9232

Working Paper Series

Some Empirical Evidence on the Effects of Monetary Policy Shocks on Exchange Rates

Martin Eichenbaum and Charles Evans

Working Papers Series
Macroeconomic Issues
Research Department
Federal Reserve Bank of Chicago
December 1992 (WP-92-32)

FEDERAL RESERVE BANK
OF CHICAGO

Some Empirical Evidence on the Effects of Monetary Policy Shocks on Exchange Rates

Martin Eichenbaum*
Northwestern University, NBER and
the Federal Reserve Bank of Chicago

Charles Evans†
Federal Reserve Bank of Chicago

December 12 1992

*We would like to thank Steve Strongin for many helpful conversations.

†The views expressed in this paper do not necessarily reflect the views of the Federal Reserve Bank of Chicago or the Federal Reserve System.

Abstract

This paper presents new empirical evidence on the effects of monetary policy shocks on U.S. exchange rates, both nominal and real. Three measures of monetary policy shocks are considered: orthogonalized shocks to the Federal Funds rate, the ratio of Non Borrowed to Total Reserves and the Romer and Romer (1989) index. Using data from the flexible exchange rate era, we find that expansionary shocks to U.S. monetary policy lead to sharp, persistent depreciations in U.S. nominal and real exchange rates as well as to sharp, persistent increases in the spread between various foreign and U.S. interest rates. The temporal pattern of the depreciation in U.S. nominal exchange rates following a positive monetary policy shock is inconsistent with simple overshooting models of the type considered by Dornbusch (1976). We also find that U.S. monetary policy was less volatile under fixed exchange rates than under floating exchange rates. Finally, we find less evidence that monetary policy shocks had a significant impact on U.S. real exchange rates under the Bretton Woods agreement.

Martin Eichenbaum
Department of Economics
Northwestern University
2003 Sheridan Road
Chicago Illinois 60208
1-708-491-8232

Charles Evans
Research Department
Federal Reserve Bank of Chicago
230 South LaSalle Street
Chicago Illinois 60604
1-312-322-5812

1. Introduction

This paper presents new empirical evidence that expansionary monetary policy shocks generate substantial, persistent depreciations in U.S. nominal and real exchange rates. Our analysis builds on work by Stockman (1983), Mussa (1986), Baxter and Stockman (1989), Backus and Kehoe (1992) and Meltzer (1992) who have documented key features of international business cycles. Unlike these authors, we do not focus on unconditional correlations. Instead, we ask how interest rates and exchange rates (nominal and real) respond to a specific impulse, namely a shock to monetary policy.

We focus on conditional correlations because of the difficulty of interpreting unconditional correlations in environments where agents are subject to multiple sources of uncertainty. Consider for example the widely noted fact that real exchange rates have been substantially more volatile after the collapse of the Bretton Woods agreements. This fact is equally consistent with Mussa's (1986) view that it reflects the importance of sluggish price adjustment and monetary policy shocks or Stockman's (1988) view that it reflects the greater variance of real shocks in the floating exchange rate era. In addition, the relative volatility of real exchange rates across the different regimes could also be rationalized, in principle, by models like those of Grilli and Roubini (1991,1992) and Schlagenhauf and Wrase (1992a,b) who emphasize the liquidity effects of monetary policy shocks on interest rates and exchange rates.

In this paper we concentrate on isolating a measure of shocks to monetary policy and ask how interest rates and exchange rates respond to these shocks. By focusing on these types of conditional moments of the data we follow recent work on the effects of monetary policy shocks on interest rates in closed economy settings.[1] This literature is relevant to our study for two reasons. First, it makes concrete the importance of explicitly adopting identifying assumptions to measure the exogenous component (if any) of changes in monetary policy. Second, several studies in this literature argue that widely used measures of monetary policy shocks such as innovations to high order monetary aggregates are inconsistent with the actual operating procedures of the Federal Reserve system. Moreover the use of these measures lead to misleading inference regarding the interest rate effects of policy shocks (see Bernanke and Blinder (1992), Christiano and Eichenbaum (1992a,b) and Strongin (1992)). In this paper we use the measures of monetary policy shocks proposed by these authors (orthogonalized innovations to the Federal Funds rate and the ratio of Non Borrowed to Total Reserves) as well as the index proposed by Romer and Romer (1989)) to study the effects of monetary policy on exchange rates.

Our main results can be summarized as follows. First, we find that expansionary shocks to U.S. monetary policy are followed by sharp, persistent declines in U.S. interest rates, and sharp, persistent increases in the spread between various foreign and U.S. interest rates. Second, we find that the same shocks lead to sharp, persistent depreciations in U.S. nominal and real exchange rates. Taken together these first two findings cast doubt on international Real Business Cycle (RBC) models in which money is introduced simply by adding cash-in-advance constraints or a transactions role for money. A generic implication of these models is that positive shocks to the money supply cause domestic interest rates to rise and lead to a fall in the spread between foreign and domestic interest rates. (See Schlagenhauf and Wrase (1992a,b) for a discussion of this point). As such these findings provide support for the model economies considered by Grilli and

[1]For a review of this literature see Christiano and Eichenbaum (1992a).

Roubini (1991,1992) and Schlagenhauf and Wrase (1992a,b) which allow for liquidity effects.

Third, we strongly reject the null hypothesis that the maximal depreciation of the U.S. nominal (or real) exchange rate in response to a positive money supply shock occurs in the period of the monetary shock. This finding is inconsistent with the theoretical implications of simple overshooting models of the sort considered by Dornbusch (1976). In conjunction with our finding that monetary policy shocks lead to a rise in the spread between foreign and U.S. interest rates, this finding is also inconsistent with the hypothesis of uncovered interest rate parity. This is because the larger interest rate differential induced by a positive shock to monetary policy shock is *not* expected to be offset by expected future appreciations in the dollar.

Fourth, we find that U.S. monetary policy was less volatile under fixed exchange rates than under floating exchange rates. This is consistent with the notion that the fixed exchange regime imposed constraints on U.S. monetary policy. Finally, we find that there is somewhat less evidence that monetary policy shocks had a significant impact on U.S. real exchange rates during the fixed exchange rate era. Taken together these last two findings are consistent with the notion that increased volatility of monetary policy directly contributed to the increased volatility of real exchange rates in the post Bretton Woods era. However it does not bear on the empirical plausibility of the hypothesis that real shocks were also more volatile in the post Bretton Woods era.

The remainder of this paper is organized as follows. Section 2 discusses the measures of shocks to monetary policy that are used in our analyses. Section 3 presents findings using data from the post Bretton Woods era. Section 4 briefly considers the Bretton Woods era. Finally, section 5 contains some concluding remarks.

2. Measuring Shocks to Monetary Policy

To measure the effects of shocks to monetary policy, we must take a stand on an empirical measure of those shocks. In this paper we consider three measures: orthogonalized components of the innovation to the ratio of Non Borrowed to Total Reserves, orthogonalized components of the innovation to the Federal Funds rate, and the Romer and Romer (1989) index of monetary policy contractions.

The basic strategy underlying the first two measures is to identify monetary policy shocks with the disturbance term in a regression equation of the form:

$$V_t = \zeta(\Omega_t) + \epsilon_{Vt}. \tag{1}$$

Here V_t is the time t setting of the monetary authority's policy instrument, ζ is a linear function, Ω_t is the information set available to the monetary authority when V_t is set and ϵ_{Vt} is a serially uncorrelated shock that is orthogonal to the elements of Ω_t. To rationalize interpreting ϵ_{Vt} as a policy disturbance one must view (1) as the monetary authority's decision rule for setting V_t. The first two measures of policy shocks which we use correspond to different specifications of V_t and Ω_t. Conditional on this specification, the dynamic response of a variable to a monetary policy shock is measured by the regression coefficients of the variable on current and lagged values of the residuals to equation (1).

This procedure is asymptotically equivalent to computing the impulse response function of a variable to a particular shock in an appropriately identified Vector Autoregression (VAR). Denote the set of variables in a VAR by Z_t. Assume that Ω_t includes the lagged values of Z_t as well as the time t values of a subset of the variables in Z_t, which we denote by X_t. The identifying assumptions in (1) correspond to a Wold ordering in which X_t is (causally) prior to V_t. This corresponds to the assumption that the monetary authority sets V_t seeing lagged values of all the components of Z_t and the current values of X_t. The 'shock' to monetary policy is the component of the innovation to V_t which is orthogonal to innovations in X_t.

This basic strategy for identifying shocks to monetary policy has been used by a variety of authors. For example Barro (1977), Mishkin (1983), Litterman and Weiss (1985) and King (1991) identify shocks to monetary policy with innovations to monetary aggregates like M1 and M2, i.e. V_t is set to $M1_t$ or $M2_t$ which the Federal Reserve Board is assumed to choose on the basis of time t-1 information. In addition to using M1 and M2, Leeper and Gordon (1992) also consider the innovation to the base (M0) as a measure of monetary policy shocks.

We do not pursue the general scheme of identifying policy shocks with orthogonalized innovations to broad monetary aggregates for a number of reasons. First, Strongin (1992) argues that they rely on assumptions which are simply counter factual in light of the actual operating procedure of the Federal Reserve Board. Second, a number of authors such as Gordon and Leeper (1992) show, in closed economy contexts, that so measured, monetary policy shocks are followed by *increases* in short term interest rates. Christiano and Eichenbaum (1992a) show that when the analysis is redone using the measure of money that is directly affected by open market operations, Non Borrowed Reserves (NBR), one reaches precisely the opposite conclusion, namely that expansionary monetary policy shocks are followed by sharp, persistent *decreases* in short term nominal interest rates. Moreover Eichenbaum and Evans (1992) show that positive innovations to NBR are followed by increases in higher order monetary aggregates. Christiano and Eichenbaum (1992b) argue that these results indicate that NBR innovations primarily reflect exogenous shocks to monetary policy, while innovations to broader monetary aggregates primarily reflect shocks to demand.

While Christiano and Eichenbaum (1992a,b) use NBR as the monetary aggregate in their analysis, Strongin (1992) argues that an even sharper measure of exogenous shocks to the money supply can be obtained measuring V_t by the ratio of NBR to Total Reserves. We denote this ratio by NBRX. [2] In our context, working with NBR's or NBRX leads to qualitatively similar results.[3] For this reason, here we report results only for NBRX.

Our second measure of shocks to monetary policy is motivated by arguments in McCallum (1983), Sims (1992) and Bernanke and Blinder (1992) that, at least relative to high-order monetary aggregates like M1 and M2, orthogonalized shocks to the Federal Funds rate are a better measure of shocks to monetary policy than orthogonalized shocks to the stock of money. Finally, our third measure of monetary policy shocks is motivated by results in Romer and Romer (1989) who use historical methods to identify specific periods in which the Federal Reserve Board initiated contractionary changes in monetary policy. Given the widespread attention that their index of monetary policy has received we wish to document the robustness of our results to their measure of policy shocks.

3. Empirical Results: The Flexible Exchange Rate Era

This section examines the dynamic response of nominal and real exchange rates to U.S. monetary policy shocks in the flexible exchange rate period. In deciding which variables to include in our empirical analysis, we are forced to

[2] Strongin actually measures V_t as $NBR_t/(\text{Total Reserves})_{t-1}$ while we use $NBR_t/(\text{Total Reserves})_t$. This has virtually no impact on our results.

[3] Eichenbaum and Evans (1992) provide evidence to substantiate this claim.

deal with the following trade-off. In the interest of minimizing omitted variable bias, we would like to include as many variables in our VAR's as possible. On the other hand, we must confront the problem of parameter profligacy. Specifically, if we include k lags of n variables in a VAR, then we must estimate $k \times n^2$ free parameters. Clearly, one's degrees of freedom rapidly disappear and inference becomes impossible. One must impose some restrictions on the variables to be included in the VAR. In light of this, when we included a measure of foreign output and a measure of short term foreign interest rates in a VAR, we did not include a measure of a high order foreign monetary aggregate. Doing so seemed to have little added value given our objective of identifying shocks to U.S. monetary policy. Moreover, Sims (1992) argues that shocks to foreign monetary policy are better captured by orthogonalized shocks to foreign interest rates than by orthogonalized shocks to broad foreign monetary aggregates.

The results reported in this section are based on monthly data covering the sample period 1974:1-1990:5. The appendix contains a detailed description of our data. Eichenbaum and Evans (1992) document the qualitative robustness of our results to breaking the sample in 1985:1 (the approximate date of the Louvre agreement). All VAR's were estimated using 6 lags of all variables.[4]

We consider five nominal (spot) exchange rates, e_t^{For}, For = {Yen, Deutchmark (DM), Lira, French Franc (FF), U.K. Pound (PD)}. Here e_t^{For} denotes the number of foreign currency units needed to buy one U.S. dollar at time t. Defined in this way, an increase in e_t^{For} corresponds to an *appreciation* of the US dollar. In addition we consider five real exchange rates, e_{Rt}^{For}, For = {Yen, DM, Lira, FF, PD} where e_{Rt}^{For} is defined as

[4]Our lag length was selected based on evidence regarding the serial correlation in the VAR error term, as measured by the Q statistic discussed in Doan (1990), as well as robustness of inference to higher order lags.

$$e_{Rt}^{For} = \frac{e_t^{For} P_t}{P_t^{For}}.$$

The variables P_t and P_t^{For} denote the time t U.S. and foreign price levels, respectively. Given this definition, an increase in e_{Rt}^{For} denotes an appreciation in the real U.S. exchange rate.

3.1 Empirical Results: NBRX Based Measures of Policy Shocks.

In this subsection we consider results from two VAR's. In the first, the interest rate variable is the *difference* between the level of foreign and U.S. short term nominal interest rates. This VAR is of interest for two reasons. First, a variety of authors like Meese and Rogoff (1983) consider empirical models where it is the difference between foreign and U.S. interest rates that is relevant for exchange rate determination. Second, this system captures, in a parsimonious way a subset of our key results. In the second VAR, the level of foreign and US interest rates enter as separate variables. This allows us to (i) document the robustness of the basic features of results based on the more parsimonious VAR, and (ii) examine the impact of policy shocks on the level of domestic and foreign interest rates, per se.

We begin by reporting results from a five variable VAR that includes U.S. industrial production (Y), the U.S. Consumer Price Level (P), the ratio of NBR to Total Reserves ($NBRX$), a measure of the difference between U.S. and foreign short term interest rates ($R^{For} - R^{US}$), and the real exchange rate, e_R^{For}. The short term foreign interest rate, R^{For}, was measured using a short term interest rate taken from the *International Financial Statistics* tape. The short term U.S. interest rate, R^{US}, was measured using the three month Treasury Bill rate.

Rows 1 and 2 of Figure 1 report a subset of the dynamic impulse response functions emerging from the estimated VAR. These were calculated assuming a Wold ordering of {Y, P, NBRX, $R^{For} - R^{US}$, e_R^{For}}. This corresponds to the assumption that the contemporaneous portion of the U.S. monetary authority's feedback rule for setting $(\text{NBRX})_t$ involves Y_t and P_t but not $R^{For} - R^{US}$ or e_{Rt}^{For}. So here a monetary shock is measured as the component of the innovation in $(NBRX)_t$ that is orthogonal to innovations in Y_t and P_t.[5] Columns 1 through 5 of Figure 1 report results for the Japanese, German, Italian, French and U.K. cases, respectively. The solid lines in Rows 1 and 2 report the dynamic response of $R_t^{For} - R_t^{US}$ and e_{Rt}^{For}, respectively, to a one standard deviation shock to monetary policy. The dashed lines denote a one standard deviation band about point estimates of the coefficients in the impulse response functions.[6] We redid our analysis replacing the real exchange rate with the corresponding nominal exchange rate in the VAR. The resulting dynamic response functions of $R_t^{For} - R_t^{US}$ to a monetary policy shock are virtually identical to those reported in Row 1. Row 3 of Figure 1 reports the dynamic response functions of e_t^{For} to the policy shock.

A number of important results emerge from Figure 1. First, a positive shock to monetary policy leads to a persistent, significant increase in $R_t^{For} - R_t^{US}$, i.e. an increase in the spread between short term foreign and U.S. interest rates. For example, according to Figure 1 the initial impact of a one standard deviation (roughly 1.18%) shock to $(NBRX)_t$ is a {28, 38, 27, 22, 44} basis point change in $\{R_t^{For} - R_t^{US} : For = Yen, DM, Lira, FF, PD\}$, respectively.[7] Second, the

[5]No restrictions are imposed on the lagged components of the monetary authority's feedback rule.

[6]These were computed using the method described in Doan (1990), example 10.1, using 500 draws from estimated asymptotic distribution of the vector autoregressive coefficients and covariance matrix of the innovations.

[7]The actual shock to $(\text{NBRX})_t$ equals 1.16%, 1.21% 1.18%, 1.19% and 1.18% for the case in which Japan, Germany, Italy, France and the U.K. are the foreign country included in the VAR.

estimated impulse response functions of nominal and real exchange rates are very similar. This is consistent with the well known fact that movements in real and nominal exchange rates are highly correlated with each other (see for example Mussa (1986)). Third, a positive shock to monetary policy leads to persistent depreciations in both e_{Rt}^{For} and e_t^{For}. For example, the initial impact of a one standard deviation (roughly 1.18%) shock to $(NBRX)_t$ is a {0.28, 0.50, 0.42, 0.36, 0.28} per cent fall in $\{e_{Rt}^{Yen}, e_{Rt}^{Dm}, e_{Rt}^{Lira}, e_{Rt}^{FF}, e_{Rt}^{PD}\}$, respectively. In addition, the maximal impact of the monetary shock on e_{Rt}^{For} and e_t^{For} does not occur contemporaneously. For example, the maximal impact on $\{e_t^{Yen}, e_t^{Dm}, e_t^{Lira}, e_t^{FF}, e_t^{PD}\}$ equals {-1.98, -2.85, -2.59, -2.64, -2.18} per cent which occurs {22, 34, 37, 35, 39} months after the monetary policy shock. This response pattern is difficult to reconcile with simple overshooting models of the sort considered by Dornbusch (1976) in which a positive shock to monetary policy generates a large initial depreciation in nominal (and real) exchange rates followed by subsequent appreciations. In these models, uncovered interest rate parity holds so that the higher time t foreign nominal interest rate must be offset by an expected appreciation of the dollar between time t and time t+1. This prediction is clearly at variance with the impulse response functions reported in Figure 1. There we see that, in response to a time t positive monetary shock, $R_t^{For} - R_t^{US}$ rises and e_t^{For} declines between time t and time t+1. So the time t expected return on the foreign asset is higher for two reasons: (i) the nominal return is higher and (ii) the foreign currency is expected to *appreciate* between time t and time t+1. It seems difficult to reconcile these results with the uncovered interest rate parity hypothesis. Instead, we think of them as reflecting the widely documented statistical rejection of that hypothesis (see for example Hodrick (1987)).

In principle, one could construct a variety of statistics to summarize the 'shape' of the impulse response functions as a way of characterizing the dynamic response of exchange rates to policy shocks. For example one could ask whether the impulse response function is identically equal to zero. We find it more revealing to consider the *average* response of e_{Rt}^{For} and e_t^{For} to a time t monetary shock over various time horizons, say from time $t+i$ to time $t+j$. We denote these responses by $\mu_{For,R}(i,j)$ and $\mu_{For}(i,j)$, respectively. In population these are equal to the average value of coefficients i through j of the corresponding impulse response functions.

We cannot use the standard deviation bands about the estimated impulse response functions in Figure 1 to formally test hypotheses about $\mu_{For,R}(i,j)$ and $\mu_{For}(i,j)$. This is because each element in these bands summarizes the sampling uncertainty in the corresponding element of the estimated impulse response function, *not* taking into account the covariance between different coefficients in the impulse response functions. Consequently, they cannot be used to formally test hypotheses involving the joint behavior of these coefficients.

To deal with these problems, we adopted the following procedure. Let β and V denote the coefficients in a given VAR and the covariance matrix of the corresponding innovations to the VAR, respectively. After estimating the VAR, we proceeded as follows:

(1) First, we calculated a consistent estimate of the parameters governing the joint asymptotic distribution of β and V (see Doan (1990), example 10.1).

(2) Second, we drew a sample, β_k^* and V_k^*, from the estimated impulse response functions of e_{Rt}^{For} and e_t^{For}, k =1, ...,500.

(3) Third, for each (B_k^*, V_k^*), we calculated the impulse response functions of e_{Rt}^{For} and e_t^{For} to a monetary shock.

(4) Fourth, we calculated the sample values of $\mu_{For,R}(i,j)$ and $\mu_{For}(i,j)$ in these

impulse response functions. Denote these by $\mu^{K}_{For,R}(i,j)$ and $\mu^{K}_{For}(i,j)$, {(i, j), = (1,6), (7,12), (13-18), (19-24), (25-30), (31-36)}.

(5) Fifth, we calculated the standard deviations of $\mu^{k}_{For,R}(i,j)$ and $\mu^{k}_{For}(i,j)$.[8]

Table 1A reports the results of this procedure as applied to the five variable VAR containing e^{For}_{Rt}. Columns 1 through 5 report results for the case in which the foreign country is Japan, Germany, Italy, France and the U.K., respectively. Row 1 reports the estimated correlation between the *innovation* to $e^{FOR}_{Rt}$and $(NBRX)_t$. Numbers in parentheses denote standard errors, while numbers in brackets denote the significance level of the t test for the one sided hypothesis that the correlation equals zero in population against the alternative that it is negative. Notice that for every measure of the exchange rate, the estimated correlation is negative and significantly different from zero. Rows 2 through 7 report the estimated values of $\mu_{For,R}(i,j)$,$\{(i,j) = (1,6),\ (7,12),(13,18),\ (19,24),\ (25,30),\text{and}\ (31,36)\}$, respectively. Numbers in parentheses denote standard errors, while numbers in brackets denote the significance level of the t test for the one sided hypothesis that $\mu_{For,R}(i,j)$ is equal to zero against the alternative that it is negative. Notice that for each country, there exist a number of horizons corresponding to different specifications of (i, j) for which this hypothesis can be rejected at conventional significance levels. For Germany, France and Italy, the hypotheses can be rejected for every specification of (i, j) at the 5% significance level. Consistent with Figure 1, these rejections are not the strongest for the early periods. For example, according to our point estimates, e^{Yen}_{Rt} drops on average by .53%, 1.16%, 1.53%, 1.67%, 1.61% and 1.39% in the first through sixth half year horizons after a positive monetary shock. The corresponding significance levels for the test that these

[8]Alternatively, inference could be based on the empirical distribution function of these statistics. In practice we found that inference was very robust to which procedure was adopted.

responses are zero in population attain their maximum value for the third half year horizon, after which they decline. Row 8 reports the maximal impact of a positive monetary policy shock on e_t^{For}.[9] In every case the point estimate of this statistic is negative and exceeds (in absolute value) $\mu_{For,R}(1,6)$. Also notice that in every case we strongly reject the null hypothesis that the maximal impact is equal to zero.

Row 9 reports the time to the maximal depreciation in the real exchange rate following a policy shock.[10] As can be seen, there is substantial uncertainty about the exact time period when the maximal depreciation occurs. Still for every country we can easily reject the null hypothesis that it occurs contemporaneously. Table 1B is the exact analog to Table 1A except that it is based on the five variable VARs that include e_t^{For}. As before, using nominal rather than real exchange rates has very little impact on inference.

We now discuss the overall contribution of monetary shocks to the variability of exchange rates. To this end, we computed the percentage of the variance of the k step ahead forecast error that is attributable to monetary shocks. As k goes to infinity, this corresponds to the percentage of the variance of exchange rates that is due to monetary shocks. Row 10 of Tables 1A and 1B reports the average of this percentage over the 31 to 36 month horizon for real nominal exchange rates, respectively. The estimated percentages range from a low of 18% (U.K., nominal exchange rates) to a high of 43% (Germany, real). While there is substantial sampling uncertainty associated with these point estimates, in the case of Germany, Italy and France, one can easily reject the null hypothesis that

[9]Numbers in parenetheses denote standard errors, while numbers in brackets denote the significance level of the t test for the hypothesis that the maximal impact is equal to zero.

[10]Numbers in parentheses denote standard errors, while numbers in brackets denote the significance level of the t test for the hypothesis that the maximal depreciation occurs in the period of the shock.

the percentage is zero, for either real or nominal exchange rates. The rejections are more marginal for Japan and the U.K.

We now consider the results of analyzing a VAR in which foreign and U.S. interest rates enter separately. Rows 1 through 3 of Figure 2 report results from a seven variable VAR that includes US industrial production (Y), the U.S. Consumer Price Level (P),foreign output (Y^{For}), the foreign interest rate (R^{For}), the ratio of NBR to TR (NBRX), the real exchange rate, e_R^{For}, and the three month U.S. Treasury Bill rate, R_t^{US}. Impulse response functions were calculated assuming a Wold ordering of $\{Y, P, Y^{For}, R^{For}, NBRX, R^{US}, e_R^{For}\}$. This corresponds to the assumption that the contemporaneous portion of the US monetary authority's feedback rule for setting $(NBRX)_t$ involves $(Y_t,\ P_t, Y_t^{For}, R_t^{For})$ but not R_t^{US} or e_{Rt}^{For}. So here a monetary shock is measured as the component of the innovation in $(NBRX)_t$ that is orthogonal to innovations in Y_t, P_t, Y_t^{For} and R_t^{For}. Columns 1 through 5 report results for the Japanese, German, Italian, French and U.K. cases, respectively. The solid lines in Rows 1, 2 and 3 report the dynamic response of R_t^{US}, R_t^{For} and e_{Rt}^{For}, respectively, to a one standard deviation impulse to our measure of a monetary policy shock. The dashed lines denote one standard deviation bands about point estimates of the coefficients in the impulse response functions. We redid our analysis replacing the real exchange rate with the corresponding nominal exchange rate in the VAR. The resulting dynamic response functions of R_t^{US} and R_t^{For} to a monetary policy shock are virtually identical to those reported in Rows 1 and 2. Row 4 of Figure 2 reports the dynamic response functions of e_t^{For} to the policy shock.

Notice that, irrespective of which foreign country is included in the analysis, a positive shock to U.S. monetary policy leads to a sharp, persistent decrease in the US interest rate. In addition the shock leads to a persistent decline in all of the foreign interest rates, except the U.K. The statistical significance of this decline depends on which foreign country is included in the analysis. In all cases, though, the declines in R_t^{US} exceeds the corresponding decline in R_t^{For} so that, consistent with Figure 1, the shock leads to an increase in $R_t^{For} - R_t^{US}$. Also as before, a positive monetary shock leads to pronounced, persistent depreciations in real and nominal U.S. exchange rates. Perhaps not surprisingly given the large number of variables in the VAR (and the correspondingly large number of parameters that must be estimated), the impulse response functions of e_{Rt}^{For} and e_t^{For} are less precisely estimated than in the five variable VAR systems underlying Figure 1. Tables 2A and 2B, which are the exact analogs to Tables 1A and 1B, confirm this impression. In particular, we find substantially less evidence against the null hypotheses that $\mu_{For,R}(i,j)$ and $\mu_{For}(i,j)$ are equal to zero in population. Still for each country there exists at least one specification of (i,j) for which one can reject, at the 10% significance level (or better), these null hypotheses. Moreover, for every country, we can reject at the 5% significance level or better, the null hypothesis that the maximal deprecation of e_t^{For} to a positive money shock is zero. Finally, for all countries except for Japan, one can reject, at the 5% significance level, the null hypothesis that the correlation between the innovations to NBRX and e_{Rt}^{For} (or e_t^{For}) is equal to zero. For Japan this hypothesis can be rejected at the 7% significance level.

Row 10 of Tables 2A and 2B reports the average percentage of the variance of the forecast error over the 31 to 36 month horizon for real and nominal exchange rates that is attributable to monetary shocks. Notice that the estimated percentages are lower than those emerging from the five variable VAR and now range from a low of 8% (France, real exchange rates) to a high of 14% (Italy, nominal exchange rates). In addition the standard errors of these statistics are substantially larger than before.

3.2 Empirical Results: Federal Funds Rate Based Measures of Policy Shocks

In this subsection we display results obtained measuring monetary policy as an orthogonalized component of the innovation to the Federal Funds rate. Rows 1 through 4 of Figure 3 reports results from a seven variable VAR that includes data on U.S. industrial production (Y), the U.S. Consumer Price Level (P), foreign output (Y^{For}), the foreign interest rate (R_t^{For}), the Federal Funds rate (FF_t),the ratio of NBR to TR (NBRX), and the real exchange rate, e_{Rt}^{For}. Impulse response functions were calculated assuming a Wold ordering of $\{Y, P, Y^{For}, R^{For}, FF, NBRX, e_R^{For}\}$. This Wold ordering corresponds to the assumption that the contemporaneous portion of the U.S. monetary authority's feedback rule for setting FF_t involves (Y_t, $P_t, Y_t^{For}, R_t^{For}$) but not $NBRX_t$ or e_{Rt}^{For}. Columns 1 through 5 of Figure 3 reports results for the Japanese, German, Italian, French and U.K. cases, respectively. The solid lines in Rows 1, 2 and 3 report the dynamic response of $NBRX_t$, R_t^{For} and e_{Rt}^{For}, respectively, to a one standard deviation shock to monetary policy. The dashed lines denote one standard deviation bands about point estimates of the coefficients in the impulse response functions. We redid our analysis replacing the real exchange rate with the corresponding nominal exchange rate in the VAR. The resulting dynamic response functions of NBRX and R_t^{For} to a monetary policy shock are virtually identical to those reported in Rows 1 and 2. Row 4 of Figure 3 reports the dynamic response functions of e_t^{For} to the policy shock.

Our results here are consistent with those of the previous subsection. Consistent with the presence of a strong liquidity effect, Figure 3 reveals that a positive shock to the Federal Funds rate generates sharp, persistent declines in NBRX. Notice also that a negative monetary policy shock (a positive shock to the Federal

Funds rate) is associated with persistent appreciations in nominal and real U.S. exchange rates. For example, according to Figure 3, the initial impact of an approximately 60 basis point positive shock to the Federal Funds rate is a {0.31, 0.46, 0.40, 0.38, 0.15} percent rise in $\{e_{Rt}^{Yen}, e_{Rt}^{DM}, e_{Rt}^{Lira}, e_{Rt}^{FF}, e_{Rt}^{PD}\}$, respectively. As before, the maximal impact of the monetary shock on e_{Rt}^{For} and e_t^{For} does not occur contemporaneously. For example, the maximal impact on $\{e_t^{Yen}, e_t^{DM}, e_t^{Lira}, e_t^{FF}, e_t^{PD}\}$ of an approximately 60 basis point shock to FF_t is a {1.76, 1.88, 1.66, 1.78, 1.33} per cent rise that occurs {21, 28, 28, 28, 28} months later. As in subsection 3.1, the dynamic response functions of real and nominal exchange rates to monetary shocks are very similar.

It is important to note that the dynamic responses of e_{Rt}^{For} and e_t^{For} to a policy shock are estimated more precisely now than when orthogonalized innovations to NBRX are used as the measure of monetary policy shocks. This can be seen informally by comparing the relevant standard deviation bands in Figures 2 and 3. This impression is confirmed by Tables 3A and 3B. These are the exact analogs to tables 2A and 2B, constructed using the VARs underlying Figure 3.

A number of key results emerge from these tables. First, Row 1 of Tables 3A and 3B reveal that innovations to the Federal Funds rate are *positively* correlated with innovations to nominal and real exchange rates. The null hypothesis that either of these correlations equals zero in population can be easily rejected for the Japanese, German, Italian and French cases. The rejection is more marginal for the U.K. Second, there is very strong statistical evidence that monetary policy shocks affect real and nominal exchange rates. For example, except for the U.K. case, the null hypothesis that $\mu_{For,R}(i,j)$ equals zero can be rejected, at the 4% significance level or better, for all six specifications of (i,j). In the U.K. case we can reject this hypothesis at the 5% significance level in 4 out of 6 specifications of (i, j). From row 8 of Tables 3A and 3B we see that the null hypotheses that the maximal impact of a monetary policy shock on e_{Rt}^{For} and e_t^{For} equal zero can be strongly rejected. Finally, as before, we find substantial evidence that the maximal effect of a policy shock does not occur contemporaneously. From Row 9 of Tables 3A and 3B we see that for every country one can easily reject the null hypothesis that the maximal effect on a policy shock on e_{Rt}^{For} and e_t^{For} occurs contemporaneously.

Row 10 of Tables 3A and 3B reports the average percentage of the variance of the forecast error over the 31 to 36 month horizon for real and nominal exchange rates that is attributable to monetary shocks. Here two key results emerge. First, for all countries, except the U.K., monetary shocks are estimated to account for over 20% of the variance of real and nominal exchange rates. Second, there is less sampling uncertainty with this measure of monetary shocks than with NBRX based measures. Specifically, for all countries (except for the U.K.) we can easily reject the null hypothesis that monetary shocks do not account for any of the variance in real or nominal exchange rates. So once we move to Federal Funds based measures of policy shocks, we find substantial evidence that an important percentage of the variability of exchange rates can be attributed to policy shocks, even with the seven variable VAR's.

3.3 Empirical Results: Measuring Monetary Shocks Using the Romer and Romer (1989) Index

In this subsection we report results obtained using the Romer and Romer (1989) index of monetary policy. Figure 4 report results obtained from a VAR that includes U.S. industrial production (Y), the U.S. Consumer Price Level (P), foreign output (Y^{For}), the foreign interest rate (R^{For}), the ratio of NBR to TR

(NBRX), the real exchange rate, e_R^{For}, and the Federal Funds rate, FF. In addition, the VAR includes the Romer and Romer (1989) index of monetary policy. Specifically, we consider a VAR for the vector of variables Z_t :

$$Z_t = A(L)Z_{t-1} + \beta(L)d_t + \epsilon_t. \tag{2}$$

Here $A(L)$ and $\beta(L)$ are one sided polynomials in the lag operator L, and the vector Z_t equals $[Y_t, P_t, Y_t^{For}, R_t^{For}, NBRX_t, e_{Rt}^{For}, FF]'$. The variable d_t denotes the time t value of the Romer and Romer index . This variable equals one for the month at which a Romer and Romer episode begins. It is equal to zero otherwise. The response of Z_{t+k} to a time t Romer and Romer monetary contraction ($d_t = 1$, $d_{t+k} = 0$ for $k > 0$) is given by the coefficient on L^k in the polynomial $[I - A(L)]^{-1}\beta(L)$.[11]

Columns 1 through 5 of Figure 4 report results for the Japanese, German, Italian, French and the U.K. cases, respectively. Rows 1, 2, 3 and 4 display the dynamic impulse response functions of FF_t, $NBRX_t$, R_t^{For} and e_{Rt}^{For} to the onset of a Romer and Romer episode. The dashed lines denote one standard deviation bands about point estimates of the coefficients in the impulse response functions. We redid our analysis replacing the real exchange rate with the corresponding nominal exchange rate in the VAR. The resulting dynamic response functions of FF_t, $NBRX_t$ and R_t^{For} to a Romer and Romer shock are virtually identical to those reported in Rows 1, 2 and 3. Row 5 of Figure 4 reports the dynamic response functions of e_t^{For} to the policy shock.

Rows 1 and 2 of Figures 4 provide corroborating evidence that the Romer and Romer dummy variables do indeed correspond to monetary policy contractions.

[11]The dates of the Romer and Romer (1989) episodes are 1974:4, 1978:8 and 1979:10. Since our sample ends after theirs, we included a dummy variable for the period 1988:8 suggested by Oliner and Rudebusch (1992).

In particular, a unit increase in the Romer and Romer index is associated with a sharp, persistent increase in the Federal Funds rate and a decrease in NBRX. Notice that the maximal increase in the Federal Funds rate and the maximal decrease in NBRX do not occur at the time of the change in the index. Instead both occur six months later. The initial change in the Federal Funds rate equals roughly 50 points. Six months later the Federal Funds rate is almost 300 basis points higher than it was initially. Evidently Romer and Romer episodes correspond to large monetary contractions, relative to the types of shocks considered in subsection 3.1 and 3.2. Our previous results indicated that we reached very similar conclusions whether we use NBRX or Federal Funds rate based measures of monetary shocks. In light of this, it is not surprising that the dynamic impulse responses functions of NBRX and the Federal Funds rate to a change in the Romer and Romer index appear to be mirror images of each other.

The fact that the peak effect of a change in the Romer and Romer on NBRX and the Federal Funds rate occurs with a six month delay helps explain the dynamic response functions of e_{Rt}^{For} and e_t^{For}. The initial response of real and nominal exchange rates is either very close to zero or slightly negative. However in all cases, after six months, real and nominal exchange rates undergo persistent appreciations. This is consistent with the results of subsections 3.1 and 3.2. The large responses of FF_t, R_t^{For}, e_{Rt}^{For} and e_t^{For} reflect the magnitude of the Romer and Romer episodes. The main difference between the results reported here and those of subsections 3.1 and 3.2 is that the dynamic responses of e_t^{For} and $e_{R,t}^{For}$ are now measured with much less precision. This is not surprising in light of the small number of observations on monetary contractions used here. Tables 4A and 4B provide additional evidence on this point. Rows 1 through 6 of these tables report the estimated values of $\mu_{For,R}(i,j)$ and $\mu_{For}(i,j)$, {(i, j) = (1,6), (7,12), (13,18), (19, 24), (25,30) and (31,36)}, respectively. Notice that here we cannot reject, at conventional significance levels, the null hypothesis that these are equal to zero. Still, even with this method of measuring policy shocks, we can reject, at the 7% and 8% significance levels, the null hypotheses that the maximal impact on the real and nominal exchange rate is equal to zero (see Row 7 of Tables 4A and 4B, respectively). Finally, with the exception of the U.K., there is strong evidence that the maximal effect of a policy shock on real and nominal exchange rates does not occur in the initial period of the shock (see row 8 of Table 4A and 4B, respectievly).

4. Money Supply Shocks, Interest Rates and Exchange Rates in the Pre-Bretton Woods Era.

In this section we examine the effects of shocks to monetary policy on real exchange rates during a subset of the Bretton Woods era. While exchange rates were 'fixed' before 1971, there were various episodes in which the exchange rates of different countries were revalued. Because of this we redid the analysis of sections 3.1 and 3.2 using different sub samples of 1959:1 - 1971:7. For each foreign country we chose the sub sample so that the nominal exchange rate was constant. Specifically, we used data over the period {1959:7-1971:7, 1961:1-1969:10, 1960:10-1971:9, 1959:7-1969:7, 1959:7-1967:11} for the Japanese, German, Italian, French and U.K. cases respectively.

Our analysis focuses on two key questions: (i) What were the relative magnitudes of monetary policy shocks during the flexible and fixed exchange rate regimes? (ii) Was the relationship between monetary policy shocks and real exchange rates different in the flexible and fixed exchange rate regimes?

Recall from section 3 that, from a statistical point of view, our sharpest results were obtained using a Federal Funds based measure of monetary policy shocks. Not surprisingly, the differences between the flexible and fixed exchange rate period emerge most starkly when we use this measure of policy shocks.[12]

Consider Figure 5 which is the exact analog to the first three rows of Figure 3. Here we report results based on a seven variable VAR that includes US industrial production (Y), the U.S. consumer Price Level (P), foreign output (Y^{For}), the foreign interest rate (R^{For}), the Federal Funds rate (FF), the ratio of NBR to Total Reserves (NBRX), and the real exchange rate (e_R^{For}). As in subsection 3.2, the impulse response functions of R_t^{US}, R_t^{For}, and e_t^{For} to a monetary shock (rows 1, 2 and 3, respectively) were calculated assuming a Wold ordering of {Y, P, Y^{For}, R^{For}, FF, NBRX, e_R^{For}}, so that a monetary policy shock is measured as the component of the innovation to the Federal Funds rate that is orthogonal to innovations in Y_t, P_t, Y_t^{For}, and R_t^{For}. Table 5 is the analog to Table 3A and reports the results of implementing the testing procedures described in section 3.

Three key results emerge here. First, the standard deviation of shocks to monetary policy is estimated to be much smaller in the Bretton Woods era. Specifically, during the flexible exchange rate period, the standard deviation of our Federal Funds based measure of policy is approximately 60 basis points. The corresponding standard deviation in the fixed exchange rate period equals 24, 13, 22, 17, and 14 basis points for the Japanese, German, Italian, French and U.K. cases, respectively.[13] So, according to this metric, monetary policy is *much* more volatile in the floating exchange rate regime. Second, while still positive (except for Italy)

[12]Some care must exercised in interpreting these results as there is less reason to believe that the Federal Reserve Board followed a tight policy of targeting the Federal Funds rate in the pre-1974 period. For a discussion of this point see Goodfriend (1991).

[13]These estimates are not the same because each is generated from a VAR with a different set of variables in it corresponding to the different specifications of Y_t^{For}, e_{Rt}^{For} and R_t^{For} considered.

the correlation between the innovation to the Federal Fund rate and the real exchange rate appears to be smaller and less significant in the fixed exchange rate regime (see row 1 of table 5). This provides corroborating evidence for the view that the link between real exchange rates and monetary policy shocks was weaker in the fixed exchange rate regime. Third, the standard error bands in Figures 3 and 5 indicate a weaker dynamic response of real exchange rates to monetary policy shocks in the fixed exchange rate regime. This impression is confirmed by the statistical results summarized in Tables 3A and 5. Recall that, for the floating exchange rate period, we found overwhelming evidence against the null hypothesis that $\mu_{For,R}(i,j)$ is equal to zero, for almost all specifications of (i, j). In sharp contrast, according to Table 5, for the fixed exchange rate period, we cannot reject this hypothesis for any specification of (i, j) in the Japanese, Italian, French and U.K. cases. There is substantial evidence that the U.S. real exchange rate *vis a vis* Germany appreciated following a contractionary monetary policy shock. At the same time it should be emphasized that the magnitude of the response is much smaller (roughly one fourth after correcting for the smaller size of the shock) in the fixed exchange rate period compared to the floating exchange rate period.

Row 10 of Table 5 reports the average percentage of the variance of the forecast error over the 31 to 36 month horizon for the real exchange rate. The percentages range from a low of 7% for Germany to a high of 29% for Italy. However, with the exception of Italy, we cannot reject, at the 10% level, the null hypothesis that monetary shocks account for any of the forecast error variance of the real exchange rate.[14] Recall from Table 3A that this hypothesis could be rejected for all five countries in the flexible exchange rate regime.

[14]Recall that for Italy we obtained the unusual result that a positive innovation to the Federal Funds rate leads to a depreciation of the real U.S. exchange rate.

Next consider the difference between the flexible and fixed exchange rate periods with the NBRX based measure of shocks to monetary policy. Here the difference is less stark, although the basic pattern of our results is unaffected. Figure 6 is the analog to the first three rows of figure 2. Here we report results from a seven variable VAR that includes US industrial production (Y), the U.S. consumer Price Level (P), foreign output (Y^{For}), the foreign interest rate (R^{For}), the ratio of NBR to Total Reserves (NBRX), the real exchange rate (e_R^{For}), and the three month U.S. Treasury Bill (R^{US}). As in subsection 3.1, the impulse response functions of R_t^{US}, R_t^{For}, and e_t^{For} to a monetary shock (rows 1, 2 and 3, respectively) were calculated assuming a Wold ordering of {Y, P, Y^{For}, R^{For}, NBRX, R^{US}, e_R^{For}}, so that a monetary policy shock is measured as the component of the innovation to NBRX that is orthogonal to innovations in Y_t, P_t, Y_t^{For}, and R_t^{For}. Table 6 is the exact analog to Table 2A.

Two key points emerge. First, there is less of a contrast between the flexible and fixed exchange rate periods when we move to the NBRX based measures of shocks to monetary policy. Specifically, with the exception of Italy, the pattern of a statistically significant, negative correlation between innovations to NBRX and the real exchange rate is present in both periods. In addition Tables 2A and 6 indicate that positive innovations to monetary policy cause statistically significant appreciations in U.S. real exchange rates. However according to Tables 2A and 6 indicate that in both exchange regimes, NBRX based measures of monetary policy shocks do not account for a significant percentage of the forecast error variance of real exchange rates. Recall that Second, the standard deviation of shocks to monetary policy is estimated to be much smaller in under fixed exchange rates. Specifically, during the flexible exchange rate period, the standard deviation of our NBRX based measure of policy shocks is approximately 1.18%. The corresponding standard deviation in the fixed exchange rate period equals .68%, .35%, .66%, .44%, .33% for the Japanese, German, Italian, French and U.K. cases, respectively.

Viewing the results of this section as a whole we conclude that (i) irrespective of which measure of policy is used, U.S. monetary policy was less volatile in the fixed exchange rate period, and (ii) there is mixed evidence on whether monetary policy shocks had a significant impact on U.S. real exchange rates during the fixed exchange rate era.

5. Conclusion

This paper investigated the effects of shocks to monetary policy on nominal and real U.S. exchange rates. We found strong evidence that expansionary policy shocks lead to significant, persistent depreciations in exchange rates, both nominal and real. In addition, we found that these policy shocks contribute significantly to the overall variability of U.S. exchange rates in the post Bretton Woods era. At the same time though, these shocks do not explain the majority of movements in U.S. exchange rates. Monetary policy was important but it was by no means the sole determinant of changes in real exchange rates. Our results are entirely consistent with the notion that real changes which affect the relative prices of the different goods produced by different countries were at least as important as monetary policy in the process of exchange determination.

References

1. Backus, David K. and Patrick J. Kehoe (1992), 'International Evidence on the Historical Properties of Business Cycles,' *American Economic Review, 82:* 864-888.

2. Barro, Robert J. (1977), 'Unanticipated Money Growth and Unemployment in the United States,' *American Economic Review, 67:* 101-115.

3. Baxter, Marianne and Alan C. Stockman (1989), 'Business Cycles and the Exchange Rate Regime: Some International Evidence,' *Journal of Monetary Economics,* 23, 377-400.

4. Bernanke, Ben and Alan Blinder (1992), 'The Federal Funds Rate and the Channels of Monetary Transmission,' *American Economic Review 82,* 901-921.

5. Christiano, Lawrence J. and Martin Eichenbaum (1992a), 'Identification and the Liquidity Effect of a Monetary Policy Shock,' in Alex Cuikerman, Zvi Hercowitz and Leonardo Leiderman, ed.s, *Political Economy, Growth and Business Cycles,* Cambridge, MA: MIT Press.

6. Christiano, Lawrence J. and Martin Eichenbaum (1992), 'Liquidity Effects, Monetary Policy and the Business Cycle,' NBER Working Paper No. 4129.

7. Doan, Thomas (1990), Users Manual, RATS Version 3.10, VAR Econometrics, Evanston, Il.

8. Dornbusch, Rudiger (1976), 'Expectations and Exchange Rate Dynamics,' *Journal of Political Economy, 84:* 1161-1176.

9. Eichenbaum, Martin and Charles Evans, (1992), 'Appendix to Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates,' manuscript, Northwestern University.

10. Goodfriend, Marvin (1991), 'Interest Rates and the Conduct of Monetary Policy,' *Carnegie Rochester Conference, 34:* 7-30.

11. Grilli, Vittorio and Nouriel Roubini (1990), 'Liquidity, Capital Controls and Exchange Rates,' manuscript, Yale University.

12. Grilli, Vittorio and Nouriel Roubini (1991), 'Liquidity and Exchange Rates,' *Journal of International Economics, 32:* 339-352.

13. Hodrick, Robert (1987), *The Empirical Evidence on the Efficiency of Forward and Futures Exchange Markets,* Chur, Switzerland, Harcourt Academic Publishers.

14. King, Robert (1991), 'Money and Business Cycles,' manuscript, University of Rochester.

15. Leeper, Eric M. and David B. Gordon (1992), 'In Search of the Liquidity Effect,' *Journal of Monetary Economics, 29:* 341-69.

16. Litterman, Robert E. and Laurence Weiss (1985), 'Money, Real Interest Rates, and Output: A Re-Interpretation of Postwar U.S. Data,' *Econometrica, 53:* 129-156.

17. McCallum, Bennett T. (1983), 'A Reconsideration of Sims' Evidence Concerning Monetarism,' *Economic Letters:* 13, 167-171.

18. Meese, Richard and Rogoff, Kenneth (1983), 'Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?,' *Journal of International Economics, 14:* 3-24.

19. Meltzer, Allan H. (1992), 'Real Exchange Rates: Some Evidence From The Postwar Years,' manuscript, Carnegie Mellon University.

20. Mishkin, Frederick S. (1983), *Rational Expectations Approach to Macroeconometrics: Testing Policy Ineffectiveness and Efficient-Markets Models*, National Bureau of Economic Research, University of Chicago Press.

21. Mussa, Michael (1986), 'Nominal Exchange Rate Regimes and the Behavior of Real Exchange Rates,' *Carnegie Rochester Conference on Public Policy, 25:* 117 - 214.

22. Oliner Stephen D. and Glenn D. Rudebusch (1992), 'The Transmission of Monetary Policy to Small and Large Firms,' manuscript, Board of Governors of the Federal Reserve System.

23. Romer, Christina D. and David H. Romer (1989), 'Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz,' in Olivier J. Blanchard and Stanley Fischer, eds., *NBER Macroeconomics Annual 1989,* Cambridge, MA: MIT Press, 121-170.

24. Schlagenhauf, Don E. and Jeffrey M. Wrase (1992a), 'Liquidity and Real Activity in a Simple Open Economy Model,' Working Paper 52, Research Department, Federal Reserve Bank of Minneapolis.

25. Schlagenhauf, Don E. and Jeffrey M. Wrase (1992b), 'A Monetary, Open Economy Model With Capital Mobility,' Discussion Paper 67, Institute for Empirical Economics, Federal Reserve Bank of Minneapolis.

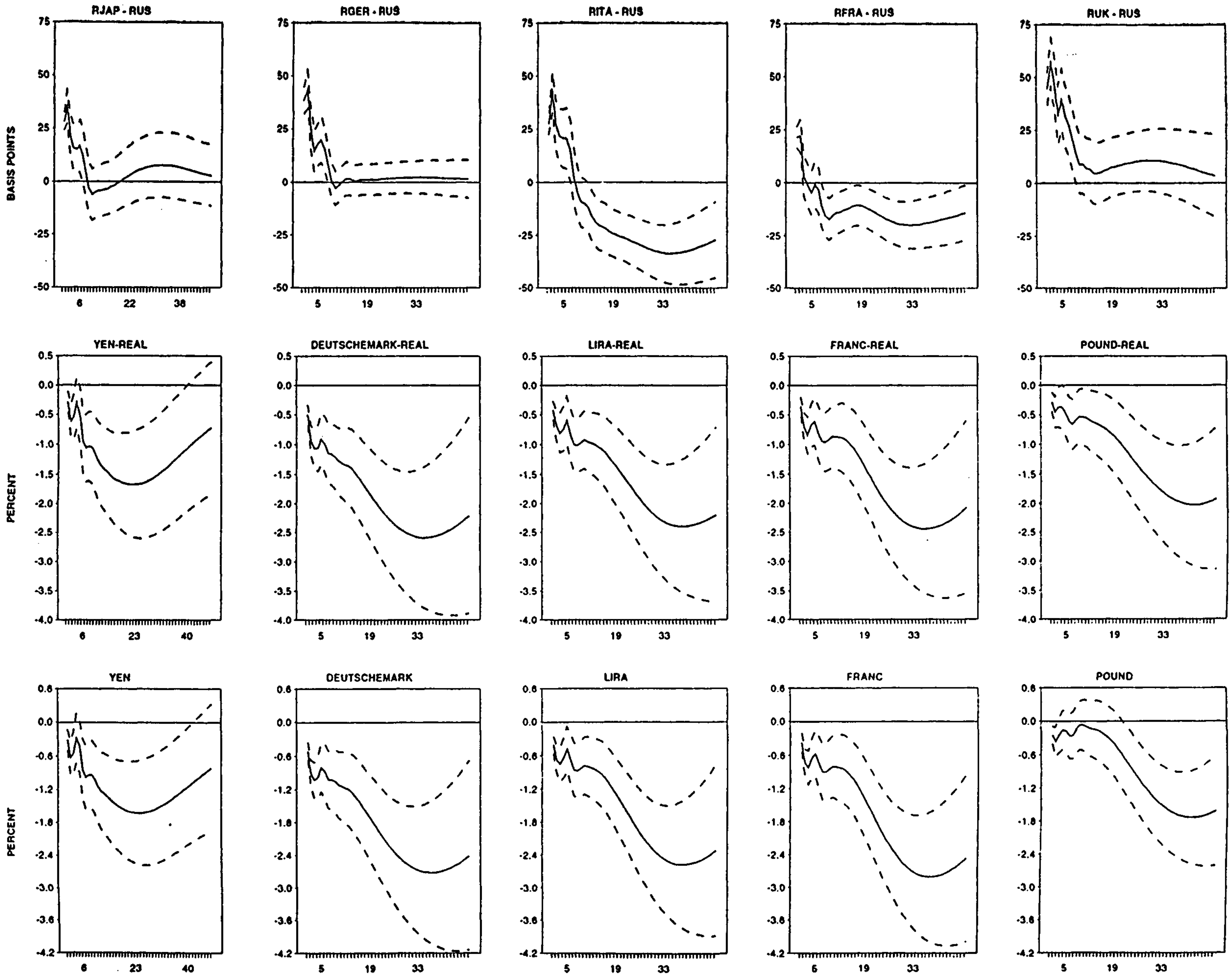
26. Sims, Christopher A. (1992), 'Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy,' *European Economic Review, 36:* 975-1000.

27. Stockman, Alan (1983), 'Real Exchange Rates Under Alternative Nominal Exchange Rate Systems,' *Journal of International Money and Finance 2*, 147-166.

28. Stockman, Alan C. (1988) 'Real Exchange Rate Variability Under Pegged and Floating Nominal Exchange Rate Systems: An Equilibrium Theory,' in Karl Brunner and Alan Meltzer (eds.) *Carnegie Rochester Conference on Public Policy, 29:* 259-294.

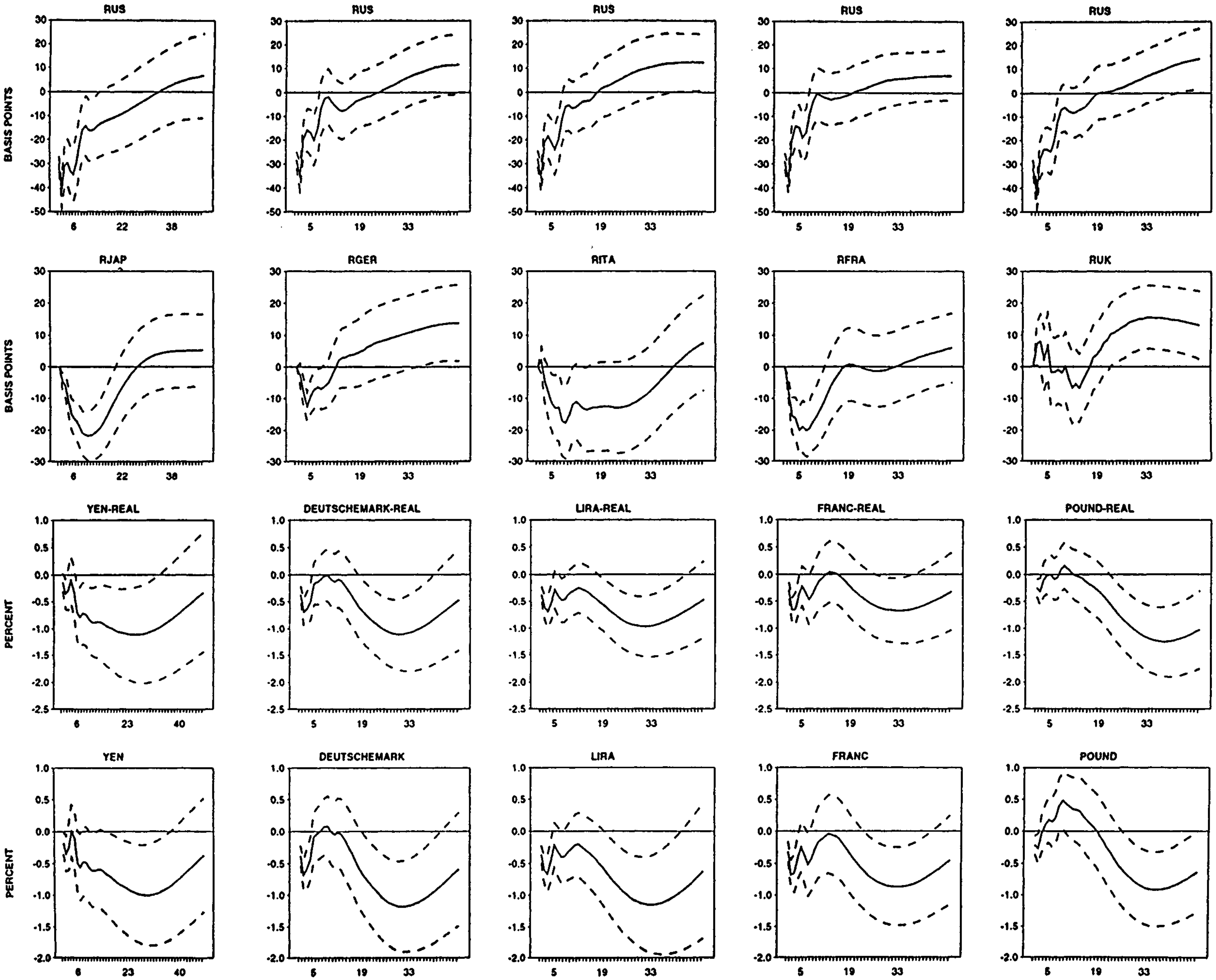
29. Strongin, Steven (1992), 'The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle,' manuscript, Federal Reserve Bank of Chicago.

Figure 1
Dynamic Response Functions: Orthogonalized Shock in NBRX
5 Variable System*



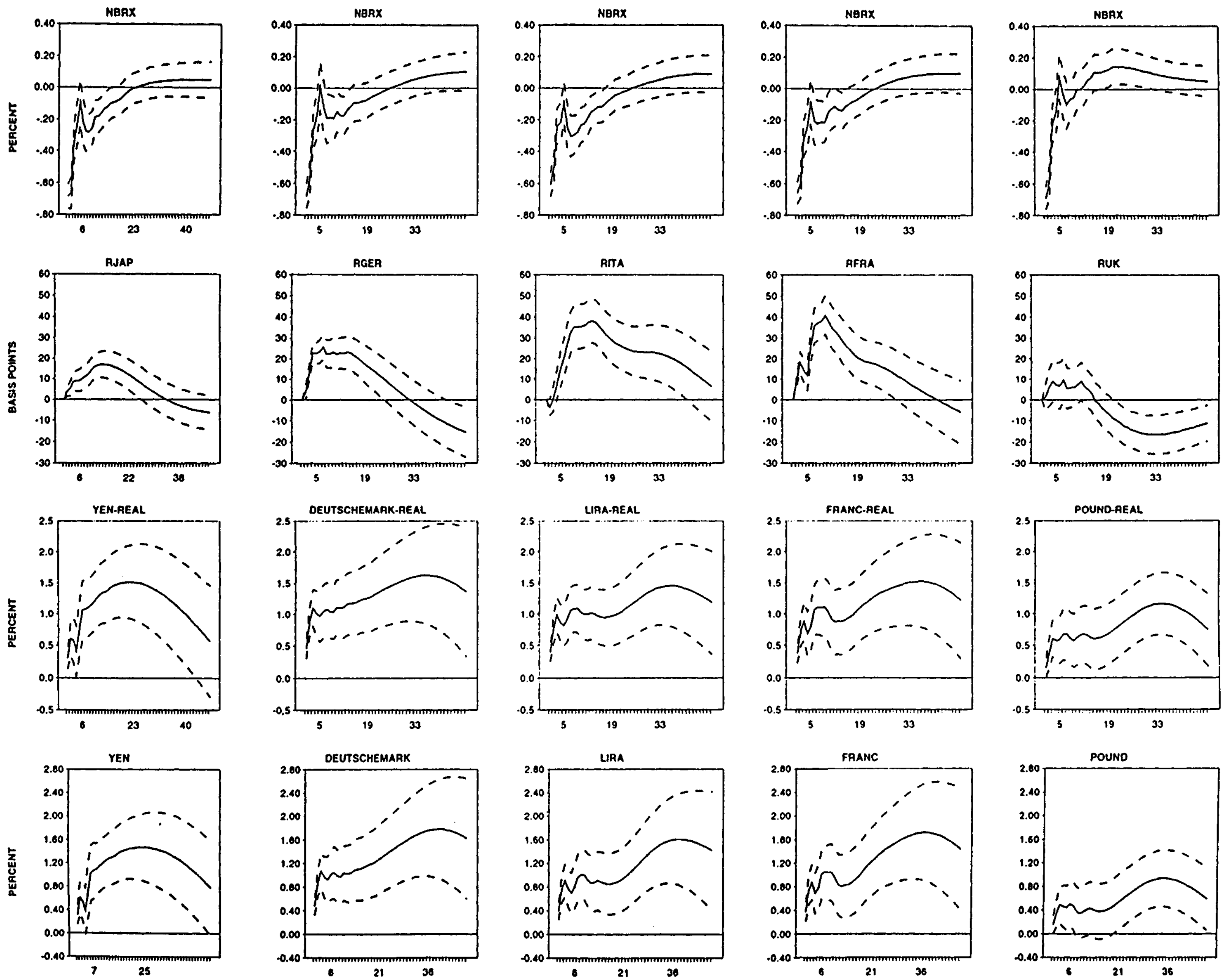
*Column 1 displays the dynamic effect of an orthogonalized innovation in NBRX on the difference between Japanese and U.S. interest rates (RJAP-RUS), the real U.S.-Japan exchange rate (YEN-REAL) and the nominal U.S.-Japan exchange rate (YEN). Columns 2 through 5 do the same for Germany, Italy, France, and the U.K., respectively.

Figure 2
Dynamic Response Functions: Orthogonalized Shock in NBRX
7 Variable System*



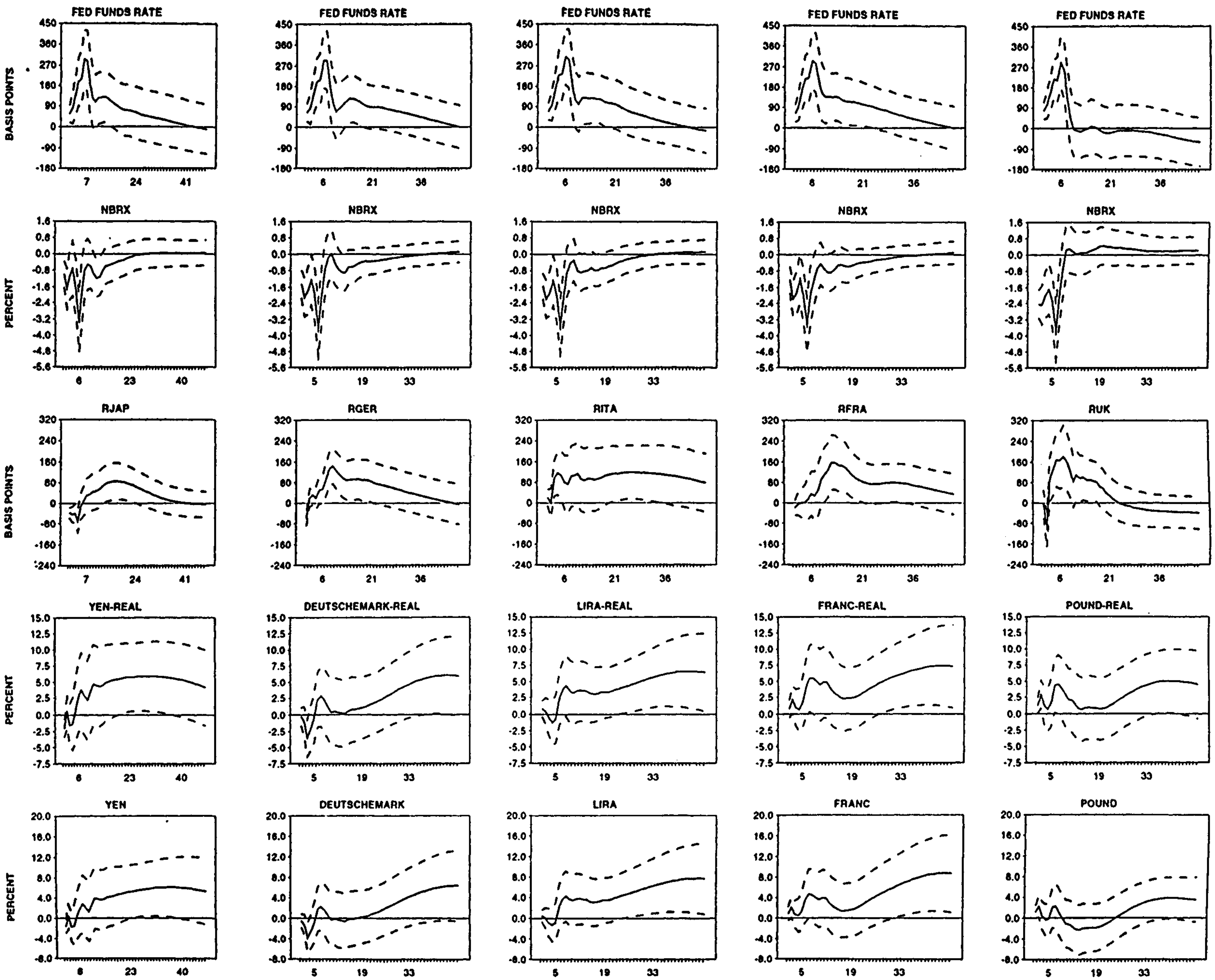
*Column 1 displays the dynamic effect of an orthogonalized innovation in NBRX on the U.S. interest rate (RUS), the Japanese interest rate (RJAP), the real U.S.-Japan exchange rate (YEN-REAL) and the nominal U.S.-Japan exchange rate (YEN). Columns 2 through 5 do the same for Germany, Italy, France, and the U.K., respectively.

Figure 3
Dynamic Response Functions: Orthogonalized Shock in Federal Funds Rate
7 Variable System*



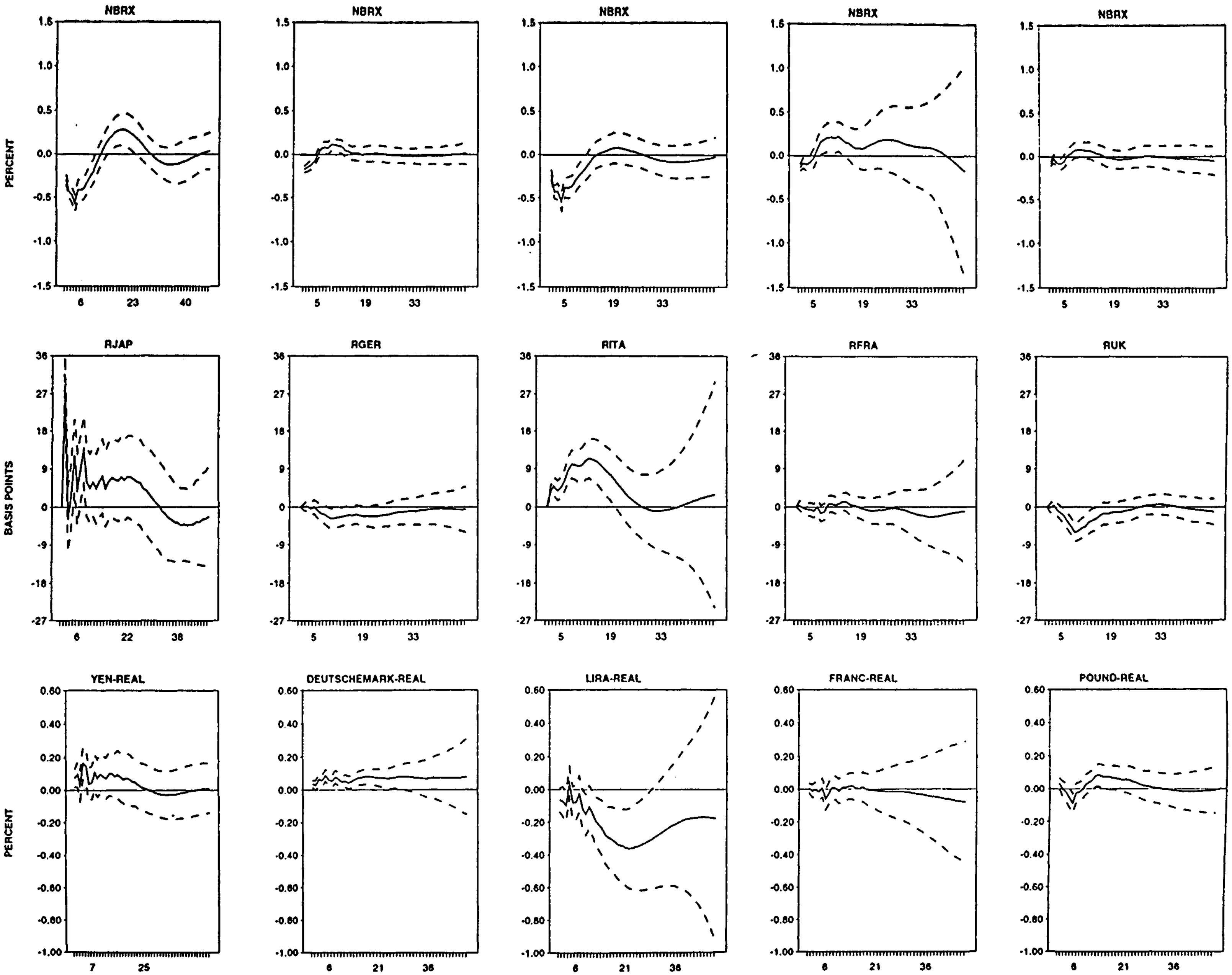
*Column 1 displays the dynamic effect of an orthogonalized innovation in the Fed Funds rate on NBRX, the Japanese interest rate (RJAP), the real U.S.-Japan exchange rate (YEN-REAL) and the nominal U.S.-Japan exchange rate (YEN). Columns 2 through 5 do the same for Germany, Italy, France, and the U.K., respectively.

Figure 4
Dynamic Response Functions: Romer and Romer Shock
8 Variable System*



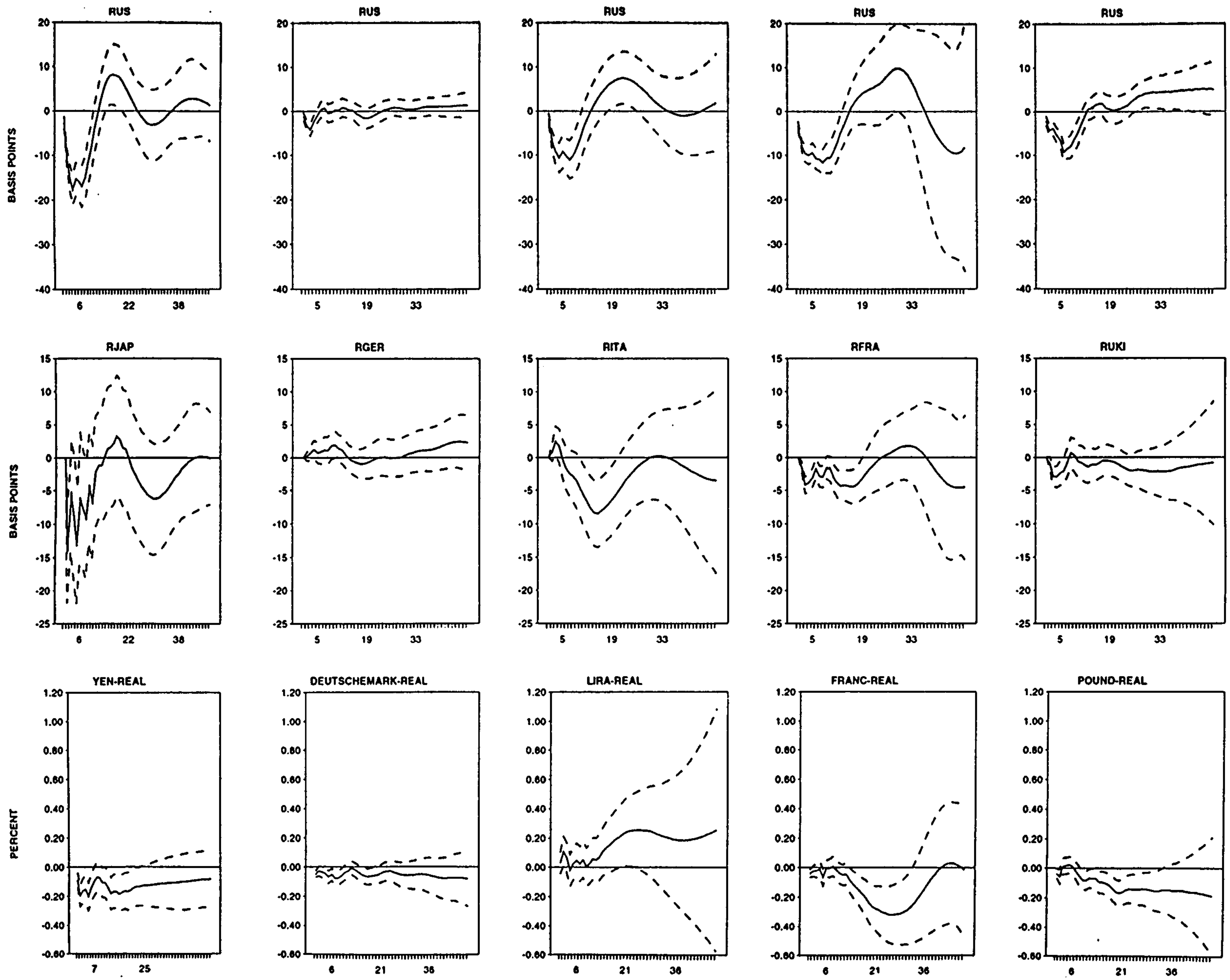
*Column 1 displays the dynamic effect of a Romer and Romer shock on the Fed Funds rate, NBRX, the Japanese interest rate (RJAP), the real U.S.-Japan exchange rate (YEN-REAL) and the nominal U.S.-Japan exchange rate (YEN). Columns 2 through 5 do the same for Germany, Italy, France, and the U.K., respectively.

Figure 5
Dynamic Response Functions: Orthogonalized Shock in Federal Funds Rate
7 Variable System, Fixed Exchange Rate Period*



*Column 1 displays the dynamic effect of an orthogonalized innovation in the Fed Funds rate on NBRX, the Japanese interest rate (RJAP), and the real U.S.-Japan exchange rate (YEN-REAL). Columns 2 through 5 do the same for Germany, Italy, France, and the U.K., respectively.

Figure 6
Dynamic Response Functions: Orthogonalized Shock in NBRX
7 Variable System, Fixed Exchange Rate Period*



*Column 1 displays the dynamic effect of an orthogonalized innovation in NBRX on the U.S. interest rate (RUS), the Japanese interest rate (RJAP), and the real U.S.-Japan exchange rate (YEN-REAL). Columns 2 through 5 do the same for Germany, Italy, France, and the U.K., respectively.

Table 1A
NBRX Based Measure of Policy Shocks, 5 Variable System
Real Exchange Rates

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	CORR(NBRX,EXCH)	-0.1534	-0.2665	-0.2207	-0.2086	-0.1662
	standard error	(0.069)	(0.070)	(0.069)	(0.067)	(0.069)
	significance level	[0.013]	[0.000]	[0.001]	[0.001]	[0.008]
(2)	1-6 months	-0.5343	-0.9135	-0.6824	-0.6681	-0.4302
	standard error	(0.347)	(0.303)	(0.294)	(0.289)	(0.286)
	significance level	[0.062]	[0.001]	[0.010]	[0.010]	[0.066]
(3)	7-12 months	-1.1615	-1.2471	-0.9771	-0.9107	-0.5798
	standard error	(0.605)	(0.538)	(0.464)	(0.502)	(0.449)
	significance level	[0.028]	[0.010]	[0.018]	[0.035]	[0.098]
(4)	13-18 months	-1.5311	-1.5459	-1.1255	-1.0409	-0.7084
	standard error	(0.747)	(0.689)	(0.583)	(0.626)	(0.560)
	significance level	[0.020]	[0.012]	[0.027]	[0.048]	[0.103]
(5)	19-24 months	-1.6677	-2.0291	-1.5575	-1.621	-1.0423
	standard error	(0.873)	(0.817)	(0.704)	(0.726)	(0.659)
	significance level	[0.028]	[0.007]	[0.014]	[0.013]	[0.057]
(6)	25-30 months	-1.6114	-2.4044	-2.0227	-2.1586	-1.4889
	standard error	(0.961)	(0.974)	(0.831)	(0.862)	(0.761)
	significance level	[0.047]	[0.007]	[0.008]	[0.006]	[0.025]
(7)	31-36 months	-1.3945	-2.5753	-2.3238	-2.411	-1.839
	standard error	(1.017)	(1.158)	(0.991)	(1.030)	(0.876)
	significance level	[0.085]	[0.013]	[0.010]	[0.010]	[0.018]
(8)	Max Impact	-1.9808	-2.846	-2.5921	-2.6444	-2.1842
	standard error	(0.921)	(1.422)	(1.340)	(1.278)	(1.123)
	significance level	[0.016]	[0.023]	[0.027]	[0.019]	[0.026]
(9)	Max Month	22.438	34.346	36.932	35.362	39.228
	standard error	(10.417)	(9.520)	(8.773)	(8.615)	(9.419)
	significance level	[0.016]	[0.000]	[0.000]	[0.000]	[0.000]

Variance Decompositions

		Japan	Germany	Italy	France	U.K.
(10)	31-36 Months	23.0162	42.9168	38.1219	37.52	26.1525
	standard error	(13.640)	(15.713)	(15.481)	(14.877)	(15.034)
	significance level	[0.092]	[0.006]	[0.014]	[0.012]	[0.082]

Table 1B
NBRX Based Measure of Policy Shocks, 5 Variable System
Nominal Exchange Rates

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	CORR(NBRX,EXCH)	-0.1505	-0.265	-0.2213	-0.2057	-0.1378
	standard error	(0.074)	(0.064)	(0.065)	(0.070)	(0.070)
	significance level	[0.020]	[0.000]	[0.000]	[0.002]	[0.024]
(2)	1-6 months	-0.509	-0.852	-0.6042	-0.6474	-0.2486
	standard error	(0.351)	(0.302)	(0.288)	(0.291)	(0.270)
	significance level	[0.074]	[0.002]	[0.018]	[0.013]	[0.178]
(3)	7-12 months	-1.0369	-1.089	-0.8262	-0.851	-0.1317
	standard error	(0.607)	(0.566)	(0.493)	(0.532)	(0.431)
	significance level	[0.044]	[0.027]	[0.047]	[0.055]	[0.380]
(4)	13-18 months	-1.3947	-1.3894	-0.9919	-1.0201	-0.2277
	standard error	(0.773)	(0.707)	(0.585)	(0.640)	(0.544)
	significance level	[0.036]	[0.025]	[0.045]	[0.055]	[0.338]
(5)	19-24 months	-1.5885	-1.9387	-1.5346	-1.6841	-0.6297
	standard error	(0.896)	(0.826)	(0.681)	(0.742)	(0.609)
	significance level	[0.038]	[0.010]	[0.012]	[0.012]	[0.151]
(6)	25-30 months	-1.5954	-2.4131	-2.1136	-2.3513	-1.1617
	standard error	(0.974)	(0.984)	(0.816)	(0.875)	(0.658)
	significance level	[0.051]	[0.007]	[0.005]	[0.004]	[0.039]
(7)	31-36 months	-1.4399	-2.6739	-2.4836	-2.7288	-1.5534
	standard error	(1.011)	(1.182)	(0.991)	(1.050)	(0.721)
	significance level	[0.077]	[0.012]	[0.006]	[0.005]	[0.016]
(8)	Max Impact	-1.9472	-2.9456	-2.7958	-3.0006	-1.8895
	standard error	(0.988)	(1.546)	(1.369)	(1.345)	(0.917)
	significance level	[0.024]	[0.028]	[0.021]	[0.013]	[0.020]
(9)	Max Month	23.692	35.604	37.712	37.15	39.642
	standard error	(10.971)	(9.114)	(7.563)	(7.217)	(7.958)
	significance level	[0.015]	[0.000]	[0.000]	[0.000]	[0.000]

Variance Decompositions

		Japan	Germany	Italy	France	U.K.
(10)	31-36 Months	22.0842	41.0213	38.7669	38.4735	18.7524
	standard error	(13.901)	(16.271)	(15.135)	(15.879)	(12.428)
	significance level	[0.112]	[0.012]	[0.010]	[0.015]	[0.131]

Table 2A
NBRX Based Measure of Policy Shocks, 7 Variable System
Real Exchange Rates

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	CORR(NBRX,EXCH)	-0.1031	-0.2511	-0.2256	-0.2124	-0.1494
	standard error	(0.070)	(0.071)	(0.067)	(0.066)	(0.073)
	significance level	[0.069]	[0.000]	[0.000]	[0.001]	[0.021]
(2)	1-6 months	-0.3224	-0.4128	-0.4806	-0.4213	-0.1315
	standard error	(0.343)	(0.277)	(0.258)	(0.264)	(0.264)
	significance level	[0.174]	[0.068]	[0.031]	[0.056]	[0.309]
(3)	7-12 months	-0.8108	-0.0741	-0.363	-0.2084	0.0511
	standard error	(0.582)	(0.472)	(0.424)	(0.502)	(0.407)
	significance level	[0.082]	[0.438]	[0.196]	[0.339]	[0.550]
(4)	13-18 months	-0.9413	-0.3522	-0.3829	-0.0341	-0.1464
	standard error	(0.724)	(0.556)	(0.470)	(0.564)	(0.492)
	significance level	[0.097]	[0.263]	[0.208]	[0.476]	[0.383]
(5)	19-24 months	-1.0861	-0.8246	-0.6988	-0.3798	-0.5019
	standard error	(0.823)	(0.583)	(0.500)	(0.576)	(0.530)
	significance level	[0.093]	[0.079]	[0.081]	[0.255]	[0.172]
(6)	25-30 months	-1.106	-1.0779	-0.9269	-0.6155	-0.9284
	standard error	(0.902)	(0.628)	(0.537)	(0.583)	(0.566)
	significance level	[0.110]	[0.043]	[0.042]	[0.145]	[0.050]
(7)	31-36 months	-0.9796	-1.072	-0.9454	-0.6677	-1.1861
	standard error	(0.973)	(0.717)	(0.581)	(0.608)	(0.611)
	significance level	[0.157]	[0.067]	[0.052]	[0.136]	[0.026]
(8)	Max Impact	-1.5207	-1.3257	-1.1981	-1.0094	-1.3773
	standard error	(0.844)	(0.655)	(0.467)	(0.468)	(0.665)
	significance level	[0.036]	[0.021]	[0.005]	[0.016]	[0.019]
(9)	Max Month	21.128	24.154	23.7	18.586	36.144
	standard error	(11.591)	(13.561)	(14.001)	(15.573)	(9.904)
	significance level	[0.034]	[0.037]	[0.045]	[0.116]	[0.000]

Variance Decompositions

		Japan	Germany	Italy	France	U.K.
(10)	31-36 Months	13.2631	12.893	13.5346	8.3719	10.6872
	standard error	(10.677)	(8.830)	(10.324)	(6.448)	(7.814)
	significance level	[0.214]	[0.144]	[0.190]	[0.194]	[0.171]

Table 2B
NBRX Based Measure of Policy Shocks, 7 Variable System
Nominal Exchange Rates

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	CORR(NBRX,EXCH)	-0.1029	-0.2482	-0.235	-0.2133	-0.1233
	standard error	(0.072)	(0.067)	(0.067)	(0.070)	(0.070)
	significance level	[0.075]	[0.000]	[0.000]	[0.001]	[0.038]
(2)	1-6 months	-0.2352	-0.3663	-0.4347	-0.4514	-0.0168
	standard error	(0.327)	(0.266)	(0.246)	(0.278)	(0.254)
	significance level	[0.236]	[0.084]	[0.038]	[0.052]	[0.474]
(3)	7-12 months	-0.5529	0.013	-0.3046	-0.2706	0.3766
	standard error	(0.541)	(0.466)	(0.431)	(0.532)	(0.433)
	significance level	[0.153]	[0.511]	[0.240]	[0.305]	[0.808]
(4)	13-18 months	-0.658	-0.2916	-0.3613	-0.1289	0.2083
	standard error	(0.638)	(0.585)	(0.534)	(0.612)	(0.534)
	significance level	[0.151]	[0.309]	[0.249]	[0.417]	[0.652]
(5)	19-24 months	-0.8626	-0.8141	-0.726	-0.5152	-0.2153
	standard error	(0.721)	(0.641)	(0.603)	(0.606)	(0.570)
	significance level	[0.116]	[0.102]	[0.114]	[0.198]	[0.353]
(6)	25-30 months	-0.9893	-1.1174	-1.0397	-0.7933	-0.6589
	standard error	(0.776)	(0.689)	(0.678)	(0.607)	(0.583)
	significance level	[0.101]	[0.053]	[0.063]	[0.096]	[0.129]
(7)	31-36 months	-0.952	-1.1527	-1.1387	-0.8627	-0.8833
	standard error	(0.825)	(0.741)	(0.776)	(0.615)	(0.586)
	significance level	[0.124]	[0.060]	[0.071]	[0.080]	[0.066]
(8)	Max Impact	-1.3113	-1.3684	-1.3533	-1.1458	-1.0782
	standard error	(0.683)	(0.688)	(0.835)	(0.513)	(0.512)
	significance level	[0.028]	[0.023]	[0.053]	[0.013]	[0.018]
(9)	Max Month	23.534	26.562	27.494	22.592	34.224
	standard error	(12.008)	(13.117)	(13.333)	(15.698)	(11.038)
	significance level	[0.025]	[0.021]	[0.020]	[0.075]	[0.001]

Variance Decompositions

		Japan	Germany	Italy	France	U.K.
(10)	31-36 Months	11.1799	13.2704	13.743	8.6336	9.4064
	standard error	(9.497)	(9.329)	(9.601)	(7.004)	(6.134)
	significance level	[0.239]	[0.155]	[0.152]	[0.218]	[0.125]

Table 3A
Fed Funds Rate Based Measure of Policy Shocks, 7 Variable System
Real Exchange Rates

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	CORR(FF,EXCH)	0.1571	0.2647	0.2312	0.22	0.1088
	standard error	(0.069)	(0.068)	(0.073)	(0.068)	(0.072)
	significance level	[0.011]	[0.000]	[0.001]	[0.001]	[0.065]
(2)	1-6 months	0.6232	0.9089	0.7893	0.7495	0.4952
	standard error	(0.312)	(0.274)	(0.234)	(0.268)	(0.251)
	significance level	[0.023]	[0.001]	[0.000]	[0.003]	[0.024]
(3)	7-12 months	1.1793	1.0776	1.0403	1.0212	0.639
	standard error	(0.453)	(0.424)	(0.373)	(0.453)	(0.406)
	significance level	[0.005]	[0.006]	[0.003]	[0.012]	[0.058]
(4)	13-18 months	1.4154	1.194	0.9703	0.935	0.6287
	standard error	(0.516)	(0.505)	(0.430)	(0.511)	(0.469)
	significance level	[0.003]	[0.009]	[0.012]	[0.034]	[0.090]
(5)	19-24 months	1.5062	1.3233	1.0328	1.2034	0.7842
	standard error	(0.580)	(0.560)	(0.476)	(0.538)	(0.474)
	significance level	[0.005]	[0.009]	[0.015]	[0.013]	[0.049]
(6)	25-30 months	1.4504	1.4913	1.2632	1.3988	1.027
	standard error	(0.657)	(0.634)	(0.537)	(0.613)	(0.478)
	significance level	[0.014]	[0.009]	[0.009]	[0.011]	[0.016]
(7)	31-36 months	1.2799	1.6026	1.4282	1.5027	1.1549
	standard error	(0.726)	(0.729)	(0.616)	(0.695)	(0.491)
	significance level	[0.039]	[0.014]	[0.010]	[0.015]	[0.009]
(8)	Max Impact	1.755	1.8838	1.6647	1.778	1.3298
	standard error	(0.686)	(0.818)	(0.643)	(0.725)	(0.475)
	significance level	[0.005]	[0.011]	[0.005]	[0.007]	[0.003]
(9)	Max Month	20.734	28.452	28.12	28.38	27.688
	standard error	(9.840)	(15.056)	(14.840)	(14.165)	(13.074)
	significance level	[0.018]	[0.029]	[0.029]	[0.023]	[0.017]

Variance Decompositions

		Japan	Germany	Italy	France	U.K.
(10)	31-36 Months	21.6427	26.5427	25.3986	24.7293	16.9572
	standard error	(10.456)	(11.456)	(10.093)	(11.733)	(10.052)
	significance level	[0.039]	[0.021]	[0.012]	[0.035]	[0.092]

Table 3B
Fed Funds Rate Based Measure of Policy Shocks, 7 Variable System
Nominal Exchange Rates

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	CORR(FF.EXCH)	0.1472	0.2679	0.2437	0.2181	0.0989
	standard error	(0.071)	(0.064)	(0.069)	(0.073)	(0.072)
	significance level	[0.019]	[0.000]	[0.000]	[0.002]	[0.085]
(2)	1-6 months	0.5994	0.8844	0.7217	0.7425	0.4018
	standard error	(0.306)	(0.265)	(0.241)	(0.273)	(0.260)
	significance level	[0.025]	[0.000]	[0.001]	[0.003]	[0.061]
(3)	7-12 months	1.154	1.0122	0.935	0.9537	0.4017
	standard error	(0.422)	(0.439)	(0.422)	(0.467)	(0.406)
	significance level	[0.003]	[0.011]	[0.013]	[0.021]	[0.161]
(4)	13-18 months	1.348	1.1207	0.8694	0.9046	0.3968
	standard error	(0.465)	(0.527)	(0.502)	(0.542)	(0.458)
	significance level	[0.002]	[0.017]	[0.042]	[0.048]	[0.193]
(5)	19-24 months	1.4525	1.2851	0.9764	1.2504	0.5627
	standard error	(0.531)	(0.581)	(0.535)	(0.577)	(0.466)
	significance level	[0.003]	[0.013]	[0.034]	[0.015]	[0.113]
(6)	25-30 months	1.4475	1.5154	1.2955	1.5178	0.8044
	standard error	(0.611)	(0.644)	(0.597)	(0.654)	(0.464)
	significance level	[0.009]	[0.009]	[0.015]	[0.010]	[0.042]
(7)	31-36 months	1.35	1.7018	1.5441	1.6805	0.9283
	standard error	(0.682)	(0.733)	(0.695)	(0.754)	(0.472)
	significance level	[0.024]	[0.010]	[0.013]	[0.013]	[0.025]
(8)	Max Impact	1.7202	2.0057	1.7763	1.956	1.1208
	standard error	(0.641)	(0.880)	(0.893)	(0.811)	(0.441)
	significance level	[0.004]	[0.011]	[0.023]	[0.008]	[0.006]
(9)	Max Month	21.962	32.342	33.43	31.214	28.054
	standard error	(10.951)	(14.450)	(13.394)	(13.427)	(13.883)
	significance level	[0.023]	[0.013]	[0.006]	[0.010]	[0.022]

Variance Decompositions

		Japan	Germany	Italy	France	U.K.
(10)	31-36 Months	22.908	25.9663	23.1556	26.7491	11.5707
	standard error	(10.853)	(11.208)	(10.250)	(12.145)	(7.933)
	significance level	[0.035]	[0.021]	[0.024]	[0.028]	[0.145]

Table 4A
Romer and Romer Policy Shocks, 8 Variable System
Real Exchange Rates

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	1-6 months	-0.2221	-0.8979	0.21	1.6952	1.9819
	standard error	(3.252)	(2.703)	(2.569)	(2.734)	(2.563)
	significance level	[0.527]	[0.630]	[0.467]	[0.268]	[0.220]
(2)	7-12 months	3.5563	1.2126	3.6529	4.9778	2.8181
	standard error	(5.922)	(4.818)	(4.590)	(5.333)	(4.625)
	significance level	[0.274]	[0.401]	[0.213]	[0.175]	[0.271]
(3)	13-18 months	4.8741	0.5203	3.2519	2.7843	0.815
	standard error	(5.759)	(4.948)	(4.216)	(5.026)	(4.823)
	significance level	[0.199]	[0.458]	[0.220]	[0.290]	[0.433]
(4)	19-24 months	5.6292	1.4961	3.6175	3.0102	1.1015
	standard error	(5.307)	(4.625)	(3.864)	(4.674)	(4.749)
	significance level	[0.144]	[0.373]	[0.175]	[0.260]	[0.408]
(5)	25-30 months	5.8686	3.0898	4.6161	4.7997	2.9253
	standard error	(5.261)	(4.727)	(4.127)	(4.741)	(4.723)
	significance level	[0.132]	[0.257]	[0.132]	[0.156]	[0.268]
(6)	31-36 months	5.7854	4.6728	5.688	6.1384	4.4119
	standard error	(5.461)	(5.148)	(4.636)	(5.158)	(4.766)
	significance level	[0.145]	[0.182]	[0.110]	[0.117]	[0.177]
(7)	Max Impact	9.0819	7.9303	8.5931	9.8147	7.9368
	standard error	(5.544)	(5.128)	(5.095)	(5.730)	(4.502)
	significance level	[0.051]	[0.061]	[0.046]	[0.043]	[0.039]
(8)	Max Month	24.452	31.886	29.89	28.114	22.496
	standard error	(13.865)	(17.297)	(17.004)	(18.579)	(18.700)
	significance level	[0.039]	[0.033]	[0.039]	[0.065]	[0.115]

Table 4B
Romer and Romer Policy Shocks, 8 Variable System
Nominal Exchange Rates

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	1-6 months	-0.3857	-1.1982	0.0224	1.4963	0.907
	standard error	(3.102)	(2.672)	(2.550)	(2.618)	(2.456)
	significance level	[0.550]	[0.673]	[0.497]	[0.284]	[0.356]
(2)	7-12 months	2.7511	0.6485	3.7961	4.08	-0.1356
	standard error	(5.781)	(4.969)	(4.773)	(5.117)	(4.325)
	significance level	[0.317]	[0.448]	[0.213]	[0.213]	[0.513]
(3)	13-18 months	4.028	-0.1906	3.3762	1.9085	-2.0435
	standard error	(5.705)	(5.286)	(4.558)	(5.229)	(4.670)
	significance level	[0.240]	[0.514]	[0.229]	[0.358]	[0.669]
(4)	19-24 months	4.9427	0.7415	3.8983	2.366	-1.1687
	standard error	(5.283)	(5.074)	(4.328)	(5.177)	(4.399)
	significance level	[0.175]	[0.442]	[0.184]	[0.324]	[0.605]
(5)	25-30 months	5.5808	2.4363	5.1283	4.6209	1.1879
	standard error	(5.199)	(5.203)	(4.695)	(5.502)	(4.147)
	significance level	[0.142]	[0.320]	[0.137]	[0.201]	[0.387]
(6)	31-36 months	5.9273	4.2423	6.3582	6.5352	3.0301
	standard error	(5.546)	(5.611)	(5.334)	(6.111)	(3.979)
	significance level	[0.143]	[0.225]	[0.117]	[0.142]	[0.223]
(7)	Max Impact	8.8048	8.0523	9.5084	10.3899	6.141
	standard error	(5.710)	(5.705)	(6.007)	(6.792)	(3.896)
	significance level	[0.062]	[0.079]	[0.057]	[0.063]	[0.058]
(8)	Max Month	26.446	35.004	33.088	32.632	25.532
	standard error	(15.061)	(16.884)	(16.745)	(18.061)	(18.935)
	significance level	[0.040]	[0.019]	[0.024]	[0.035]	[0.089]

Table 5
Fed Funds Rate Based Measure of Policy Shocks, 7 Variable System
Real Exchange Rates, Fixed Exchange Rate Period

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	CORR(FF,EXCH)	0.1214	0.1963	-0.0574	0.0544	0.0632
	standard error	(0.083)	(0.103)	(0.087)	(0.087)	(0.099)
	significance level	[0.071]	[0.028]	[0.745]	[0.266]	[0.263]
(2)	1-6 months	0.09	0.0574	-0.062	-0.0143	-0.0244
	standard error	(0.069)	(0.026)	(0.072)	(0.039)	(0.040)
	significance level	[0.095]	[0.013]	[0.806]	[0.642]	[0.729]
(3)	7-12 months	0.0842	0.0572	-0.1366	0.0001	0.0326
	standard error	(0.103)	(0.034)	(0.117)	(0.064)	(0.051)
	significance level	[0.206]	[0.044]	[0.878]	[0.500]	[0.261]
(4)	13-18 months	0.0995	0.0754	-0.2813	0.0168	0.0765
	standard error	(0.130)	(0.044)	(0.182)	(0.080)	(0.067)
	significance level	[0.223]	[0.043]	[0.939]	[0.417]	[0.126]
(5)	19-24 months	0.0684	0.0797	-0.355	-0.0001	0.0552
	standard error	(0.141)	(0.064)	(0.248)	(0.123)	(0.081)
	significance level	[0.314]	[0.105]	[0.924]	[0.500]	[0.247]
(6)	25-30 months	0.0154	0.0857	-0.3254	0.0007	0.0186
	standard error	(0.139)	(0.096)	(0.310)	(0.161)	(0.090)
	significance level	[0.456]	[0.187]	[0.853]	[0.498]	[0.418]
(7)	31-36 months	-0.0134	0.0839	-0.2505	-0.0135	-0.0042
	standard error	(0.141)	(0.139)	(0.376)	(0.200)	(0.098)
	significance level	[0.538]	[0.274]	[0.747]	[0.527]	[0.517]
(8)	Max Impact	0.2285	0.191	0.1124	0.1594	0.1398
	standard error	(0.119)	(0.314)	(0.165)	(0.260)	(0.088)
	significance level	[0.028]	[0.271]	[0.248]	[0.270]	[0.056]
(9)	Max Month	10.59	22.76	14.44	20.722	16.514
	standard error	(10.502)	(17.125)	(17.262)	(15.199)	(9.324)
	significance level	[0.157]	[0.092]	[0.201]	[0.086]	[0.038]

Variance Decompositions

		Japan	Germany	Italy	France	U.K.
(10)	31-36 Months	15.765	6.7015	28.6339	8.9259	20.3442
	standard error	(11.875)	(4.763)	(15.310)	(6.938)	(12.445)
	significance level	[0.184]	[0.159]	[0.061]	[0.198]	[0.102]

Table 6
NBRX Based Measure of Policy Shocks, 7 Variable System
Real Exchange Rates, Fixed Exchange Rate Period

Dynamic Response Functions

		Japan	Germany	Italy	France	U.K.
(1)	CORR(NBRX,EXCH)	-0.1482	-0.2107	0.0457	-0.1516	-0.1346
	standard error	(0.079)	(0.101)	(0.093)	(0.089)	(0.104)
	significance level	[0.031]	[0.019]	[0.698]	[0.045]	[0.097]
(2)	1-6 months	-0.1579	-0.0457	0.0433	-0.0284	-0.0004
	standard error	(0.064)	(0.027)	(0.077)	(0.039)	(0.039)
	significance level	[0.007]	[0.046]	[0.714]	[0.232]	[0.495]
(3)	7-12 months	-0.099	-0.0471	0.0359	-0.0241	-0.0599
	standard error	(0.092)	(0.036)	(0.122)	(0.062)	(0.051)
	significance level	[0.141]	[0.093]	[0.615]	[0.349]	[0.118]
(4)	13-18 months	-0.1733	-0.0485	0.1383	-0.1451	-0.0971
	standard error	(0.114)	(0.044)	(0.176)	(0.097)	(0.067)
	significance level	[0.065]	[0.134]	[0.784]	[0.067]	[0.074]
(5)	19-24 months	-0.1449	-0.042	0.2378	-0.2815	-0.1455
	standard error	(0.128)	(0.057)	(0.233)	(0.155)	(0.085)
	significance level	[0.128]	[0.230]	[0.846]	[0.035]	[0.043]
(6)	25-30 months	-0.1218	-0.0503	0.2451	-0.3137	-0.131
	standard error	(0.149)	(0.080)	(0.298)	(0.204)	(0.109)
	significance level	[0.208]	[0.265]	[0.795]	[0.062]	[0.115]
(7)	31-36 months	-0.1095	-0.0524	0.2027	-0.2208	-0.1327
	standard error	(0.175)	(0.104)	(0.389)	(0.275)	(0.139)
	significance level	[0.266]	[0.308]	[0.699]	[0.211]	[0.170]
(8)	Max Impact	-0.2841	-0.1619	-0.1203	-0.4264	-0.2596
	standard error	(0.095)	(0.138)	(0.125)	(0.296)	(0.241)
	significance level	[0.001]	[0.121]	[0.168]	[0.075]	[0.140]
(9)	Max Month	11.032	22.442	13.264	28.46	28.15
	standard error	(10.070)	(18.223)	(15.051)	(8.420)	(13.494)
	significance level	[0.137]	[0.109]	[0.189]	[0.000]	[0.019]

Variance Decompositions

		Japan	Germany	Italy	France	U.K.
(10)	31-36 Months	13.0994	7.1687	4.6498	9.5577	10.8567
	standard error	(9.770)	(3.867)	(4.736)	(5.270)	(7.758)
	significance level	[0.180]	[0.064]	[0.326]	[0.070]	[0.162]

Appendix

This appendix describes the data used in this study.

Nominal exchange rates:
The data are bilateral monthly average exchange rates between the U.S. dollar and Japanese Yen, German Deutschemark, French Frank, Italian Lira, and United Kingdom Pound. For the flexible exchange rate period, the data source is the Federal Reserve Board database. For the fixed exchange rate period, the single (nominal) exchange rate for each bilateral country is taken from *International Financial Statistics*.

U.S. data:
The source for the following data is the Federal Reserve database: Industrial Production index, Consumer Price index-Urban, Federal Funds rate, monthly average of daily rates, 3 month Treasury bill rates, monthly average of daily rates, Total Reserves, Nonborrowed Reserves with Extended Credit and Special Borrowings.

Foreign data:
For each country (Japan, Germany, Italy, France and the United Kingdom), the data source is the *International Financial Statistics* database. Industrial Production (line 66) and Consumer Price Indices (line 64) are used to measure foreign output and foreign price levels. The choice of foreign interest rate depended upon availability over the sample period.

Japan:
Flexible period: Short-term money market rate
Fixed period: Short-term money market rate.

Germany:
Flexible period: Short-term money market rate
Fixed period: Long term bond rate.

France:
Flexible period: Short-term money market rate
Fixed period: Long-term bond rate.

Italy:
Flexible period: Short-term money market rate
Fixed period: Long term bond rate.

United Kingdom:
Flexible period: Short-term Treasury bill rate
Fixed period: Long term bond rate.