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Reexamining the Sources of Fluctuations in Real Exchange Rates

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This paper reexamines the sources of fluctuations of the real exchange rates. Using real U.S. exchange rates against the Canadian dollar, the British pound, the Japanese yen and the German mark, this paper identifies the dynamic effects of supply and demand shocks and analyze the relative contributions of both shocks on the variability of the real exchange rates. In contrast to the previous studies, this study indicates that demand shocks are the dominant source of movement in the real exchange rates and support the explanation that fiscal and monetary policies in the United States are mainly responsible for wide swings of the real exchange rate in the 1980s.

I. Introduction

Since the floating exchange rate system has been adopted in 1973, the movement of the U.S. dollar has shown wide swings: the substantial dollar depreciation between 1977 and 1979, the following dollar appreciation until the end of 1984 and the offsetting dollar depreciation by the end of 1987. Because relative inflation rates have been relatively stable during the same period, such wide swings in the dollar with respect to other major currencies have accompanied with similar fluctuations in the real exchange rates. Statistically this fact implies that the real exchange rate

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process has a unit root.

Because the existing structural models of the exchange rate determination have performed poorly in explaining the movement of nominal exchange rates, several studies have been undertaken to explain the movement of real exchange rates using different time series techniques. Especially, they have investigated whether the real exchange rates have a mean-reverting component and if so, what extent to which the movement of the real exchange rates can be explained by either changes in the temporary component or changes in the permanent component.

Using a univariate Beveridge-Nelson decomposition,[1] Huizinga [15] decomposed the real exchange rate into permanent and transitory components and found that there exist substantial temporary components in real exchange rates. Campbell and Clarida [6] used the Kalman filtering method to identify permanent components in the real exchange rate and found that the most of the movement of the real exchange rates come from changes in the permanent component. Cumby and Huizinga [7] and Baxter [2] confirmed the findings in Huizinga, and Campbell and Clarida, using a multivariate Beveridge-Nelson decomposition.

Either a Beveridge-Nelson decomposition approach or a Kalman filtering technique assumes a specific time series representation of real exchange rates. The Beveridge-Nelson decomposition method requires that the permanent component should follow a random walk and the Kalman filtering approach assumes that the unobservable state variables follow AR(1) processes. Therefore, to avoid such a restriction on the time series representation of real exchange rates, Lastrapes [16] and Evans and Lothian [9] used so called structural VAR approaches.[2] Specifically, they used the method developed by Blanchard and Quah [5] to identify the dynamic effects of structural disturbances on real exchange rates.

Both studies interpreted the permanent and transient shocks on real exchange rates as the real and nominal shocks, respectively and then imposed the same long run restriction on the movements of the real exchange rates to identify real and nominal shocks. That is, the nominal shocks such as nominal demand shocks (e.g., monetary shocks) do not have permanent effects on real exchange rates. Based on the above identifying restriction, they found that real shocks such as technology and taste shocks dominate the movement of real exchange rates and supported the inference

1) For details, see Beveridge and Nelson [3].

2) For details, see Blanchard [4] and Gali [14].

in Meese and Rogoff [17] that the monetary shocks may not be a main source of the movement of real exchange rates. Therefore, their conclusions are critically dependent on the assumption that the nominal shocks do not affect real exchange rates permanently and that only the real shocks affect the long run level of the real exchange rate.

When we accept their interpretations, the large swings of the real U.S. exchange rates against major foreign currencies in the 1980s should be explained in terms of either the productivity shocks or the taste shocks. If the productivity shocks had been the main source for the fluctuations of real exchange rates, as Evans and Lothian pointed out, positive (negative) productivity shocks in the U.S. should have been followed by either negative (positive) productivity shocks of the almost same size in the U.S. or positive (negative) productivity shocks of the almost same size in foreign countries. Furthermore, if the taste shocks had been the main source for such large swings, the country risk or the risk premium should have consistently changed in terms of the movement of real exchange rates. Intuitively and empirically, both explanations do not seem to provide good reasons why the real U.S. dollar values have fluctuated largely during the 1980s.[3]

Using widely known models of exchange rate determination,[4] it is easily shown that shocks in aggregate demand may have permanent effects on the real exchange rate. For example, Dornbusch's sticky price model predicts that the permanent shift in aggregate demand (e.g., the permanent shift in government spending) has permanent effects on the real exchange rate. The portfolio balance model predicts that monetary shocks have permanent effects on the real exchange rate through current account equilibrium. Therefore, it is surprising that Lastrapes and Evans and Lothian did not consider such long run effects of aggregate demand shocks on real exchange rates in their studies.

The main purpose of this paper is also to identify the relative contributions of structural disturbances to the movement of real U.S. exchange rates against the Canadian dollar, the British pound, the Japanese yen and the German mark using

3) Using the differentials between European and U.S. interest rates, Frankel and Froot [11] argued that the country risk shifted against the U.S. from 1982 to February 1985, so that a shift in country risk could not explain the real appreciation of the U.S. dollar during that period. Using the survey data, Froot and Frankel [12] also showed that the market risk premium does not vary much and failed to reject the hypothesis that the market premium is constant.

4) For details, see Obstfeld and Stockman [18].

the Blanchard and Quah's method. It is assumed that real exchange rates are affected by supply shocks (e.g., productivity shocks) and demand shocks (e.g., IS shocks and money supply shocks). However, we do not impose the restriction that demand shocks do not have permanent effects on real exchange rates. Instead, to identify structural disturbances, we use the standard macroeconomic prediction that demand shocks do not affect output permanently. Thus, if the empirical evidence in this paper shows that the supply shocks largely determine the real exchange rate movement, we can identify the real shocks in their models as the supply shocks. But, if the demand shocks dominate the fluctuations of real exchange rates, their interpretation of permanent shocks as the real shocks may be misleading. Therefore, this study also tests whether shocks identified in the above two studies actually correspond to real and nominal shocks as they have been interpreted.

II. Empirical Model

Because the identification approach used in this paper allows to identify as many structural disturbances as observed variables, we use the first differences of the real exchange rate and relative income to identify the supply and demand shocks.

Let q_t, y_t and y_t^* denote the logarithm of the real exchange rate, domestic output and foreign output, respectively. First, we assume that the first differences of the real exchange rate and relative income are covariance stationary and a vector, $\triangle x_t$ $\{=[\triangle(y - y^*), \triangle q]'\}$ follows a covariance stationary process such as

$$\triangle x_t = A(L)\,\varepsilon_t \qquad (1)$$

where $A(L)$ is a matrix of lag polynomials $[A(L) = A_0 I + A_0 L + A_2 L^2 + \cdots]$, $\triangle$ denotes the first difference operator and ε_t is the vector of structural disturbances, $(\varepsilon_{1t}, \varepsilon_{2t})'$. ε_{1t} and ε_{2t} are called supply and demand disturbances, respectively. It is assumed that two disturbances, ε_{1t} and ε_{2t} are uncorrelated and their covariance matrix is the identity. This vector moving average representation is called a structural vector moving average representation.

Because demand shocks do not have permanent effects on output, we have the following restriction on the matrix of lag polynomials, $A(L)$:

$$A_{12}(1) = 0 \tag{2}$$

(2) says that demand shocks do not have permanent effects on the relative income process.

Because $\triangle x_t$ is covariance stationary, it also has an unique moving average representation by the Wold theorem.[5] Compared to the structural vector moving average representation, this vector moving average representation is called the reduced form vector moving average representation:

$$\triangle x_t = B(L)\,\eta_t \tag{3}$$

where $B(L)$ is a matrix of lag polynomials $[B(L) = I + B_1 L + B_2 L^2 + \cdots]$, $cov(\eta_t) = \sum$ and $E(\eta_t\, \eta_s') = 0, \forall t \neq s$. η_t is called the reduced form disturbance and formally defined by $\eta_t = x_t - E[x_t \mid x_{t-j}, j > 0]$ where x_t is a vector of $[(y - y^*)_t, q_t]'$.

To know the dynamic effects of structural disturbances on the exchange rate process, it is necessary to identify structural disturbances from reduced form disturbances, i.e., it is required to identify a transformation matrix, S, such that

$$S\,\varepsilon_t = \eta_t \tag{4}$$

where $SS' = \sum$. From $SS' = \sum$, three restrictions on the matrix, S, are obtained. The remaining one restriction can be found from the restriction on $A(L)$, (2), so that the transformation matrix, S, is exactly identified. Computationally, the restriction (2) is used to derive the Cholesky factor of $B(1)\sum B(1)'$. Because $S = B(1)^{-1} A(1)$, it is commonly known that S is uniquely identified.[6]

Using S, the reduced form vector moving average representation can be rewritten into the structural vector moving average representation.[7] The structural vector moving average representation will be used to find out the dynamic implications of structural shocks on the real exchange rate process.[8]

5) Here $\triangle x_t$ is assumed to be purely indeterministic. For details of the Wold theorem, see Sargent [20].

6) For details, see Ahmed, Iches, Wang and Yoo [1]. Furthermore, because $\triangle x_t = A(L)\, A_0^{-1} A_0\, \varepsilon_t = B(L)\, \eta_t$ where A_0 is the contemporaneous effect of the structural disturbance, ε_t, on $\triangle x_t$, the unique transformation matrix, S, is actually A_0.

7) The reduced form vector moving average representation is obtained by inverting a(reduced form) vector autoregressive representation in the usual way.

8) For details, see Blanchard and Quah [5].

III. Empirical Results

For empirical analysis, the data for the U.S. dollar relative to the Canadian dollar, British pound, German Mark and Japanese Yen are used. Monthly nominal exchange rates and CPI series are obtained from the International Financial Statistics data base. Monthly industrial production indices are obtained from the OECD's Main Economic Indicators and used as a proxy for real output. Observations from January 1976 to December 1990 are used for estimation.

1. Unit Roots and Cointegration Tests

First, real exchange rates and relative income are tested for a unit root. The augmented Dickey-Fuller test is done by running the regression:[9]

$$\triangle z_t = \alpha + \beta z_{t-1} + \gamma \triangle z_{t-1} + \theta_t \tag{5}$$

The null hypothesis of a unit root in z_t is inconsistent with a large negative estimate of β. Table 1 shows the results of the augmented Dickey-Fuller regression. The results are consistent with the hypothesis that q_t and $(y - y^*)_t$ are first-difference stationary, i.e., I(1) processes.

If q_t and $(y - y^*)_t$ are cointegrated, a vector moving average representation of $\triangle x_t \{=[\triangle(y - y^*), \triangle q]'\}$, (3), cannot be invertible so that a reduced form vector autoregression representation (VAR) cannot be estimated.[10] Therefore, to justify the

〈Table 1〉 Unit Root Tests

	$t(\hat{\beta})$			
	Canada	UK	Japan	Germany
q_t	−1.86	−1.16	−1.41	−0.96
$\triangle q_t$	−11.05	−8.92	−8.64	−8.31
$(y - y^*)_t$	−2.22	−2.07	−1.01	−2.41
$\triangle(y - y^*)_t$	−12.25	−10.43	−12.33	−12.64

Note: The augmented Dickey-Fuller regression equation is $\triangle z_t = \alpha + \beta z_{t-1} + \gamma \triangle z_{t-1} + \theta_t$. The 5 and 10 percent critical values for 250 observations are −2.88 and −2.57, respectively (Fuller [13], Table 8.5.2, p. 373).

9) Augmented Dickey-Fuller tests with different lags do not change results.

10) For details, see Engle and Granger [8].

〈Table 2〉 **Test for Cointegration**

	$t(\hat{\rho})$			
	Canada	UK	Japan	Germany
DF	−1.67	−1.26	−1.34	−1.47
ADF	−1.42	−1.27	−1.43	−1.15

Note: The cointegration regression equation is $q_t = \alpha + \beta(y - y^*)_t + \nu_t$, the simple Dickey-Fuller regression equation is $\Delta\nu_t = \rho\nu_{t-1} + \theta_t$ and the augmented Dickey-Fuller regression equation is $\Delta\nu_t = \rho\nu_{t-1} + \delta\Delta\nu_{t-1} + \theta_t$. The 5 and 10 percent critical values for the simple DF test are −3.37 and −3.03, respectively. The 5 and 10 percent critical values for the augmented DF test are −3.17 and −2.84, respectively(Engle and Granger [8], Table II, p. 269).

empirical model used in this paper, tests for cointegration are done in Table 2. We find no cointegration between the real exchange rate and relative income.

2. Dynamic Effects of Structural Disturbances

We estimate a (reduced form) VAR with four lags to estimate the reduced form vector moving average representation.[11] Using the identification restriction, the unique transformation matrix, S, is computed. With the computed S matrix, the structural vector moving average representation is obtained. However, because this vector moving average representation is in the difference form, the vector moving average representation is transformed into the level form to analyze the dynamic effects of structural disturbances on real exchange rates.

The impulse responses of real exchange rates to supply and demand disturbances are shown in Figures 1, 2, 3 and 4. All impulse responses are drawn in terms of the one standard deviation shock.

Figure 1 displays the impulse response function for the U.S. dollar−Canadian dollar. Supply disturbances initially have negative effects. This negative effects on the real exchange rates become stronger over the next four months, rising back to a permanently lower level. In response to the demand shock, the real exchange rate initially rises, but then rapidly decreases, reaching the long run level after about eight months.

11) A VAR system with twelve lags is estimated and tested against one with four lags. The χ^2 test shows that the VAR with four lags is not significantly different from the VAR with twelve lags. Furthermore, when the VAR with twelve lags is used, the empirical results discussed below do not change significantly.

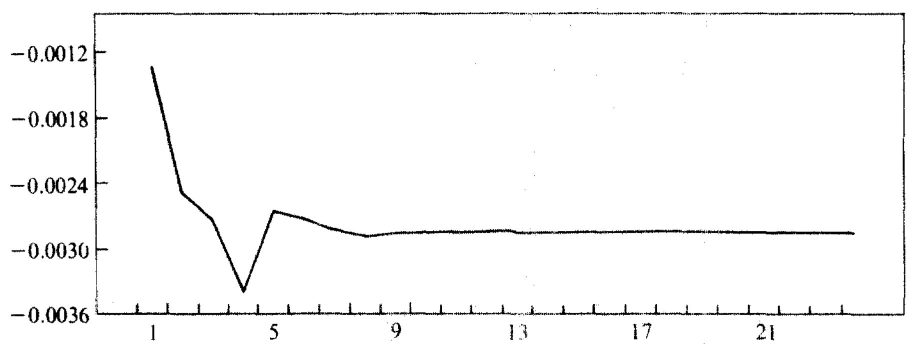
Figure 2 shows the dynamic responses of the real exchange rates in the U.S. dollar-British pound case. In response to supply shocks, the real exchange rate initially rises, then rapidly decreases over the next five months. It reaches a long run level after about eight months. As seen in Figure 2.a, the permanent effects of supply disturbances on the real U.S. dollar-British pound rates are very small. Demand shocks also have initial positive effects. The real exchange rates rise further over the next five months, then gradually converging to the permanently higher level.

The responses of the real U.S. dollar-Japanese yen rates to the one standard deviation shocks of two disturbances are depicted in Figure 3. The supply shock initially raises the real exchange rate. It then cycles rapidly for the next one year before settling down at a new, permanently higher level. In response to the demand shock, the real exchange rate initially rises. Then, it rapidly rises for over six months to its permanently higher level.

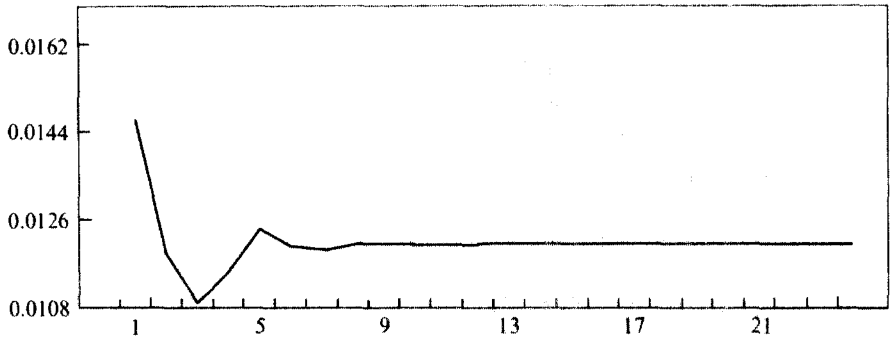
Figures 4 shows the impulse responses of the real U.S. dollar-German mark rates. The response to the supply shock is roughly similar to that in the U.S. dollar-Canadian dollar, though the real exchage rate decreases to a much lower long run level. The impact of the demand shock on the real U.S. dollar-German mark rates is qualitatively the same as in the real U.S. dollar-Canadian rates. Compared to the U.S. dollar-Canadian dollar rate, the U.S. dollar-German mark rate initially jumps more in response to the demand shock, reachig a much higher permanent level.

Interestingly, demand shocks have larger permanent effects on real exchange rates than supply shocks for all cases.

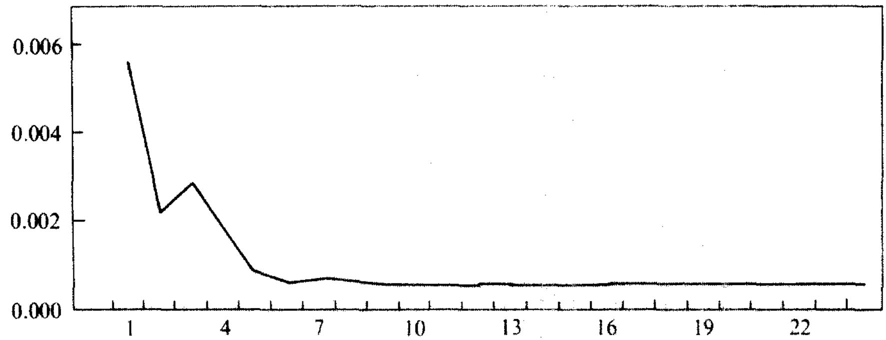
⟨Figure 1.a⟩ Canada: Response to Supply Shock



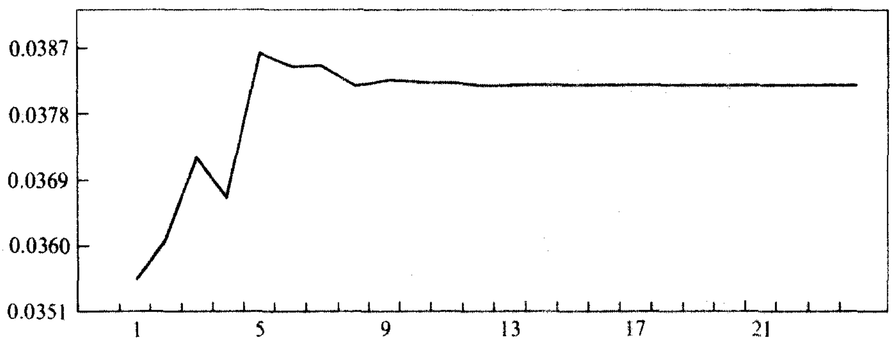
〈Figure 1.b〉 **Canada: Response to Demand Shock**



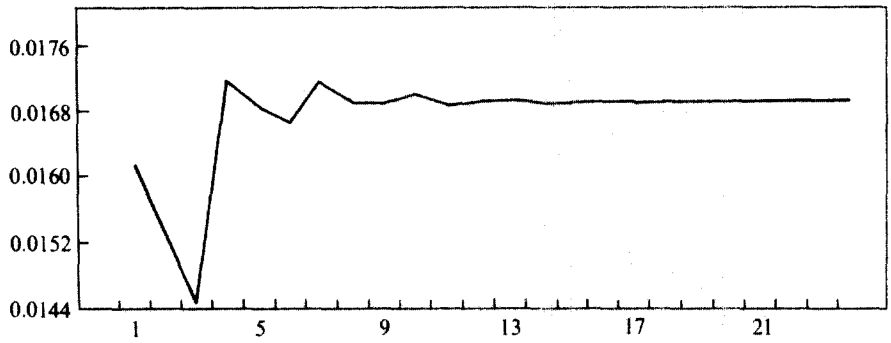
〈Figure 2.a〉 **UK: Response to Supply Shock**



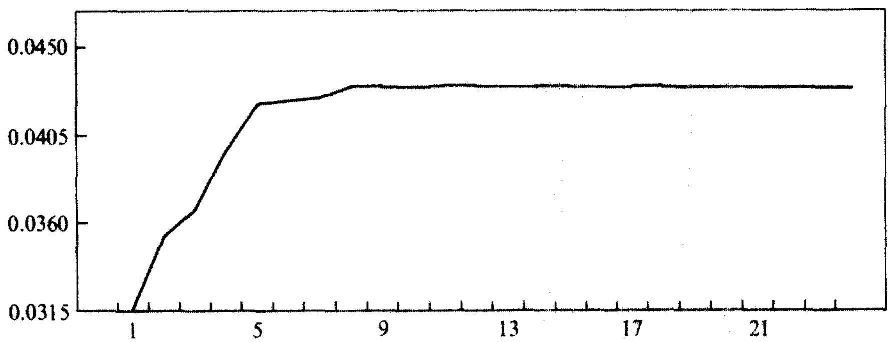
〈Figure 2.b〉 **UK: Response to Demand Shock**



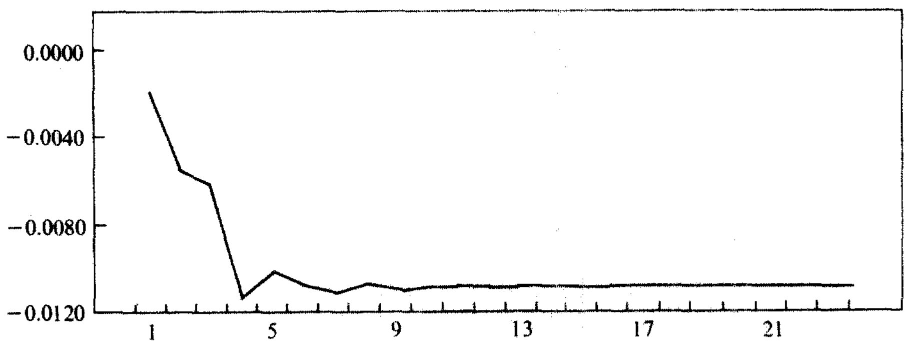
〈Figure 3.a〉 Japan: Response to Supply Shock



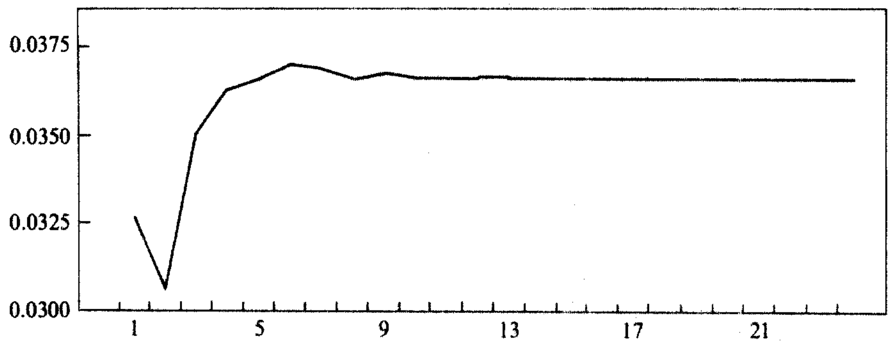
〈Figure 3.b〉 Japan: Response to Demand Shock



〈Figure 4.a〉 Germany: Response to Supply Shock



〈Figure 4.b〉 Germany: Response to Demand Shock



3. Relative Contributions of Supply and Demand Disturbances

Using forecasting error variance decompositions and historical decompositions of the real exchange rate, relative contributions of the two structural disturbances are investigated here.

Table 3 shows the forecasting error variance decompositions of the real exchange rates due to the demand shock at forecasting horizons of 1 - 48 months. The numbers in the table show the percentage of variance of the n-month ahead forecast error due to the demand disturbance.

The following observations are based upon the table. First, the demand disturbance is the main source of variation at all forecasting horizons. Demand shocks explain above 80 percent of the variance in all cases. Second, as for the U.S. dollar-Canadian dollar and the U.S. dollar-German mark rates, the importance of the supply shock to the variance slightly rises over the forecasting horizon. However, supply shocks become less important in the U.S. dollar-Japanese yen rate. As for the U.S. dollar-British pound rate, the relative importance of the supply shock also becomes slightly less over the forecasting horizon.

By setting the other innovations to zero at a time, we can decompose the time path of the real exchange rate forecast error into two components, which are associated with supply shocks and demand shocks, respectively. Figures 5, 6, 7 and 8 display historical decompositions of the real exchange rate forecast errors into two components with the actual forecast error. As expected from the variance de-

〈Table 3〉 **Variance Decompositions of Real Exchange**

Horizon (Months)	Canada	UK	Japan	Germany
1	99.1	97.5	79.4	99.6
2	97.8	98.5	82.0	98.3
3	96.8	98.8	83.6	97.8
4	95.7	99.0	83.8	95.7
8	95.4	99.5	85.2	93.8
12	95.2	99.6	85.7	93.1
16	95.1	99.7	85.9	92.8
20	95.0	99.8	86.1	92.6
24	95.0	99.8	86.2	92.5
36	94.9	99.8	86.3	92.3
48	94.8	99.9	86.4	92.3

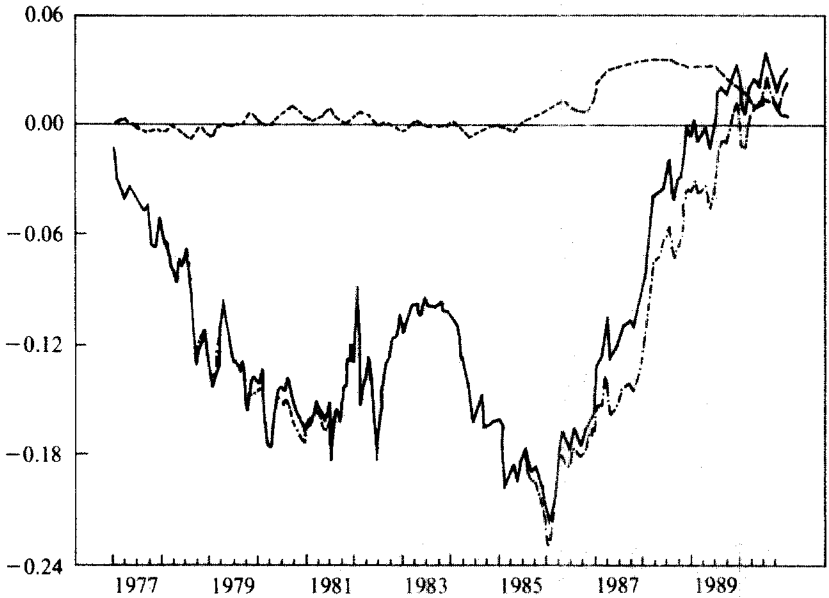
Note: The numbers in each row show the percentages of k-month ahead forecasting error variances in real exchange rates due to the demand shock.The relative contributions of the supply shock are given by 100 minus those numbers.

compositions in Table 3, all figures show that the movement of real exchange rates are dominated by the demand shocks. As for the U.S. dollar-British pound rate, the demand component nearly mimics the actual forecast error series. However, except for the U.S. dollar-British pound rate, supply shocks contribute to the variation of the real exchange rate over some periods, such as 1989 in the U.S. dollar-Canadian dollar rate and 1987 in the U.S. dollar-Japanese yen and the U.S. dollar-German mark rates.

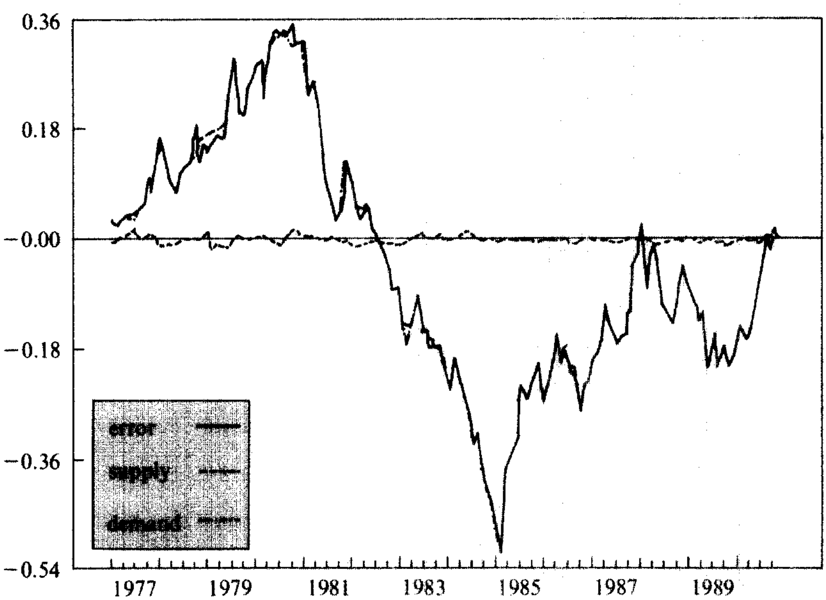
IV. Summary and Conclusion

This paper investigates the dynamic effects of supply and demand shocks on the fluctuations of four real exchange rates: the U.S. dollar-Canadian dollar, the U.S. dollar-British pound, the U.S. dollar-Japanese yen and the U.S. dollar-German mark. To identify two structural disturbances, we do not impose an identifying restriction where demand shocks do not have permanent effects on the real exchange rate. Instead, we use the restriction that demand shocks do not affect output per-

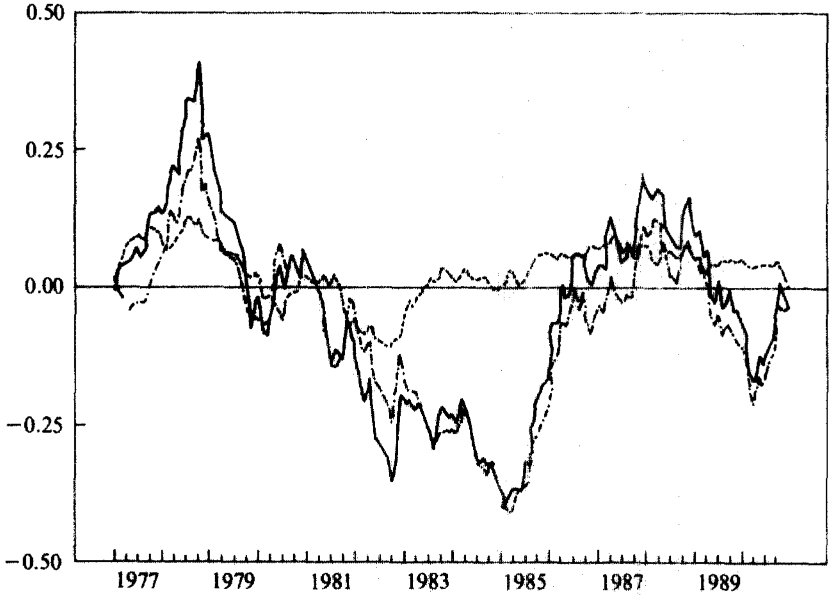
〈Figure 5〉 **Canada: Historical Decomposition**



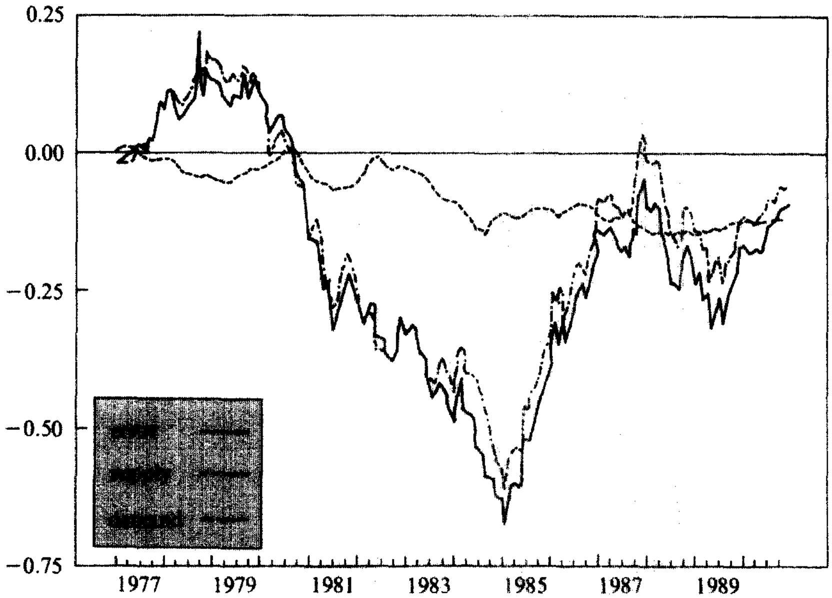
〈Figure 6〉 **UK: Historical Decomposition**



〈Figure 7〉 Japan: Historical Decomposition



〈Figure 8〉 Germany: Historical Decomposition



manently.

Using the bivariate VAR system with the first-difference time series of the real exchange rate and relative income, the following observations are obtained. First, impulse response functions show that both shocks have permanent effects on the real exchange rate. However, compared to other cases, the long run effect of the supply shock on the real U.S. dollar-British pound rate is relatively very small. Second, variance decompositions at various forecast horizons show that demand shocks are the dominant source of the variation of the real exchange rate in all cases. Third, as expected from variance decompositions, it is seen from the historical decompositions of the forecast errors that the fluctuations of real exchange rates are dominantly explained by demand components. In conclusion, these evidences support the explanation that fiscal and monetary policies in the United States are mainly responsible for wide swings of the real exchange rate in the 1980s (Sachs [19], and Frankel [10]).

The above evidence clearly indicates that we cannot interpret the permanent shock in Lastrapes and Evans and Lothian as the productivity shock. By the same token, the temporary shock cannot be understood as the nominal shock. This tells us that in order to obtain useful results from the structural VAR approach, it is really important to use economically meaningful identification restrictions in identifying structural disturbances. Obviously, the remaining question is to distinguish monetary shocks from government spending shocks (i.e., IS shocks) and domestic shocks from foreign shocks using the extended model.

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