Exchange Rate Variation and Monetary Policy

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United States monetary policy has undergone several significant changes over the past decade. These "changes" are not in the Federal Reserve System's ultimate goals of curbing inflation while promoting high employment and sustainable growth. Rather, the changes are in the Federal Reserve's methods for achieving such goals—that is, in the Fed's intermediate targets. While the Federal Reserve has altered over time the relative emphasis it has placed on interest rates, monetary aggregates and credit aggregates as intermediate targets, little attention has been paid to exchange rate movements as a potential indicator for monetary policy. Although exchange rate movements have influenced U.S. policy decisions during times of apparent crisis, the absence of a *systematic* role for exchange rates in the conduct of U.S. monetary policy is in contrast with the monetary policies of other industrialized countries. For example, in March 1982 the Bank of England announced that monetary policy would no longer focus on a single monetary aggregate but would emphasize explicitly several variables, with the exchange rate "specifically listed as a variable that provided information about monetary conditions and that would be taken into account in policy decisions."[1] Bank for International Settlements reports note that this view is shared by several non-U.S. central banks: "Exchange rates have come to be regarded as intermediate targets or indicators of monetary policy in many countries . . . ."[2]

This article explores two ways in which exchange rates might systematically influence U.S. monetary policy.[3] The first part examines how a central bank's ability to achieve, in the short run, given domestic monetary objectives deteriorates as a country's money market is increasingly disturbed by international shocks. Empirical evidence is provided that suggests foreign interest rates and expected exchange rate changes have significant effects on domestic money demand in the United States. These results imply that Federal Reserve short-run control over domestic monetary aggregates is probably less than it would be without international influences.

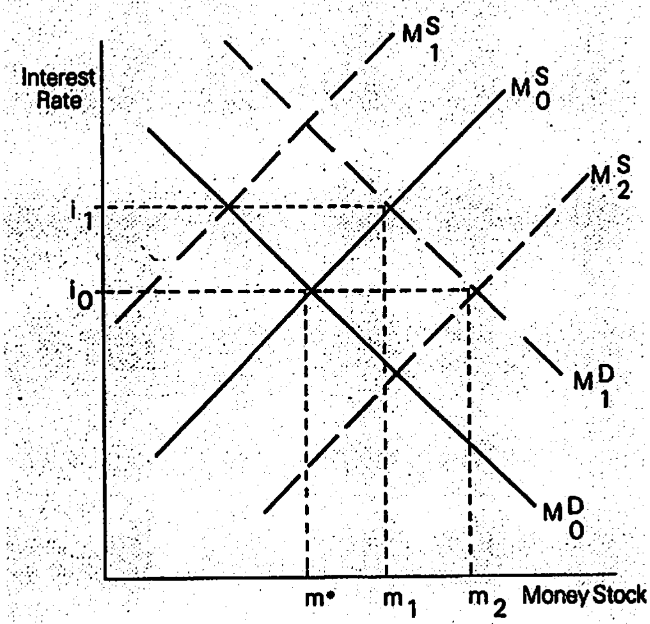
The second part addresses the much broader issue of how information from foreign exchange markets might help a central bank to achieve its ultimate economic goals. In particular, this section discusses the strengths and weaknesses of the exchange rate as a barometer of economic activity. Some summary statistics suggest that exchange rate movements—in conjunction with changes in a monetary aggregate—provide useful information about fluctuations in nominal GNP, real GNP, and the price level.

I. Exchange Rate Variation and Short-Run Domestic Monetary Control

Policy action records show that the Federal Open Market Committee (FOMC) regularly espouses the Federal Reserve's goals of reducing the inflation rate, sustaining economic growth, and attaining reasonable equilibrium in the balance of payments. To achieve these ultimate objectives, the FOMC has employed a variety of "intermediate" targets that it attempts to attain over the course of a year by adjusting the availability of bank reserves from week to week. These intermediate targets have included growth rate ranges for various monetary aggregates as well as a range for the federal funds rate. The federal funds rate range was intended to be consistent with ranges for the monetary aggregates' growth rates. Moreover, such targets were presumed to be stably related to the Fed's ultimate objectives. The latter issue will not be addressed in this section; rather, the intermediate targets are assumed to be given.

As matters developed, the ranges for the federal funds rate and the monetary aggregates were frequently inconsistent. Monetary growth rates often exceeded or fell short of their "tolerance ranges" because the Federal Reserve tended to adjust the federal funds rate by smaller amounts than were necessary to meet these ranges. In principle, when the public's demand for money is subjected persistently to unanticipated disturbances, a money target and an interest rate target are inconsistent. To illustrate, let the money stock initially equal m*—a hypothetical target value chosen by the central bank—where the quantity of money demanded by the public equals the quantity of money supplied by the commercial banking system at the interest rate i_0 (Figure 1).[4] Suppose the public's demand for money unexpectedly increases at the prevailing interest rate—caused, say, by an increase in income—as represented by the rightward shift in the money demand curve from M_0^D to M_1^D. The money

Figure 1
Alternative Policy Responses to an Increase in Domestic Money Demand



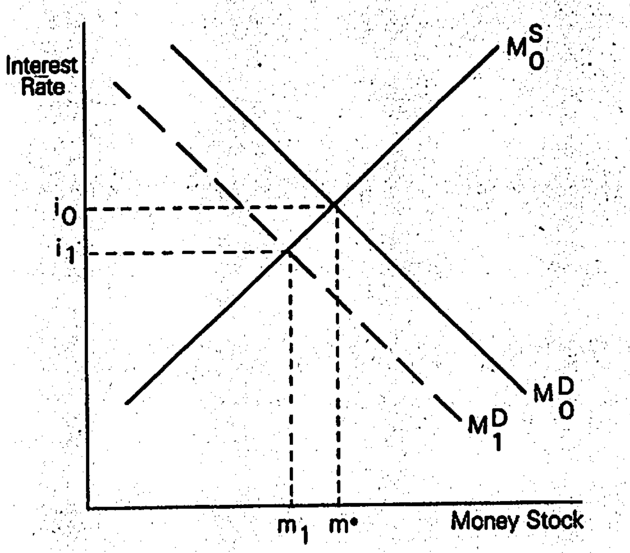
demand increase tends to raise the federal funds rate (to i_1) as commercial banks compete for reserves to support the higher level of deposits. If the monetary authorities are fully committed to achieving the money target (m*), the central bank must withdraw enough reserves from the banking system to shift the money supply leftward from M_0^S to M_1^S. If instead the monetary authorities prefer a stable interest rate, the central bank must expand reserves enough to shift the money supply curve rightward from M_0^S to M_2^S.

A previous *Review* article showed how a central bank's ability to control a domestic monetary aggregate can deteriorate as its country's economy and money market become increasingly "open."[5] Greater international trade relative to national output makes domestic money demand more sensitive to international shocks. For instance, greater foreign demand for U.S. goods and services will increase demand for domestic money on the part of foreigners, the bulk of U.S. exports being paid for in dollars. Greater foreign demand for U.S. products is usually attributed to a rise in foreign income, a decline in the real exchange rate, or both, other things equal.[6]

International capital market linkages also serve to transmit unanticipated disturbances to domestic money demand. Much recent empirical evidence is consistent with the notion that comparable short-term U.S. and foreign financial assets are imperfect substitutes.[7] Thus, if investors worldwide, at some point, decide that foreign securities have become less attractive investments compared to U.S. securities, then capital will flow into the United States as investors reduce their demand for foreign securities and raise their demand for U.S. securities, accepting a relatively lower yield on U.S. instruments. If U.S. securities are substituted for foreign securities dollar for dollar, there is no direct effect on domestic money demand. Yet there is an indirect effect as investors adjust their portfolios to the changed relative international expected rates of return. The net foreign capital outflow causes the foreign interest rate adjusted for the expected exchange rate change—that is, the exchange-adjusted foreign interest rate—to rise. This increase in the implicit cost of holding domestic money (forgone interest on foreign bonds) reduces the quantity of domestic money that would be demanded if domestic interest rates remained unchanged. The induced decline in domestic money demand is represented in Figure 2 by the leftward shift of the money

Figure 2

The Impact on Domestic Money Demand of a Portfolio Shift from Foreign Securities to Domestic Securities



demand curve from M_0^D to M_1^D, which lowers the domestic money stock from m* to m_1 and the domestic interest rate from i_0 to i_1. Consequently, portfolio shifts between foreign and domestic securities can erode domestic monetary control.[8]

The analysis underlying this negative relationship between domestic money and the exchange-adjusted foreign interest rate mirrors that used in closed-economy studies of the effects on monetary control of changes in expected relative rates of return among domestic assets. Assuming imperfect substitutability among alternative domestic investments, previous studies have found that money demand is inversely related to changes in long-term government bond rates and to changes in proxies for the rate of return on physical capital, at a given short-term interest rate and level of income.[9]

To provide some evidence on the quantitative importance of international factors for domestic monetary control, this article presents estimates for a standard U.S. money demand function augmented by a weighted average of foreign interest rates and a weighted average of expected exchange rate changes vis-à-vis the major trading partners of the United States. The representative U.S. money demand function selected for this analysis is from the Board of Governors' Monthly Money Market Model.[10] Money (M1) is first separated into two components—currency plus travelers checks and demand plus other checkable deposits—with the demand for each estimated separately. The demand for either component, adjusted for inflation, is expected to be positively related to real income; a rise in the latter increases the demand for real transaction balances. A rise in the interest rate on U.S. short-term investments (here, commercial paper) increases the implicit cost of holding money, reducing real money demand. Price increases will have no effect on real money demand, as long as nominal money demand rises proportionately to inflation.

The standard demand equation for each component of M1 is augmented by the "effective," or weighted-average, foreign interest rate and the "effective" expected exchange rate change. A rise in the effective foreign interest rate, other things equal, raises the implicit cost (forgone interest) of holding domestic money, reducing domestic money demand.

While an effective foreign interest rate is easily calculated, an effective expected exchange rate change is not, because it is by no means certain how exchange rate expectations are formed. In this study, exchange rate expectations are assumed to be "regressive," or "stabilizing," as in the Board of Governors' Multicountry Model. In that model, the expected *change* in the nominal exchange rate between two currencies over the term of the corresponding domestic and foreign securities is a function of the *level* of the real exchange rate.[11] To illustrate, suppose initially that the nominal exchange rate between two currencies has a value equal to the ratio of the two countries' price levels. Under regressive expectations, a subsequent appreciation of the home currency with no change in prices in these countries generates the expectation of an eventual depreciation of the home currency to restore parity. Thus, a rise in the level of the U.S. real effective exchange rate relative to the base period suggests a higher expected rate of depreciation (or lower expected rate of appreciation) of the dollar vis-à-vis a weighted average of foreign currencies. A rise in the expected rate of depreciation of the dollar, other things equal, increases the exchange-adjusted foreign interest rate and raises the implicit cost of holding domestic money, reducing U.S. money demand.[12]

The results of estimating alternative currency demand (CURR) equations are presented in Table 1. Equation (1) presents the closed-economy currency demand equation typically estimated in the Monthly Money Market Model. Equation (2) augments that model by including the real exchange rate as an explanatory variable. Consistent with the hypothesis mentioned above, rises in the real exchange rate significantly reduce domestic currency demand while leaving the influences of other factors largely unchanged. A 1 percentage point rise in the rate of real appreciation of the dollar has more than twice the negative effect on the rate of increase of currency demand of a 1 percentage point rise in the rate of increase of the domestic interest rate. The overall explanatory power of the equation, as measured by the standard error of the regression, improves with the additional explanatory variable. Equation (3) augments (2) by including the foreign interest rate. This variable has the expected negative influence on currency demand, but not nearly the effect of the real exchange rate. The coefficients of the income and domestic interest rate variables are altered substantially by the inclusion of the foreign interest rate, although the standard error of equation (3) is lower than that of (2). Detailed results, including post-sample forecast error summary statistics, are presented in the appendix.

The determinants of demand for transaction deposits—that is, demand plus other checkable deposits (DOCD)—are similar to those for currency demand. In addition to income and commercial paper

Table 1

Alternative Domestic Money Demand Functions

Regression	Dependent Variable	Real Income	Expenditures Price Deflator	Commercial Paper Rate	Small Time Deposits Rate	CREDCON	CON2	Real Effective Exchange Rate	Effective Foreign Interest Rate	Constant	S.E.R.	rho	D.W.
(1)	CURR	.641 (.163)	0	−.045 (.012)	—	—	—	—	—	.000 (.000)	.00220	.267	2.06
(2)	CURR	.618 (.147)	0	−.043 (.011)	—	—	—	−.094 (.033)	—	.000 (.000)	.00215	.179	2.01
(3)	CURR	.426 (.167)	0	−.033 (.012)	—	—	—	−.110 (.032)	−.018 (.011)	.000 (.000)	.00213	.128	2.00
(4)	DOCD	1	0	−.119 (.010)	−.027 (.011)	.537 (.141)	−.004 (.001)	—	—	.002 (.001)	.00510	.160	2.01
(5)	DOCD	1	0	−.119 (.010)	−.027 (.011)	.553 (.141)	−.004 (.001)	−.050 (.013)	—	−.001 (.000)	.00509	.151	2.02
(6)	DOCD	1	0	−.124 (.011)	−.027 (.011)	.561 (.138)	−.005 (.001)	−.051 (.013)	−.001 (.011)	−.001 (.001)	.00505	.100	2.00

Note: CURR denotes real currency plus travelers checks. DOCD denotes real demand plus other checkable deposits. The quasi-dummy variable CREDCON represents the effects of the 1980 credit control program and the dummy variable CON2 represents the effects of the mid-1970s shift in demand for transaction deposits. Numbers in parentheses are standard errors of coefficient estimates; coefficient estimates without standard errors reflect constrained coefficient sums. S.E.R. is the standard error of the regression; rho is the estimate on the final iteration; and D.W. is the Durbin-Watson statistic. Estimation uses monthly data from January 1974 to December 1982. Details of estimation techniques are provided in the appendix.

Source of data: Board of Governors of the Federal Reserve System.

rate effects, the demand for inflation-adjusted transaction deposits is expected to be negatively related to the interest rate on small time deposits, which reflects an additional opportunity cost of holding money.[13] Dummy variables representing the effects of the short-lived 1980 credit control program (CREDCON) and a shift in transaction deposits demand in the mid-1970s (CON2) are included in the Board's transaction deposits demand equation.

The results of estimating alternative transaction deposits demand equations are presented in Table 1. Equation (4) presents the closed-economy demand equation typically estimated in the Monthly Money Market Model. Equation (5) augments that model by including the real exchange rate as an explanatory variable. As before, a real appreciation of the dollar in foreign exchange markets has a significant negative effect on domestic transaction deposits demand while leaving the influences of other factors largely unchanged. A 1 percentage point increase in the rate of real appreciation of the dollar has half the negative effect on the rate of increase of transaction deposits demand of a 1 percentage point rise in the rate of increase of the commercial paper rate, but almost twice the negative effect of a 1 percentage point rise in the rate of increase of the small time deposits rate. Furthermore, the overall explanatory power of the equation is improved with the addition of the real exchange rate. Finally, equation (6) augments (5) by including the foreign interest rate. This variable again has the expected negative sign, but its impact is negligible.[14]

In summary, international factors have significant effects on domestic money demand. This suggests that the Federal Reserve might enhance domestic monetary control by taking into account the effects on U.S. money demand of expected exchange rate changes and foreign interest rate movements.

II. The Exchange Rate as a Guide for U.S. Monetary Policy

For many years, the Federal Reserve System has used a "modified intermediate target" approach to monetary policy. Under this approach, the Fed first sets a range for changes over time in a readily observable intermediate variable, such as M1, and then makes weekly adjustments in bank reserves or a short-term interest rate to keep the target variable within the range. This approach is considered "modified" for two reasons. First, the Federal Reserve has employed several intermediate targets simultaneously and has altered the relative importance of these targets over time. For instance, from October 1979 to October 1982 the Federal Reserve emphasized M1 as its intermediate target.[15] Yet in fall 1982, the Federal Reserve explicitly deemphasized M1 as its intermediate target, placing greater importance on M2 and M3. Second, the Federal Reserve has not pursued its intermediate targets in isolation from other economic data. For example, the FOMC has reported conducting monetary policy recently in light of "continuing appraisal of the relationships not only among the various measures of money and credit but also between those aggregates and nominal GNP, including evaluation of conditions in domestic credit *and foreign exchange markets.*"[16]

With exchange rate movements apparently gaining more attention as an economic guide, it is appropriate to consider how such movements might provide additional information to the monetary authorities about (concurrently) unobservable fluctuations in nominal GNP, real GNP, and the price level. The first part of this section discusses some of the strengths and weaknesses of exchange rates as a barometer of domestic economic activity. The second part provides empirical evidence suggesting that exchange rate changes could have provided systematic supplemental information to the monetary authorities regarding economic conditions during the past decade. For instance, the results imply that for predicting domestic inflation the information value of the exchange rate would have almost equaled that of the money stock.

A Conceptual Overview

The following analysis assumes that a central bank uses the domestic money stock as an intermediate target to achieve its ultimate economic objectives of curbing domestic inflation while promoting sustainable growth of domestic real GNP. To achieve its intermediate target, the monetary authority is assumed to use nonborrowed reserves targeting; hence, the domestic interest rate is allowed to vary. The exchange rate is also assumed to vary without central bank intervention. Quarterly changes in real GNP and monthly changes in the price level are assumed to be observed only with a considerable lag. By contrast, the domestic money stock, domestic interest rate, and exchange rate are assumed to be observable continuously and with virtually no lag. The domestic economy is assumed to be small; hence, the foreign interest rate, foreign price level, and foreign income are assumed given.[17]

In this setting, an example illustrates how the central bank might use information from exchange rate changes to better predict unobservable output and price changes. Assume that initially the rate of increase of the money stock is in the middle of its target range. Subsequently the central bank observes a persistently rising interest rate and rate of increase of the money stock. These observed changes are consistent with various unobserved economic events, such as an unanticipated increase in aggregate demand caused, say, by a larger than anticipated response to a tax cut. A rise in aggregate demand, by raising the demand for money, tends to increase the money stock above its target range and to raise the interest rate. If output is well below its full employment level, an unobserved rise in aggregate demand tends to increase production and employment with little corresponding inflation. On the other hand, if output is near its full employment level, an unobserved rise in aggregate demand tends to increase inflation with little corresponding rise in production and employment. Without more information, the central bank would be uncertain if the excessive (relative to target) monetary expansion and rising interest rate were portending more growth with stable prices, rising inflation with sluggish growth, or some combination.

In some circumstances, the direction of exchange rate movements can help reveal what growth/inflation combination is more likely to follow and thereby suggests a more suitable monetary policy reaction.

In some circumstances, the direction of exchange rate movements can help reveal what growth/inflation combination is more likely to follow and thereby suggests a more suitable monetary policy reaction. If output is well below the full employment level, an increase in aggregate demand tends to raise domestic income and the prospect of further growth. The higher nominal interest rate tends to reflect a higher expected rate of return on domestic investment which, other things equal, induces a net inflow of foreign capital and an appreciation of the home currency. However, if output is near the full employment level, the increase in aggregate demand tends to aggravate inflation with little corresponding growth. Rising prices tend also to increase money demand and the nominal interest rate. But the rising price level tends to reduce foreign demand for the country's exports, raise import demand, and lower the foreign exchange value of the home currency. Consequently, a rising interest rate and rate of increase of the money stock and an *appreciating* home currency portend growth with little inflation, following an unanticipated and unobserved increase in aggregate demand. A rising interest rate and rate of increase of the money stock but a *depreciating* home currency portend greater inflation with little growth following such a shock.[18] Since curbing inflation is assumed to be a prominent ultimate objective, the central bank would more likely tighten monetary policy in the latter instance but not the former.

Such circumstances seem to have existed in the United States last year. In the first half of 1984, M1 grew at a 7.2 percent annual rate (near the top of its range), the one-year U.S. Treasury bill rate rose from 9.2 percent to 10.9 percent, and the effective foreign exchange value of the dollar rose at a 10 percent annual rate. While the high rate of M1 expansion and the rising interest rate suggested that money demand had increased, the accompanying rise in the dollar's foreign-currency value intimated underlying noninflationary economic growth. In fact, U.S. real GNP grew at an 8 percent annual rate (quarter over quarter) in this period—much faster than anticipated—while the implicit GNP price deflator rose a modest 4 percent.[19]

Moreover, at certain times the exchange rate can help reveal the source of an unobserved economic event. For instance, a falling rate of increase in the money stock and a declining interest rate could signal, among other things, an unexpected decline in domestic aggregate demand, an unexpected decline in the public's demand for liquidity, or a shift in investors' preferences from foreign securities to domestic securities. The first two events tend to be associated with a depreciation of the home currency. However, as noted in part I, a declining interest rate and rate of increase of the money stock and an *appreciating* home currency are consistent with a shift in investors' preferences from foreign to domestic securities.

Such a change in investors' preferences from foreign to U.S. securities might have occurred in late 1984. M1 grew by only 2 percent (annual rate) in the last quarter of that year, below the bottom of its target range, while the one-year U.S. Treasury bill rate fell from 10.5 percent in September to 8.6 percent in December. Such signals suggested to many forecasters a possible end to the economic recovery, following a rise of less than 1 percent (annual rate) in personal consumption spending in the third quarter of 1984. However, the dollar appreciated at a 17 percent annual rate in the fourth quarter of 1984, suggesting that investors worldwide continued to anticipate a high—and perhaps rising—rate of return on U.S. investments relative to foreign investments and further growth in U.S. output. In fact, real GNP rose at a 4.3 percent annual rate in that quarter, following a 1.6 percent increase in the previous quarter, while the implicit price deflator rose only 2.4 percent, mitigating many doubts about the prospect for continued noninflationary U.S. economic growth.[20]

A caveat is in order. While they can be informative, exchange rate changes—like movements in domestic financial variables—will not *necessarily* reveal the source of an unobserved economic event or its implications for nominal GNP. For instance, a rising money growth rate, interest rate, and exchange rate are consistent with an unexpected increase in aggregate demand for goods and services that tends to raise nominal GNP. Yet a rising money growth rate, interest rate, and exchange rate are consistent also with an unanticipated increase in the public's demand for liquidity—unaccompanied by an increase in goods and services demand—that tends to reduce nominal GNP, as the rising interest rate curbs demand in interest-sensitive industries and the appreciation of the home currency dampens net export sales. This suggests why central banks in many countries have come to use several information variables in setting monetary policy, including unemployment rates, industrial production indexes, and retail sales figures. Moreover, many central banks now rely on large macroeconomic forecasting models to incorporate information from these multiple sources.

A Statistical Summary

The preceding analysis suggests that the relationship between a monetary (or credit) aggregate, the interest rate, or the exchange rate, on the one hand, and output or prices, on the other hand, is very tenuous because of all the possible unexpected and unobserved economic events that can occur. Even so, the close statistical correlation that has been observed between changes in various financial aggregates and changes in nominal GNP or prices has been adduced to support the view that such aggregates should serve as intermediate targets for monetary policy; typical findings are that a 1 percentage point rise in the rate of increase of M1 is associated after four quarters with a 1 percentage point rise in the rate of increase of U.S. nominal GNP and after four years with a 1 percentage point increase in the U.S. inflation rate.[21] Similarly, a close statistical correlation between changes in the exchange rate and changes in output or prices would support the view that this rate should serve as an *indicator* for monetary policy.

A typical change in the rate of appreciation of the dollar has 84 percent of the capacity of a typical change in the rate of increase of M1 for predicting changes in the inflation rate.

In this section, a statistical analysis is used to illustrate how information on exchange rate movements can be helpful for predicting changes in nominal GNP, real GNP, and the GNP price deflator. The first part of the analysis uses typical regression techniques to show that a 1 percentage point increase in the rate of appreciation of the dollar is associated with much smaller changes in the rates of increase of nominal GNP, real GNP and the price level than a 1 percentage point rise in the rate of increase of M1, a result to be expected since international trade in goods and services is only 10 percent of our national product. In the second part of the analysis, all variables are transformed to eliminate the effects of scale. This "normalization," as will be explained, makes it possible to estimate the *relative* importance of changes in M1 and in the exchange rate for predicting fluctuations in nominal GNP, real GNP, and the price deflator.

Columns (2) and (3) in Table 2 summarize the results of estimating the relationship between changes in nominal GNP, real GNP, or the price defla-

Table 2
Relationships between M1 and the Exchange Rate and Nominal GNP, Real GNP or the GNP Price Deflator

	A *one percentage point* rise in the rate of increase of these independent variables is associated with the following percentage point change in the rate of increase of the dependent variable:		A *typical* rise in the rate of increase of these independent variables is associated with the following number of units of typical change in the rate of increase of the dependent variable:	
(1) Dependent Variable	(2) M1	(3) Exchange Rate	(4) M1	(5) Exchange Rate
Nominal GNP	1.135 (.694)	.098 (.063)	.998 (.600)	.262 (.165)
Real GNP	1.181 (.638)	.104 (.057)	1.117 (.593)	.298 (.162)
Price Deflator	1.195 (.712)	−.235 (.068)	1.947 (1.079)	−1.626 (.472)

Notes: Standard errors of the coefficient estimates are in parentheses. Quarterly data are for 1975:2 to 1984:2. Details of estimation technique are provided in the appendix.
Sources of data: Board of Governors of the Federal Reserve System and OECD *Main Economic Indicators: Historical Statistics 1964–1983.*

tor and changes in M1 and in the exchange rate using a typical regression analysis. A 1 percentage point rise in the rate of increase of M1 is associated with an 1.1 percentage point rise in the rate of increase of nominal GNP and a 1.2 percentage point rise in the growth rate of real GNP after five quarters and is associated with a 1.2 percentage point increase in the inflation rate after five years. Yet a 1 percentage point increase in the rate of appreciation of the dollar is associated with only a 0.1 percentage point rise in the rate of increase of nominal or real GNP in the concurrent quarter and with a 0.2 percentage point decrease in the inflation rate after two years.

However, this standard regression approach fails to reveal the relative importance of M1 and the exchange rate for predicting changes in output, inflation, and nominal GNP. That is, each regression coefficient estimate in columns (2) and (3) measures the change in the dependent variable associated with a *1 percentage point* change in the independent variable.[22] While a 1 percentage point change in the rate of increase in M1 in a given quarter is common, such a change in the rate of appreciation of the dollar is unusually small. The typical change in the rate of appreciation of the dollar during a quarter is more than 3 percentage points.[23] Standard regression coefficients are unsuitable for determining the relative informational values of M1 and the exchange rate, because they fail to estimate the change in a dependent variable associated with a *typical* change in the rate of increase of M1 or of the exchange rate. However, all variables can be transformed to have a common degree of variability. Coefficient estimates from the normalized regressions (beta coefficients) indicate the change in the dependent variable associated with typical changes in these two independent variables. Comparing the two coefficient estimates from a normalized regression suggests the relative importance of changes in M1 and the exchange rate for predicting movements in nominal GNP, output, and prices.[24]

Columns (4) and (5) in Table 2 summarize the results of estimating the relationship between typical changes in the rates of increase of nominal GNP, real GNP, or the price deflator and typical changes in the rates of increase of M1 and of the exchange rate using this approach. The elements in the first two rows of these columns indicate that a typical, or 1 standard deviation, rise in the rate of increase of M1 (about 1 percentage point) is associated after five quarters with a 1 standard deviation rise in the rate of increase of nominal GNP (about 1.1 percentage points) and a 1.1 standard deviation rise in the rate of growth of real GNP (about 1.2 percentage points). A 1 standard deviation increase in the rate of appreciation of the dollar is associated in the concurrent quarter with a 0.3 standard deviation rise in the rate of increase of nominal or real GNP. Comparing the M1 and exchange rate coefficients from the nominal GNP regression reveals that a typical change in the rate of appreciation of the dollar has 26 percent of the predictive capacity of a typical change in the rate of increase of M1 (.262/.998 = .26). A typical change in the rate of appreciation of the dollar has 27 percent of the potential of a typical change in the rate of increase of M1 for predicting a change in the rate of growth of real GNP (.298/1.117 = .27). Moreover, the elements in the last row of these two columns imply that a typical change in the rate of appreciation of the dollar has 84 percent of the capacity of a typical change in the rate of increase of M1 for predicting changes in the inflation rate (1.626/1.947 = .84).

Lags between changes in money or the exchange rate and changes in prices, output, or nominal GNP should be interpreted cautiously. For instance, the delayed associations are not meant to imply that an increase in M1 or a depreciation of the dollar necessarily "causes" inflation after a period of time. Rather, the framework described earlier in this article suggests that an exogenous policy action, such as an increase in bank reserves, might be reflected in changes in monetary aggregates and exchange rates *before* changes in price indexes.

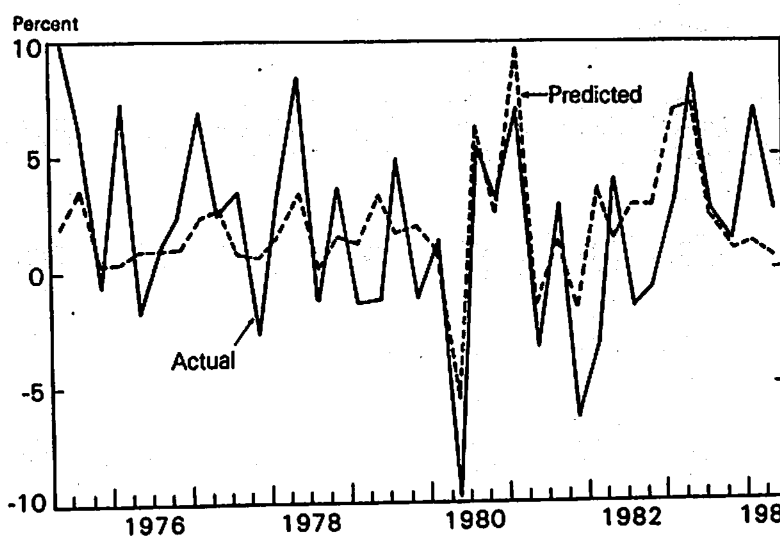
Finally, what do these statistical results imply for forecasting changes in real GNP and prices? Chart 1 illustrates the relationship between actual quarterly changes in U.S. real GNP and the quarterly changes in output predicted by changes in M1 and in the exchange rate. The relationship is not very close in general. During the last half of the 1970s, current and lagged changes in M1 and in the exchange rate generally underpredicted—and often incorrectly predicted—changes in output. In some periods, though, the equation performed satisfactorily. From the first quarter of 1980 to the last quarter of 1981, changes in M1 and in the exchange rate predicted the sharp changes in the growth rate quite well. But from the beginning of 1982 to mid-1984, the predictive power of the model lapsed again.

Changes in M1 and in the exchange rate predicted the trend of the inflation rate quite well.

By contrast, changes in M1 and in the exchange rate predicted the trend of the inflation rate quite well. Chart 2 illustrates the relationship between actual quarterly changes in the U.S. implicit GNP price deflator and the quarterly changes in the deflator predicted by changes in M1 and in the exchange rate. The equation predicted the lower inflation rate of 1976, the higher inflation rate from 1978 through

Chart 1

Actual versus Predicted Percentage Changes in U.S. Real GNP

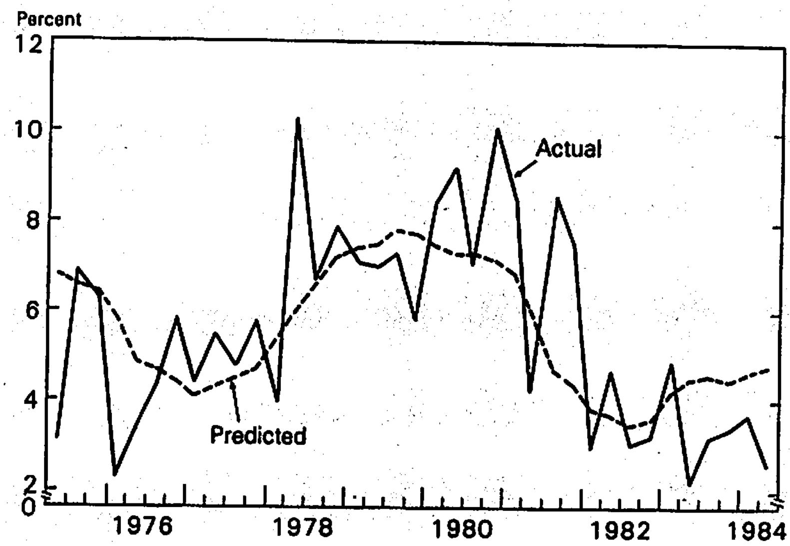


Note: Quarterly data are the actual and fitted annualized percentage changes in real GNP (adjusted for autocorrelation) using the respective normalized regression described in the Appendix, Part II.

Source: See Table 2.

Chart 2

Actual versus Predicted Percentage Changes in the U.S. Implicit GNP Price Deflator



Note: Quarterly data are the actual and fitted annualized percentage changes in the implicit GNP price deflator (adjusted for autocorrelation) using the respective normalized regression described in the Appendix, Part II.

Source: See Table 2.

1980, and the lower inflation rate since 1981.

Even more interesting perhaps is the decomposition of the predicted changes in the price level to separate the change predicted by M1 and that predicted by the exchange rate (Chart 3). The predicted inflation rate attributable to exchange rate changes rose and fell along with—and sometimes *ahead of*—the total predicted inflation rate, while that attributable to M1 changes tended to follow the predicted inflation rate. Moreover, the lower inflation rate since 1981 predicted by this model is attributable largely to exchange rate changes. As Chart 3 shows, changes in M1 since 1981 have predicted a much higher inflation rate than changes in the exchange rate. This result should be interpreted cautiously, however, since changes in M1 and in the exchange rate are not independent.

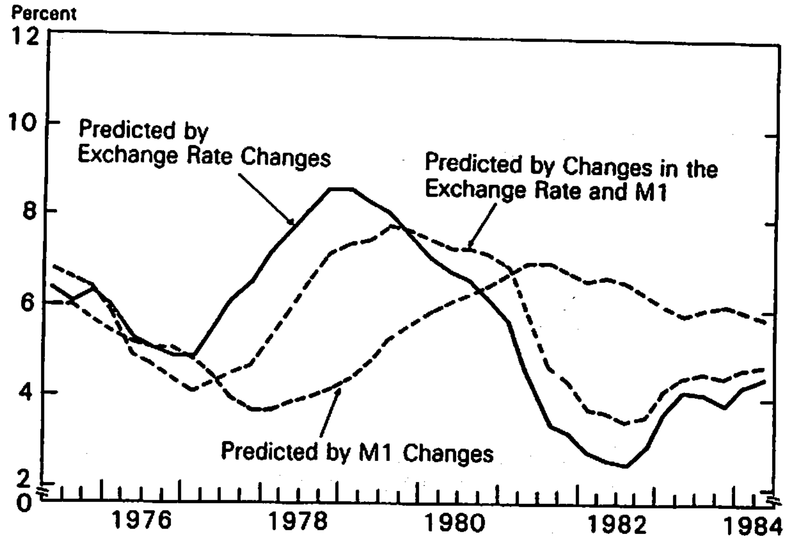
III. Conclusions and Policy Implications

This article has explored international aspects of U.S. monetary policy from a dual perspective. First, much of the international finance literature has focused on the exchange rate effects of changes in the (presumed exogenous) domestic money stock. This article, by contrast, examined conceptually and demonstrated empirically that changes in the inflation-adjusted exchange rate—as a proxy for expected exchange rate changes—and changes in the foreign interest rate have significant lagged effects on domestic money demand. In reality, exchange rates and the domestic money stock are likely influenced contemporaneously by common policy actions and unanticipated economic events. A recent empirical analysis that examined whether exchange rate movements "cause" money stock changes, or vice versa, found mixed results; in 8 of the 15 industrial countries investigated, exchange rate changes were found to "cause" —as well as be "caused by"—money stock changes.[25] Moreover, the results from the first section of this article indicate that some of the perceived instability in domestic money demand that is considered to have eroded short-run monetary control could be attributed to international factors.

The second part of this article demonstrated that exchange rates provide potential "information" to central banks for setting monetary policy. In many industrial countries including the United States, the central banks employ monetary aggregates as intermediate targets for achieving such ultimate objectives as curbing inflation while promoting sustainable growth in goods and services output. In this article, exchange rates were shown empirically to provide significant supplemental information to the monetary authorities—in conjunction with a monetary aggregate—for predicting changes in nominal or real GNP and, especially, the GNP price deflator. For instance, the information value of exchange rates for predicting the inflation rate almost equaled that of M1.

Chart 3

Predicted Percentage Changes in the U.S. Implicit GNP Price Deflator



Note: Quarterly data are the annualized percentage changes in the GNP price deflator predicted by changes in the exchange rate, by changes in M1, or by changes in the exchange rate and M1, weighted (in normalized form) by their respective coefficient estimates from the normalized regression described in the Appendix, Part II.

Source: See Table 2.

Changes in M1 and in the exchange rate predicted the overall trend of changes in the U.S. price level reasonably well. The predicted inflation rate attributable to the exchange rate moved contemporaneously with the total predicted inflation rate, while that attributable to M1 tended to lag behind the total predicted inflation rate. Moreover, since early 1981 the predicted inflation rate attributable to exchange rates is largely responsible in this model for predicting a lower inflation rate, since changes in M1 have predicted a much higher inflation rate.

Appendix

Part I.

Coefficient estimates presented in Table 1 summarize the results of regressing monthly percentage changes in real currency plus travelers checks (CURR) or real demand plus other checkable deposits (DOCD) on polynomial distributed lags (PDL) of the independent variables. Regressions (1)–(3) were estimated in the general form:

$$(A1)\quad \Delta \ln CURR_t = a + \sum_{i=0}^{10} b_i \Delta \ln RPI_{t-i} + \sum_{i=0}^{4} c_i \Delta \ln PCE_{t-i} + \sum_{i=0}^{11} d_i \Delta \ln RCP_{t-i} + \sum_{i=0}^{9} e_i \Delta \ln RER_{t-i} + \sum_{i=0}^{11} f_i \Delta \ln FIR_{t-i}$$

where RPI is real (personal-consumption-expenditures-deflated) personal income, PCE is the personal consumption expenditures deflator, RCP is the 30-day commercial paper rate, RER is the real effective exchange rate (foreign currency/U.S. dollar), FIR is the effective foreign interest rate, and a is a constant. RPI coefficients were constrained to follow a second order PDL with the far endpoint constrained to zero. PCE coefficients followed a second order PDL with their sum constrained to zero. RCP coefficients followed a second order PDL with the far endpoint constrained to zero. RER coefficients followed a second order PDL with the far endpoint constrained to zero and all e_i were constrained to zero in regression (1). FIR coefficients followed a second order PDL with the far endpoint constrained to zero and all f_i were constrained to zero in regressions (1) and (2). The real effective exchange rate was constructed in the same manner as the Board of Governors' nominal effective exchange rate except that nominal bilateral exchange rates were first adjusted by relative wholesale price indexes. The effective foreign interest rate is the Board of Governors' trade-weighted-average foreign interest rate. All variables were adjusted first for autocorrelation.

Regressions (4)–(6) were estimated in the general form:

$$\text{(A2)}\quad \Delta\ln DOCD_t = a + \sum_{i=0}^{6} b_i \Delta\ln RPI_{t-i} + \sum_{i=0}^{3} c_i \Delta\ln PCE_{t-i} + \sum_{i=0}^{7} d_i \Delta\ln RCP_{t-i} + \sum_{i=0}^{7} e_i \Delta\ln RER_{t-i} + \sum_{i=0}^{11} f_i \Delta\ln FIR_{t-i} + \sum_{i=0}^{4} g_i \Delta\ln RSAV_{t-i} + h\,\Delta\ln CREDCON_t + k\,CON2_t$$

where RSAV is the small time deposits rate (see text footnote 13), CREDCON is a quasi-dummy variable for the 1980 credit control program equaling the intervention factors used to preadjust transactions deposits for credit controls prior to seasonal adjustment for 1980:3–1980:8 and one otherwise, and CON2 is a demand shift dummy equaling one for 1974:3–1977:3 and zero otherwise. RPI coefficients followed a second order PDL with the far endpoint constrained to zero and with their sum constrained to one. PCE coefficients followed a second order PDL with their sum constrained to zero. RCP coefficients followed a second order PDL with the far endpoint constrained to zero and with their sum constrained stochastically to equal −.16 (i.e., the constraint is "inexact" in the sense that estimation of the variable's coefficients allows the variance of the unrestricted model to equal 15 percent of the variance of the restrictions). RER coefficients followed a second order PDL with the far endpoint constrained to zero and with their sum constrained stochastically to equal −.05 in regressions (5) and (6) and all e_i were constrained to zero in regression (4). FIR coefficients followed a second order PDL with the far endpoint constrained to zero and with their sum constrained stochastically to equal −.01 in regression (6) and all f_i were constrained to zero in regressions (4) and (5). RSAV coefficients followed a second order PDL with the far endpoint constrained to zero and with their sum constrained stochastically to equal −.05.

In-sample and post-sample static and dynamic simulations were made for each of these six regressions and their results are summarized using root mean square error statistics shown in the Appendix Table. In-sample simulations are for 1974:1–1982:12. Post-sample simulations are for 1983:1–1983:12. Both static (one period ahead) and dynamic simulations begin in 1974:1.

Individual coefficient estimates are presented in an addendum available upon request from the author.

Part II.

Coefficient estimates presented in the first two rows of columns (2) and (3) in Table 2 summarize the results of estimating:

$$\text{(A3)}\quad \Delta\ln NGNP_t = a + \sum_{i=0}^{4} b_i \Delta\ln M1_{t-i} + c\,\Delta\ln NER_t$$

$$(\text{or } \Delta\ln RGNP_t)$$

where NGNP is nominal GNP, RGNP is real GNP, NER is the Board of Governors' trade-weighted-average nominal exchange rate, and all variables were adjusted first for autocorrelation using the Cochrane-Orcutt iterative procedure. The estimates in the last row of columns (2) and (3) summarize the results of estimating:

$$\text{(A4)}\quad \Delta\ln DEFL_t = a + \sum_{i=0}^{19} b_i \Delta\ln M1_{t-i} + \sum_{i=0}^{7} c_i \Delta\ln NER_{t-i}$$

where DEFL is the GNP price deflator, M1 coefficients were constrained to follow a third order PDL with both endpoints constrained to zero, NER coefficients followed a second order PDL, and all variables were prefiltered for autocorrelation.[26]

The entries presented in columns (4) and (5) in Table 2 summarize the results of estimating (A3) and (A4) again except that all variables (prefiltered for autocorrelation using the corresponding rho estimates) were normalized first by subtracting from each variable its mean and dividing the difference by the variable's standard deviation; the resulting estimates are called beta coefficients.[27]

Individual coefficient estimates are presented in an addendum available upon request from the author.

Appendix Table
In-Sample and Post-Sample Simulation Root Mean Square Errors

	Regression					
	(1)	(2)	(3)	(4)	(5)	(6)
In-sample Static Simulation	.00213	.00206	.00202	.00489	.00485	.00479
In-sample Dynamic Simulation	.00220	.00209	.00203	.00495	.00491	.00481
Post-sample Static Simulation	.00299	.00336	.00335	.00654	.00631	.00602
Post-sample Dynamic Simulation	.00367	.00388	.00370	.00672	.00643	.00606

Source of data: Board of Governors of the Federal Reserve System.

[1] Karen H. Johnson, "Foreign Experience with Targets for Monetary Growth," *Federal Reserve Bulletin*, October 1983, p. 748.

[2] Bank for International Settlements, *Annual Report*, June 1981, p. 60.

[3] See also Ralph C. Bryant, *Money and Monetary Policy in Interdependent Nations* (Washington, D.C.: The Brookings Institution, 1980), Michael Mussa, "The Role of Official Intervention," Group of Thirty Occasional Papers, No. 6, 1981, and Ronald I. McKinnon, *An International Standard for Monetary Stabilization* (Washington, D.C.: Institute for International Economics, March 1984).

[4] The money demand curve M^D in Figure 1 is downward sloping because a rise in the interest rate on domestic securities raises the implicit cost (forgone interest) of holding money rather than securities, causing a decline in the quantity of money demanded (for a given level of income). The money supply curve M^S is upward sloping because the commercial banking system partly determines the supply of money to the public. Seventy-five percent of the measure of money known as M1 consists of demand and other checkable deposits at banks. While banks must hold required reserves along with earning assets against these deposits, at any given time some banks also hold excess reserves (i.e., in excess of the required level) that earn no interest. For a given level of nonborrowed reserves in the banking system and a fixed discount rate, an increase in money demand induces banks without excess reserves to increase borrowings from the Federal Reserve and to offer a higher federal funds rate to induce banks holding excess reserves to loan them in the federal funds market. In this way, the borrowing banks raise their reserves to support an expansion of loans and deposits, increasing the quantity of money supplied for a given level of nonborrowed reserves. For empirical evidence on the negative relationship between net free reserves (i.e., excess reserves minus borrowings) and the differential between the federal funds and discount rates, see Ralph C. Bryant, *Controlling Money*, (Washington, D.C.: The Brookings Institution, 1983), Appendix B.

[5] See Jeffrey H. Bergstrand, "Short-Run Domestic Monetary Control in an International Money Market," *New England Economic Review*, July/August 1984.

[6] In this article, the real exchange rate denotes the inflation-adjusted foreign-currency value of the dollar. A real exchange rate decline implies an inflation-adjusted depreciation of the dollar.

[7] The claim that domestic and foreign interest rates on corresponding short-term domestic and foreign assets need not match even when adjusted for the expected exchange rate change implies the existence of a time-varying differential reflecting an additional return (commonly termed an "exchange risk premium") that investors require to hold the relatively riskier asset. Empirical tests by necessity have had to test the joint hypothesis of market efficiency and perfect asset substitutability (the latter implying the absence of a risk premium). Many studies have rejected this joint hypothesis, including Lars P. Hansen and Robert J. Hodrick, "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," *Journal of Political Economy*, vol. 88 (October 1980), pp. 829-853 and Eugene F. Fama, "Forward and Spot Exchange Rates," *Journal of Monetary Economics*, vol. 14 (November 1984), pp. 319-338.

[8] This statement is consistent with the view that international linkages can enhance domestic monetary control by transmitting abroad some domestically generated disturbances. The argument here rather is that the variance of the money stock around a given target under reserves targeting or interest rate targeting in an open money market will exceed that in a closed money market under most conditions. This point is demonstrated formally in Jeffrey H. Bergstrand, "Short-Run Domestic Monetary Control in an International Money Market: A Technical Note," available from the author upon request.

[9] See, for example, Michael J. Hamburger, "Behavior of the Money Stock: Is There a Puzzle?" *Journal of Monetary Economics*, vol. 3 (July 1977), pp. 265-268.

[10] These equations are described in Helen T. Farr, "The Monthly Money Market Model," Federal Reserve Board staff working paper, July 1981, and in Bryant, *Controlling Money*, Appendix B.

[11] See Guy V.G. Stevens et al., *The U.S. Economy in an Interdependent World*, Board of Governors of the Federal Reserve System, 1984, pp. 102-104. Formally, the expected rate of depreciation of the dollar (x) can be expressed as:

$$x = c(e-e^*)$$

where e is the logarithm of the foreign currency value of the dollar, e^* is the logarithm of the equilibrium value of the dollar consistent with relative purchasing power parity, and c is a positive constant. The formation of regressive expectations is one of several alternative methods of forming expectations, none of which has been shown empirically more tractable than another. Several studies have used the forward premium (or discount) on the foreign exchange value of the home currency as a proxy for expected exchange rate changes; these studies have had mixed empirical results. However, the forward premium is a biased predictor of expected exchange rate changes if domestic and foreign securities are imperfect substitutes. See, for example, Michael D. Bordo and Ehsan U. Choudhri, "Currency Substitution and the Demand for Money," *Journal of Money, Credit and Banking*, vol. 14 (February 1982), pp. 48-57; Betty C. Daniel and Harold O. Fried, "Currency Substitution, Postal Strikes, and Canadian Money Demand," *Canadian Journal of Economics*, vol. 16 (November 1983); and Dallas S. Batten and R.W. Hafer, "Currency Substitution: A Test of Its Importance," Federal Reserve Bank of St. Louis *Review*, vol. 66 (August/September 1984), pp. 5-14.

[12] A negative correlation between the real exchange rate and the domestic money stock may not reflect merely the relationship between expected exchange rate changes and domestic money demand. A rise in the real exchange rate tends to lower foreign demand for U.S. net exports and for U.S. money balances. A fall in foreign income tends to have the same consequences. Because a decline in U.S. net exports tends to lower national income, both of these influences (reduced price competitiveness, lower foreign income) may be correlated with domestic income, and the latter variable may capture statistically their effect on domestic money demand.

[13] In this model, this variable is represented by the Fitzgerald rate. See Helen T. Farr, "Derivation of the Fitzgerald Time Deposit Rate Used in the Monthly Money Market Model," Division of Research and Statistics, Federal Reserve Board staff memorandum, 1979.

[14] Multicollinearity does not appear to be a problem in this analysis. The real effective exchange rate and effective foreign interest rate are not highly correlated with domestic income or with either of the domestic interest rates. The highest partial correlation coefficient between a foreign and a domestic variable is (as might be expected) that between the effective foreign interest rate and the U.S. commercial paper rate (.35).

This standard U.S. money demand function, as well as similar specifications in this class, are well known for being plagued by statistical deficiencies, such as simultaneous equations bias. For an excellent discussion of such deficiencies, see Thomas F. Cooley and Stephen F. LeRoy, "Identification and Estimation of Money Demand Functions," *American Economic Review*, vol. 71 (December 1981), pp. 825-844.

[15] Stephen Axilrod, Staff Director for Monetary and Financial Policy, Board of Governors, reported that the implementation of nonborrowed reserves targeting in October 1979 was designed to "increase the odds that money growth, particularly M1. . ., would in fact be controlled within target ranges. . . ." See Stephen Axilrod, "U.S. Monetary Policy in Recent Years: An Overview," *Federal Reserve Bulletin*, January 1985, p. 17.

[16] "Records of Policy Actions of the Federal Open Market Committee," *Federal Reserve Bulletin*, April 1983 (February 8-9, 1983 meeting). The italicized phrase (italics added) started appearing regularly beginning with this meeting.

[17] The small open economy assumption is used often in the international finance literature to allow the foreign price level, the foreign interest rate and foreign income to be treated as exogenous. The relevance of the following analytical conclusions with respect to the United States depends on the extent to which changes in U.S. variables influence these foreign variables in violation of the small open economy assumption.

[18] Moreover, the analysis suggests how an appreciation or depreciation of the home currency can occur at the same time the