Eurodollar Arbitrage

What are the links between the Eurodollar money market and the U.S. domestic banking system, and how strong are those links? One hypothesis asserts that the U.S. money market and the Eurodollar market are closely integrated sectors of a world dollar market. Indeed, the character of the assets and liabilities in the two sectors—dollar-denominated bank deposits and loans—is nearly identical. The usually close correspondence of Eurodollar and domestic interest rates since the removal of U.S. capital controls in 1974 strongly supports this hypothesis.

At times the Eurodollar market has appeared detached from domestic financial markets, and large variable differentials between Eurodollar interest rates and U.S. money market rates have emerged. In fact, an unusually wide interest rate differential has persisted since late 1980. These episodes support the alternative hypothesis that the Eurodollar market is effectively independent with a life of its own.

The U.S. and Eurodollar money markets are linked by the arbitrage activities of nonbank depositors, nonbank borrowers, and large multinational banks. Any financial transaction, undertaken in response to a widening in the Eurodollar-domestic interest rate differential which tends to narrow that differential, counts as arbitrage. This definition includes the familiar arbitrage transaction of simultaneously borrowing relatively cheap funds and profitably relending them elsewhere, as well as portfolio shifts among assets or among liabilities according to changes in relative yields or costs. Arbitrage transactions limit movements in the Eurodollar-domestic interest rate differential. When it becomes profitable to shift or to arbitrage between

markets, the shifts tend to restore a narrower gap between interest rates so that further arbitrage becomes unattractive.

The interest rate differentials perceived by nonbank depositors, nonbank borrowers, and banks differ because of market pricing practices and bank regulations. Nonbank depositors face unadjusted nominal interest rates on domestic and external deposits, while nonbank borrowers must compare effective loan costs that might include different rate-basing options, compensating balance requirements, and even varying loan spreads (above the base rate) over time. Banks must consider the impact of reserve requirements and deposit insurance. As a consequence, arbitrage incentives may differ among these three groups. For instance, nonbank depositors might have an incentive to shift funds from the United States to the offshore dollar market while at the same time U.S. banks might have an incentive to move funds onshore.

This article shows that Eurodollar arbitrage by U.S. banks is the primary channel linking the Euromarket and the domestic banking sector. Large multinational banks operate daily and in volume in both markets and usually respond promptly to any profitable interest rate discrepancies. The Eurodollar-domestic interest rate differentials faced by nonbank depositors and borrowers and the flows of funds associated with these differentials depend critically on whether or not bank arbitrage is effective.

Bank arbitrage does not necessarily determine a unique level of Euromarket rates corresponding to a given level of domestic interest rates, but it does impose limits on the size of the gap between domestic

and external rates. From early 1974 when U.S. capital controls ended until late 1980, the differential between Eurodollar rates and domestic rates was consistent with effective bank arbitrage. Since 1980, however, U.S. banks have faced an apparently persistent arbitrage incentive to borrow funds in domestic markets and simultaneously to lend in the Euromarket.

Banks have not fully exploited this current arbitrage opportunity. First of all, bank management and bank stock analysts have grown more sensitive to the rate of return on total assets and the potentially adverse effects of arbitrage on this rate. Secondly, bank regulators have helped focus attention on the adequacy of bank capitalization and the erosion of capital-asset ratios. It is interesting that prudential supervision, by reducing the effectiveness of bank arbitrage, may *indirectly* affect the behavior of nonbank depositors and borrowers and affect domestic and international monetary relationships.[1] Finally, U.S. banks recently may have grown more concerned about the riskiness of interbank placements because of the problems encountered by other banks with loans to Eastern Europe and developing countries.

Overview of bank arbitrage

A variety of transactions may be classified as bank arbitrage. In some of these operations, a bank simultaneously issues new liabilities and acquires new assets, thereby expanding its balance sheet. Other arbitrage activities leave the size of a bank's balance sheet unchanged but shift funding among liability categories. This distinction between arbitrage activities that expand a bank's balance sheet and those that do not can be important because the effectiveness of arbitrage will be influenced by banks' willingness to expand.

Outward arbitrage

Large U.S. banks balance competing credit demands in domestic and external markets primarily through transactions with their branches abroad. Consequently, their arbitrage activities can also be classified as *outward* or *inward* arbitrage depending on the direction that funds flow in response to interest rate incentives. To do outward arbitrage, a U.S. bank typically purchases domestic funds by issuing large certificates of deposit (CDs) and redeposits those funds with its

[1] For a discussion of the monetary control problems associated with nonbank shifts between the U.S. and Eurodollar money markets, see Edward J. Frydl, "The Eurodollar Conundrum", this *Quarterly Review* (Spring 1982), pages 11-19; and Laurie Goodman, "Eurodollars and the U.S. Money Supply", Federal Reserve Bank of New York, Research Paper No. 8001 (January 1980).

offshore branches. If the branches then redeposit the funds in the interbank Euromarket or make new loans to nonbank borrowers, outward arbitrage will increase the size of the bank's worldwide consolidated balance sheet.

A U.S. bank which considers raising funds domestically and ultimately placing those funds in the Euromarket naturally compares the effective cost of acquiring an additional domestic deposit with the return on an additional placement in the Euromarket. The *effective* cost of funds in the domestic market equals the nominal interest rate on domestic deposits adjusted for the costs of deposit insurance and noninterest-bearing required reserves. Two conditions must hold for a U.S. bank to have an incentive to move funds offshore: (1) the external return must exceed the effective cost of domestic funds and (2) the external return must exceed the available domestic return; otherwise, newly acquired funds would be placed domestically. In the absence of government controls on capital outflows, a U.S. bank will move funds offshore until interest rates adjust to remove at least one of the above conditions or until an internal arbitrage constraint is reached. Under normal circumstances, an equilibrium in which banks lose their incentive to move funds offshore will occur when the effective cost of domestic funds equals or exceeds the external interest rate. This behavior imposes a ceiling on the external deposit rate: whenever the Eurodollar rate rises above the effective cost of domestic funds, U.S. banks will borrow domestically and shift funds offshore, bidding up the domestic deposit rate and bidding down the Eurodollar rate until arbitrage is no longer profitable (Box 1).

While outward arbitrage is usually related to costs in the domestic CD market, U.S. banks can utilize other domestic funding sources. For example, if rates are favorable, outward Eurodollar arbitrage might be funded by new issues of bank holding company commercial paper. Nevertheless, banks rely much more on the CD market than on the commercial paper market as a source of arbitrage funds. The CD market is larger and offers a more liquid secondary market, and therefore it provides a more hospitable environment for raising arbitrage finance.

Outward arbitrage transactions usually gross up a bank's balance sheet. But this is not an absolute necessity; a bank could use new domestic CD funding to replace existing Eurodollar interbank liabilities at its overseas branches. In practice, this second method of outward arbitrage is less important. Major changes in the funding pattern of a branch network solely to take advantage of Eurodollar arbitrage opportunities would be unusual, given the decentralized management practices prevalent at most large multinational banks.

Inward arbitrage

Outward arbitrage may be performed using either of the two methods described previously, but the dominant method of outward arbitrage expands a bank's balance sheet. Inward arbitrage, however, primarily occurs when U.S. banks shift their funding from domestic to external sources. When strong domestic credit demands lead to aggressive bidding for funds by U.S. banks in the domestic CD market, the more active international banks are quick to tap the Eurodollar interbank market for cheaper funds. This technique of liability management represents the typical version of

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Box 1: Outward and Inward Arbitrage

Incentives for outward and inward bank arbitrage can best be illustrated by using some numerical examples.

Outward arbitrage

Suppose the following information is known:

Three-month secondary certificate of deposit (CD) rate	=	10.00%
Three-month Eurodollar bid rate	=	12.00%
Federal Deposit Insurance Corporation (FDIC) insurance premium	=	0.037%
CD reserve requirement	=	8% = 0.08

To determine whether an outward arbitrage incentive exists, the effective cost of domestic funds must be calculated:

$$\text{Effective cost of domestic funds} = \frac{10.00\% + 0.037\%}{(1 - 0.08)} = 10.91\%$$

This calculation indicates that a bank could make a profit of 109 basis points (= 12.00% − 10.91%) on an outward arbitrage transaction. As banks begin to act on this opportunity, they will bid up CD rates and push down Eurodollar rates until the incentive is eliminated. For example:

Three-month secondary CD rate	=	10.50%
Three-month Eurodollar bid rate	=	11.45%

The effective cost of domestic funds now is (10.50% + 0.037%)/(1 − 0.08) = 11.45%. The effective cost of domestic funds equals the external value of those funds to the U.S. bank; no incentive for outward arbitrage is present. Note that the Eurodollar-domestic rate differential has been narrowed from 200 to 95 basis points by bank arbitrage. Other things equal, this could imply reduced incentives for U.S. depositors to place funds offshore and increased incentives for U.S. borrowers to acquire funds offshore.

Inward arbitrage

Suppose the following information is known:

Three-month secondary CD rate	=	10.00%
Three-month Eurodollar offer rate	=	10.30%
FDIC insurance premium	=	0.037%
CD reserve requirement	=	12% = 0.12
Eurodollar reserve requirement	=	6% = 0.06

To determine whether an inward arbitrage incentive exists, the effective costs of both domestic and external funds must be calculated:

$$\text{Effective cost of domestic funds} = \frac{10.00\% + 0.037\%}{(1 - 0.12)} = 11.40\%$$

$$\text{Effective cost of external funds} = \frac{10.30\%}{(1 - 0.06)} = 10.96\%$$

Even though the nominal cost of Eurodollar funds is 30 basis points higher than the nominal cost of domestic funds, the *effective* cost of Eurodollar funds is actually 44 basis points *lower* than the effective cost of domestic funds. U.S. banks will have an incentive to obtain Eurodollars from their offshore branches in lieu of issuing new CDs. This activity will put upward pressure on the Eurodollar rate and downward pressure on the CD rate until effective costs are equalized. For example:

Three-month secondary CD rate	=	9.90%
Three-month Eurodollar offer rate	=	10.61%

The effective cost of domestic funds now equals (9.90% + 0.037%)/(1 − 0.12) = 11.29%, while the effective cost of Eurodollar funding has risen to (10.61%)/(1 − 0.06) = 11.29%. Since the effective costs have been equalized, no incentive for inward arbitrage remains. Note that the Eurodollar-domestic rate differential has been widened from 30 to 71 basis points by bank arbitrage. Other things equal, this could imply increased incentives for U.S. depositors to place funds offshore and reduced incentives for U.S. borrowers to acquire funds offshore.

inward arbitrage and promotes a close relationship between the external and domestic costs of funds to U.S. banks. This practice only increases the size of bank balance sheets when it finances new loans.

A U.S. bank which is considering raising funds in the Euromarket naturally compares the effective cost of external funds with the effective cost of domestic funds. The effective cost of external funds equals the nominal interest rate on Eurodollar deposits adjusted for any applicable Eurodollar reserve requirement. A U.S. bank will have an incentive to move funds onshore whenever the effective cost of external funds is less than the effective cost of domestic funds. A bank will continue to move funds onshore, either making new loans or replacing existing liabilities as they mature, until interest rates adjust and effective costs are equated. Such activity provides a floor on the cost of funds in the external interbank market. Whenever the Eurodollar interest rate falls below that limit, U.S. banks will borrow funds offshore and bid up the external rate until the lower limit is restored.

The opportunity to conduct inward arbitrage by simultaneously borrowing in the Eurodollar interbank market and placing funds in the United States is limited. The absence of a well-developed domestic interbank market for term funds constrains such activity. Rates in the term repurchase agreement market are usually unattractive, chiefly because these transactions are backed with high-quality collateral. Furthermore, participation by many banks in the term Federal funds market is constrained by regulations limiting the extent of a bank's indebtedness relative to its capital and surplus.[2]

Effective cost factors
The most important cost factor besides the levels of interest rates themselves are reserve requirements on a bank's liabilities. Required reserves on domestic liabilities and on net positive Eurodollar borrowings increase the effective cost of deposits above their nominal interest rates.

Required insurance on bank deposits also affects the true cost of domestic funds. The basic Federal Deposit Insurance Corporation (FDIC) assessment is 1/12 (0.083) percent of *total* deposits (not just those de-

posits that are insured); banks, however, can receive a credit or dividend based on FDIC net income. Over the last ten years this refund has consistently reduced the actual insurance cost to an average of 1/27 (0.037) percent per annum. Banks traditionally have used this latter amount to approximate their expected insurance costs.[3] The FDIC does not assess borrowings from an offshore branch, a basic component of an inward arbitrage transaction.

In addition to these direct cost factors, risk may impact directly on a bank's evaluation of a Eurodollar interbank placement. If banks incorporate a risk premium of 10, 25, or 50 basis points into their cost calculations and then willingly pursue all available arbitrage opportunities, the premium most closely resembles an effective cost factor. If banks require progressively larger risk premia to engage in additional arbitrage transactions at any point in time, however, a more fundamental difficulty is created for the arbitrage mechanism.

Risk premia can change over time. During periods of relative tranquillity in international financial markets premia probably are close to zero, while during periods of tension and uncertainty premia can be positive and large. A positive risk premium means that the Eurodollar interest rate could *exceed* the effective cost of domestic funds by some amount less than the risk premium without provoking capital outflows and equilibrating arbitrage activity.

Other factors
While reserve requirements, deposit insurance, and risk premia are important in determining the interest rate differentials at which arbitrage will occur, a second group of factors operates directly on the size of a bank's arbitrage transactions. This second set includes capital controls and internal balance-sheet constraints.

Capital controls can restrict or prevent a bank from engaging in external lending or borrowing. Controls are the most direct way of reducing market integration. Banks may be prohibited by law from placing funds offshore even though attractive interest rate incentives exist. Alternatively, banks may be prohibited from acquiring offshore funds even when those funds are much cheaper than domestic funds.

Bank arbitrage activities also may be limited by internal constraints based on balance-sheet considerations. These constraints may derive from the *risk perceptions* of bank management, but the actual constraints are stated in terms of certain bank balance-

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[2] 12 U.S.C. 82 limits a national bank's indebtedness to the amount of paid-in and undiminished capital plus 50 percent of surplus. The Office of the Comptroller of the Currency has interpreted this limitation to exclude securities repurchase agreements and *overnight* Federal funds as well as bills discounted by the Federal Reserve. *Term* Federal funds, however, are counted as part of a national bank's indebtedness. Many state-chartered banks are also subject to limits on indebtedness imposed by state laws.

[3] Recent distress in the thrift industry has caused some commercial banks to revise upward their expectations of FDIC insurance costs.

sheet ratios. Because outward arbitrage transactions usually expand a bank's balance sheet, they are more likely to affect adversely a bank's capital adequacy and profitability.

In a typical outward arbitrage transaction, a U.S. bank borrows domestic funds (increasing liabilities) and redeposits them offshore (increasing assets). This operation reduces its capital-asset ratio, a prudential indicator used by bank supervisors. Furthermore, outward arbitrage transactions usually have very small profit margins, as little as 3-6 basis points. At some point, a bank may be reluctant to compromise further its capital-asset ratio without an additional premium on Eurodollar placements. A second financial indicator—the rate of return on assets—is important to bank stock analysts and bank management. Outward arbitrage transactions contribute to total profits, but their low profitability often diminishes the bank's average rate of return on assets. At some point, a U.S. bank may be unwilling to pursue outward arbitrage except at substantially enhanced spreads.

A bank's balance sheet also may be constrained on the liability side. No U.S. bank enjoys an infinitely elastic supply of domestic funds. In other words, no U.S. bank can issue an unlimited quantity of domestic CDs without incurring higher interest charges and lowering its credit standing in the market. When a U.S. bank is operating at or near its self-imposed limit on domestic CD issuance, it may be reluctant to use its market "reserve" for outward arbitrage purposes unless the expected profit margin is unusually wide.

The arbitrage tunnel
The previous discussions of outward and inward bank arbitrage suggest that such activities impose upper and lower limits on the possible values of the Eurodollar interest rate *vis à vis* the U.S. CD rate. These limits do not coincide because of the small difference (bid-offer spread) between rates at which Eurobanks willingly accept deposits and lend funds and because the Eurodollar reserve requirement applies only to inward arbitrage transactions. Therefore, a *range* of Eurodollar rate values exists in which U.S. banks have no arbitrage incentive in either direction.

This range of Eurodollar rates can be summarized conveniently in an *arbitrage tunnel* within which the external interest rate should reside, provided bank arbitrage activities are effective (Appendix). The tunnel allows for the observable considerations that enter into the evaluation of arbitrage opportunities—reserve costs, FDIC insurance, and bid-offer spreads. Departures from the tunnel reflect unobservable considerations—risk, balance-sheet structure, and rate of return on assets constraints.

The tunnel underscores the fact that the correct interest rate comparison for measuring market integration depends on which form of bank arbitrage is dominant at any point in time. For example, suppose relatively strong external credit demands and *outward* bank arbitrage are keeping the Eurodollar rate near the ceiling of the tunnel. A comparison of effective costs of domestic and external funds would likely show external funds to be somewhat more costly. This latter result would not mean that markets were not integrated; it would mean only that banks had no incentive to perform *inward* arbitrage.

The width of the arbitrage tunnel depends primarily on the level of domestic interest rates and the levels of reserve requirements on CD and Eurodollar liabilities. Increases in any of these three factors will cause the arbitrage tunnel to widen. More specifically, an increase in the level of CD rates will cause both the ceiling and the floor of the tunnel to move up, with the ceiling rising more than the floor; higher interest rates increase the opportunity cost of satisfying reserve requirements by holding noninterest-bearing deposits with the Federal Reserve. An increase in the CD reserve requirement has a similar effect. An increase in the Eurodollar reserve requirement only affects the floor of the tunnel, causing it to drop. The Eurodollar arbitrage tunnel provides a useful tool for analyzing the various factors that recently have affected the linkage of the domestic and external money markets.

The tunnel in this article is drawn for the three-month maturity, primarily because large volumes of transactions occur in the domestic and Eurodollar money markets at this maturity. Markets with substantial volumes and many participants are most conducive to arbitrage activity.

Interest rate behavior: 1970-81
The Eurodollar bid rate usually stayed within the boundaries of the arbitrage tunnel from 1970 to 1981, although there were some notable departures early and late in the period (Chart 1). The varying width of the arbitrage tunnel over time and the location of the Eurodollar bid rate relative to the tunnel are more clearly portrayed if the tunnel boundaries and the Eurodollar rate are measured as deviations from the tunnel center (Chart 2).

The Eurodollar bid rate generally was above the tunnel from January 1970 to mid-1975 with the exception of the period from mid-1973 to mid-1974. During much of the former period, U.S. banks faced incentives, at times very strong incentives, to place funds offshore. The foreign lending of U.S. banks, however, was limited by the voluntary foreign credit

Chart 1
The Arbitrage Tunnel and the Eurodollar Rate
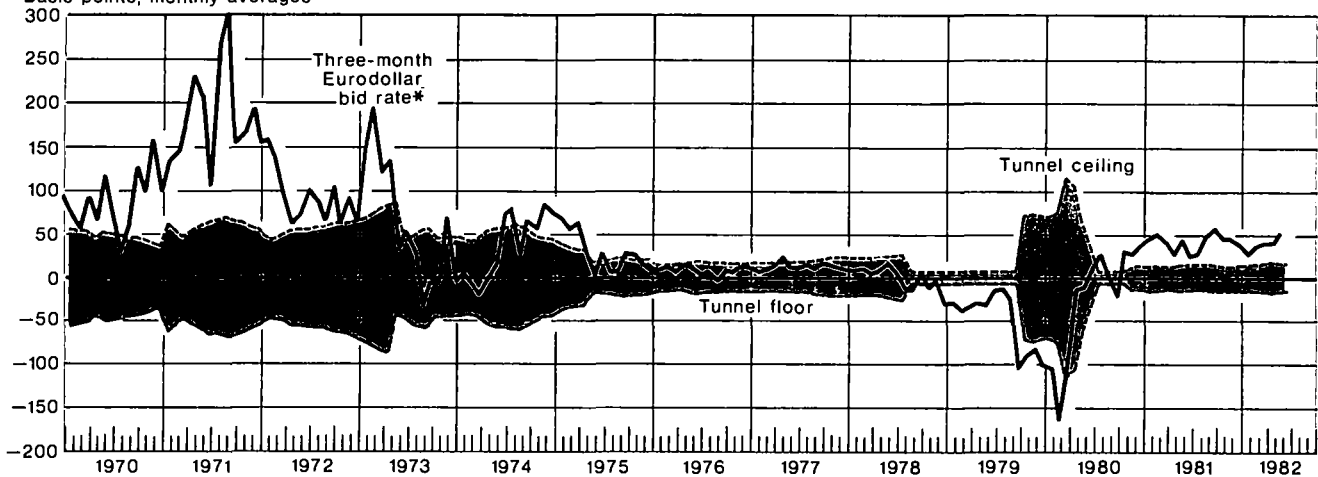
Percent per annum; monthly averages
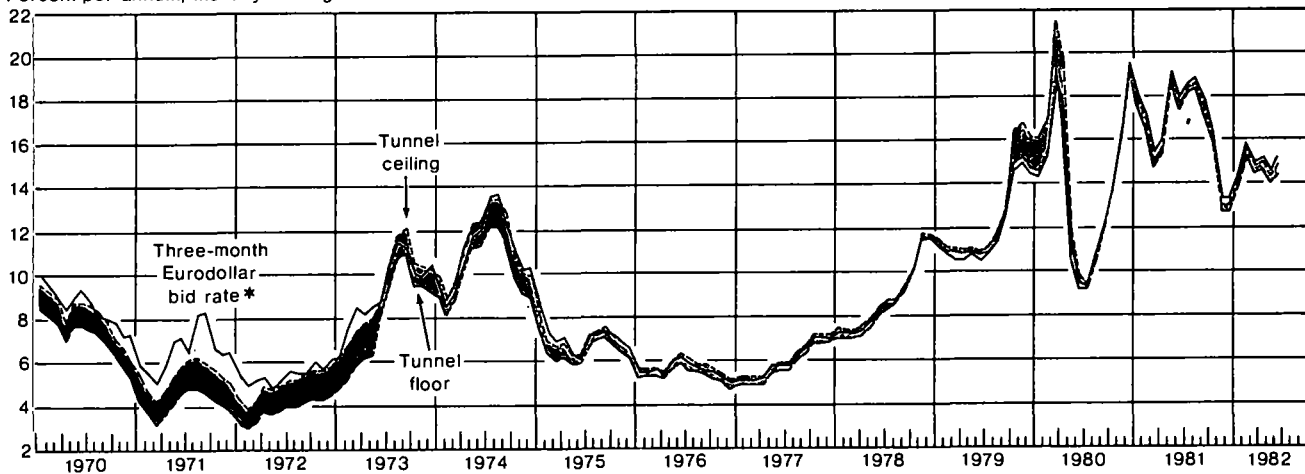
*Eurodollar bid rate above the tunnel ceiling implies an outward arbitrage incentive,
and below the tunnel floor an inward arbitrage incentive.

Chart 2
The Arbitrage Tunnel and the Eurodollar Rate
Deviations from tunnel center

Basis points; monthly averages

*Eurodollar bid rate above the tunnel ceiling implies an outward arbitrage incentive,
and below the tunnel floor an inward arbitrage incentive.

Box 2: Chronology of Policy and Economic Events Affecting Eurodollar Arbitrage

Date	Event	Comments
March 1965	Voluntary foreign credit restraint (VFCR) program introduced	Voluntary ceiling on banks' foreign lending
January 1968	Federal Reserve given authority to make VFCR mandatory	Authority never used
October 1970	CD reserve requirement changed	Reduced from 6 to 5 percent
January 1971	Eurodollar reserve requirement changed	Increased from 10 to 20 percent
August 1971	Gold window closed; wage-price controls imposed	Largest deviation of Eurodollar rate from tunnel follows in September: 241 basis points
February 1973	Eventual abolition of VFCR announced	
March 1973	Collapse of Bretton Woods system	End of fixed exchange rate system
June 1973	Reserve requirements changed	CD reserve requirement increased from 5 to 8 percent; Eurodollar reserve requirement reduced from 20 to 8 percent
September 1973 ..	CD reserve requirement changed	Increased from 8 to 11 percent
October 1973	First oil price shock	Price of oil increased from $3.92/bbl. to $6.49/bbl.
December 1973 ..	CD reserve requirement changed	Reduced from 11 to 8 percent
January 1974	VFCR abolished	
June 1974	Herstatt Bank fails; Franklin National on verge of collapse	Increased risk in international financial markets
December 1974 ..	CD reserve requirement changed	Reduced from 8 to 6 percent
May 1975	Eurodollar reserve requirement changed	Reduced from 8 to 4 percent

Date	Event	Comments
August 1975	"Concordat" proclaimed by Bank for International Settlements	Evidence of central bank cooperation; reassuring effect on international financial markets
August 1978	Eurodollar reserve requirement changed	Reduced from 4 to 0 percent
November 1978 ..	Dollar "rescue" package; CD reserve requirement changed	2 percent supplemental increases CD reserve requirement to 8 percent
October 1979	Federal Reserve operating procedures changed; marginal reserve requirements imposed	8 percent marginal requirement added to managed liabilities aggregates, including Eurodollar borrowings and large CDs
March 1980	Federal Reserve implements special credit restraint program; marginal reserve requirements increased	Marginal reserve requirement on managed liabilities increases from 8 to 10 percent; exempt base amounts decrease
June 1980	Marginal reserve requirements changed	Marginal reserve requirement on managed liabilities reduced from 10 to 5 percent
July 1980	Marginal reserve requirements eliminated; supplemental CD reserve requirement eliminated	Marginal Eurodollar reserve requirement reduced to 0 percent; CD reserve requirement reduced to 6 percent
November 1980 ..	Monetary Control Act of 1980 takes effect	Phase-in of ultimate 3 percent reserve requirements on CDs and Eurodollars begins
October 1981	Change to same-day settlement	Eurodollar transactions settled in immediately available funds as opposed to one-day lag

restraint program (VFCR), part of the capital control program initiated by the United States in the mid-1960s (Box 2). U.S. banks gradually unwound their net borrowings from their foreign branches until mid-1971 but undertook no net lending to branches through the end of 1973 (Chart 3). The VFCR was officially abolished in January 1974, although controls were partially relaxed in late 1973.

The Eurodollar rate entered the tunnel for a period of about one year beginning in mid-1973. This was an especially turbulent phase in recent economic history. The par value system of exchange rates finally collapsed in March 1973, and central bank intervention in support of the dollar diminished substantially. Within a few months, domestic CD reserve requirements were more than doubled while requirements on Eurodollar borrowings were slashed from 20 percent to 8 percent. These reserve requirement changes were intended to encourage U.S. banks to fund themselves from offshore sources by creating an incentive for inward arbitrage. Such activity was intended to support the dollar in the foreign exchange market. The large reserve ratio changes succeeded in abruptly shifting upward the ceiling and especially the floor of the arbitrage tunnel. But these changes failed to raise the floor of the tunnel above the prevailing Eurodollar rate, a necessary condition for inward arbitrage.[4] The rate fell (relatively) only slightly below the middle of the tunnel, and U.S. banks did not borrow from their offshore offices.

Also during this period the Organization of Petroleum Exporting Countries (OPEC) emerged as a power in world financial markets. The first oil price shock in late 1973 caused a huge transfer of financial wealth to the oil-exporting nations. The subsequent placement of these funds in the Euromarket by OPEC members put downward pressure on Eurodollar rates and helped position the three-month Eurodollar rate within the tunnel for this brief period.

In June 1974 the Herstatt Bank collapsed and the Franklin National Bank in the United States approached collapse. These bank failures generated considerable distress in international banking circles. For a period of about one year the Eurodollar rate moved above the arbitrage tunnel. Rather than implying market separation (such as that induced earlier by capital controls), this movement more likely reflected a required risk premium of 25-30 basis points on offshore placements by U.S. banks. By mid-1975, central banks and commercial banks had improved their monitoring of transactions, no wave of banking problems had developed, the Eurodollar market was operating more normally, and the risk premium basically disappeared.

From mid-1975 until late-1978, bank arbitrage kept the Eurodollar bid rate essentially within the arbitrage tunnel, although the rate remained at or near the ceiling of the tunnel throughout this period. U.S. banks gradually increased their net lending to their offshore branches: external credit demands were strong and the Eurodollar rate never moved much below the tunnel ceiling. During this period external credit demands regularly threatened to pull the Eurodollar rate above its ceiling and U.S. banks regularly placed sufficient funds offshore to eliminate the incipient arbitrage incentive.[5]

Beginning in early 1979, Euromarkets were flooded with new deposits in the wake of the second oil price shock and Eurodollar rates again experienced downward pressure. For the first time in nearly a decade U.S. banks faced a clear inward arbitrage incentive. The effective cost of Eurodollar funds was less than the effective cost of domestic funds and U.S. banks quickly shifted from being net suppliers of funds to the Euromarket to being net takers. Between January and August 1979, U.S. banks reversed their net position with their own foreign offices by nearly $30 billion.[6]

Banks cannot quickly or easily replace all their domestic CD liabilities with new Eurodollar borrowings. Inward arbitrage ordinarily takes time, as banks adjust their funding patterns to take advantage of cheaper external funds. Nevertheless, thanks to considerable domestic demand for new bank credit, U.S. banks absorbed sufficient offshore funds to erase the inward arbitrage incentive by the third quarter 1979.

In October 1979 the Federal Reserve imposed marginal reserve requirements on managed liabilities (including both large CDs and Eurodollar borrowings), increased the discount rate, and asked U.S. banks to refrain from extending credit for nonproductive uses. At the same time, new monetary policy operating procedures that placed greater emphasis on reserve movements and less emphasis on Federal funds rate fluctuations were introduced. These policy changes

[4] The tunnel basically shifted upward, encompassing the Eurodollar rate (Chart 1). Only the relative shift can be shown in Chart 2.

[5] Since the pressures during 1970-78 were in the direction of outward arbitrage, the reserve requirement on Eurodollar borrowings did not enter the relevant arbitrage calculation for most banks.
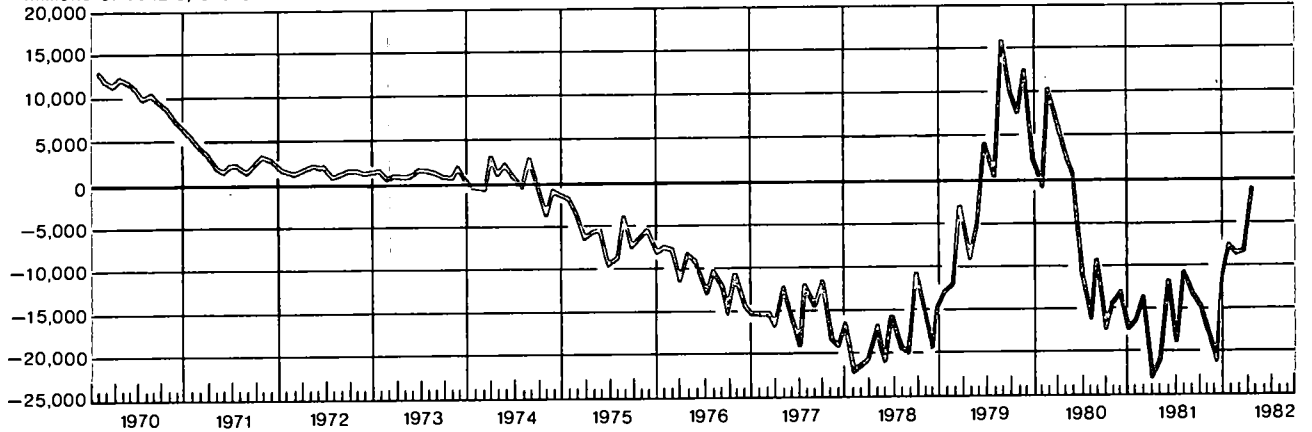
[6] Note that nonbank depositors still had an incentive to move funds offshore; nominal (unadjusted) deposit rates in the Euromarket were still higher than corresponding domestic deposit rates.

Chart 3
Net Position of United States Banks Versus Own Foreign Branches

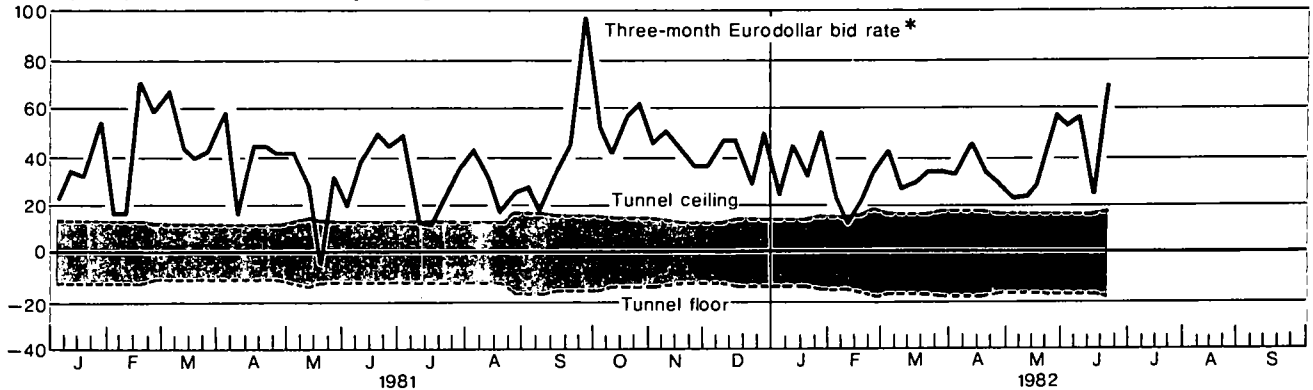Minus = net lending to branches

Millions of dollars; end-of-month levels

Source: Board of Governors of the Federal Reserve System.

Chart 4
The Arbitrage Tunnel and the Eurodollar Rate

Deviations from tunnel center

Basis points; week-ended-Wednesday averages

Three-month Eurodollar bid rate*

Tunnel ceiling

Tunnel floor

*Eurodollar bid rate above the tunnel ceiling implies an outward arbitrage incentive, and below the tunnel floor an inward arbitrage incentive.

were intended to enhance the implementation of monetary policy and to reduce the inflationary momentum that had been building in the United States for several years.

During the following few months a gap between the effective costs of domestic and external funding reappeared even as the tunnel widened dramatically (Chart 2). But U.S. banks, unlike earlier in 1979, did not aggressively pursue this apparent inward arbitrage opportunity; on the contrary, they reduced their net position with their own foreign branches to nearly zero by end-1979.

A plausible reason for this seemingly inconsistent behavior can be found in the technical features of the managed liabilities program. Marginal reserve requirements were imposed on managed liabilities in excess of a base amount calculated for each bank from an earlier period. But many banks operated with managed liabilities less than their respective base amounts and consequently were not subject to the marginal reserve requirements. For these banks, the appropriate effective cost calculations included only the basic and not the marginal reserve requirements. If the marginal reserve requirements from October 1979 to February 1980 are ignored, the floor of the tunnel drops about 15 basis points and the inward arbitrage incentive virtually disappears.

In March 1980 the Federal Reserve implemented the credit restraint program. This program increased marginal reserve requirements, reduced the managed liabilities base amounts, imposed voluntary credit restraints, and generally further reduced the ability of U.S. banks to expand domestic credit. Interest rates began a dizzying decline of nearly 10 percentage points during the next three months. But, while U.S. borrowers retreated to the sidelines of the domestic market, foreign borrowers reentered the Euromarket with a vengeance. External rates did not fall so quickly as domestic rates, and the Eurodollar rate moved up sharply relative to the tunnel floor. U.S. banks transferred funds offshore, responding to strong external credit demands and reversing once again their aggregate position with their offshore branches. By July 1980, U.S. banks had lent more than $15 billion net to their own foreign branches (Chart 3).

Anomalous behavior in 1981
The Eurodollar bid rate rose above the ceiling limit in November 1980 and has remained, on the average, 25-30 basis points above that limit ever since (Chart 4). U.S. banks now appear to require an additional premium of approximately ¼ percentage point above the effective cost of domestic funds before outward arbitrage becomes attractive. Several reasons for this new requirement may be identified.[7]

Balance-sheet constraints: assets
Explanations of recent rate behavior based on balance-sheet considerations have been corroborated in interviews with money center bankers. Because the soundness of banking practices is being questioned and bank stocks are suffering, banks are more concerned with those critical financial ratios that measure capital adequacy and profitability.

Capital-asset ratios are drawing increased attention from supervisors and investors, as some U.S. banks are being criticized for overlending on relatively small capital bases.[8] Consequently, U.S. banks have grown more conservative in expanding their balance sheets. In the last eighteen months, U.S. bankers have become less willing to compromise their capital-asset ratios for the low profits on interbank placements.

U.S. banks have also grown concerned about their rates of return on assets, which they increasingly strive to raise or at least to maintain. Although finance theory suggests that the rate of return on equity is a more meaningful measure,[9] the allocation of capital to different bank departments to compare performances is problematical. The rate of return on assets also appeals to bank stock analysts, since the measure approximates a profit rate on a bank's essential activity, i.e., making loans. And, while a bank's capital-asset ratio declines whenever a bank acquires a new asset (provided capital is unchanged), the rate of return on total assets may increase or decrease depending on the new asset's profitability. In particular, outward arbitrage transactions increase total profits but almost always reduce the average rate of return on assets since their profit margins are so narrow. Rate-of-return considerations have contributed to the recent gap between Eurodollar rates and the ceiling of the arbitrage tunnel.

[7] On October 1, 1981, the New York Clearing House switched to same-day settlement. Prior to that date, Eurodollar remittances scheduled for a particular date were immediately available as clearing-house funds but were not available as "good" funds, i.e., funds usable for transactions outside the clearing-house system, until one business day later. Although the change to same-day settlement had considerable operational impact, it had little effect on the interest rate relationships considered in this article. During the final week of September 1981, Eurodollar rates did rise well above domestic deposit rates. Banks did not want to be caught short of funds during the transition to same-day settlement. But shortly thereafter interest rates returned to their post-1980 configuration.

[8] See, for example, Henry C. Wallich, "American Banks During the 1970s and Beyond", remarks at the Roundtable on Credit Systems in the 1970s (Perugia, Italy), September 5-7, 1980; also, "Rising Profits Hide U.S. Banks' Deeper Problems", Financial Times, March 23, 1982.

[9] The rate of return on a bank's equity (capital) equals its rate of return on assets divided by its capital-asset ratio.

Balance-sheet constraints: liabilities

Arbitrage also has been constrained during the recent period by the liabilities side of banks' balance sheets. Given the relatively tight credit conditions that have prevailed in the domestic market since 1979, U.S. banks have operated at or near their self-imposed limits on issuing CDs. An especially noteworthy development in this regard has been the rapid growth of the Euro CD (as opposed to time deposit) market during the last eighteen months. The considerable appetite of investors (especially U.S. money market funds) for short-term negotiable instruments, combined with a more restrained enthusiasm from Eurobanks seeking to control their market presence, has produced both a rapid increase in the quantity of Euro CDs and a 40-50 basis point differential between the lower rate on negotiable Euro CDs and the rate on Eurodollar time deposits. After adjusting the cost of Euro CDs for the current small reserve requirement on Eurodollar borrowings, U.S. banks have found Euro CD funding an attractive alternative to domestic funding. Since March 1981, nearly $20 billion has flowed into U.S. banks from their overseas branches. But more important for arbitrage purposes, the rapid growth of the Euro CD market may have caused major U.S. banks to limit their sales of new domestic CDs related to outward arbitrage. Incidentally, branches of the most important U.S. banks have not yet arbitraged the gap between the Euro CD and Eurodollar time deposit rates because of the still small size of the Euro CD market relative to the interbank market and possibly perceptions of increased risk, as discussed below.

Risk

Some experts have surveyed bankers recently and have drawn attention to perceptions of increased riskiness of Euromarket interbank placements.[10] Debt reschedulings and anticipated debt reschedulings increased significantly during 1981 and early 1982. More than $8 billion in commercial bank claims have been rescheduled recently, including more than $2 billion for Poland and more than $4 billion for Turkey. Awareness that certain banks or groups of banks are especially vulnerable to the debt-servicing and repayment problems of various less developed countries and Eastern European countries has been growing. According to survey results, some bankers believe both international end-use lending and the international interbank market have become more risky recently and will be

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[10] "Risks in International Bank Lending", First Report of the International Banking Study Group of the Group of Thirty, New York (1982); "The Outlook for International Lending", Group of Thirty (August 1981); and "How Bankers See the World Financial Market", Group of Thirty (May 1982).

riskier still in the future. Their concerns reflect anxieties about future rescheduling difficulties and excessive exposure of banks to certain problem borrowers, and greater uncertainty about the availability of lender-of-last-resort facilities. Although it is difficult to quantify this evidence, increased risk perceptions may have influenced Eurodollar interest rate premia during the last few months.

Arbitrage at other maturities

In principle, arbitrage could link the domestic and Eurodollar money markets at other maturities besides three months, ranging from overnight to one year or longer. For any maturity, an analysis similar to this one could be utilized. But two important qualifications should be noted. First of all, the adjustments needed to make interest rates comparable may vary depending on the maturity. For example, until recently, reserve requirements on domestic CDs varied depending on maturity. Secondly, banks may be unwilling or unable to engage in sizable arbitrage transactions at every maturity. Until recently, banks were prohibited from issuing CDs with maturities of less than thirty days, and they still are prohibited from issuing CDs with maturities of less than fourteen days. Banks also have maturity preferences in organizing their balance sheets and at times may be reluctant to undertake sizable arbitrage transactions at longer maturities.

Three final points should be mentioned. First, a mechanism like the arbitrage tunnel can be constructed for most maturities. Secondly, the conformance of the Eurodollar rate at any maturity to the limits of the corresponding tunnel depends on the effectiveness of bank arbitrage at, or at least near, that maturity. Suppose the domestic and Eurodollar rates are closely linked at the one-month and three-month maturities. The two-month rates would probably appear linked, even if little arbitrage actually occurs at the two-month maturity, since the underlying yield curves are linked at one and three months. Finally, it is unlikely that domestic and Eurodollar interest rates could diverge by an unlimited amount at any maturity without provoking arbitrage pressures that tend to bring the rates more into line.

Conclusions

The extent of integration between the domestic and external money markets is difficult to measure because of the complicated adjustments needed to make domestic and external interest rates comparable. Nevertheless, these markets have been closely linked by bank arbitrage. Capital controls, risk considerations, and balance-sheet constraints have prevented perfect market integration, yet discrepancies between the

Eurodollar rate and the arbitrage tunnel compare favorably with rate differentials in other money markets thought to be closely integrated. For example, the markets for prime three-month commercial paper and three-month bankers' acceptances are generally regarded as well integrated; both instruments, although not identical, essentially represent nonbank corporate liabilities that are backed by banks.[11] Integration might be measured by the variability of the interest rate differential relative to its idealized value of zero. During the period April 1975-December 1980 the mean absolute deviation[12] between the rates on three-month commercial paper and three-month bankers' acceptances was 10 basis points. During that same period (postdating the period of capital controls and bank failures), the mean absolute differential between the Eurodollar bid rate and the arbitrage tunnel was 8 basis points.

Over the past eighteen months, however, a systematic deviation from the conditions of completely effective bank arbitrage can be observed. Constraints

[11] Much prime commercial paper is backed by bank credit lines, while bankers' acceptances are explicitly guaranteed by the "accepting" banks.

[12] The mean absolute deviation is a common measure of variability or dispersion. In the present context, a significantly larger mean absolute deviation would imply greater variability and less market integration.

on bank arbitrage have not created these deviations, but the reduced effectiveness of bank arbitrage has allowed the deviations to persist. Banks and nonbanks continue to interact in determining the Eurodollar-domestic interest rate differential, and the recent departure of the Eurodollar rate from the tunnel reflects only a weakening in the bank link between the markets.

The current deviation highlights an important yet neglected aspect of the relationship between policy objectives. A factor limiting bank arbitrage recently has been bankers' increased reluctance to conduct transactions that depress capital-asset ratios without generating sufficiently high returns. One plausible explanation for this behavior is the increasingly vocal concern of bank regulators about the capital adequacy of U.S. banks. This concern is justified on the grounds of prudential supervision. To the extent that banks accordingly refrain from arbitrage activities that would narrow the gap between domestic and Eurodollar rates, *nonbank* depositors and borrowers face wider than normal rate differentials. Their natural response to these differentials can create a problem for monetary policymakers, since nonbank shifts between domestic and Eurodollar deposits and loans may reduce the usefulness of currently defined money and credit measures for policy purposes.

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Appendix: Derivation of the Arbitrage Tunnel

Outward arbitrage

A U.S. bank will have an incentive to perform outward arbitrage until interest rates adjust and the effective cost of domestic funds equals or exceeds the obtainable external return. This condition imposes an upper limit or ceiling on the Eurodollar deposit rate:

(1) ER (external return) $\leq$ EDC (effective domestic cost)

The effective cost of funds to a U.S. bank in the domestic market is the nominal interest rate on deposits adjusted for reserve requirements and deposit insurance. The nominal interest rate used in this article is the rate on large three-month certificates of deposit (CDs). The major U.S. banks use the dealers' *bid* rate for CDs in the secondary market as a reference rate when calculating arbitrage incentives.

U.S. banks are required to insure their deposits with the Federal Deposit Insurance Corporation (FDIC). The basic assessment is 1/12 (0.083) percent, but banks receive a credit or dividend based on FDIC net income which has reduced the effective insurance premium to an average during the last ten years of 1/27 (0.037) percent.

Bringing together the three components of the effective cost of domestic funds for outward arbitrage purposes, we obtain:

(2) $EDC = \dfrac{i_{CD} + 0.037}{(1 - RR_{CD})}$,

where i_{CD} = nominal dealers' bid rate on three-month CDs in the secondary market and RR_{CD} = reserve requirement on large three-month CDs.

A U.S. bank must accept the bid rate on Eurodollar time deposits when it undertakes an outward arbitrage transaction. Combining equations (1) and (2), we obtain:

(3) $ER = i_{E\$}^{bid} \leq EDC = \dfrac{i_{CD} + 0.037}{(1 - RR_{CD})}$,

where $i_{E\$}^{bid}$ = Eurodollar bid rate on three-month deposits.

This is the mathematical expression for the arbitrage tunnel ceiling.

Inward arbitrage

A U.S bank will have an incentive to perform inward arbitrage until interest rates adjust and the effective cost of Eurodollar funds equals or exceeds the effective cost of domestic funds. This condition provides a lower limit or floor under the Eurodollar deposit rate:

(4) EEC (effective external cost) $\geq$ EDC

Reserve requirements on net Eurodollar borrowings varied considerably during the 1970s and did not bind every U.S. bank at the margin at every point in time. Currently, the sum of net borrowings from own foreign offices, gross assets sold to own foreign offices, and loans to U.S. residents by own foreign offices is reservable if that sum is positive. This analysis assumes that reserve requirements on Eurodollar borrowings have been effective when inward arbitrage tendencies were present. Furthermore, when a bank is borrowing funds in the Eurodollar interbank market, it must pay the *offer* rate. The effective cost of funds in the Eurodollar market is:

(5) $EEC = \dfrac{i_{E\$}^{offer}}{(1 - RR_{E\$})}$,

where $i_{E\$}^{offer}$ = nominal offer rate on three-month Eurodollar time deposits and $RR_{E\$}$ = reserve requirement on Eurodollar borrowings by U.S. banks.

Combining equations (2), (4), and (5), we obtain:

(6) $EEC = \dfrac{i_{E\$}^{offer}}{(1 - RR_{E\$})} \geq EDC = \dfrac{i_{CD} + 0.037}{(1 - RR_{CD})}$

Rearranging the terms in equation (6) and utilizing the relationship:

(7) $i_{E\$}^{offer} = i_{E\$}^{bid} + 0.125$

for the three-month maturity, we obtain:

(8) $i_{E\$}^{bid} \geq \dfrac{i_{CD} + 0.037}{(1 - RR_{CD})} \times (1 - RR_{E\$}) - 0.125$

This is the mathematical expression for the arbitrage tunnel floor.

Equations (3) and (8) define an arbitrage tunnel within which the three-month Eurodollar time deposit bid rate should reside as long as banks fully arbitrage between the domestic and external markets. Since the Eurodollar reserve requirement is only potentially relevant for inward arbitrage, the requirement $RR_{E\$}$ appears only in the expression for the tunnel floor (8).

The dealers' bid rate for CDs in the secondary market is normally 5-10 basis points above their offer rate. This spread may widen considerably, however, when financial markets are unsettled or whenever dealers are reluctant to add new CDs to their inventories. For purposes of this analysis, secondary bid rates were constructed by adding 5 basis points to the available secondary CD offer rate series.