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The Eurodollar Market and U.S. Residents

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An empirical test confirms that, in the 1980s, eurodollar deposits held by U.S. residents were influenced slightly by the level of interest rates and the availability of monetary reserves available to the banking system. Total eurodollar deposits, however, do not appear to be sufficiently close substitutes for money, or to have been sufficiently large in volume even at their peak in the early 1980s, to affect U.S. interest rates. For purposes of monetary control, policymakers need not be concerned about the impact of domestic currency holdings of their nationals in the eurocurrency market.

The rapid development of international banking and the euromarket that started in the late 1960s generated extensive discussion about the implications for monetary policy. While concern about the inflationary implications of the euromarket has receded in the 1980s, the possibility that euromarket activity may limit the effectiveness of monetary instruments remains pertinent.

The U.S. is at once more and less vulnerable than other economies to the external influence of the euromarket. On the one hand, the U.S. is a "large" economy, and the volume of euromarket transactions in which U.S. residents are engaged remains small in comparison to domestic financial transactions. This is particularly true with regard to the eurodollar bank deposits of U.S. nonbank residents.

On the other hand, the few restrictions on capital movements, the use of the U.S. dollar as the major currency of denomination in the euromarket, and the size of eurodollar deposits held by U.S. residents in comparison to narrow domestic money, make the U.S. financial market more susceptible to external influences by enhancing the substitutability of euromarket assets for U.S. assets and hence the arbitrage activities of U.S. banks between the domestic market and the euromarket. The U.S. experience may thus indicate the susceptibility of a large economy to external influences when there are relatively few impediments to arbitrage between the domestic financial market and the euromarket.

Aside from promoting linkages between domestic and foreign capital markets by stimulating capital flows, it has been argued that the development of the euromarket may lead to the emigration of the intermediation activities of domestic banks to the euromarket.[1] Such emigration would have several implications. For economies seeking to target monetary aggregates, the appropriate definition of the aggregate may be complicated by the creation of potentially close substitutes in the euromarket. Moreover, even an appropriately defined aggregate may be less susceptible to direct control. The crea-

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tion of euromarket substitutes for domestic money may also weaken the ability of monetary policy to influence interest rates or exchange rates, or be associated with disturbances to asset preferences that increase the volatility of those rates.

The extent to which the eurodollar market affects U.S. financial markets, and interest rates in particular, has not been conclusively determined. The earlier structural models of the linkages between the euromarket and domestic economies, such as Herring and Marston (1977), assumed that U.S. interest rates are unaffected by foreign rates. This assumption is supported by some recent evidence. For example, an unpublished study using vector autoregressions by Genberg, Saidi and Swoboda (1982) found that U.S. domestic interest rates were generally not influenced by interest rates in foreign financial markets, although U.S. rates did have a weak influence on foreign rates.

However, by applying a vector autoregression to monthly data of the 3-month U.S. commercial paper and eurodollar deposits rates, Hartman (1984), found that while U.S. interest rates appeared to have been unaffected by foreign rates before 1975, between 1/5 to 2/3 of the variation in domestic rates can be traced to foreign sources from 1975 to 1978.[2] Using weekly data, Reinhart and Harmon (1986) found closer integration in the 1980s between the federal funds market and the overnight eurodollar market, and evidence that overnight eurodollar rates Granger caused the federal funds rate.[3]

An understanding of the linkages between the eurodollar market and domestic financial markets and the implications of the use of a national currency in international transactions is particularly relevant for economies that are expanding the scope of their international banking activities. The most notable example is Japan, which today faces issues similar to those the United States started to face in the 1960s as a result of the rapid growth of the eurodollar market. The growing internationalization of Japanese banking, the use of the yen in international transactions, and the possibility that Japanese residents may shift intermediation to an incipient euroyen market raise questions that may be clarified by the U.S. experience.

This paper will discuss the influences on the emigration of domestic banking activity to the eurocurrency market, and assess the potential implications of the emigration of domestic banking activity for domestic financial markets, specifically, for interest rates. The next section discusses how certain institutional features that characterize the euromarket and international banking activity explain the growth of these sectors, leading to the emigration of U.S. banking activity to the eurodollar market via the process of arbitrage. Section II examines the determinants of equilibrium in the eurodollar market. Section III assesses the potential implications for domestic interest rates and monetary policy of the shifting of domestic bank intermediation to the euromarket.

Using the framework developed in Section II, Section IV examines the actual growth of eurodollar deposits held by U.S. non-bank residents since the late 1970s. Section V contains an empirical test to ascertain the determinants of eurodollar deposit creation and the influence of the euromarket on domestic interest rates. The conclusion follows in Section VI.

I. International Banking and the Eurodollar Market

International banking can be described in several ways, but for our purposes, it will be useful to focus on two aspects:

1. The eurocurrency market, in which deposits and loans denominated in a given currency are offered outside the country where the currency is issued. The largest segment of the eurocurrency market is the eurodollar market, where transactions are denominated in U.S. dollars. U.S. banks and U.S. nonbank residents are active participants in the eurodollar market.

2. The cross-border activities of banks based in a given country, which form part of what is traditionally understood to be international banking. This includes lending by domestic banks to foreign residents, and foreign resident deposits in domestic banks.

Certain characteristics that historically have distinguished banking in the eurodollar market from domestic banking account for the rapid growth of the former. Unlike domestic deposits, eurodollar deposits are not subject to FDIC premia or to reserve requirements. For many years, eurodollar deposits also benefited from the absence of restrictions on interest paid that applied to domestic banking. These institutional advantages encouraged demand for eurodollar deposits, particularly during the inflationary 1970s.

However, under certain conditions, borrowing by U.S. residents from the eurodollar market is subject to reserve requirements,[4] and has affected the extent to which U.S. residents have used the eurodollar market as a source of funds. In the early 1970s, reserve requirements on eurodollar market borrowing were much higher than domestic reserve requirements, effectively discouraging such borrowing. In the mid-1970s, the reverse was true as the Federal Reserve sought to encourage borrowing from the eurodollar market to strengthen the value of the dollar.[5] Since the implementation of the Monetary Control Act of 1980, the reserve requirement on eurodollar borrowing has been 3 percent, the same as that on domestic CDs.

Banks operating in the eurodollar market generally do not issue checkable deposits, but they do issue a substantial volume of very short maturity liabilities held by U.S. nonbank residents. In further contrast to the domestic money market, where banks raise the bulk of their funds from nonbanks, interbank transactions account for about 70 percent of all eurodollar market transactions.

Although other currencies have gained some prominence in recent years, dollar-denominated deposits and loans offered outside the United States or in International Banking Facilities in New York, which are exempt from domestic banking regulations, still represent the bulk of eurocurrency market activity.[6] The settlement of dollar transactions originated by U.S. or foreign banks operating in the eurodollar market ultimately involves the transfer (using the Clearing House Interbank Payments System, or CHIPS) of reserves (that is, claims on the Federal Reserve) in the domestic U.S. banking market: Such reserve transfers typically involve U.S. banks, rather than the branches of foreign banks operating in the United States.[7]

Such close links between the domestic and the eurodollar markets lead observers to treat the latter as an extension of the U.S. banking system.[8] Since bank reserves are ultimately required in the settlement of claims originating in the eurodollar market, the availability of reserves will tend to influence the volume of eurodollar deposit creation. In addition, efforts to tap the domestic and eurodollar markets to acquire reserves imply that the markets for federal funds and overnight eurodollar deposits are closely connected by arbitrage, as are the markets for term domestic and eurodollar deposits.[9] These arbitrage activities are reflected in the eurodollar deposit holdings of U.S. residents and the international assets and liabilities of banks based in the U.S.

II. Understanding Eurodollar Deposit Creation

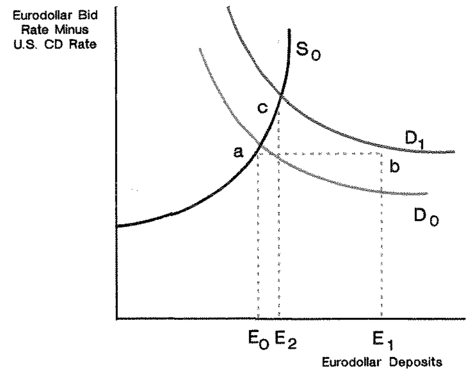
Eurodollar Supply and Demand

The arbitrage process described earlier is associated with the emigration of domestic banking activity to the eurodollar market.

The extent to which intermediation will shift from the domestic to the eurodollar market will depend on the interest rate paid on eurodollar deposits. At very high eurodollar deposit interest rates, the demand for eurodollar funds by banks will be small. As the differential between eurodollar rates and domestic U.S. rates approaches the difference in costs between dealing in the domestic and eurodollar markets, banks will be increasingly indifferent between operating in the domestic or eurodollar market, and the demand schedule will tend to flatten. The slope of the demand curve is determined by matching the marginal revenue from lending against the marginal cost of raising funds in the eurodollar markets at any given eurodollar rate.[10]

Domestic residents may be indifferent between holding domestic and eurodollar deposits when these deposits pay a premium over the domestic deposit rate sufficient to compensate them for the perceived risk of acquiring eurodollar assets. Beyond a certain point, however, depositors may require higher eurodollar rates to supply more funds to the eurodollar market, tracing an upward sloping supply schedule for eurodollar funds. The slope of the supply curve reflects the rate at which assetholders must be compensated for the perceived risk or inconvenience of banking in the eurodollar market. The equilibrium is shown by lines S and D in Chart 1.

Chart 1
Eurodollar Market Equilibrium



Determinants of Equilibrium

In an illuminating discussion of the supply and demand framework presented here, Giddy (1979), distinguished between two polar views of the eurodollar market: the *cost of regulation* view, which reflects the behavior of banks that demand eurodollar funds, and the *market price of risk* view, which reflects the behavior of assetholders who supply funds to the eurodollar market.

According to the cost of regulation view, the differential between the eurodollar and domestic deposit rate is set by banks to reflect the higher cost (reserve requirements and FDIC insurance premia) of funds in the domestic deposit market. Banks are then indifferent between demanding funds from the eurodollar or domestic deposit market. The perfectly elastic demand for funds determines the eurodollar rate, and a less than perfectly elastic supply of funds schedule is said to determine the volume of eurodollar deposits. In Giddy's version of the cost of regulation view, the demand schedule in Chart 1 would be a horizontal line.

In the *market price of risk view*, derived from portfolio management theory, the differential between the eurodollar and domestic deposit rates is set by depositholders to compensate them for the perceived risk of placing funds in the eurodollar market. Depositholders are then indifferent between placing funds in the eurodollar or domestic market. The perfectly elastic supply of funds determines the eurodollar rate, and a less than perfectly elastic demand schedule is said to determine the volume of eurodollar deposits. According to this view, the supply schedule in Chart 1 would be flat.

Giddy argues that the cost of regulation and market price of risk views are irreconcilable because market equilibrium cannot be determined when both demand and supply are infinitely elastic. One way around this disturbing conclusion, which suggests that either banks or assetholders may not behave rationally, is that neither view need imply that the demand or the supply of funds are everywhere perfectly elastic.[11] This reasoning underlies the less than perfectly elastic segments illustrated in Chart 1.

The supply and demand framework introduced above does not explicitly state where the funds raised in the eurodollar market will ultimately be placed. Kreicher (1982) analyzed this question under the cost of regulation framework by discussing the two choices available to banks, namely to obtain funds from the domestic market to fund lending abroad (outward arbitrage) or to obtain funds from the eurodollar market to fund lending in the U.S. (inward arbitrage). When the cost of domestic funds (the domestic CD rates adjusted for reserve requirements and FDIC premia) is less than the return from depositing such funds in the eurodollar interbank market (the eurodollar bid rate), there is an incentive for outward arbitrage. In the process of bidding for funds, the differential between the domestic U.S. rate and the eurodollar rate will narrow until the incentive for outward arbitrage is eliminated. The cost of domestic funds thus imposes a ceiling on the eurodollar bid rate.

In contrast, when the cost of funds in the eurodollar market (the eurodollar offer rate adjusted for the cost of reserve requirements applied to borrowing from the eurodollar market) is less than the cost of funds in the domestic market, there is an incentive for obtaining funds in the eurodollar market to fund domestic lending. This case raises the possibility of a "round trip", whereby domestic residents place the funds in the eurodollar market and these funds are subsequently lent to domestic borrowers. Once more, the cost of funds in the domestic market, this time adjusted by the reserve requirements on eurodollar borrowing and the spread between the eurodollar bid and offer rates, places a floor on the eurodollar bid rate.

Between the two thresholds for inward or outward arbitrage is an "arbitrage tunnel" within which banks are largely indifferent between obtaining funds in the domestic market and the eurodollar market. When the differential between the eurodollar rate and the domestic rate is sufficiently large, the net foreign asset position of the U.S. banking sector would tend to be positive; the reverse would be true when the eurodollar interest rate is low enough to create an incentive for inward arbitrage. The recent U.S. experience in this regard is analysed in section IV.

III. Implications of Intermediation via the Euromarket

While the preceding analysis highlights some of the key features of eurodollar market equilibrium, it is a partial analysis because it does not explicitly discuss the impact eurodollar market activities may have on domestic interest rates. In general, the potential impact may be derived from macroeconomic considerations.

In the analysis of monetary policy in a closed economy, the existence of two assets, money and bonds, is typically assumed. Money here refers to currency and checkable deposits (M1) that pay a fixed (possibly zero) rate of interest, and bonds refer to a spectrum of interest-bearing assets. In this framework, monetary policy affects interest rates by changing the supply of money; changing the supply of money, in turn, requires changes in the yield on bonds (and hence, the relative yield on money) to induce the public to accept the new money supply. For example, a policy that shrinks bank reserves forces banks to reduce their deposit liabilities (and therefore money creation) to satisfy reserve requirements. The yield on assets that are alternatives to money must then rise to eliminate the resulting excess demand for money.

The extent to which interest rates will respond to the monetary policy objectives of the central bank depends on (1) the existence of close substitutes for money and (2) the tightness of the link between reserve creation by the Federal Reserve and domestic money creation by banks. If bonds were close substitutes for money, a small increase in their yield would suffice to eliminate the excess demand for money. The effect of a given change in reserves on interest rates in that case would be small. In a closed economy, the tightness and predictability of the link between reserves and domestic money creation is strengthened by reserve requirements.

The growth of eurodollar deposits held by U.S. residents presents a potential problem for domestic monetary policy because it tends to weaken the two conditions needed for an effective monetary policy cited above. Eurodollar deposits are believed by some observers to be close substitutes for domestic money. Furthermore, because eurodollar deposits are not subject to reserve requirements, banks could potentially create a large volume of such deposits in a manner that offsets the monetary policy objectives of the Federal Reserve.

Money Substitutes

The argument that eurodollar deposits may be close substitutes for domestic money is analogous to arguments motivated by the financial innovation of the 1970s, namely, that certain domestic assets may, in various ways, reduce the demand for transactions balances. Because eurodollar deposits are of relatively short maturity, they could be close substitutes for domestic money. In addition, eurodollar deposits, particularly for the shortest maturities, may increase transactions efficiency (much like the domestic RP market), thus reducing the need for cash balances.

While domestic assets that are potential money substitutes have generated an enormous literature,[12] the evidence on the substitutability of eurodollar deposits for domestic money is thin. Studies of interest parity suggest a high degree of substitutability between assets of comparable maturity held in the U.S. and abroad,[13] with very small risk premia imposed on the assets held in industrial countries.

However, authors have generally not tested for the substitutability of eurodollar deposits for domestic money, limiting themselves instead to comparisons of the size of eurodollar deposit holdings of residents with measures of narrow domestic money.[14] The comparison implicitly assumes a high degree of substitutability between eurodollar deposits and domestic money but provides no direct evidence of such. An exception is Goodman (1984a), who found that the forecasting performance of two standard equations using narrow money (the Goldfeld money demand equation and the reduced form St. Louis equation) improved when eurodollar deposits of short maturity were included.[15] Goodman's results imply that shifting deposit activity to the eurodollar market would create substitutes for domestic money.

Tightness of Link to Monetary Reserves

Given that eurodollar deposits are, to some undetermined extent, substitutes for domestic money, the process by which eurodollar deposit creation may offset the intention of monetary policy is best seen by example. Consider a deflationary monetary policy which induces a rise in domestic interest rates in relation to those in the euromarket. If this policy were to raise loan rates by more than it raises deposit rates, and thereby increase the profit margins on lending, the rise in interest rates would create an incentive for banks to increase their intermediation. At the same time, however, by raising the cost of noninterest-bearing reserves, as well as domestic CD rates, the rise in domestic rates would tend to shift intermediation towards the eurodollar market, where the marginal cost of funds is comparatively lower. In Chart 1, these effects are illustrated by a rightward shift in the demand schedule for eurodollar funds to D_1.

Although the link between eurodollar deposits and monetary reserves may be weaker than the corresponding link between domestic deposits and reserves, the rightward shift in demand for eurodollar funds will still be limited by the following:

(1) *Liquidity Constraints:* While eurodollar deposits are not subject to reserve requirements (abstracting from reserve requirements on borrowing from the eurodollar market), banks eventually have to settle their eurodollar liabilities with dollar reserves.[16] When lending rates rise, a bank raising funds in the eurodollar market trades off the increased margins on lending these funds against the growing risk of illiquidity due to increasing intermediation. This trade-off should tend to limit the volume of loans and eurodollar deposit creation according to the availability of reserves created by the Federal Reserve, although the link is looser than in the case of the domestic market where reserve requirements are binding. The extent to which

reserve availability limits eurodollar deposit creation depends partly on the substitutability of eurodollar deposits for transactions balances and partly on the extent of maturity transformation in the eurodollar market;[17]

(2) *Loan Market Constraints.* Higher interest rates create adverse selection towards riskier borrowers and increase the probability of default.[18] These effects are generally associated with credit rationing, which limits the demand for funds on the part of banks;

(3) *Capital Constraints.* Intermediation in the eurodollar market tends to reduce capital-asset ratios. While the effect is reduced to the extent that such intermediation substitutes for intermediation in the domestic market, capital constraints have been a matter of great concern to banks in the 1980s.

For any given rightward shift in demand, motivating non-banks to place their funds in the eurodollar market bids up the eurodollar deposit rate. The rise in the rate would tend to reduce the margins on lending. This sequence may be seen as a movement from point b to point c in Chart 1 (with the differential increasing as the eurodollar rate rose). In fact, if the supply of eurodollar market funds were inelastic (for example, in times of great uncertainty abroad), eurodollar deposit rates could rise so far as to eliminate any advantage in raising funds in the eurodollar market.[19]

Our example thus suggests that the volume of eurodollar deposits will rise during periods when interest rates are high as long as the supply schedule for eurodollar deposits is not perfectly inelastic. This conclusion may have implications for domestic interest rates and monetary policy.

Consider now a shift in the supply of funds from domestic demand deposits to eurodollar deposits. The shift from reservable to non-reservable assets should lower the demand for reserves, and tend to lower domestic as well as eurodollar interest rates. A monetary authority seeking to stabilize output must offset such disturbances to interest rates caused by shifts in asset preferences. In general, the magnitude of shifts in the supply of funds between domestic demand deposits and the eurodollar market may be greater the greater the substitutability between those two assets, or smaller depending on the cost to assetholders of shifting to eurodollar deposits.

Inward and Outward Arbitrage

The extent to which a shift from domestic money towards eurodollar deposits will affect domestic interest rates will also depend on the extent of inward or outward arbitrage For example, if a rise in domestic interest rates were to create an incentive for inward arbitrage, banks may demand eurodollar deposit funds to lend at home. Such a "round trip" would tend to lower domestic interest rates and thus offset the impact of monetary policy. The effect on domestic interest rates would be attenuated if the differential between eurodollar and domestic interest rates were instead to create incentives to lend funds to the eurodollar market.

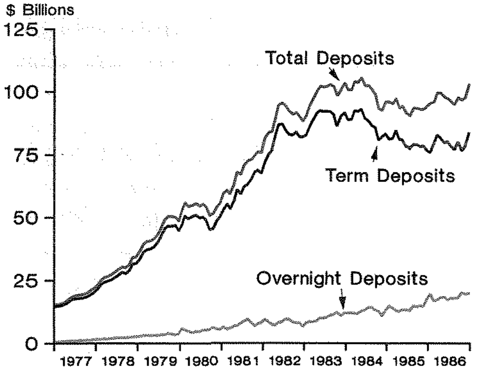
IV. U.S. Residents and the Eurodollar Market

We may now use the preceding heuristic framework to review the actual behavior of the eurodollar market and the reasons explaining the emigration of U.S. bank activity to the eurodollar market in the late 1970s and 1980s. Two indicators of the emigration of U.S. banking activity to the eurodollar market are the eurodollar deposit holdings of U.S. nonbank residents and the external asset position of U.S. banks compared to their foreign affiliates.[20]

Chart 2 shows the trend in the total, term, and overnight eurodollar deposit holdings of U.S. nonbanks with the foreign affiliates of U.S. banks since 1977. Overnight eurodollar deposits are included as part of M2, and term eurodollar deposits are part of M3 in U.S. monetary statistics.

Two features are apparent. First, after very rapid growth in the 1970s, total eurodollar deposits held by nonbank U.S. residents peaked in 1984 at approximately $105 billion, and declined subsequently. Overnight eurodollar deposits continued to grow, although they accounted for only 18 percent of total eurodollar deposits in 1986. Second, the size of eurodollar deposits held by U.S. residents is small in comparison to domestic monetary aggregates. At their peak, total eurodollar deposits were

Chart 2
Eurodollar Deposits of
U.S. Nonbank Residents



20 percent as large as M1 and 3.7 percent as large as M3.[21]

Note also that, for most of this period, there was little if any evidence of inward arbitrage, or a round trip in the form of eurocurrency market lending to U.S. residents via the banking sector, associated with these eurodollar deposits. Except for a brief episode between 1979 and 1980, U.S. banks have been net lenders to their foreign affiliates since 1977, as illustrated in Chart 3.[22]

The growth of the eurodollar market as a whole in the 1970s is often explained as a supply phenomenon: sharp increases in oil prices provided oil producers with a large supply of dollar funds which they preferred to place in the eurodollar market. However, the rapid growth of eurodollar deposits held by U.S. residents over the same period must mean that the demand for eurodollar funds — associated with the explosion in international lending starting in the 1970s — exceeded the increased supply of funds by oil producers. The growth trend was reversed by the 1982 debt crisis as declining expected returns on lending, and tightening capital constraints, lowered the demand for eurodollar funds.

Our earlier discussion suggests that, given the more favorable regulatory treatment that applies to the eurodollar market, eurodollar deposits must have grown in part because rising interst rates were associated with improved profit opportunities in lending, and relative interest rates favored intermediation via the eurodollar market. The information in charts 4 and 5 tend to confirm this explanation, as well as clarify the apparent absence of inward arbitrage.

Chart 4 illustrates the behavior of the 3-month eurodollar deposit rate and domestic CD rate. In line with our hypothesis, the fastest growth of eurodollar deposit holdings by nonbank residents occurred when interest rates were rising or at their highest levels, and eurodollar growth peaked in 1983, shortly after interest rate levels began their decline.

Chart 5 shows the difference between the 3-month eurodollar and the 3-month domestic CD rates. The top line, which is the unadjusted differential, represents the incentive to the nonbank sector to move deposits to the eurodollar market. It is remarkable that between 1979 and 1982, when the level of interest rates were at their highest, the spread between the eurodollar rate and the domestic deposit rates also peaked. The fact that eurodollar deposit growth continued at a fast pace over this period suggests that rising demand for eurodollar funds, presumably due to profit opportunities in lending, increased the unadjusted differentials between the eurodollar and domestic deposit rates. Since 1982, the spread between the eurodollar and domestic deposit rate has fallen significantly, and contributed to the contraction in eurodollar deposits held by U.S. residents.

Chart 3
Net Assets of U.S. Banks
Versus Their Foreign Branches

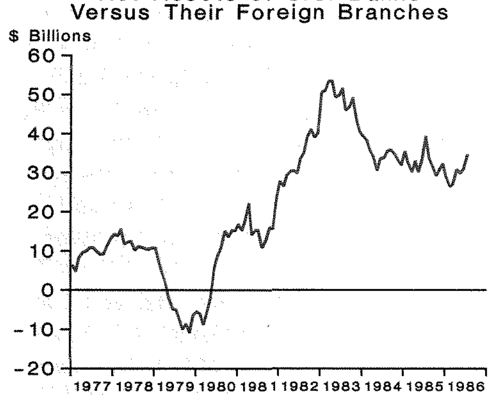
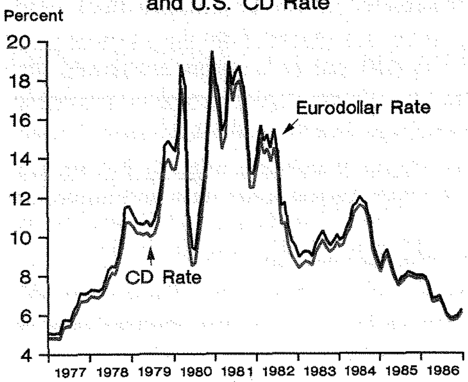


Chart 4
Three-Month Eurodollar Deposit Rate
and U.S. CD Rate



The reason that the funds raised in the eurodollar market were used for international rather than domestic lending is suggested by the bottom line of Chart 5, which represents the differential between the eurodollar bid rate and the domestic CD rate adjusted for reserve requirements. This differential reflects the incentive for banks to use the domestic market as a source of funds for lending to the eurodollar market, or the outward arbitrage cited earlier. When the differential is above zero, the eurodollar bid rate exceeds the tunnel ceiling discussed earlier, and banks have an incentive for outward arbitrage. When the differential is negative but sufficiently close to zero, banks are indifferent between using the eurodollar or the domestic market as a source of funds. When the differential is sufficiently low, the eurodollar bid rate falls below the tunnel floor, giving banks a possible incentive for inward arbitrage. The period in which this last case applied is illustrated by the shaded areas in Chart 5.[23]

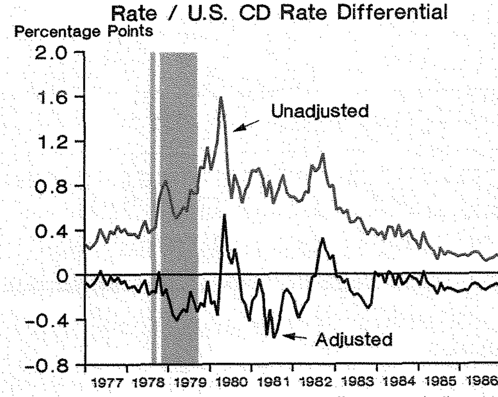
Chart 5 shows that, for most of the ten years since 1977, banks have either been indifferent between tapping the domestic or eurodollar markets, or had an incentive for outward arbitrage. The exception is 1979, when the second oil price shock created a large supply of eurodollar funds. At that time, eurodollar market rates fell sufficiently below domestic CD rates to create an incentive for banks to use the eurodollar market to fund domestic loans.

This timing roughly corresponds to the period when the net foreign asset position of domestic banks in comparison to their foreign affiliates turned negative (Chart 3).

To sum up, while the unadjusted differential of the deposit rates paid to the nonbank sector in the late 1970s (top line of Chart 5) appeared to encourage the shifting of deposits to the eurodollar market, the adjusted differential (bottom line of Chart 5), which reflects the cost of funds to the banks, simultaneously favored net lending abroad by the U.S. banking sector rather than the use of funds raised in the eurodollar market in the domestic market. Perhaps even more surprising is that, while the unadjusted differential between the domestic and eurodollar rate narrowed significantly since 1983 when the U.S. began importing unprecedented amounts of capital, the adjusted differential still reflected an outward arbitrage incentive for banks. This is confirmed by the rising net foreign assets of U.S. banks versus their foreign affiliates over the period.

While our discussion sheds some light on the behavior of eurodollar deposits over the past ten years, the importance of the various interst rate effects for eurodollar deposit holdings of U.S. residents is still unclear, as is the ultimate impact of eurodollar market on domestic interest rates. A more precise characterization of these effects requires more formal analysis.

Chart 5
Three-Month Eurodollar Deposit
Rate / U.S. CD Rate Differential



Shaded area indicates inward arbitrage opportunity

V. Dynamic Relationships

In the absence of an elaborate structural model, the determinants of the behavior of eurodollar deposits over time and the implications of the euromarket for domestic interest rates (and therefore monetary policy), can be examined more systematically by performing a vector autoregression (VAR). A VAR takes a set of variable and regresses them on the lagged values of the same set of variable, thus indicating whether the dynamic relationships in the data appear to be consistent with the relationships postulated by our understanding of how the eurodollar market works. VARs may be interpreted as reduced forms of complex structural links, they assume limited knowledge of the precise nature of these links.

Three useful results may be obtained with VARs:

1. *Tests of Granger Causality.* A variable x is said to Granger cause another variable y if the lagged values of x improve the forecast of y. Granger causality does not imply causality in the behavioral sense understood in structural models (for example, that an increase in interest rates would cause money demand to fall), but does permit statements about whether two variables appear to be connected in a systematic way over time. While Granger causality tests are useful indicators, they do not show the extent to which lagged values of x will improve the forecast of y. This information is provided by two other results obtained from VARs.

2. *Variance Decompositions.* These decompositions indicate how much of the forecast error of a particular variable results from innovations in each variable included in the VAR.

3. *Impulse Response Functions.* Based on the moving average representation of the VAR, impulse response functions provide an explicit characterization of the dynamic response of a variable to an innovation to itself or other variables.

TABLE 1

Test of Granger Casuality

	Dependent Variables			
Explanatory Variables	**Nonborrowed reserves**	**3-month Treasury bill rate**	**Euro/domestic CD rate differential**	**Total Eurodollar deposits**
Nonborrowed reserves	3.0**	0.7	1.4	4.7***
3-month Treasury bill rate	1.7	7.5***	0.9	3.9**
Euro/domestic CD rate differential	3.1**	1.3	12.0***	0.6
Total Eurodollar deposits	1.1	0.3	1.7	7.5***
$\bar{R}^2$	.08	.26	.29	.21

F-statistics on the null hypothesis that the block of coefficients is zero.
*** significant at 1%
** significant at 5%
* significant at 10%

A four-variable VAR was estimated. The variables were nonborrowed reserves (used as a proxy for liquidity constraints that may affect deposit creation in the domestic and eurodollar markets), the 3-month U.S. Treasury bill rate (as a proxy for the level of domestic interest rates), the differential between the unadjusted 3-month eurodollar and domestic CD rates (representing the incentive for arbitrage between markets and the influence of eurodollar rates), and total eurodollar deposits held by U.S. residents (representing the shift in domestic intermediation towards the eurodollar market).[24]

The data are monthly, the variables expressed in differences of logs and lagged 1 to 3 months, and the estimation period is 1979:1 to 1986:12. Short lags were chosen on the belief that the arbitrage relationships we have been discussing take place over a very short span of time. The estimation period was chosen to focus largely on the behavior of eurodollar deposits in the 1980s, when the strong variation in interest rates provides a good potential experiment for the responsiveness of eurodollar deposits.[25]

The objective of our VAR study is to shed some light on the potential impact of eurodollar deposit

TABLE 2

Variance Decomposition

Forecast Horizon (months)	Percent of forecast error explained by: Nonborrowed reserves	3-month Treasury bill rate	Euro/domestic CD rate differential	Total Eurodollar deposits
Nonborrowed Reserves				
1	100.0	0.0	0.0	0.0
6	78.1	6.2	13.8	2.0
12	77.9	6.3	13.8	2.1
24	77.9	6.3	13.8	2.1
3-month Treasury bill rate				
1	10.1	90.0	0.0	0.0
6	12.2	77.7	7.7	2.3
12	12.2	76.6	8.7	2.4
24	12.2	76.6	8.7	2.4
Euro/domestic CD Rate Differential				
1	0.4	0.3	99.4	0.0
6	3.8	2.9	89.3	4.0
12	3.8	2.9	89.2	4.0
24	3.8	2.9	89.2	4.0
Eurodollar deposits				
1	0.0	4.0	0.1	96.0
6	11.6	14.8	2.4	71.3
12	13.1	14.6	2.5	69.8
24	13.1	14.6	2.5	69.7

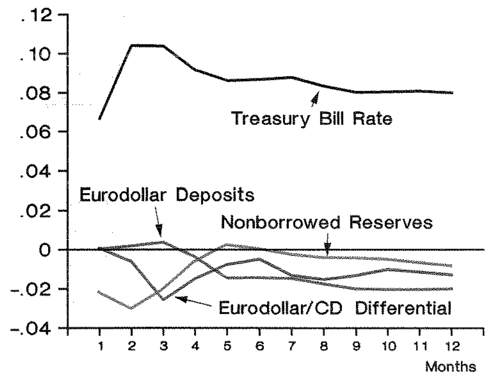
creation on domestic interest rates and on whether such eurodollar deposit creation could systematically offset the intention of monetary policy. Eurodollar deposit creation would do the latter if it were very responsive to interest rate behavior and relatively unfettered by the availability of reserves in the U.S. banking system. The dynamic links between the price (interest rate) and quantity variables should conform with the analysis presented earlier and may be interpreted as follows:

1. If U.S. interest rates were affected by the euromarket, eurodollar deposits as well as the eurodollar/domestic CD rate differential should Granger cause the U.S. Treasury bill rate, and should explain a large portion of its variance. If eurodollar deposits were to Granger cause the U.S. Treasury bill rate, one may infer that eurodollar deposits would be close substitutes for domestic money, and that, at the margin, such deposits would be large enough to have an impact on interest rates that is pertinent to domestic monetary policy.

2. If the volume of eurodollar deposit creation were responsive to interest rates, the U.S. Treasury bill rate, and the euromarket/domestic CD rate differential would Granger cause eurodollar deposits, and explain an important proportion of the variance in such deposits. In this case, eurodollar deposit creation may tend systematically to offset the direction intended by domestic monetary policy in the manner suggested earlier. In contrast, if eurodollar deposits were subject to liquidity constraints, nonborrowed reserves would Granger cause eurodollar deposits, and the extent of the offsetting effects on monetary policy will be correspondingly limited.

Table 1 reports the results of the VAR, with columns 2 and 4 being of direct interest. As can be seen in the second column of Table 1, under the specification adopted here only the lagged Treasury bill rate is statistically significant in forecasting the U.S. interest rate. In contrast to Hartman's results for the period 1975-1978, there is no evidence that the behavior of eurodollar interest rates, reflected by the interest differential between eurodollar and domestic rates, Granger cause domestic U.S. rates[26] in the 1980s. The fourth column of Table 1 reveals that eurodollar deposits are Granger caused by the domestic Treasury bill rate and nonborrowed reserves. However, the lagged values of the

Chart 6
Response of U.S. Treasury Bill Rate to One Standard Deviation Shock In:



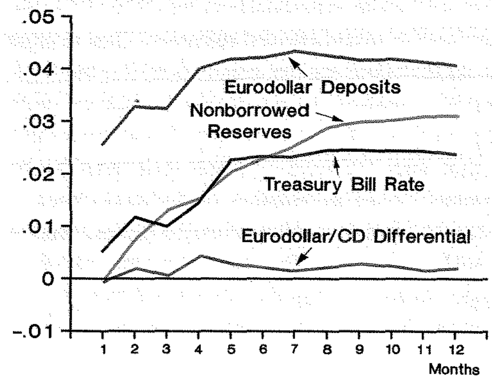
euromarket domestic CD rate differential are not significant.

The variance decomposition and impulse response functions characterize the specific contributions of innovations in the different variables to the variation of each variable in turn. Such a characterization requires the innovations specific to each variable to be isolated. For example, the innovations in nonborrowed reserves must be treated separately from innovations to the U.S. Treasury bill rate. This cannot be done by looking at the residuals of the vector autoregression equations because such residuals are typically correlated with each other. The traditional procedure, in this case, is to construct a moving average representation of the vector autoregression that recovers innovations that are not correlated with each other.[27]

The variance decompositions reported in Table 2 show the percentage of the expected squared prediction error of each of the four variables in the system that is produced by an innovation in each of the variables in turn, for forecasts for 1 to 24 months ahead. The contribution of innovations in each variable is expressed as percentages. For example, in the last item under Nonborrowed Reserves, column 1, the portion of the 24-month ahead forecast error in nonborrowed reserves that is attributed to innovations in the eurodollar/domestic CD rate differential is divided by the total expected 24-month ahead squared prediction error of nonborrowed reserves conditional on information available at the time the forecast is being made. This total error will depend on innovations in nonborrowed reserves, the U.S. interest rate, and the volume of eurodollar deposits, as well as on innovations in the eurodollar/domestic CD rate differential (recall that these variables are expressed in log differences). As can be seen, after 24 months, 78 percent of the error in nonborrowed reserves is due to innovations in nonborrowed reserves, and nearly 14 percent is due to innovations in the eurodollar/domestic CD rate differential.

In general, Table 2 shows that innovations in other variables play a limited role in explaining the standard error in the forecast of nonborrowed reserves, the U.S. interest rate, and the euromarket/domestic CD rate differential. The contribution of innovations in interest rates and nonborrowed reserves to the forecast error in total eurodollar deposits is also small.[28] After 24 months, innovations in the Treasury bill rate and nonborrowed reserves explain 15 and 13 percent, respectively, of the forecast error in total eurodollar deposits, as compared to 70 percent explained by innovations in eurodollar deposits.

Chart 7
Response of Eurodollar Deposits to One Standard Deviation Shock In:



The impulse response functions presented in Charts 6 and 7 illustrate the path of the response of the levels of the U.S. Treasury bill rate and total eurodollar deposits, respectively, to a 1 standard deviation shock in their own values and other variables in the system. The U.S. Treasury bill rate rises in response to a shock in the U.S. Treasury bill rate, but falls overall in response to a shock in nonborrowed reserves, the interest rate differential, and

TABLE 3

Covariance/Correlation Matrix

	Nonborrowed reserves	3-month Treasury bill rate	Euro/domestic CD rate differential	Total Eurodollar deposits
Nonborrowed reserves	$0.8\text{x}10^{-3}$	−.32	$-0.6\text{x}10^{-1}$	$-0.5\text{x}10^{-2}$
3-month Treasury bill rate	$-0.6\text{x}10^{-3}$	$0.5\text{x}10^{-2}$	$-0.3\text{x}10^{-1}$	.19
Euro/domestic CD rate differential	$-0.5\text{x}10^{-3}$	$-0.5\text{x}10^{-3}$	$0.7\text{x}10^{-1}$	$-0.3\text{x}10^{-1}$
Total Eurodollar deposits	$-0.4\text{x}10^{-5}$	$0.3\text{x}10^{-3}$	$-0.2\text{x}10^{-3}$	$0.7\text{x}10^{-3}$

eurodollar deposits. As indicated earlier, the effects of the last three are very small.

Total eurodollar deposits rise in response to a 1 standard deviation innovation to the U.S. Treasury bill rate and to nonborrowed reserves. This at least partly confirms our earlier suggestion that eurodollar deposit creation is positively associated with changes in domestic interest rates, but it also indicates that such deposit creation will tend to be constrained by the availability of dollar reserves.

In constructing a moving average representation of a VAR, which is the basis for the variance decompositions and impulse response functions, an assumption needs to be made as to the original source of observed disturbances. The present VAR assumes that disturbances to nonborrowed reserves are the primary source, followed by disturbances to the U.S. Treasury bill rate, the euromarket/domestic CD differential and eurodollar deposits. The sensitivity of the impulse response and variance decomposition results to the ordering adopted here depends on the covariation between the residuals of the equations, reported in Table 3. As can be seen, the correlations between the residuals are comparatively low, the highest being -32 percent for nonborrowed reserves and the U.S. Treasury bill rate. The results reported therefore are not very sensitive to the order assumed.

VI. Conclusions

Since the late 1970s, disturbances to U.S. interest rates and nonborrowed reserves influence eurodollar deposit creation. The effect of U.S. interest rates implies that eurodollar deposits may be created in a manner that offsets the intention of monetary policy. The effect of nonborrowed reserves implies that the extent of such offset will be curtailed by the availability of reserves. It should be stressed that these two effects are small. Eurodollar deposit holdings of U.S. residents are explained largely by the lagged values of those holdings.

In addition, any influence the euromarket has on domestic interest rates is negligible. Neither a proxy for the effect of the euromarket interest rate nor the volume of eurodollar deposits held by U.S. residents explains much of the variance in domestic U.S. interest rates. Specifically, total eurodollar deposits do not appear to be sufficiently close substitutes for money, or to be sufficiently large in volume even at their peak in the early 1980s, to have a strong influence on U.S. domestic rates. For purposes of monetary control, U.S. policymakers need not be concerned about the impact of domestic currency holdings of their nationals in the eurocurrency market.

This result may have implications for other large countries concerned about extending the scope of their international banking relationships. Of course, the internationalization of banking has other implications not fully explored here. Further research should seek to identify the importance of other channels that connect the euromarket to domestic financial markets, particularly, the eurobond market.

FOOTNOTES

1. See Mayer (1982). Similar reasoning underlies the framework used by Henderson and Waldo (1980, 1981).

2. The apparent absence of any influence of foreign rates on U.S. rates reported by Genberg, Saidi and Swoboda may be caused by two factors: (a) changes in the return on assets denominated in foreign currency affect exchange rate expectations in a way that diffuses the observed impact on U.S. rates, and (b) domestic interest rates and the rates in financial markets abroad are subject to such a wide variety of influences that no direct link between them may be apparent.

The absence of direct linkages between national financial markets in the U.S. and abroad does not rule out the possibility that interest rates in national financial markets abroad may influence eurocurrency market interest rates, which, in turn, may influence U.S. interest rates. Thus, the results of Genberg, Saidi and Swoboda may still be consistent with Hartman's (1984) results. However, as indicated later, Hartman's results do not appear to apply for the 1980s.

3. Overnight eurodollar rates Granger cause the federal funds rate if lagged values of the former improve the forecast of the latter. The test of Granger causality is discussed in a later section.

4. The eurocurrency liabilities of U.S. residents subject to reserve requirements are defined as the net interbank liabilities of U.S.-based banks versus those of banks operating in the euromarket and the borrowings of U.S. residents from branches of U.S. banks operating in the euromarket. AS discussed later, U.S. banks have been net creditors compared to their foreign branches over extended periods, so the reserve requirements in many cases do not apply.

5. In 1971, the reserve requirement on eurodollar borrowing was doubled to 20 percent; it was then reduced to 8 percent in June 1973. Over this period, reserve requirements on eurodollar borrowing were higher than the 5-8 percent reserve requirements on domestic CDs. From the last quarter of 1973 to 1978, the reserve requirement on eurodollar borrowing was progressively reduced to 0 to encourage borrowing from the eurodollar market in order to strengthen the value of the dollar, while the domestic CD requirement had risen to as high as 11 percent.

6. The share of dollar-denominated transactions in the euromarket has fallen in recent years. For example, lending denominated in U.S. dollars by banks in London — which is the major euromarket center — has fallen from a peak of 80 percent in 1983 to 72 percent in 1985, while the shares of transactions denominated in yen and deutschemarks have risen (to 7 and 10 percent respectively).

7. The reason is that foreign bank branch daylight overdrafts at the Federal Reserve are restricted, so foreign banks prefer to settle using deposits held with U.S. banks rather than with the reserves they have been required to hold with the Federal Reserve since 1978. Originally, foreign banks were not allowed to run daylight overdrafts. At present, foreign bank overdrafts are limited to 5 percent of their U.S. liabilities.

8. For example, Aliber (1979), points out: "The growth of the deposits of offshore banks can be thought of as the growth of the deposits of domestic branches not subject to reserve requirements . . . Banks do not hold separate reserves against offshore deposits because the reserves held against domestic deposits exceed normal liquidity needs . . ."

9. The arbitrage between the federal funds and overnight eurodollar market is discussed by Reinhart and Harmon (1987). The arbitrage between domestic and eurodollar CDs is highlighted by Johnston (1979) and Kreicher (1982).

10. The marginal conditions can be derived from the theory of the banking firm. The marginal revenue to be equated to marginal cost is the interest income from lending funds received by increasing eurodollar liabilities. For a given level of domestic deposits and interest rates, the marginal cost depends on the extent to which increasing eurodollar liabilities will affect desired holdings of (noninterest-bearing) reserves, the interest cost of the additional eurodollar liabilities, the expected penalty associated with the increased probability of becoming illiquid as eurodollar liabilities rise, and the marginal cost to the firm of an increase in its size. In a profit-maximizing equilibrium, the size of the banking firm, the share of the domestic and eurodollar market in loans and deposits, and the quantity of desired reserves are all determined simultaneously.

11. Such an approach would explain why the differential between the eurodollar deposit rate and domestic deposit rates of comparable maturity is not explained by the differential in the cost of funds in the two markets when there are large disturbances to asset preferences (for example, following the Herstatt Bank failure of June 1974). This implies that for sufficiently large changes in interest rates associated with shifts in the supply of eurodollar funds, the demand for eurodollar deposits is not perfectly elastic either.

12. See Judd and Scadding (1982).

13. For a recent discussion, see Frankel (1985).

14. For example, see Mayor (1982).

15. Goodman's definition of eurodollar deposits of short maturity includes overnight eurodollar deposits and either 20 percent or 40 percent of term eurodollar deposits held by U.S. residents (the latter is taken as the upper limit on eurodollar deposits under 8 days). Her equations are estimated quarterly from 1959 to 1974 and then simulated out-of-sample through the third quarter of 1982.

16. When foreign banks are involved, the settlement may first involve bank deposits held with U.S. banks. This eventually will result in the transfer of reserves.

17. Niehans and Hewson (1976) argued that banks largely match the maturities of their assets and liabilities in the euromarket, suggesting that the extent of maturity transformation, and therefore liquidity creation, is small. However, more recently, Sneddon-Little (1979) found that the extent of maturity transformation may be as large as for domestic banking.

18. See Stiglitz and Weiss (1981); or Sachs (1984).

19. One may also think of a leftward shift in the supply of funds schedule caused by the rise in domestic lending rates, which may or may not fully offset the rightward shift in demand.

20. These two indicators do not provide a complete representation of eurodollar activity that may be relevant for domestic monetary policy because the arbitrage activities of nonbank foreign residents between the domestic U.S. market and the eurodollar market are not considered. However, a large portion of the foreign resident holdings of eurodollars is unconnected with U.S. economic activity (for example, eurodollar entrepot operations). Since it is difficult, if not impossible, to ascertain that proportion of foreign eurodollar holdings that should be included in the analysis, we have confined our study to the emigration of intermediation by U.S. residents.

21. The analysis raises the question of whether it is appropriate to compare total eurodollar deposits with M1. Because of their short maturity, overnight eurodollar deposits are considered the closest substitutes for M1. However, a large proportion of eurodollar deposits are of very short maturity. Goodman (1984a), for example, assumes that up to 40 percent of eurodollar deposits mature in less than 8 days.

22. The pattern in the overall net foreign asset position of U.S. banks appears to be consistent with the pattern shown in Chart 3. Although the U.S. economy as a whole has been a net creditor from early this century up to the 1980s, total U.S. international banking liabilities typically exceeded assets up to the early 1970s. This was partly because the role of the dollar as a reserve currency resulted in the holding of significant dollar-denominated deposit holdings on the part of foreign governments. However, growing bank lending reversed this situation by the end of 1975. The net foreign assets of U.S. banks rose from $1.1 billion in that year to a peak of $130.2 billion in the first quarter of 1983, before falling to $42.1 billion in the first quarter of 1986. The decline reflected the 1982 debt crisis, which prompted U.S. banks to reduce the growth of their external lending, particularly to less developed countries, and that portion of growing U.S. borrowing that had been channeled through the banking sector.

23. The cost of domestic funds, which defines the tunnel ceiling, may be described by the formula: $c = (i+p)/(1-r_d)$, where c is the cost, i is the interest paid on the domestic deposit, p is the FDIC premium, and r is the reserve requirement on domestic deposits.

The tunnel floor is described by: $f = [(i+p)(1-r_e)/(1-r_d)] - s$, where r_e is the reserve requirement on borrowing from the eurodollar market, and s is the spread between the eurodollar bid and offer rates. For a discussion of how these values are derived, see Kreicher (1982). Unlike Kreicher, statutory FDIC premia are used here.

24. Instead of taking the U.S. Treasury bill rate and the difference between the euromarket and domestic CD rates, we could have used a U.S. domestic rate and a comparable euromarket rate. The two series would have reflected both the effect of the overall level of the rates as well as the effect of the differential between them. Experiments with this alternative specification gave similar results.

25. Extending the estimation period to 1977 does not alter the basic results.

26. Hartman estimates a two-variable vector autoregression with the 3-month U.S. commercial paper rate and the 3-month eurodollar deposit rate and finds evidence that the 3-month eurodollar rate Granger caused domestic rates for the period 1974-1978. Direct estimates performed by the author using a similar bivariate system in levels and rates of change confirmed this finding, but indicated that, after 1979, the eurodollar rates do not Granger cause domestic rates. This is consistent with the results in the text. Reinhart and Harmon's (1986) finding that overnight eurodollar rates Granger cause the federal funds rate in the 1980s then indicates that the term structure relationship of the euromarket and domestic interest rates has changed. This warrants further investigation.

27. In vector autoregressions, variables that are not expected to have predictive values for other variables are put last. This assumption is reflected in the ordering of the equations reported in Table 1.

The procedure for isolating the innovations in each variable follows naturally from this assumption. The innovations to nonborrowed reserves were left unchanged. Any systematic relationship between the residuals in the nonborrowed reserves equation and the U.S. Treasury bill equation was then eliminated to obtain the innovations to be attributed to the U.S. Treasury bill rate. The innovations in the euromarket/domestic CD differential were then obtained by eliminating any systematic relationship with the residuals of nonborrowed reserves and U.S. Treasury bill equations. A similar process yielded the innovations in the eurodollar rate. As indicated later, the low correlation between the innovations suggests that the results are not very sensitive to the order assumed.

28. Recall that all variables are expressed in log differences.

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