Japanese Monetary Policy and the Yen: Is there a “Currency War”?  

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Abstract

The Japanese currency has recently weakened past 100 yen to the dollar, leading to some criticism that Japan is engaging in a “currency war.” The reason for the recent depreciation of the yen is the expectation of higher inflation in Japan, owing to the rapid projected growth in Japanese base money, the sum of currency and commercial banking reserves at the Bank of Japan.

Hamada (1985) and Hamada and Okada (2009) among others argue that in general, the expansion of the money supply or the credible announcement of a higher inflation target does not necessarily constitute a “currency war”. We show through our empirical analysis that expansionary Japanese monetary policies have generally helped raise U.S. GDP, despite the appreciation of the dollar.

1 Introduction.

The Japanese currency has recently weakened past 100 yen to the dollar, leading to criticism that Japan is engaging in a “currency war.” The reason for the recent depreciation of the yen is the expectation of higher inflation in Japan, owing to the rapid projected growth in Japanese base money, the sum of currency and commercial banking reserves at the Bank of Japan. Hamada (1985) and Hamada and Okada (2009) among others argue that in general, the expansion of the money supply or the credible announcement of a higher inflation target does not necessarily constitute a “currency war”. Under a flexible exchange rate regime, national monetary policies are the basic determinant of exchange rates among nations. Hamada and Okada (2009) show in a two-country game that contrary to common belief, in this world money game under flexible rates, competitive devaluation that results from a monetary expansion does not lead the world into an undesirable disequilibrium. Their analysis is echoed in Korinek (2013) who argues in an application of the theory of the second best, that if there is an aggregate demand externality, say of insufficient demand, then the country suffering from that externality should enact policies to lessen the effects of that insufficient demand, such as an expansionary monetary policy that depreciates the exchange rate, even if that should mean than another country is hurt by its own appreciating currency.

The implications of the theories of Hamada (1985), Hamada (1976), Hamada and Okada (2009), and Korinek (2013) are clear. However, empirical work is necessary to see if in the case of Japan, the assumptions behind the theories hold true. That is, we should examine if expansionary monetary policies in Japan, whether in the form of a cut in short-term interest rates or an expansion of base money (currency plus reserves), indeed results in an increase in Japanese inflation rates or output. We show in our vector autoregressions that a cut in Japanese short-term interest rates do raise Japanese inflation, inflationary
expectations, and output, although the effects of an expansion in Japanese base money are less clear.

The pareto optimality criterion that justify unilateral exchange rate depreciations in Hamada (1985), Hamada and Okada (2009) and Korinek (2013) is, however, a bit narrow and limiting in real world international relations. This is because the pareto optimality criterion is silent about world income distribution, and that in the real world, an appreciating yen-dollar rate would hurt and upset the U.S., possibly damaging U.S.-Japan relations if continued. It would be much better if expansionary monetary policies in Japan are accompanied not only by a depreciating yen, but also expanding Japanese GDP and asset (equity and bond) prices. If the rising Japanese GDP and asset prices help raise U.S. GDP, then the U.S. will have less reason to get upset.

This argument is reminiscent of Eichengreen and Sachs (1985, 1986) who showed in theory as well as in historical fact, that the sequence of devaluations in the 1930s did not lead to the collapse of economies, but rather contributed to the recovery of nations. They argued that the reflationary policies of the 1930s led to recovery of domestic equity markets and economic growth, leading to positive spillover effects on other countries, helping the global economies recover. Thus, under some circumstances, governments should not refrain from continuing to ease the money supplies to stimulate the economy, since such easing, while they may depreciate the currency, may help increase the GDPs of partner countries.\footnote{See Cooper (1985) for a more formal analysis of this "positive spillover" case of national monetary policies, where a proposal is made for international monetary coordination.}

We show in our two country (U.S.-Japan) vector autoregressions that a cut in Japanese short-term interest rates, while depreciating the yen, will tend to raise Japanese GDP and asset prices. We show that the increase in Japanese GDP and asset prices will also tend to raise U.S. GDP. Thus, Japanese expansionary monetary policies should be welcomed by the U.S. We show in a multicountry VAR model (GVAR—Global VAR), however, that expansionary monetary policies in Japan will tend to hurt the GDPs of Japan’s smaller (non-China) neighbors.

In this paper, we are not claiming to do a serious empirical analysis of monetary interdependence in a two- or N-country world. For that, estimation of game-theoretic phenomena such as those used in modern structural industrial organization econometrics is required. Rather, our goal in our empirical work here is less ambitious, but broader. From the two country (say, U.S. and Japan) monetary analysis of the next Section and in the work by Eichengreen and Sachs (1985;1986), monetary expansion in Japan should be accompanied by an increase in Japanese GDP or asset prices, and such an expansion should be followed by some increase or at least not a decrease in real output in the U.S. It is well-known that the stability of VARs is constrained by regime shifts and changing expectations. It is usually very hard or fortuitous to obtain significant effects of say short term interest rate movements on inflation or real output
(Sims, 1992). We try to address these problems by estimating our model on different sub-samples, by including time dummy variables, and specifications. Still, given the limitations of our VAR analysis, we cannot make a strong claim that Japanese monetary expansion—especially that of base money—will directly increase GDP growth in the U.S. We can say that Japanese monetary expansion will tend to raise Japanese GDP and equity prices, and the increase in Japanese GDP and equity prices will help raise U.S. GDP. Thus, policies to expand Japanese GDP and equity prices that not only include monetary policies, but also fiscal and structural reform policies, may help raise U.S.

In the U.S., and particularly in Japan, recent monetary policy has been characterized by quantitative easing, which is to allow reserves held by depository institutions far above the required level, while keeping the policy rate close to zero. In our empirical analysis, such a regime is characterized by a near zero policy interest rate and high growth in base money. In principal, at interest rates near zero, the relationship between monetary policy and other variables such as the exchange rate become non-linear. Researchers have tried to handle such non-linear relationships using non-linear time series econometrics such as Markov-switching structural vector autoregressions. For example, in Japan, Fujiwara (2006), Inoue and Okimoto (2008), Kimura and Nakajima (2013) and Hayashi and Koeda (2013) find that the impulse response of inflation and output to the monetary base is positive. None of these authors examine the relationship between the expansion of base money in Japan and the exchange rate or real output in the U.S., the main focus of our paper. In our paper, we are mainly concerned with monetary spillovers between Japan and the U.S., from 1971 to 2013, so our time scope is longer than just the recent period of quantitative easing in the two countries.

In our time series work below, we are careful to estimate and put in dummy variables in Japan over different sub-periods. Since the post-2000 period is especially susceptible to the criticism that our estimates are biased due to the upward censoring of the short-term interest rate (because of the zero lower bounds reached in Japan and in the U.S.), in the Appendix, we depict impulse responses using only the sample from 1971 to 1999. We find that our main results in the body of our paper still hold: that an expansion in base money depreciates the Japanese exchange rate, and the expansion of the Japanese exchange rate is expansionary for Japanese output, and that an expansion of Japanese output in turn raises U.S. output.

Still overall, we are susceptible to criticism that our estimates are subject to the usual biases in linear vector autoregressions of structural change, shifting regimes and expectations, etc. However, we consider the use of non-linear time series econometrics as beyond the scope of the current paper for the following reasons. First, our short-term interest rate variable in Japan is the three month interest rate, not the call rate, which is the policy rate. The Japanese three-month interest rate never touches zero and has fluctuated up and down (albeit slightly) even during Japan’s quantitative easing period of the early 2000s. Second, impulse response functions that we use extensively in this paper are ill-defined in a non-linear econometrics framework (Hayashi and Koeda,
2013). And third, our model has many more variables than the three or four variables used in earlier studies, so our estimates will run into degrees of freedom problems, especially in maximum-likelihood estimation.

This paper is organized as follows. In the next Section, we present a simple graphical analysis of monetary interdependence in a two-country world, following Hamada (1985) and Hamada and Okada (2009). The third Section presents Vector Autoregressions of Japanese monetary policies, using data from 1970 to 2013. We run both non-structural and structural vector autoregressions for Japan; non-structural and structural vector autoregressions for a two-country model of Japan and the U.S.; and finally, a multicountry non-structural GVAR (Global Vector Autoregression) following DiMauro and Pesaran (2013). Section 4 concludes.

2 Monetary Interdependence in a Two-country World.

Let us introduce a classical world economy where the price levels of the two countries, Japan and U.S., are related by purchasing power parity. We assume full employment and flexible prices.

\[ P_J = e^* P_{U.S.} \]

where \( P_J \) is the price level of Japan, and \( P_{U.S.} \) is the price level of the U.S., and \( e \) is the yen dollar exchange rate. The purchasing power relation yields the exchange rate as proportional to the outstanding relative amounts of money (sometimes called the Soros-relation, although George Soros has denied to one of us, this attribution.)

\[ e = [M/M] * [Y/Y]. \]

The increase in the money supply of the home country will increase the domestic price level, and the increase in the money supply in the foreign country will depreciate the foreign currency.

That is, \( \Delta P_J = \Delta M_J - a \Delta M_{U.S.}; \quad \Delta P_{U.S.} = \Delta M_{U.S} - a \Delta M_J; \) and where we assume that the strength of the foreign monetary policy is not as strong as the domestic monetary policy, \( 0 < a < 1 \). We assume here the negative spillover of the foreign monetary policy on the home country. An expansionary monetary policy in the U.S. will lower the inflation rate in Japan, as the yen appreciates against the dollar.

The monetary authority is assumed to minimize the divergence between the actual inflation rate and the desired inflation rate. From the inflation equations above, we can then derive reaction curves for each country as each country minimizes a quadratic loss function with respect to its inflation rate (depicted in the middle graph, as in Hamada and Okada (2009)). Since \( a > 0 \), this is a case of strategic complements in game theory. The increase in home money will induce the increase of foreign money and vice versa. As each country pursues
its own inflation target, the system will converge to a stable ratio of money supplies and therefore a stable exchange rate (as long as $a<1$).

Let us compare the three cases of monetary interaction of the two countries, depending on the objectives of monetary policy. Our standard case is drawn in the second graph in the middle.

In Figure 0, we depict reaction curves in Japan and in the U.S. The three graphs in Figure 0 depict how Japan’s money supply will react, given the money supply in the U.S. and vice-versa. The objectives of Japan and the U.S. differ in the three graphs. In the top graph, the two countries pursue nominal exchange rate targets. In the middle graph, the two countries pursue their own home inflation targets. In the bottom graph, the two countries choose to pursue an inflation target in the other country, which admittedly is an unusual scenario.

The top graph depicts the reaction curves when each country pursues a different exchange rate. Here U.S. pursues a nominal exchange rate of 95 yen to the dollar, and Japan pursues a nominal exchange rate of 105 yen to the dollar. Given constant velocities of money in the two countries, the nominal exchange rate would be equal to the ratio of monies in Japan and in the U.S. The top graph shows that in this case, the exchange rate will zig-zag between 105 yen to the dollar, and 95 yen to the dollar, all the while raising the inflation rates in both countries, as money supplies expand.

In the middle graph, each country pursues a different home inflation target. Suppose as it is reasonable, Japan’s inflation rate is affected by more of its own monetary growth rate, rather than the monetary growth rate in the U.S.

In the third graph, Japan targets the inflation rate in the U.S., and the U.S. targets the inflation rate in Japan. In that case, the money supplies or the inflation rates either explode or goes to zero.

We can see that the world economy is stable as long as $0<a<1$. In fact, this condition of stability can be generalized to the $a>2$ case. The discussion on the stability of the Leontief system has the result that if the sum of the absolute values of the effects of a home country monetary expansion to other countries is in absolute value smaller than the effect on the home country, then the system is stable.

The above model assumes full-employment and fully flexible prices, so that monetary growth directly raises the inflation rate, and the ratio of monetary growth rates changes the exchange rate. As Hamada and Okada (2009) show, the analysis carries over to the sticky-price case when the target, rather than the inflation rate, is a point on Phillips curve. Then a country can choose to target a level of the inflation rate and unemployment (or output) together. In this case, when there is a negative spillover in monetary policies, $a>0$, an expansion in monetary policy say in the U.S., will raise unemployment for every given level of the inflation rate in Japan. Note that even when there are negative spillovers in monetary policies, $a>0$, as in the middle graph above, the independent pursuit of the optimal inflation-output tradeoff in each country would be pareto optimal.

In a modern treatment, Korinek (2013) shows that if prices are not flexible, there will be an aggregate demand externality. If the country facing this ag-
aggregate demand externality can remove the effects of this externality through expansionary monetary policy, then the world would move towards a pareto superior outcome. If this expansionary monetary policy happens to have negative spillovers on the other country, that is not of relevant concern. If the other country also has an aggregate demand externality, then that country just should engage in an expansionary monetary policy itself to remove that externality. As in Hamada and Okada (2009), there is no need for the two countries to coordinate their monetary policies.

The analysis in Hamada (1985), Hamada and Okada (2009), and Korinek (2013) implies that countries should independently pursue their monetary policies, and provided certain conditions, as in the middle graph of Figure 0, the actions of the two countries will result in pareto optimality, despite the fact that one country’s monetary policies may have negative externalities on the other country. However, as noted by Hamada and Okada (2009), the assumptions behind the middle graph of Figure 0 may not always be satisfied.

The incidence of the Lehman crisis and in particular, the effects of the drastic quantitative easing in the U.S. and in U.K. seem to suggest that the initial reaction of the monetary expansion under flexible rates is negative (in terms of GDP) on other countries. Otherwise, Japan would not have been driven into recession when the U.S. and the U.K. were expanding money drastically. The positive effect of a monetary expansion is likely to come later, as we see in the impulse responses below.

In particular, all of the graphs in Figure 0 including the middle graph assume that a more expansionary monetary policy in Japan can change the inflation rate in Japan, or with a Phillips curve, output and the inflation rate. Since 1998 until today, when Japan adopted its zero interest rate policy, Japanese monetary policy certainly weakened its grasp on the inflation rate and on output. However, the quantitative expansion of money can impact the economy, through the interest rate by way of an increase in Tobin’s q (by raising the stock market), by the credit accelerator effect, and the Soros effect. In this regard, the Chinese situation today may need more attention. If China reacts to its current subprime-like financial situation by expanding its monetary policy, then Japan may be affected negatively. Japan, however, may be able to undo such a negative impact by further expanding its money supply.

Hamada and Okada (2009) show that it is not necessary for these Japanese expansionary monetary policies to be pareto superior or that they increase output or inflation in the U.S. For these policies to be pareto superior, they just need to raise Japanese output or inflation. However, as noted by Eichengreen and Sachs (1985; 1986) if such policies raise Japanese output by lowering U.S. output, say through a depreciation of the yen, then Japan may be accused of "beggar-thy-neighbor" policies. It is far better for long-term U.S.-Japan relations if Japanese expansionary policies help raise U.S. output as well.

Below, we will run vector autoregressions to see if Japanese monetary policies have had any effect on Japanese inflation rate and GDP growth on average, using quarterly data from 1971 to 2013. We try to control for the various regime changes and expectatioal shifts by including time dummy variables and
estimating the model on various subsamples. We will also try to see if expansionary Japanese monetary policies have had positive spillovers on U.S. inflation or output, either through higher Japanese growth or asset prices.


In this paper, we empirically examine the impact of Japanese monetary policies through vector autoregressions. While it is by now well established that economies should be characterized by dynamic stochastic general equilibrium models, often such models build in either monetary neutrality (real business cycle models) or monetary effectiveness (New Keynesian models). In these highly structural models, there is little scope to examine whether or not Japanese monetary policy has been to able affect the real economies in Japan and the U.S. in the first place, since the result is already assumed. Moreover, there is yet to be developed, a well accepted quantitative model of monetary policies under the zero lower interest rate bound, or of quantitative easing by the central bank, which both the Bank of Japan and the Federal Reserve have recently engaged in. In this paper, we try to impose as little structure as possible to make the data speak, with regards to the effectiveness of Japanese monetary policies over the entire period of 1971-2013.

It is by now well known that it is difficult to uncover the properties of the underlying dynamic general equilibrium models through vector autoregressions (Chari, Kehoe, and McGratten, 2008; Christiano, Eichenbaum, and Vigfusson, 2006). Still, vector autoregressions can be useful in discerning regularities in the data (Fernandez-Villaverde, Rubio-Ramirez, Sargent, and Watson, 2007 ). We examine aggregate data from when the U.S. and Japan went off the Bretton Woods system—in 1971—to the recent start of "Abenomics," when Japan embarked on a massive increase in base money. While this 40 year period has been sparked by numerous regime, expectational, and structural changes, we try to (partially) capture these changes through the use of dummy variables, the estimation of the model on subperiods, and restrictions on the error term (in the so-called "structural vector autoregressions").

Figure 1 depicts the short-term nominal interest rates for Japan and for the U.S. For Japan, for short-term rates, we used the contracted 3-month interest rates on loans and discounts (available from the Bank of Japan). We use these data, rather than the data on overnight call rates, which are directly controlled by the Bank of Japan, because the call rates have had a zero lower bound between 2000 and 2006 and again from 2009 onwards. For the U.S., we use the Federal Funds rate as the short-term interest rate variable. For the U.S. the Federal Funds rate has been nearly zero since only 2009. Since the 1970s,

\(^2\)In empirical analysis of Japanese monetary policy since the late 1990s, it is common to use Japanese three-month treasury bill rate (Ueda, 2009).
U.S. short rates have almost always been higher than in Japan. Since 1996, Japanese short rates have been nearly zero, with a blip in rates 2006 when the first period of quantitative easing was dropped. Short-term interest rates were again brought to zero after the late 2000s financial crisis.

Figure 2 examines the relationship between the gap in U.S. and Japanese short-term nominal interest rates and the yen-dollar exchange rate. Interest rate parity suggests that when the gap is large, the yen should be depreciating (the line should be downward sloping), but we can hardly discern such pattern in this simple plot. This lack of a pattern is another example of the well-known failure of the short-term interest rate parity condition. That is, there appears to be no consistent relationship between U.S. and Japanese interest rate differentials and movements in the yen-dollar nominal exchange rate.

Figure 3 depicts the ratio of base money in the U.S. to base money in Japan, from 1971Q2 to 2013Q1. This ratio started to decline from the mid-1980s, showing the desire of the Bank of Japan to reflate the economy after the sharp appreciation of the yen after the Plaza Accord in 1985 (see Hamada and Okada, 2009). Starting at around 1990, the ratio of base monies sharply increased. This is a result of the relative tightening of monetary policy in Japan, as the Bank of Japan tried to burst the real estate bubble of the late 1980s and early 1990s. In the late 1990s, Japan embarked on the first of its quantitative easing programs, and the ratio of base monies declined; this was in spite of relatively loose money in the U.S. Starting in 2006, and then in 2009, the ratio of base monies rose at an unprecedented rate, the second rise owing to the series of quantitative easing programs adopted in the U.S. Very recently the ratio of base monies between Japan and the U.S. started to decline, as Japan sharply increased its base money supply under "Abenomics."

Figure 4 depicts the correlation between the ratios of base monies in the U.S. and in Japan with the nominal yen dollar rate. This figure is the so-called "Soros" diagram, a folk tale in the financial world. The upward tilt in the correlation between the yen-dollar rate and the ratio of base monies on the right hand side of the graph depicts the appreciation of the yen after the 1971 Bretton Woods float to about 1974. This was a movement towards yen-dollar purchasing parity (the yen was undervalued before 1971) after the post-Bretton Woods dollar float. The negative correlation between the ratio of base monies and the exchange rate on the left-hand side are from the post-2006 period. After the massive recent increases in the base money supply in the U.S., the yen sharply appreciated relative to the dollar. Overall, in Figure 4, there appears to be a negative relationship between the ratio of base monies and the yen-dollar exchange rate. That is, when the base money of Japan grows faster than the base money of the U.S., the yen tends to depreciate.\textsuperscript{3} We confirm this relationship between the expansion of base money and the depreciation of the currency in our impulse responses below.

Finally, Figure 5 shows the correlation between the Japanese actual CPI

\textsuperscript{3}This relationship between base money ratios and the exchange rate was first noted in the academic literature by Hamada and Okada (2010).
inflation rate and one-year ahead inflation expectations. The two series move surprisingly close together, although there is a persistent upward bias in household inflationary expectations. As shown in previous studies of Japanese inflationary expectations (Ueda, 2009), households in Japan appear to form their expectations based on actual inflation of goods that they purchase often such as food and electricity, which are impacted by imported food and energy prices. Households tend to see inflation rates as much higher than what they are actually. Still, we find that movements in actual and expected inflation are highly correlated, and that inflation expectations change more quickly than does realized inflation. The correlation between our measure of expected inflation and realized inflation is about 0.57 from 1971 to 2013, and the expected inflation rate leads realized inflation by two to three quarters. Through massive injections of base money and a depreciation of the yen-dollar nominal exchange rate, which should increase imported food and energy prices, "Abenomics" seeks to raise inflationary expectations and thereby actual inflation rates.

2.2 Japan: Non-structural Vector Autoregressions.

Here we estimate vector autoregressions using Japanese data. We run vector autoregressions on the output gap, one year ahead CPI inflation rate, the three month nominal interest rate, one year ahead CPI inflation rate forecast, log base money (currency plus reserves), and the nominal yen-dollar rate, from 1971 Q1 to 2013 Q2. We have also tried different sample periods such as starting the sample in 1980Q1 or 1990Q1. In terms of symbols: \{y^J_g, \pi^J, m^J, i^J, \pi^e, e\}. All vector autoregressions include the CPI inflation rate in energy and in food as an exogenous variable. Other vector autoregressions in addition include as exogenous variables, U.S. macroeconomic variables such as the U.S. output gap, the U.S. CPI inflation rate, and U.S. log base money. In most cases, starting the sample at a later date, or including the U.S. macroeconomic variables as exogenous conditioning variables did not make a difference in the pattern of impulse responses. In most cases, the monetary policy shocks—defined to be the unexplained fluctuations in nominal interest rates and in base money—are small, given that the VARs of the kind that we estimate have R-squared of above 0.95 for most of the equations (Boivin and Giannoni, 2002).

In all vector regressions, the optimal lag length was chosen to be two or three quarters by the Swartz criterion. In all cases, the roots of the vector regressions were shown to be within the unit circle, implying the stability of the regressions.

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4 Japan does not have a ready series of consumer inflationary expectations. Of the various surveys, the Consumer Confidence Survey collected by Bank of Japan, which began in 1971, covers the longest period. This survey is thus useful in conducting time-series analysis. A major limitation is that its information is qualitative, that is households are asked if future price changes are expected to be "lower" or "higher." Following Ueda (2009), we transform this information into quantitative information by using the method of Carlson and Parkin (1975). We thank Professor Kozo Ueda of Waseda University and formerly from the Bank of Japan to give us his EXCEL programs for converting the qualitative information in the Consumer Confidence Survey to quantitative information on inflation rates.
2.2.1 Impulse Responses.

Our first set of impulse responses (Figure 6) are based on the subset of variables: \( \{y^g_\text{J}, \pi^g_\text{J}, i^g_\text{J}, \pi^e_\text{J} \} \). While our interest is mostly in the impact of Japanese monetary policy variables on other macroeconomic variables, in these initial vector autoregressions, we depict the full array of the impulse responses. We focus on the generalized impulse responses of Pesaran and Shin (1999), so these responses are immune to the ordering of the variables in the vector autoregression.

The results generally accord with most accepted macroeconomic models. An output shock raises inflation, interest rates, and inflationary expectations, with the output effect on the rise in interest rates being persistent. An inflation shock initially raises output, then over time lowers output, but always raises nominal interest rates. An inflation shock unsurprisingly raises inflationary expectations. A positive interest rate shock initially raises the output gap, but soon, the output gap turns negative, as recession gradually sets in. Actual inflation rates decline with an increase in interest rates.

An increase in short term interest rates initially lowers inflationary expectations, but then inflationary expectations rise, suggesting that agents may be inferring from the rise in interest rates, that monetary authorities expect future inflation rates to be high. A shock to inflationary expectations initially raises output, but then causes a recession. Unsurprisingly, actual inflation and interest rates rise in response to a rise in inflationary expectations.

Our initial findings show that a tightening of Japanese interest rates results in a fall in actual inflation, while the link from a tightening monetary policy to a rise in inflationary expectations is more ambiguous. Our results are robust to different starting samples and also to the inclusion of exogenous U.S. macroeconomic variables.

We next depict impulse responses (Figure 7) when log base money is added to the initial set of variables: \( \{y^g_\text{J}, \pi^g_\text{J}, i^g_\text{J}, \pi^e_\text{J}, m^J_\text{J} \} \). We focus on the impact of shocks to the monetary variables, \( i^g_\text{J}, m^J_\text{J} \). The inclusion of log base money leaves unaffected, the effect of a positive interest rate shock on the output gap (positive) and actual inflation (negative). Now on impact, a positive shock to interest rates lowers inflationary expectations, which is what we expect. Unsurprisingly, a positive interest rate shock lowers the demand for base money.

However, the impulse responses of a positive shock to base money are the opposite of what are predicted in established models. Although the effects are small, a positive shock to base money lowers the output gap, the actual inflation rate, and inflationary expectations, and raises the short-term interest rate. Over time, the output gap tends to rise, suggesting that expansionary monetary policy takes time to work. These results are robust to different sample starting dates and to the inclusion of exogenous U.S. macroeconomic variables as conditioning variables.

Our third set of impulse responses (Figure 8) depict the results including the nominal yen-dollar exchange rate into the vector autoregressions: \( \{y^g_\text{J}, \pi^g_\text{J}, i^g_\text{J}, \pi^e_\text{J}, m^J_\text{J}, e \} \). Unlike the earlier results, the results here are sensitive to the inclusion of exogenous U.S. macroeconomic variables that are assumed to be exogenous to
Japan. Without the U.S. variables, a shock to interest rates has the same effects on \( y^d, \pi^d, i^d, \pi^e \). As is many other findings in the literature, a positive shock to interest rates has a tendency to depreciate the Japanese exchange rate (because of the failure of uncovered interest rate parity). Importantly, when the yen-dollar rate is included in the VAR system, a rise in Japanese short term interest rates lowers the output gap. A positive shock to base money also has the counterintuitive effects on the output gap and on the inflation rate as in the impulse responses above. A positive shock to base money depreciates the yen-dollar exchange rate, which accords with intuition.

Finally, a shock to the nominal yen-dollar rate tends to slightly raise the output gap on impact, raise the actual and expected inflation rates, log base money, and the interest rate over time. The expansionary effects of the depreciation of the exchange rate accord with most conventional models. When U.S. macroeconomic conditioning variables are included, a positive shock to base money keeps the yen-dollar exchange rate the same.

To summarize, we have shown through non-structural VARs that a positive shock to Japanese interest rates lowers the Japanese output gap (which is counterintuitive), actual inflation rates, and base money supply, but over time tends to raise inflationary expectations and depreciate the nominal yen-dollar rate. A shock to base money lowers the output gap initially, but over time the output gap rises. Expansionary base money policies thus appear to take a while to work. The impact of a positive base money shock on inflation and inflationary expectations are negative or small. A shock to base money either keeps the yen constant or depreciates the yen, depending on whether U.S. exogenous conditioning variables are included in the VARs.

### 2.3 Structural Vector Autoregressions and Impulse Responses.

Given the ambiguous effects of the monetary variables above, of both the short term interest rates and of base money supplies on Japanese macroeconomic outcomes, here we construct structural vector autoregressions and run impulse responses based on these new autoregressions. Structural vector autoregressions place restrictions derived from macroeconomic theory, on which variables appear contemporaneously in affecting other variables. Examples of structural vector autoregressions examining the role of monetary policy variables in the U.S. are Sims and Zha (2006) and Eichenbaum, Evans, and Vigfussen (2006). Kim (1999) and Kim and Roubini (2000) examine the role of monetary policy variables including the exchange rate in non-U.S. G-7 economies. Some of this earlier work has found that the strange results as above in the impulse responses of say, a shock to the short term interest rate on exchange and inflation rates disappear when more structure is placed on the error terms. We include the Japanese inflation rate on food and energy and the U.S. macroeconomic variables above as exogenous conditioning variables. Starting our sample from 1970Q1
instead of 1980Q1 or 1990Q1 do not qualitatively affect our results, although, quantitatively, the impact of monetary variables (short-term interest rates, base money) are higher when we start the sample from 1990Q1.

In our first set of findings, we impose the structure:

\[ y_J^g = A_1 X_{t-i} + u_g \]
\[ \pi_J^g = A_2 X_{t-i} + u_{\pi,ij} \]
\[ i^j = a_1 y_J^g + a_2 \pi_J^g + A_3 X_{t-i} + u_{ij} \]
\[ \pi^e = a_3 y_J^g + a_4 \pi_J^g + a_5 i^j + A_4 X_{t-i} + u_{\pi^e} \] (1)

In the system above, \( X_{t-i} \)is a vector of the four variables (lagged). The output gap and the inflation rate are assumed to depend only on lagged variables (of all the variables, as in the nonstructural VARs above). As far as the setting of the nominal interest rate, we assume a traditional Taylor-type equation, the Bank of Japan is assumed to set the interest rate, observing the contemporaneous output gap and inflationary expectations. Finally, we assume that inflationary expectations depend contemporaneously on all the variables.

Figure 9a depicts the impulse responses from the structural VAR system (1). In response to an output shock, actual inflation, interest rates, and inflationary expectations increase. In response to an inflation shock, the output gap slightly falls, and interest rates and inflationary expectations increase. In response to a shock to short-term interest rates, the output gap slightly increases in the short-run and then declines as recession sets in. The actual inflation rate falls in response to a rise in interest rates on impact then returns to its origin. Inflationary expectations decline, then rises in response to an increase in interest rate shocks. In response to shock to inflationary expectations, the output gap slightly rises, actual inflation rises, and short-term interest rates rise, as the Bank of Japan contracts respond to an increase in inflation expectations.

We next add the (log) base money demand equation to (1). In the structural VAR literature, it is common to introduce the demand for money as depending on the nominal interest rate and on output (gap) (Kim(1999)):

\[ m_s = a_6 y_J^g + a_7 i^j + A_5 X_{t-i} + u_m \] (1)'

Figure 9b depicts the impulse responses from the structural VAR system (1)'. Now in response to an interest rate shock, the output gap initially rises as before, but in eight quarters, turns negative, reflecting the delayed response of output to a rise in interest rates. The actual inflation rate turns positive on impact, but then starts declining to turn negative. Inflationary expectations
responds quicker and behaves the same way as the actual inflation rate, first increasing and then decreasing to fall below its original level. The immediate rise in inflation rates is a manifestation of the well-known "price puzzle" in vector autoregression (Sims 1992).

In response to a positive shock to Japanese base money, the output gap is relatively flat, but actual and expected inflation initially increase and then fall back towards zero. Thus, a positive monetary shock has a positive effect on inflation, although the effects are not persistent. The short-term interest rate initially rises in response to a positive base money shock, but then declines to fall below its original level. This initial increase in the short-term interest rate in response to a money shock is the well-known "liquidity puzzle" in vector autoregressions. In sum, our structural vector autoregressions with base money suggest that while a positive base money shock has essentially little effect on the output gap, the money shock tends to increase Japanese inflation and inflationary expectations rates in the short-run.

Finally, we add (log) nominal exchange rates to the VAR system (1)', with the following restrictions:

\[ (1)'' \]

and

\[ e_t = a_9 y_t^J + a_{10} \pi_t^J + a_{11} m_s^J + A_6 X_{t-i} + u_e \]  

That is, nominal exchange rates are assumed to depend on output gap, the inflation rate, and (log) base money supply. Figure 9b also depicts the VAR system (1)". A positive shock (depreciation) of the yen-dollar nominal exchange rate raises the output gap, actual inflation, and the Japanese nominal interest rate. Thus, a depreciation of the Japanese nominal exchange rate is highly expansionary for Japan.

A shock to the output gap, surprisingly, appreciates the nominal exchange rate; while shocks to the inflation rate and nominal interest rates do not affect the nominal exchange rate. A shock to inflationary expectations and to Japanese base money supply depreciates the nominal yen-dollar exchange rate, consistent with most models. Thus, the effect of the yen-dollar nominal exchange on Japanese macroeconomic variables appears to accord with accepted theory; the yen depreciation expands the economy and raises actual inflation rates. In turn, in our structural VARs, an expansion in Japanese base money tends to depreciate the yen.

2.4 Inclusion of Time Dummies, the Stock Market, and Long term Interest Rates.

In addition to depreciating the nominal exchange rate, the expansion of base money can expand the economy by raising stock market prices and lowering long term interest rates. One key result and perhaps even intent of the recent
The expansion of base money in Japan is the simultaneous rise in the Japanese stock market. In addition, the expansion of base money is also targeted to help reduce long-term interest rates, but here the evidence is less clear, as long-term interest rates have not decreased since the post-2012 base money expansion. Below, we examine impulse responses from non-structural vector autoregressions that include in addition, the stock market values and the long term interest rates in Japan. The long term interest rate in Japan is 10-year government bond interest rate, the value of the stock markets is the log of the TOPIX index. We also include time dummies to capture the effects of changing monetary regimes. We include time dummies for the 1980s, 1990s, 2000-2008, and 2009 onwards and the Japanese CPI on food and energy as exogenous regressors, that is, \( \{y^J, \pi^J, i^J, \pi^e, m^J, e, s^J, i^l/J\} \), where \( s^J \) is the value of the Japanese stock market, and \( i^l/J \) is the Japanese long-term interest rate.

Figures 10a and 10b depict the results. The Figures show that both a cut in short term interest rates or an expansion in base money supply raises stock market values on impact, with the rise in base money having longer lasting effects on equity prices. Stimulative monetary policy in the form of a cut in short term interest rates sharply lowers long term interest rates, but a rise in base money supply actually raises long term interest rates. This latter result is perhaps because a rise in base money raises inflation and inflationary expectations, leading to a rise in long term interest rates. Figure 10b shows that the output gap increases when there is an increase in stock market values and, surprisingly, a rise in long-term interest rates. A rise in stock market values appear to raise actual inflation rates in the short-run and expected inflation rates over a longer period. Inflation rates and inflationary expectations both appear to increase with shocks to long term interest rates.

Thus, it appears that in Japan, expansionary monetary policies that attempt to lower long-term interest rates have perverse effects on output, but monetary policies that raise stock market values appear to reliably raise output. Japanese long rates are strongly influenced by actual and especially, expected inflation rates in the country. Thus, expansionary monetary policies that raise inflationary expectations tend to raise long term interest rates and output at the same time.

3 Impact of Japanese Monetary Policy Variables on the U.S. Economy.

3.1 Non-structural Vector Autoregressions.

As argued above, the expansion of Japanese monetary policy is likely to result in a better outcome for both Japan and the U.S. in the real world if the increase in Japanese output results in an increase in U.S. output, and the depreciation of the yen results in a negligible decline in U.S. output. Here we present non-structural vector autoregressions including both Japanese and U.S. variables.
We examine the variables \( \{y^u, \pi^u, m^u, i^u, e, y^j, m^j, \pi^j, e^j, i^j\} \). We focus on the impact of Japanese monetary variables and the yen-dollar nominal exchange rate on U.S. The Swartz criterion gives the optimal lag length at two, and all roots were found to be within the unit circle.

Our findings are that with regards to U.S. output, an increase in the Japanese output gap sharply raises the U.S. output gap (Figures 11 and 12). Thus, any Japanese policy measure—including monetary policy measures—that raises Japanese output will likely raise U.S. output. A positive nominal interest rate shock to Japan lowers U.S. output over the medium run. Counterintuitively, a positive shock to Japanese base money slightly lowers U.S. output on impact, and a depreciation of the yen initially raises U.S. output and then over time lowers U.S. output. For U.S. inflation, a positive shock to the Japanese output gap, base money; and the depreciation of the yen-dollar nominal exchange rate all as expected, raise the U.S. inflation rate. To summarize, our vector autoregressions suggest that policies that raise Japanese output will raise U.S. output, while a yen depreciation appears to lower U.S. output somewhat over time.

### 3.2 U.S.-Japan Structural Vector Autoregressions.

For our structural vector autoregressions, we impose the structure:

\[
\begin{align*}
y^u &= A_1 X_{t-i} + u^y^u \\
\pi^u &= A_2 X_{t-i} + u_\pi \\
i^u &= a_1 y^u + a_2 \pi^u + A_3 X_{t-i} + u^i^u \\
m^u &= a_3 y^u + a_4 i^u + A_4 X_{t-i} + u^m^u \\
y^j &= A_5 X_{t-i} + u^y^j \\
i^j &= a_5 y^j + a_6 \pi^j + a_7 q + A_6 X_{t-i} + u^i^j \\
m^j &= a_8 y^j + a_9 i^j + A_7 X_{t-i} + u^m^j \\
e &= a_{10} y^u + a_{11} y^j + a_{12} m^u + a_{13} m^j + u_e
\end{align*}
\]

To keep adequate degrees of freedom for the estimation, we exclude Japanese inflationary expectations. As before, we assume that the output gap (both for the U.S. and Japan), and the U.S. inflation rate depend only on past values of all the variables. The U.S. equation for the setting of the Federal Funds rate is assumed to depend only on the U.S. output gap and the U.S. inflation rate. The demand for U.S. base money is assumed to depend on the U.S. output gap and the U.S. Federal Funds rate; and the setting of the Japanese short-term interest rate is assumed to depend on the Japanese output gap, the U.S. inflation rate, and the yen-dollar nominal exchange rate. Japanese base money demand is assumed to depend on the Japanese output gap and the Japanese short-term interest rate. The log nominal yen-dollar exchange rate is assumed to depend on the output gaps of the U.S. and Japan and the base monies of the U.S. and Japan.

---

\(^{5}\text{We exclude inflationary expectations for the U.S. since our time series of U.S. inflationary expectations do not extend back into the 1970s.}\)
Figures 13a and 13b depict the impulse responses from our 8 variable structural VAR system. A shock to the Japanese output gap on impulse raises the U.S. output gap. The shocks on the output gaps, however, are asymmetric. A shock to the U.S. output gap has a much larger effect on the Japanese output gap. A shock to the U.S. Federal Funds rate lowers the U.S. output gap; while a positive shock to U.S. base money surprisingly lowers the U.S. output gap. A shock to Japanese base money has a negligible impact on the U.S. output gap, while a dollar appreciation first raises and then lowers the U.S. output gap. A rise in Japanese short-term interest rates has a negligible impact on the U.S. gap. Our results are robust to starting the sample in 1980 or 1990.

Thus, both the nonstructural and structural vector autoregressions suggest that a shock to the Japanese output gap will raise the U.S. output gap, at least in the short-run. A nominal appreciation of the U.S. dollar against the yen has a slightly negative impact on the U.S. output gap over the longer run. The tightening of Japanese short-term interest rates has slightly negative impact on the U.S. output gap, while the tightening of Japanese base money has a negligible impact on the U.S. output gap.

3.3 MultiCountry Vector Autoregressions.

Using both non-structural and structural VARs, we have so far examined whether expansionary monetary policies in Japan have resulted in increases in the output gaps and inflation rates in Japan and in the U.S., and in inflationary expectations in Japan. Although yen-dollar policies are largely determined in discussions between the Ministry of Finance in Japan and the Treasury Department in the U.S., movements in the yen-dollar nominal exchange rate usually affect the domestic economies of Japan’s other trading partners as well. The nominal yen-dollar rate, the nominal won-yen rate, Japan’s nominal effective and real effective exchange rates tend to be very highly correlated. The correlation coefficients between the nominal yen-dollar rate, the nominal won-yen rate, and the Japanese nominal and real effective exchange rates are 0.92, 0.91, and 0.58 respectively, in monthly data from 1980 to mid-2013. These high correlations suggest that a change in the nominal yen-dollar is highly correlated with changes in Japan’s exchange rate with other important trading partners. That is, for the case of Korea, a depreciation of the yen against the dollar will tend to appreciate the won against the yen, thereby hurting the competitiveness of Korean tradeable industries. Thus, we should examine the spillover of Japanese monetary policies not only to the U.S., but to other Japanese trading partners as well.

Here we adopt the GVAR model of di Mauro and Pesaran (2013) to examine how shocks to Japanese monetary policies are transmitted, not only to the U.S., but to other Japanese trading partners. The GVAR model is essentially a multicountry nonstructural vector autoregression model with enough exogeneity assumptions to make the model estimable and to conduct impulse responses.
The variables included in our particular version of the GVAR model are the nominal short-rate, the nominal long-rate, the inflation rate, real equity prices, the real exchange rate, and real GDP. Since we are primarily interested in the impact of expansionary monetary policies, we first examine shocks to the nominal short-rates.

In the GVAR model, declines in U.S. short-term nominal interest rates have large positive international spillover effects on GDP (not depicted). A one standard error negative shock to U.S. nominal short-rates raises U.S. GDP, Japanese and non-Japan, non-China Asian GDPs after one period. The Japanese real exchange rate (against the U.S. dollar) appreciates for the entire period, while non-Japan Asian exchange rates (against the U.S. dollar) first appreciates, then depreciates. Equity prices appreciate in the U.S., Japan, and in non-Japan Asia.

In the GVAR model, changes in Japanese short-term nominal interest rates have somewhat surprising results. A fall in Japanese short rates does not lower U.S. or non-Japan Asian short-term rates. Real GDPs in Japan, Asia, and the U.S. decline (Figure 14). The yen and other Asian currencies depreciate against the U.S. dollar, while equity prices increase in Japan, non-Japan Asia, and in the U.S. Long-rates in Japan and non-Japan Asia fall.

It appears that the decline in short-rates does not directly positively impact output abroad (or even domestically in Japan), but may indirectly impact foreign output through the Japanese short-rates' effect on long-term interest rates and equity prices. In addition, it is likely that if base money could be included in the GVAR estimates, an expansion in base money would most likely lower long-rates, raise equity prices, and depreciate the yen, as in our one- and two-country VARs above (although the GVAR model lacks the "base money" variable).

A one standard error decline in Japanese long-term interest rates expands Japanese GDP, and the GDPs in non-Japan Asia, but slightly lowers the GDP of the U.S. A one standard error increase in Japanese equity prices unambiguously increases the GDPs of Japan, the rest of Asia and the U.S. A depreciation of the real yen against the U.S. dollar raises Japanese GDP, but lowers the GDPs of Asia and the U.S (Figure 15). Finally, Figure 16 shows that the expansion of Japanese GDP unambiguously expands the GDPs of Asia and the U.S. Thus, while expansionary Japanese monetary policies are likely to lower the GDPs of the U.S. and non-Japan Asia through the depreciation of the real yen-dollar rate, such policies should help expand the GDP of Japan through the decline in long term interest rates and the rise in the yen. The expansion of Japanese GDP, and equity and bond prices should help raise the GDPs of the rest of Asia and the U.S.

4 Conclusion.

6The exchange rates are bilateral vis-a-vis the U.S.
7Since base money data are not available for a broad cross-section of countries, we could not include them in the VAR analysis.
In this paper, we showed theoretically in a two country classical model that an expansion in Japanese monetary policy need not be coordinated with an expansion of U.S. monetary policy for the two country model to result in a pareto-optimal outcome. We argued that the assumptions behind the theoretical model may not always be valid in the real world, and a broader view than pareto optimality may be necessary. Following Eichengreen and Sachs (1985; 1986), we argued that if an expansionary monetary policy in Japan resulted in some positive spillovers for the U.S., then U.S. may be less hurt by a Japanese monetary expansion induced exchange rate appreciation, and may actually benefit. While a monetary expansion induced currency depreciation in one country can hurt the output of the other country, if a monetary expansion causes a global expansion in GDP, say from an increase in equity prices, then both countries can benefit from the monetary expansion in the one country.

We admit the limits of our theoretical arguments. We need to develop a two country, dynamic Dornbusch model to assess the paths of prices (or output) and exchange rates in a two country flexible exchange rate setting. In such a model, if a country tries to devalue its own currency, then the other country will try to follow as soon as possible. Thus, a similar picture like ours may emerge, but this new model will require more analysis.

To test the implications of the theory, we examine several impulse responses from vector autoregressions. The single, two country, or multicountry vector autoregressions show that the expansion in Japanese monetary policy, whether due to a cut in short-term interest rates or an expansion in base money, always results in a depreciation of the yen. The depreciation of the yen or the rise in equity prices caused by the looser Japanese monetary policy always expands Japanese GDP. We show in our impulse responses from our two- and multicountry VARs that while the depreciation of the yen will lower somewhat U.S. and Asian GDPs, the expansion in Japanese GDP always raises the GDPs of the U.S. and Asia. Thus, there is some empirical justification that Japanese expansionary monetary policy, while depreciating the yen, can help expand the GDPs of the U.S. or its Asian neighbors, through the rise in Japanese GDP.

5 Appendix: Vector Autoregressions using the 1971 to 1999 Subsample.

The above vector autoregressions and corresponding impulse responses, while robust to various subsamples, all include the period 2000 to 2013. This latter period includes the low interest rate to zero interest rate period in Japan until 2006 and again from 2012; and the low interest rate period in the U.S. from 2009. To assure that the abnormally expansive monetary policies from this period do not overly influence our results, here we depict the generalized impulse responses from the vector autoregressions from the subsample excluding the period, 2000 to 2013.
In Figures A1 and A2, we depict the impulse responses from the non-structural U.S.-Japan vector autoregressions using the variables: \(\{y^{us}, \pi^{us}, m^{us}, i^{us}, \epsilon, y^J, m^J, \pi^J, \pi^e, i^J\}\). The graphs in the Figure show that U.S. output and inflation rise with increases in the monetary base; increases in the federal funds rate have surprisingly positive effects on output (as above). Japanese output increases with U.S. output. An expansion in U.S. base money has a slightly negative effect on the Japanese output gap and raises the Japanese inflation rate.

With respect to a shock to the Japanese output gap, the U.S. output gap expands for about 8 quarters and then declines. The U.S. output gap and inflation rate decrease with a rise in Japanese short term interest rates. The U.S. output gap and inflation rate, while fluctuating in the short-run, increase slightly with an increase in base money. The U.S. output gap remains relatively unchanged with respect to a Japanese exchange rate depreciation. The Japanese output gap expands with a rise in Japanese base money and a depreciation of the yen.

References


Figure 0: Three Reaction Curves.

Japanese Reaction Curve Targetting ¥/$=105

U.S. Reaction Curve Targetting ¥/$=95

Move(Japan)
Move(US)

US Reaction Curve Targeting $\bar{P}_{us}$

Japan Reaction Curve Targeting $\bar{P}_{j}$

Japan Reaction Curve Targeting $\bar{P}_{us}$

US Reaction Targeting $\bar{P}_{j}$

$M_J$

$M_{US}$
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Figure 2: The Gap in U.S. and Japanese Short-term Interest Rates (DIFFINTER; in percent) and the Yen-Dollar Nominal Exchange Rate (EXJPUS)
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Growth in U.S Base Money-Growth in Japanese Base Money

Growth in U.S. Base Money
Growth in Japanese Base Money

-7.4
-7.2
-7.0
-6.8
-6.6
-6.4
-6.2
-6.0

Figure 4: The Yen Appreciates when U.S. Base Money Grows Faster than Japanese Base Money

Yen-Dollar Rate and U.S.-Japan Base Money Growth, 1991-2013
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Response to Generalized One S.D. Innovations ± 2 S.E.
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Response to Generalized One S.D. Innovations ± 2 S.E.

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Stock market to Japan base money

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Figure 11: Impact on the US Output Gap and US Inflation on Shocks to Japanese Output, Short-term Interest Rates, Base Money, and the Yen-Dollar Exchange Rate

Response to Generalized One S.D. Innovations ± 2 S.E.
Figure 12: Impact on the US Output Gap and US Inflation on Shocks to Japanese Output, Short-term Interest Rates, Base Money, and the Yen-Dollar Exchange Rate
Figure 13a: US-Japan: Impulse Responses of U.S.-Japan Variables to Shocks to the U.S. and Japanese Output gaps and Short term Interest Rates

Response to Structural One S.D. Innovations ± 2 S.E.
Figure 13b: US-Japan: Impulse Responses of US and Japanese Variables to Shocks to the U.S. and Japanese Base Monies and the Yen-Dollar Nominal Exchange Rate
Figure 14: Impulse Responses of 1 sd Negative Shock to Japanese Short-term Interest Rates (GVAR Multicountry Estimates)

Japanese GDP

Rest-of Asia GDP

US GDP

Yen-Dollar Real Exchange Rate (Depreciation)

Rest-of-Asia-Dollar Real Exchange Rate
Figure 15: Japan one sd increase (depreciation) of the Yen-Dollar Real Exchange Rate

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<th>Japanese GDP</th>
<th>Rest of Asia GDP</th>
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U.S. GDP
Figure 16: Japan: 1 sd Shock to Real GDP.

Japanese GDP

Rest of Asia GDP

U.S. GDP
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