first QE in the early 2006, shrank its asset size within several months, and started to raise the call rate target, its policy rate. However, facing the world financial crisis and the drastic GDP decline in the late 2008, Bank of Japan started to ease somewhat by utilizing the dollar-swap agreement with the U.S. Fed and by supplying the low-rate loan to banks with their business loans as collaterals.

Later in October 2010, just before the U.S. QE2, BOJ started the Comprehensive Monetary Easing (CME) policy, purchasing ETF, REIT, long-term JGB, and etc. Next, at the beginning of 2013, it introduced the inflation target, 2% CPI inflation. Finally, it initiated the Qualitative and Quantitative Easing (QQE) policy in April 2013; it announced to try attaining 2% inflation in 2 years by doubling the MB. It started to purchase the long-term JGBs in large amount.

It modified the QQE in 2017 by introducing the Negative Interest Rate Policy(NIRP). It started to reduce the amount of the asset purchase. In addition, responding to the criticism from the financial industries against the flattened yield curve, the BOJ modified its NIRP by adding the long-term interest rate target; it aimed at 0% on 10 years JGB rate. This is called the NIRP with yield curve control(YCC).

3 Literature survey and Model

3.1 Literature survey

In evaluating the spillover effects of the U.S. QE policy, many researches, like Georgiadis (2016), Chen et al. (2016) and Feldkircher and Huber (2016), have used Global VAR models. However, their researches have common weakness in assuming the stability of parameters over time. It is reasonable that many relationships among the important variables changed substantially in the crisis situations. Indeed, Ijiri (2016), Ijiri (2017), Ijiri and Matsubayashi (2019) show that the effects of monetary policy had changed significantly in the observation period including the world financial crisis. When examining the spillover effect of the US monetary policy after the Lehman shock, it is important to use the model that allows some structural changes.

Cuaresama et al. (2018) have developed a Time Varying Parameter (TVP) -GVAR model and applied it to examine the effects of U.S. monetary policy spillovers. Their model does allow that the effects of monetary policy change through time. However, their analysis has another deficiency that their data frequency, which is quarterly , is not appropriate in the crisis situation. After the Lehman shock, both the U.S. and Japanese central banks have introduced additional monetary easing policies one after another with only short intervals so that much information might be lost by using quarterly data. Therefore, in this research, we use TVP-VAR model and monthly data to examine the changing spillover effects of the monetary policies of the U.S. and Japanese central banks on each other's economy.

3.2 Model and Data

We employ the TVP-SVAR model in a manner similar to those adopted by Primiceri (2005), Nakajima (2011). The TVP-VAR system is given by

$$A_t z_t = C_{1t} z_{t-1} + C_{2t} z_{t-2}, \cdots, + C_{st} z_{t-s} + \epsilon_t \tag{1}$$

$$\epsilon_t \sim N(0, V_t), t = s+1, s+2, \cdots, T$$

where A_t and C_{it} are matrices of time-varying coefficients$(n \times n)(i = 1, 2, \cdots, s)$, C_t is a vector of economic variables$(n \times 1)$, ϵ_t is a vector of the fundamental structural shocks $(n \times 1)$, and V_t is a variance-covariance matrix $(n \times n)$[1]. Rewrite (1) as for reduced form as

$$z_t = B_{1t} z_{t-1} + B_{2t} z_{t-2}, \cdots, +B_{st} z_{t-s} + u_t \tag{2}$$
$$u_t \sim N(0, A_t^{-1} V_t A_t^{-1\prime}), t = s+1, s+2, \cdots, T$$

where $B_{it} = A_t^{-1} C_{it}$, and $u_t = A_t^{-1} \epsilon_t$. u_t is an error term vector $(n \times 1)$. Then, the variance of u_t was subjected to a Cholesky decomposition to impose recursive restriction;

$$A_t^{-1} V_t A_t^{-1\prime} = A_t^{-1} \Sigma_t \Sigma_t{}' A_t^{-1\prime} \tag{3}$$

where A_t is a lower triangular matrix in which the diagonal elements are equal to one, and Σ_t is the diagonal matrix[2]. Following impulse response analysis, Θ_t indicated identifying condition for each shock. Then,

$$z_t = Z_t \beta_t + A_t^{-1} \Sigma_t e_t \tag{4}$$
$$e_t \sim N(0, I_n)$$

where $\beta_t = vec[B_{1t}{}', \cdots, B_{st}{}']$, and $Z_t = I_s \otimes (z_{t-1}{}', z_{t-2}{}', \cdots, z_{t-s}{}')$[3]. Here, the lower triangular elements of β_t and the natural logarithm for diagonal elements of Σ_t were defined as $\alpha_t = (\alpha_{21,t}, \alpha_{31,t}, \alpha_{32,t}, \cdots, \alpha_{nn-1,t})'$ and $\sigma_t = (\sigma_{11,t}, \cdots, \sigma_{nn,t})'$, respectively. Then, the dynamics of these parameters are determined according to the random walk process:

$$\beta_{t+1} = \beta_t + u_t^{\beta} \tag{5}$$
$$\alpha_{t+1} = \alpha_t + u_t^{\alpha} \tag{6}$$
$$\sigma_{t+1} = \sigma_t + u_t^{\sigma} \tag{7}$$

Moreover, the error term vector of each of the variables is

$$\begin{pmatrix} u_t^{\beta} \\ u_t^{\alpha} \\ u_t^{\sigma} \end{pmatrix} \sim N\left(O, \begin{pmatrix} w_\beta & O & O \\ O & w_\alpha & O \\ O & O & w_\sigma \end{pmatrix} \right) \tag{8}$$

[1] A_t indicates the simultaneous relations among the economic variables.
[2] Σ_t is the time-varying SD matrix of ϵ_t.
[3] I is an identity matrix.

where it is assumed that $(w_\beta, w_\alpha, w_\sigma)$ are diagonal matrices[4].

In this paper, we focus on the impulse responses of the two countries' real and financial variables to the US MB shocks. Following Miyao and Okimoto (2017), we examine the results in the stock price model first, and then the exchange rate model. The stock price model includes US unemployment rate (UR^{US}), US MB (MB^{US}), Japanese stock price (S^{US}), Japanese MB (MB^{JP}) and the production index (Y^{JP}). The order is ($UR^{US}, M^{US}, S^{JP}, M^{JP}, Y^{JP}$). The exchange rate model includes US unemployment rate (UR^{US}), US MB (MB^{US}), yen-dollar rate (EX), Japanese MB (MB^{JP}) and the production index (Y^{JP}). The order is ($UR^{US}, M^{US}, EX, M^{JP}, Y^{JP}$). We used monthly data spanning January 2007 to September 2016[5].

4 Results 1: The responses to the U.S. MB shock

4.1 The Stock Price Model

Figure 2 shows the impulse responses to the US MB shock in the stock price model.

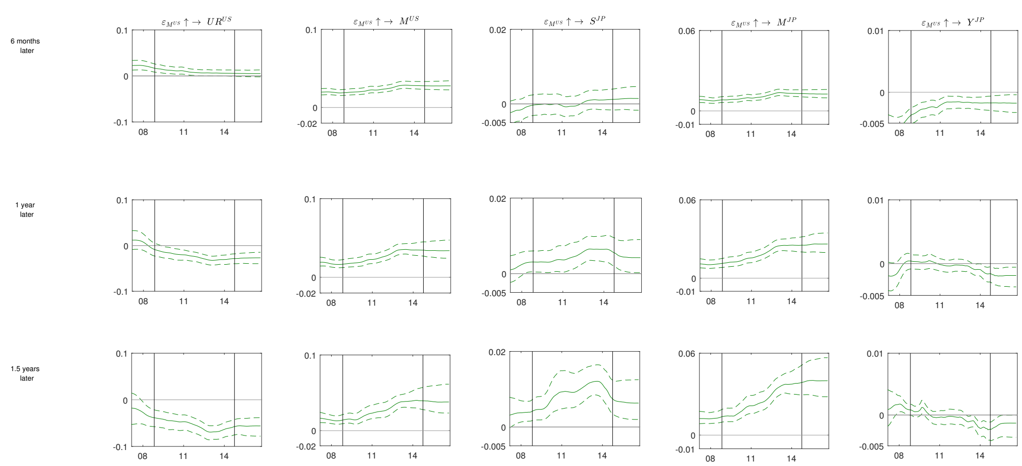

Figure 2: The impulse responses to the US MB shock in the stock-price model

Domestic variables respond mostly in the natural ways. The U.S. unemployment rate decreases significantly 1 and 1.5 years after its MB shock. The response size grows as time passes after the shock. The response size changes through the calendar time, too; it is larger in the later period of the U.S. QE; it is the largest during the QE3 period. This seems reasonable since, in the early period, MB increases largely

[4]The dimensions of w_β, w_θ, and w_σ are $(n^2s \times n^2s), ((n^2-n)/2 \times (n^2-n)/2)$, and $(n \times n)$.

[5]All data is sourced from Datastream. The data except UR^{US} are logarithm. All data are demeaned. The two models set two lags.

correspond to the injections of liquidity into the financial institutions facing the crisis and they might not stimulate the credit to finance the real business activities. As the U.S. financial institutions recovered their soundness in the later period, MB shocks could stimulate more credit expansion towards real activities.

The U.S. MB increases significantly 6 months, 1 year and 1.5 years after its MB shock. The response size largely grows as time passes after the U.S. MB shock; it would take some time to expand credits. However, it is noteworthy that the U.S. MB response did not grow with time in the QE1 period. It seems to reflect the fact that the injected funds just stay in the financial institutions. The response size of the U.S. MB also changes through the calendar time. It is larger in the later period of the U.S. QE and the largest in the QE3 period, too. It would reflect again that MB shocks started to stimulate more credit expansion as the recoveries of the U.S. financial institutions.

The Japanese stock price increases significantly 1 and 1.5 years after the U.S. MB shock. We should note that these are not the immediate market responses to the policy actions but the longer-run responses generated through the evolution of the macro-economy. The response size grows as time passes after the shock. In addition, the response size changes through the calendar time. It is again larger in the later period in the U.S. QE. It became larger in the QE2 period, stayed large in the MEP period, and became the largest in the QE3 period. It was well reported that the QE3's "open end" character strongly influenced financial markets.

The Japanese MB increases significantly 6 months, 1 and 1.5 years after the U.S. MB shock. Its response size grows as time passes after the shock. However, it did not grow much during the QE1 period as is the case of the U.S. MB responses. In addition, its response size also changes with the calendar time. It became larger through the QE periods and the largest in the QE3 period. The Japanese MB's response size is about 1 tenth of that of the US MB response at the peak.

The Japanese output response is significantly negative 6 months after the U.S. MB shock all through the observation period. It might reflect the influence through the depreciation of the U.S. dollar in the short run, as pointed out by Deckle and Hamada (2015). The size of its negative response shrinks as time passes after the shock in the QE1 and QE2 periods; it became significantly positive briefly in the QE1 period at 1.5 years after the shock. This might correspond to the results reported by Deckle and Hamada (2015); they argued that the expansions in US economy stimulate the imports from Japan in the longer run. In addition, it might reflect the recoveries of the Japanese exports due to the improvements in trade finance. However, even at 1.5 years after the shock, the Japanese output responses were insignificant during the QE2 and MEP periods. Moreover, its response became significantly negative in the late QE3 period, at 1 and 1.5 years after the U.S. MB shock[6].

4.2 The Exchange Rate Model

Let us examine the results depicted in Figure 3, which presents the impulse responses when the exchange rate, the yen-dollar rate, is used instead of stock prices. Using the exchange rate yields very similar response in the US variables, MB and unemployment rate. An exogenous increase in the MB again leads to lower unemployment rate at 1 and 1.5 years after the shock. It increased the U.S. MB, at 6 months, 1 year, and 1.5 years after the shock. In addition, the Japanese MB's response is quite significant and large, at 6 months, 1 year, and 1.5 years after the shock. Their response sizes change through the calendar time as in the stock price model; they became larger in the QE2 and MEP periods and the largest in the QE3 period.

The exchange rate's response is around zero and insignificant at 6 months after the U.S. MB shock. It should be noted again that this is not an immediate market response to the MB shock but rather a result of the macroeconomic evolution after the shock. Actually, the Japanese Yen appreciates significantly against the U.S. Dollar at 3 months after the US MB shock[7]. Afterword, at 1 year after the shock, the Yen depreciates significantly in the QE3 period; at 1.5 years later, it mostly depreciates significantly. In sum, the yen appreciates in response to the U.S. MB shock in the very short run but it depreciates in the longer run with the macroeconomic evolution including the Japanese MB responses. The Japanese Yen's depreciation size at 1.5 years after the U.S. MB shock has two peaks, a lower peak in the QE1 period and a higher peak in the QE3 period.

The Japanese output shrinks significantly at 6 months after the U.S. MB shock[8]. Its shrink size is the largest in the QE1 period and gets smaller through the QE2 period. However, after 1 year, that negative response mostly disappears. In particular, it responds positively in the QE1 period, though it is barely not significant. At 1.5 years after the shock, it becomes positive and significant in the QE1 period; but, it becomes insignificant in the QE2 and MEP periods and negative and significant in the late QE3 period.

In sum, the above results have shown the US MB shock has significant spillover effects onto the Japanese

[6] This does not accord with the result of Deckle and Hamada (2015), which estimated the fixed parameter model.

[7] The impulse response at 3 months after the shock is shown in the appendix.

[8] It is understandable when we look at the impulse response at 3 months later. At 3 months later, the Yen appreciate in response to the US MB expansion, which results in the decline in exports and output. See Figure 6 in appendix.

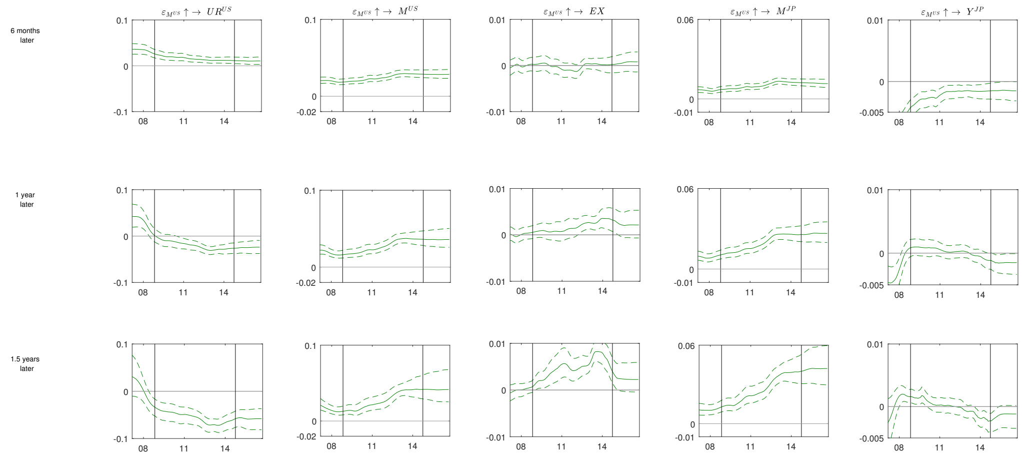

Figure 3: The impulse responses to the US MB shock in the exchange-rate model

financial market and its real economy as well as those of the U.S., with changing magnitude through the calendar time. Basically, the US MB shock's influences onto the U.S. and the Japanese financial markets are the largest in the QE3 period. Onto the real variables, its influence is the largest in the QE3 for the U.S., but in the QE1 for Japan. The last result might show that its influences onto the Japanese real economy is limited only during the crisis time.

5 Results 2: The impulse responses to the Japanese MB shock

In this section, we examine the impulse responses to the Japanese MB shock.

5.1 The Stock Price Model

Figure 4. impulse response to the Japanese MB shock in the stock price model.

The domestic variables respond to the Japanese MB shock in the reasonable ways. The Japanese MB increases significantly to the shock. Its response size grows slightly as time passes after the MB shock, though it did not grow much in the pre CME period. The response size changes with the calendar time. It is larger in the QQE period basically; it has a small peak in the early CME period, too. This may show that the financial institutions extended slightly more credit in the early CME and the QQE period.

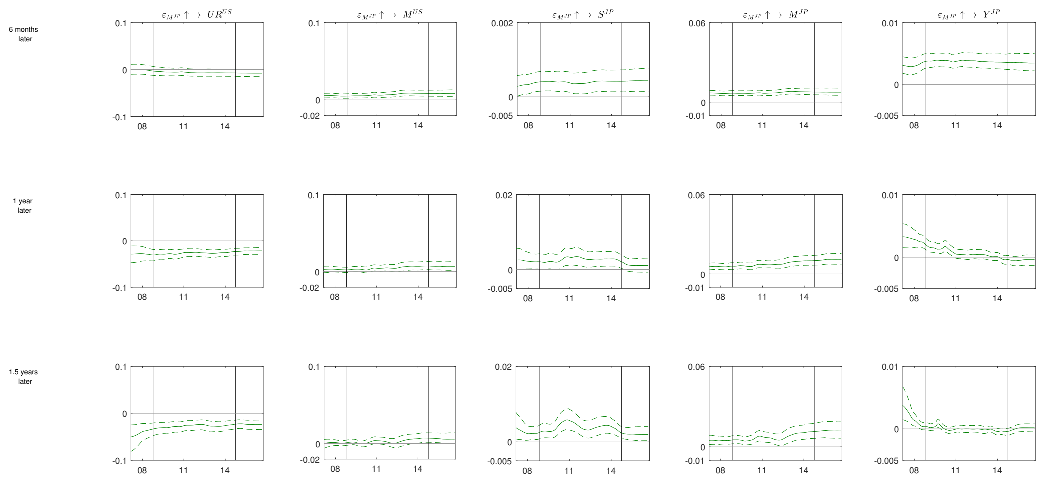

Figure 4: The impulse response to the Japanese MB shock in the stock price model

The Japanese stock price rises significantly in response to the Japanese MB shock, too. Unlike the cases in the other variables, the response sizes did not change monotonically as time passed after the shock. When we compare them at 6 months and 1 year after the shock, they are mostly comparable. At 1.5 years later, the response size has two peaks, a larger one in the CME and a smaller one in the QQE periods. The ETF purchase in the CME operations might have contributed the larger peak.

The Japanese output increases significantly 6 months after the MB shock all through the observation period. However, its response size decreases as time passed after the shock. It is still positive and largely significant in the pre CME and the CME periods but became not significant in the QQE period, at 1 and 1.5 years after the shock. In sum, the Japanese output response to the Japanese monetary policy shock has a standard hump-back shape so that it shrinks as time passes after the shock, except for the crisis time when its influence lasts longer.

The U.S. variables also respond in largely natural ways. The US unemployment rate response is not significant 6 months after the Japanese MB shock all through the observation period. However, it decreases significantly 1 and 1.5 years later. The response size is larger in the pre CME and the CME period.

The U.S. MB slightly but significantly increases to the Japanese MB shock at 6 months after the shock all through the observation period. Its response is still slightly positive and barely significant at 1 year after the shock. However, it is significant only in the early CME and the late QQE periods, at 1.5 years after the shock. When we look at the size variation over the calendar time, it tends to be larger in the QQE period; it also has small peak in the early CME period.

In sum, the Japanese MB shock does have the spillover effects onto the US financial markets and its economy with the changing magnitude over calendar time. It influenced more on to real variables in the Pre CME and the CME periods but on to the financial variables in its QQE period.

5.2 The Exchange Rate Model

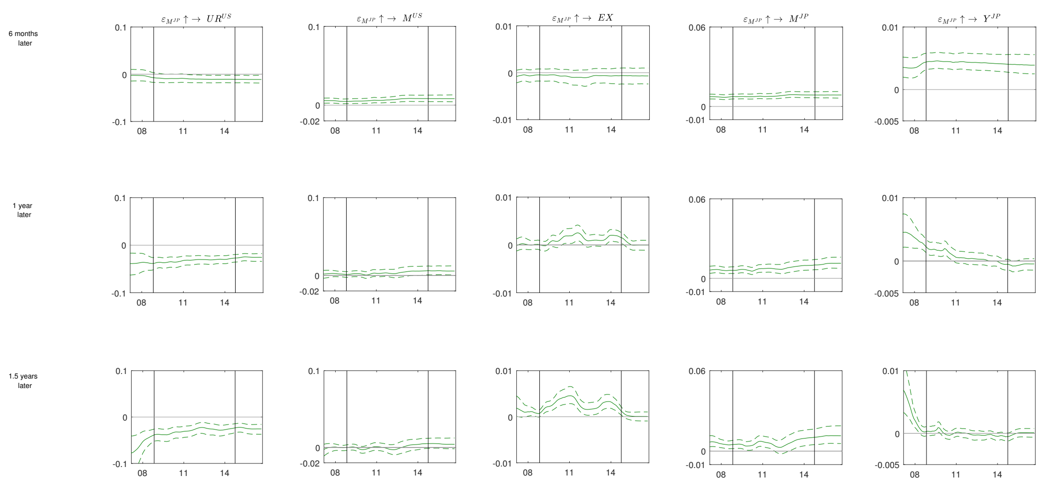

Figure 5: The impulse response to the Japanese MB shock in the exchange rate model

The domestic variables respond to the Japanese MB shock in the reasonable ways. The Japanese MB increases significantly to the shock. Its response size grows slightly as time passes after the MB shock, though it did not grow much in the pre CME period. The response size changes with the calendar time. It is larger in the QQE period basically; it has a small peak in the early CME period at the 1.5 years later, too. This may show that the financial institutions extended slightly more credit in the early CME and the QQE period.

The exchange rate response to the Japanese MB shock is around zero and insignificant mostly at 6 months later[9]. At 1 year and 1.5 years after the shock, the Yen depreciate against the Dollar significantly. The size of depreciation grows as time passes after the shock. It changes through calendar time also; it has two peaks,

[9] The three months impulse (Figure7) are in the appendix.

a larger one in the CME period and a smaller one in the QQE period.

The Japanese output responses are almost similar to those in the stock price model. It increases significantly at 6 months after the MB shock all through the observation period. However, its response size decreases as time passes after the shock. It is still positive and largely significant in the pre CME and the CME periods but becomes insignificant in the QQE period at 1 year after the shock. It becomes almost zero and insignificant at 1.5 years later, except for the pre CME period. In sum, the Japanese output response to the Japanese monetary policy shock has a standard hump-back shape so that it shrinks as time passes after the shock, except for the crisis time when its influence lasts longer.

The U.S. variables also respond in largely natural ways as in the stock price model. The US unemployment rate response is around zero and insignificant 6 months after the Japanese MB shock all through the observation period. However, it decreases significantly 1 and 1.5 years later. The response size is larger in the pre CME and the CME period.

The U.S. MB slightly but significantly increased to the Japanese MB shock 6 months after the shock all through the observation period. Its response was still slightly positive and barely significant only in the QQE period at 1 year after the shock. However, it became around zero and mostly insignificant at 1.5 years after the shock. When we look at the size variation over the calendar time, it tends to be larger in the QQE period.

In sum, both the stock price and the exchange rate models show the similar results. The Japanese MB shock has expansionary spillover effects onto the U.S. financial markets and its real economy as well as those of the Japan, with changing magnitude through the calendar time. The sizes of its influences on to the real economies and to the stock price/exchange rate are larger in the pre and early CME period while those on the two economies' MBs are larger in the QQE.

6 Conclude remark

We have estimated the two-economies macro VAR models with time varying parameters. The results have shown that the monetary expansion shocks of the two economies influenced both economies each other with changing magnitude during their quantitative easing periods.

The US MB shock has significant spillover effects onto the Japanese financial market and its real economy as well as those of the U.S., with changing magnitude through the calendar time. Basically, the US MB shock's influences onto the U.S. and the Japanese financial markets are the largest in the QE3 period. Onto the real variables, its influence is the largest in the QE3 for the U.S., but in the QE1 for Japan. The last result might show that its influences onto the Japanese real economy is limited only during the crisis time.

The Japanese MB shock has expansionary spillover effects onto the U.S. financial markets and its real economy as well as those of the Japan, with changing magnitude through the calendar time. The sizes of its influences on to the real economies and to the stock price/exchange rate are larger in the pre and early CME period while those on the two economies' MBs are larger in the QQE.

These results are robust since both the stock price and the exchange rate models show the similar results. However, the reasons for the changing magnitude are beyond the range of this paper's examination.

Appendix

Figure 6 shows the impulse responses of 3 months and 2 years after US MB shock in the exchange rate model.

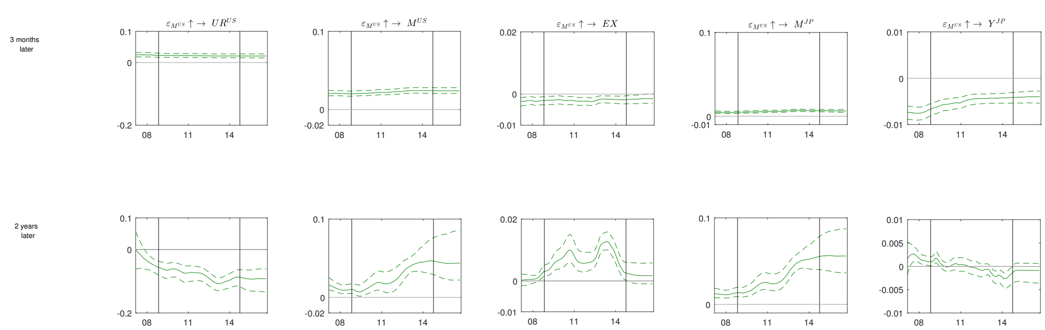

Figure 6: The impulse response to the US MB shock in the exchange rate model

Figure 7 shows the impulse responses of 3 months and 2 years after Japanese MB shock in the exchange rate model.

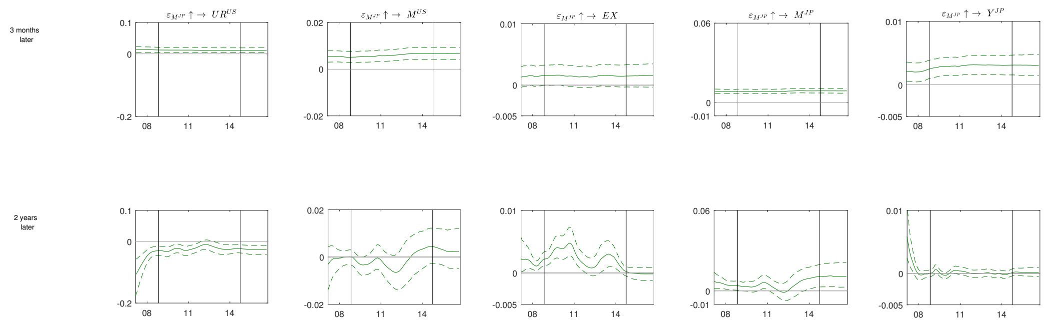

Figure 7: The impulse response to the Japanese MB shock in the exchange rate model

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