Some aspects of the determination of euro-currency interest rates

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Summary

This article discusses some systematic relationships which have been observed between domestic and euro-currency interest rates. It describes a model to explain these relationships, based on the extra costs which banks incur from holding reserve requirements against domestic deposits. Statistical tests have been used to compare the marginal cost of three-month money (after allowing for the extra cost of reserve requirements) in the euro-dollar and domestic US markets, and in the euro-deutschemark and domestic West German markets. These tests confirm that, in the absence of disruptions to the free flow of capital, the differences in these costs are virtually zero and that domestic banks effectively arbitrage between the euro and domestic money markets. The article concludes that the euro-currency market is not independent of domestic money markets and that its rôle as a channel for short-term capital flows appears to be very closely linked to the activities of domestic banks.

Introduction

Because of the close substitutability between assets in domestic and in external money markets, it is clear that, in the absence of restrictions on the free flow of capital, interest rates in the two markets should be closely related. Also, because of the availability of forward cover in the foreign exchange market and the close association of the euro-currency market with the foreign exchange market, there should clearly be a very close relationship between the interest rates offered, on different currency deposits, in the euro-currency market, and the costs of forward cover. Such relationships are well known.[1] Analysis of the movement of euro-currency interest rates, however, within this general framework, has revealed more specific and systematic relationships between domestic and euro-currency deposit rates; indeed some of the observed margins between interest rates in the domestic and external money markets have been so stable as to be termed a technical differential.

This article attempts to rationalise some of the observed relationships within a fairly general framework of the supply of, and demand for, individual euro-currencies. The first section considers a simple model of a single euro-currency deposit market and recent empirical experience which illustrates how restrictions and imperfections can cause systematic deviations from the model. The model is then extended, in the second section, to discuss how two euro-currency deposit markets and the spot and forward exchange markets interact. This section also considers why interest-rate parity appears to hold between euro-currency interest rates for different currencies but not between nominal interest rates in different domestic markets, and also the rôle of the euro-markets in channelling short-term capital flows. Recent empirical experience is reported in support of the model. In the final section, some of the wider implications for the analysis of the euro-currency markets are briefly presented.

A model of the relationship between the euro-currency and domestic markets

The initial assumptions of the model are that:

1 euro-currency deposits and domestic deposits are, in terms of the number of settlement days and marketability, perfect substitutes;

2 there are no capital controls on the movement of funds between the domestic money market and the euro-currency market;

3 domestic banks are required to hold non-interest-bearing reserve balances against domestic currency deposits;[2]

4 institutions which take deposits and make loans in a currency other than that of the country in which they are operating—hereafter termed euro-banks[3]—are not legally obliged to hold reserves against such foreign currency deposits;[4]

5 private non-bank holders of funds may have strong, non-pecuniary preferences for holding either a domestic or a euro-currency deposit; and

6 for domestic banks, loans to euro-banks are no more risky than loans made in the domestic inter-bank market.

The first four assumptions are factual in nature and, therefore, may be easily verified. In general, assumptions 3 and 4 hold for most currencies in the euro-currency market; the validity of assumption 2 varies as between currencies and over time; assumption 1 need not strictly hold, but it does not seem an unreasonable simplification.[5]

[1] See, for example, R. J. Herring and R. C. Marston, *National Monetary Policies and International Financial Markets* (Amsterdam: North-Holland, 1977), chapters 4 and 8; and G. Dufey and I. H. Giddy, *The International Money Market* (Englewood Cliffs, New Jersey: Prentice-Hall, 1978), especially pages 48–77.

[2] The conclusions from the model would be unchanged if an uncompetitive rate of interest were paid on reserve balances held with the central bank, although this would have to be allowed for in the subsequent analysis.

[3] The distinction between domestic banks and euro-banks is of course artificial but is made for convenience of analysis. In practice, an institution which is primarily concerned with taking deposits and making loans in foreign currencies may also be permitted to take deposits and make loans in the currency of the country in which it is resident. However, such transactions may be viewed, without loss of generality, as domestic banking operations.

[4] It might, however, be expected that some margin of reserves would be held against the possibility of withdrawals. The analysis requires only the assumption that this margin is less than the legal domestic reserve requirement, or that these reserves can be employed at a rate of interest greater than the domestic interest rate payable on obligatory reserves.

[5] A deposit between euro-banks in London is normally for the delivery of funds on the second business day after the deal has been made, and may therefore be somewhat longer than for a domestic agreement, which is usually for the delivery of funds on the same day as the deal or the day after.

Private non-bank holders of funds are assumed to have non-pecuniary preferences for depositing in one market rather than the other (assumption 5). This may reflect different perceived degrees of political or financial risk in the two markets.

The validity of assumption 6 is likely to depend on domestic banks' perceived degree of risk in lending to the euro-currency market. This may vary over time. One reason for expecting this risk to be small is that euro-banks have very close links with domestic banks—in many cases euro-banks are the wholly or partly-owned subsidiaries or branches of domestic banks in a foreign country—which may, as a matter of routine, make loans to or take deposits from their overseas affiliates. Whether, in fact, domestic banks' perceived degree of risk in lending to the euro-currency market is small is an empirical question investigated below. For the purposes of exposition, it is assumed here to be zero.

It is now possible to derive the supply and demand curves for euro-currency deposits under this set of assumptions and four simple propositions about the behaviour of non-bank holders of funds, domestic or parent banks, and euro-banks.

- Non-banks' supply of funds to the euro-currency market will depend, among other things, on the relative return on deposits in the two markets, and it is likely that, *ceteris paribus*, for a given domestic deposit rate, the supply of currency to (demand for deposits from) the euro-market will be positively related to the euro-currency deposit rate. This may be simply written as:

$$S_{ec}^{nb} = f_1(i_{ec} - i_d) \qquad (1)$$

with

$$\frac{\delta S_{ec}^{nb}}{\delta i_{ec}} > 0$$

where i_{ec} and i_d are respectively the euro-currency and domestic currency deposit rates; and S_{ec}^{nb} is the supply of euro-currency by non-banks.[1] This supply schedule is illustrated as segment 1 in Chart A. It is drawn so that even when the euro-currency deposit rate is below the domestic deposit rate there is a positive supply of currency to the euro-market, on the assumption that there exist investors who, even in these circumstances, would prefer a euro-currency holding to a domestic currency deposit.

- The supply of currency to the euro-market by domestic banks will depend on the cost to banks of raising deposits domestically and on the returns they receive from lending these in the euro-currency market. To a domestic bank, the effective cost it pays for loanable funds at the margin is not just the nominal deposit rate but this nominal cost adjusted for the extra costs it incurs from holding (non-interest-bearing) reserves against these deposits plus any extra costs, such as the cost of Federal Deposit Insurance in the United States. The effective cost per unit of loanable funds to a domestic bank is therefore:

$$i_d^e = \frac{i_d + x_d}{1 - r_d} \qquad (2)$$

where r_d is the domestic reserve requirement on resident deposits and x_d is any extra cost of domestic currency borrowing to domestic banks.

Given this effective cost to banks of raising funds in the domestic market, they would only on-lend funds to the euro-market if the rate they could obtain on euro-currency deposits exceeds this cost.

This gives the supply condition for domestic banks:

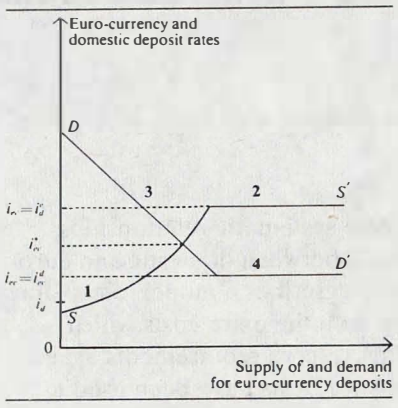
$$S_{ec}^{b} = f_2(i_{ec} - i_d^e) \qquad (3)$$

with

$$S_{ec}^{b} = 0 \text{ when } i_{ec} \leqslant i_d^e$$
$$= f_2 \text{ when } i_{ec} > i_d^e$$

It might also be expected that this schedule would be highly elastic with respect to the euro-currency deposit rate: if this rate exceeded the effective cost to domestic banks of raising loanable funds, any domestic bank could obtain a profit simply by borrowing domestically and lending the proceeds in the euro-currency market. In the absence of capital controls and other imperfections in the market, arbitrage by banks between the domestic and euro-currency markets should therefore be such as to place an upper ceiling on the euro-currency deposit rate.[2] The supply schedule is therefore illustrated as being perfectly elastic at the effective cost of loanable funds to domestic banks—segment 2 of Chart A.

Chart A



[1] Under the assumption that domestic and external deposits are imperfect substitutes to private non-bank wealth holders, equation 1 is viewed as a stock relationship, in line with the portfolio selection theory of capital flows. See J. H. Makin, 'Demand and supply functions for stocks of euro-dollar deposits: an empirical study', *Review of Economics and Statistics*, Vol. LIV, November 1972, pages 381–91.

[2] This formulation of the supply schedule for domestic banks suggests a flow, rather than a stock-adjustment model of capital movements. The justification for this is that it is assumed that domestic banks, unlike non-banks, are largely indifferent between lending to euro-banks and lending in the domestic money market, and therefore, while it might be appropriate to formulate equation 1, for non-bank wealth holders, as a stock-adjustment relationship, it would seem more appropriate to view equation 3 as a flow relationship. For a model which analyses the supply of euro-dollar deposits by financial intermediaries in terms of a flow relationship, see P. H. Hendershott, 'The structure of international interest rates: the US Treasury bill rate and the eurodollar deposit rate', *The Journal of Finance*, Vol. XXII, 1967, pages 455–65.

- The demand for funds (supply of deposits) by euro-banks will depend on the demand for loans from euro-banks by final users. We might expect, *ceteris paribus*, that this demand for loans, and the euro-banks' derived demand for funds, would be inversely related to the euro-currency deposit rate.[1] This demand curve for funds is therefore drawn downward-sloping (segment 3 of Chart A). The determinants of the relative position of this curve are likely to be fairly complex, but would be expected to depend upon the relative costs to final users of borrowing from banks in the euro-currency rather than the domestic market—this latter cost would depend, *inter alia*, on the cost of loanable funds to domestic banks (i_d^e)—and on the relative ability to borrow in the two markets.[2] This might be expressed algebraically as:

$$D_{ec}^{nb} = f_3(i_{ec} - i_d^e) + X \qquad (4)$$

with

$$\frac{\delta D_{ec}^{nb}}{\delta i_{ec}} < 0$$

which shows the derived demand for funds by euro-banks as a function of the relative effective cost of loanable funds in the two markets plus exogenous factors (X) such as relative lending margins.

- A domestic bank would only borrow its own currency from the euro-currency market if the effective cost of raising loanable funds from the euro-currency market were less than the effective cost of loanable funds in the domestic market. The euro-currency interest rate at which this becomes profitable will depend on relative interest rates in the two markets and on the relative reserve requirements on resident and non-resident deposits.

The effective cost per unit to a domestic bank of raising loanable funds in the euro-currency market is:

$$i_{ec}^e = \frac{i_{ec}}{1 - r_e} \qquad (5)$$

where r_e is the domestic reserve requirement on non-resident deposits, on the assumption that domestic banks do not pay any extra costs on their euro-currency borrowing. Combining equations 2 and 5, the euro-currency interest rate at which it will become profitable for domestic banks to borrow euro-currency is given at:

$$i_{ec}^e = i_d^e \qquad (6)$$

or where

$$i_{ec} = i_{ec}^d = \frac{(i_d + x_d)(1 - r_e)}{(1 - r_d)}.$$

At this rate, the demand for funds from the euro-currency market by domestic banks should become nearly perfectly elastic with respect to the euro-currency deposit rate. This might be expressed algebraically as:

$$D_{ec}^b = f_4(i_{ec}^d - i_{ec}) \qquad (7)$$

with

$$D_{ec}^b = 0 \text{ when } i_{ec} \geq i_{ec}^d$$
$$= f_4 \text{ when } i_{ec} < i_{ec}^d$$

This is illustrated as segment 4 in Chart A.

This completes the simple analysis of the supply of, and demand for, a single euro-currency in isolation from the rest of the euro-currency market.

The equilibrium euro-currency deposit rate is then determined by the intersection of the demand and supply schedules at i_{ec}^* in Chart A. This chart also shows that the equilibrium euro-currency deposit rate is constrained within narrow limits by the arbitrage activity of domestic banks, the upper arbitrage limit (segment 2) depending on the nominal cost to domestic banks of raising deposits in the domestic market and the level of reserve requirements on resident deposits, and the lower arbitrage limit (segment 4) depending on the domestic deposit rate and the relative level of reserve requirements on resident and non-resident deposits.

A test of the model

As a test of this analysis, Chart B compares, from January 1973 to end-March 1978, the three-month euro-dollar bid rate[3] and the US secondary market three-month certificate of deposit (CD) rate, corrected for US domestic reserve requirements and the costs of Federal Deposit Insurance,[4] i.e. the effective cost to US banks of raising loanable funds in the domestic market.

The chart shows that the relationship between the two rates has been particularly close since end-1975, suggesting that, in this period, the three-month euro-dollar rate has been determined by the rate at which it was profitable for US domestic banks to supply funds to the euro-dollar market (i.e. at an intersection of the demand curve with segment 2 of the supply curve in

[1] Euro-bank loans are usually in the form of bank credits of a specified term. The interest rate on these credits is normally a fixed spread over LIBOR (London inter-bank offered rate)—the rate at which major banks are prepared to lend funds in the London inter-bank market. The above formulation of the demand curve for loans suggests that this demand is responsive to the total cost of borrowing, i.e. the euro-currency interest rate plus the spread.

[2] Because of the practice of syndicating loans in the euro-market, very large amounts ($2 billion is not unknown) may be raised on competitive terms in the euro-market, and there may be no close substitute for these in the domestic market.

[3] The bid rate is taken to approximate the rate which US banks would receive on their lending to the market. This is the rate at which a selection of large banks in the euro-market are prepared to borrow funds in the London inter-bank market. In practice, the bid rate would be the subject of negotiation between individual banks.

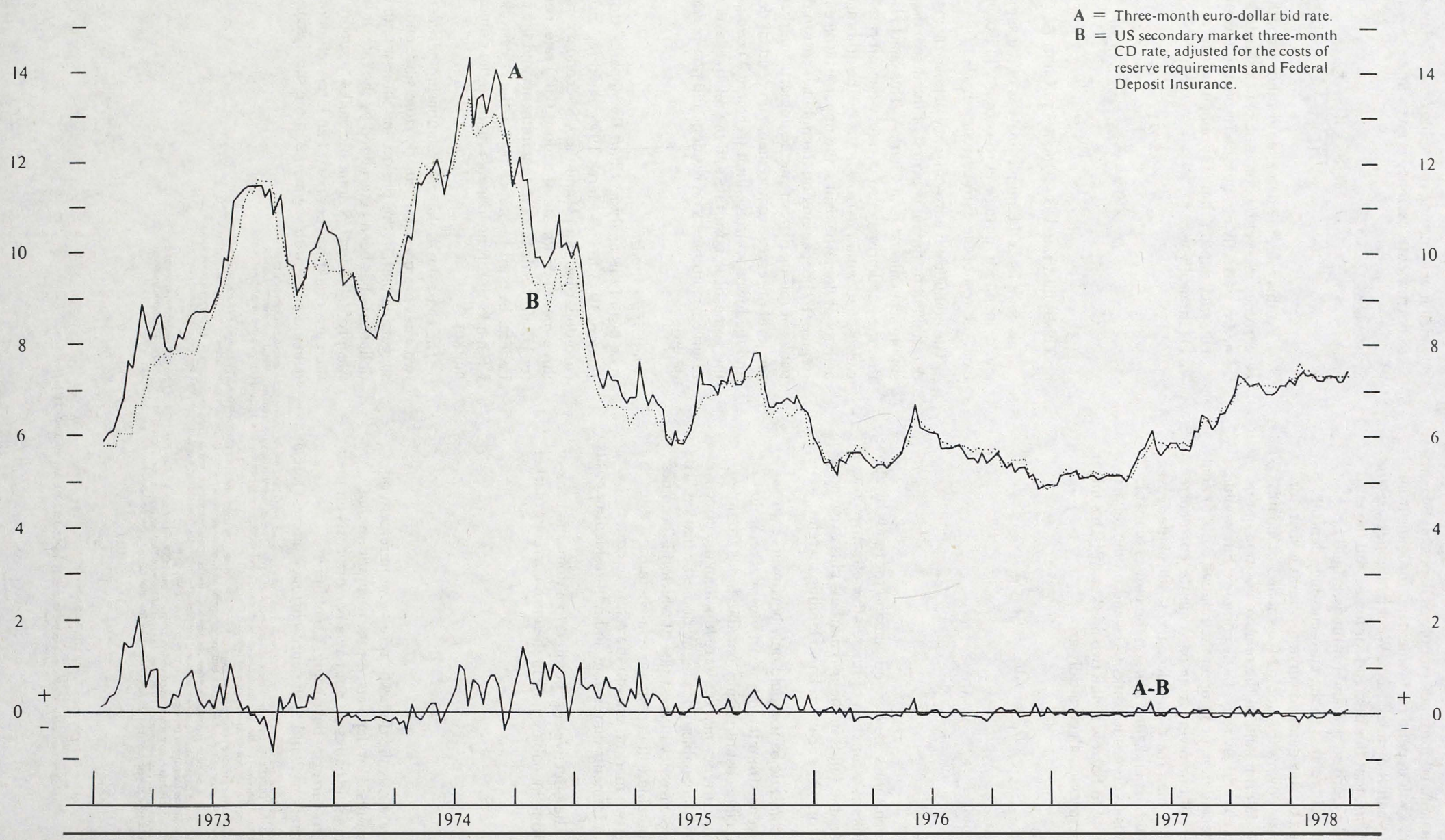
[4] The US domestic reserve requirement on large denominated CDs was, from 1st October 1970 to 12th December 1974, 5% and thereafter, until 2nd November 1978, 6%. The cost of Federal Deposit Insurance is approximately 0.036%. The formula used to calculate the effective cost to US banks of raising loanable funds in the domestic market was therefore:

$$i_d^e = \frac{i_d + 0.036}{1 - r_d}$$

where

r_d = 0.05 1st October 1970 to 12th December 1974
= 0.06 after 12th December 1974
and i_d was the dealers' offer rate in the secondary market for large denominated CDs in New York.

Chart B


A = Three-month euro-dollar bid rate.
B = US secondary market three-month CD rate, adjusted for the costs of reserve requirements and Federal Deposit Insurance.
A
B
A-B
14
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8
6
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2
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+
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1973
1974
1975
1976
1977
1978

Chart A). Indeed the mean differential between the two rates after 1st January 1975 was only 0.07 percentage points with a variance of only 0.05 percentage points (see Table A).[1] Not surprisingly, published Bank for International Settlements statistics on the size of the euro-market also show US banks as large net suppliers of funds to the euro-market during this period (see Table B).

Table A

Three-month euro-dollar rate less effective cost to US banks of loanable funds in the domestic market[a]

	Mean	Variance	Number of observations
1 January 1973–end-December 1973	0.48	0.26	52
Mid-June 1974–end-December 1974	0.64	0.18	28
Mid-June 1974–mid-June 1975	0.53	0.16	52
1 January 1975–end-March 1978	0.07	0.05	169
Total sample	0.22	0.16	249

[a] Calculated as the US secondary market three-month CD rate corrected for the cost of reserve requirements and Federal Deposit Insurance.

Table B

External assets and liabilities of US banks

$ billions	Assets	Liabilities[a]
1974 December	46.2	60.4
1975 December	59.8	58.7
1976 December	81.1	70.7
1977 December	92.6	78.1
1978 March	98.8	79.3

Source: Bank for International Settlements statistics on international banking developments.

[a] Excluding US Treasury bills and certificates held in custody on behalf of non-residents.

This in itself might be accepted as sufficient evidence to support the model in terms of the efficiency of arbitrage flows from the US domestic market to the euro-dollar market.[2]

It is, however, worth considering why during 1973 and 1974 the differential between the two rates fluctuated sharply. One reason may be that during this period US domestic banks were either unable or unwilling to arbitrage between the two markets.

Until 1974, the United States enforced a capital restraint programme which included ceilings on US domestic bank lending to non-residents. This had the effect of making the upper arbitrage limit (segment 2 of Chart A) ineffective, allowing the euro-dollar rate to rise above the effective cost to US banks of domestic dollar borrowing.[3] After the removal of the controls in January 1974, the differential between the rates narrowed temporarily; however, during the summer of 1974 a crisis of confidence developed in the euro-currency market after the closure of the Cologne bank, ID Herstatt, on 26th June. Although this banking failure was due to heavy losses sustained in foreign exchange dealings, it produced more general fears about the solvency of banks in the euro-currency market. In these circumstances, it would not have been unusual for depositors to require a significant risk premium for depositing in the euro-currency market or, as a consequence, for euro-dollar rates to move erratically and above the effective cost to US banks of borrowing domestically. In September 1974, the central bank Governors from countries of the Group of Ten and Switzerland stated that they were satisfied that means were available for the purpose of the provision of temporary liquidity to the euro-markets and would be used if and when necessary. Subsequently worries about the solvency of euro-banks appear to have largely evaporated, and by mid-1975 the differential between the rates had returned to its technical level.

In the year before the removal of capital controls, the mean and variance of the differential between the rates were respectively 0.48 and 0.26 percentage points, while, during the Herstatt crisis (mid-June to end-December 1974, or mid-June 1974 to mid-June 1975) the mean and variance of the differential were 0.64 and 0.18 percentage points respectively. For both these periods, the means and variances of the differential were significantly different from those found for the period after January 1975, thus tending to confirm the visual evidence (see Table C).

Table C

Analysis of variance: euro-dollar/domestic CD differential

	1 January 1973–end-December 1973	Mid-June 1974–end-December 1974
Mid-June 1974–end-December 1974	$F_{51,\ 27} = 1.4$	
1 January 1975–end-March 1978	$F_{51,\ 168} = 5.3$[a]	$F_{27,\ 168} = 3.7$[a]

[a] Indicates that the variances are significantly different at a 1% level of significance.

The movement in euro-dollar interest rates in recent years tends to give strong support for the simple model developed above and suggests that, in the absence of market imperfections such as capital controls, there is at the margin a very close relationship between the effective cost of loanable funds to banks in the euro-dollar and US domestic markets. This analysis also confirms that, in the absence of serious crises of confidence, domestic banks, do not generally regard the risks of depositing in the euro-currency market as significantly greater than those of depositing in the domestic market.

The analysis also tends to suggest that the euro-dollar rate is determined largely independently of both the forward exchange market and the interest rates on other euro-currencies. While this might not be unreasonable for the euro-dollar which is the dominant currency in the euro-market, making up about three

[1] While these statistics indicate that the population mean is significantly different from zero, this may only reflect measurement error or transactions costs in the markets. For example, the difference between the rates offered by dealers in the secondary market and the actual cost to US banks of borrowing high-denomination CDs, although subject to variations, might, in normal circumstances, amount to some 0.10–0.15 percentage points. Allowing for this difference could completely eliminate the mean differential observed between the rates during the period.

[2] This analysis does not test the efficiency of arbitrage flows from the euro-market to domestic markets. This is, however, considered in the next section.

[3] Such restraints may have also increased US corporations' external borrowing, since the capital controls restricted their raising capital domestically for use overseas. By increasing the demand for funds from the euro-currency market, this would also have tended to widen the differential between domestic and euro-dollar interest rates.

quarters of its gross size, and which also acts as the numeraire in the foreign exchange market, it is certainly not the case for other currencies in the euro-market.[1] The question of the inter-relationship between euro-currency interest rates and the foreign exchange market is considered in the next section.

An extension of the model

In fact, the supply of, and demand for, a euro-currency are not independent of the rate of interest on alternative currencies in the euro-market as assumed above. Euro-currency interest rates are instead directly related through the forward market, since an investor holding say euro-dollars could sell the dollars spot for say deutschemarks, invest the deutschemarks in the euro-deutschemark market and cover forward. Indeed, arbitrageurs would shift funds between currencies as long as it was profitable to do so. For equilibrium, the euro-currency rate should equal the euro-dollar rate less the forward discount on dollars *vis-à-vis* the currency—the familiar interest-rate parity theorem. To explain the determination of euro-currency interest rates, it is, therefore, necessary to discuss the forward exchange market and its relationship with the euro-currency market.

Before proceeding to this, it should be noted that it is usual practice in the euro-market for banks to determine a non-dollar euro-currency rate as simply the euro-dollar rate less the forward discount or plus the forward premium on dollars against that currency, implying that interest-rate parity holds between currencies in the euro-market. However, even in the absence of restrictions on capital flows, arbitrage flows between domestic money markets do not seem to bring national interest rates into interest-rate parity. Indeed, to the extent that euro-currency interest rates are different from nominal domestic interest rates, interest-rate parity between euro-currency rates (and the forward exchange market) may be inconsistent with interest-rate parity between nominal domestic interest rates—and there has been considerable discussion among economists on the reasons for a less than perfectly elastic arbitrage demand schedule for forward exchange.[2]

To simplify the analysis, no discussion is made of the spot exchange market. The justification for this is that, following Walras' Law, the excess demand in the four markets (the spot and forward exchange market and two euro-currency markets) must sum to zero and therefore one market (here taken as the spot exchange market) is redundant.

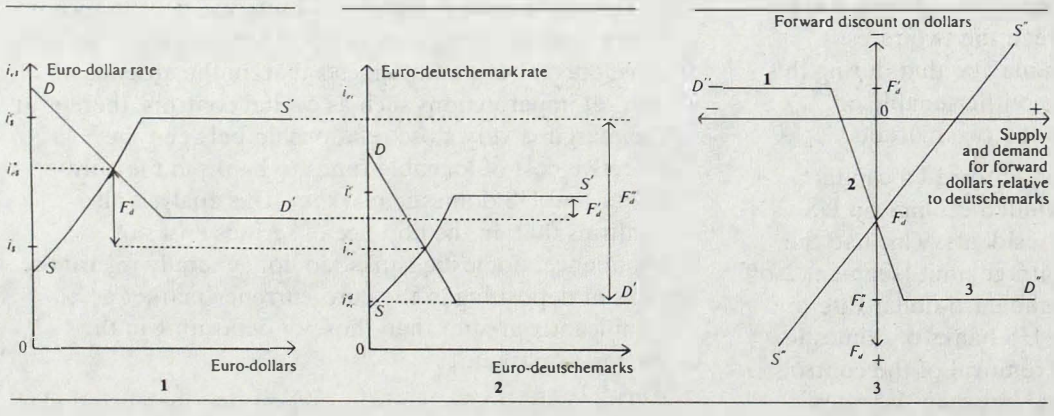
An integrated model

In diagrams 1 and 2 of Chart C, the supply and demand curves for two individual euro-currencies—the euro-dollar market and one other euro-currency market (for example, the euro-deutschemark market)—have been redrawn under the assumptions described previously. These show the supply of, and demand for, the euro-currency, given the level of interest rates and reserve requirements in the two domestic markets.[3] For illustrative purposes it is assumed that West German domestic interest rates are less than US domestic rates.[4] The equilibrium euro-dollar and euro-deutschemark rates are assumed, initially, to be $i_{e\$}^{\bullet}$ and $i_{ec}^{\bullet}$ respectively.

Diagram 3 of the chart illustrates the supply and demand for forward cover in the foreign exchange market.

Chart C

The euro-dollar market | **The euro-deutschemark market** | **The forward exchange market**



[1] Domestic and euro-market interest rates, and forward and spot exchange rates are jointly determined. While the size of the US domestic money market suggests that a causal chain from events there to the euro-dollar market, and thence to the forward exchange market, will often explain changes in all markets, this will not always, nor even generally, be the case. Euro-markets may at times affect US money markets: for example, if New York banks borrow domestically in order to lend in the euro-markets, this would tend to push up US CD rates.

[2] See, for example, L. H. Officer and T. D. Willett 'The Covered-Arbitrage Schedule: A Critical Survey of Recent Developments', *Journal of Money, Credit and Banking*, Vol. 2, May 1970, pages 247–57. Of particular interest is the paper by W. H. Branson, 'The Minimum Covered Interest Differential Needed for International Arbitrage Activity', *Journal of Political Economy*, Vol. 77 December 1969, pages 1028–35, in which it is suggested that transactions costs will produce a discontinuity in the arbitrageurs' demand schedule for forward exchange. This proposition is considered further below.

[3] For the purposes of simplifying the analysis, it is assumed that the level of domestic interest rates is given exogenously of short-term capital flows. In fact it has already been observed (footnote[1] above) that capital flows can affect domestic money markets, but this assumption may not be unreasonable in the short term if domestic monetary authorities set (interim) targets for the level of domestic short-term interest rates.

[4] This does not necessarily imply that the equilibrium euro-dollar rate need be greater than the euro-deutschemark rate. Instead it will depend on the relative interest rates at which US domestic banks find it profitable to borrow from the euro-dollar market (the perfectly elastic segment of *DD'* in diagram 1 of the chart) and West German domestic banks find it profitable to supply funds to the euro-deutschemark market (the perfectly elastic segment of *SS'* in diagram 2 of the chart). This model would therefore suggest that, even when there is a free flow of capital, perverse relationships could develop between domestic and euro-currency interest rates.

The speculators' supply of forward exchange,[1] which is illustrated as $S''S''$ in diagram 3 of Chart C, will depend, *inter alia*, on their expectations about the future spot dollar/deutschemark exchange rate and on the forward discount on dollars. The shape of the supply schedule will reflect the aggregation of individual speculators' supplies, which may themselves depend on the size of individuals' outstanding forward contracts; the effect of one speculator's supply on another's; their wealth and their ability to borrow. Indeed there does not appear to be any reason why the total supply curve should even be stable. For simplicity, however, it is here assumed that, for a given set of expectations about the future spot exchange rate, speculators' supply of forward exchange is a linearly decreasing function of the forward discount on dollars. Thus if the forward discount on dollars is less than F_d^*, speculators will supply forward dollars relative to deutschemarks; if it is greater than F_d^*, they will supply forward deutschemarks relative to dollars.

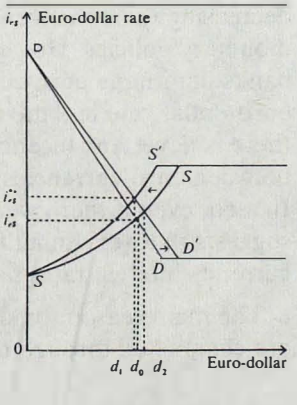
The arbitrageurs' demand for forward exchange may be derived from an analysis of the supply and demand curves for the two euro-currencies—it is illustrated as $D''D''$ in diagram 3 of Chart C. Between the points F_d' and F_d'', this schedule is shown to be nearly perfectly inelastic with respect to the forward discount on dollars (segment 2), i.e. in this range any change in the forward discount will produce only small capital movements, while beyond these points the schedule becomes perfectly elastic (segments 1 and 3). The reason for this is as follows: given US and West German domestic interest rates and reserve requirements, then domestic banks' arbitrage limits with the euro-currency market are fixed—and these are shown as the perfectly elastic sections of the demand and supply schedules in diagrams 1 and 2 of the chart. Therefore, provided domestic interest rates (and reserve requirements) are unchanged, the maximum possible euro-dollar rate is $i_{\$}^{e}$, the rate at which US domestic banks find it profitable to supply dollars to the euro-dollar market, and the minimum possible euro-deutschemark rate is the rate at which West German domestic banks find it profitable to borrow euro-deutschemarks, i_{ec}^{d}. The maximum possible forward discount on dollars is therefore the difference between these rates, shown as F_d'' in diagrams 2 and 3 of the chart, and arbitrageurs' demand for forward dollars must become perfectly elastic at this forward discount.

For if the forward discount on dollars were to rise and to become greater than F_d'', then arbitrageurs in the euro-currency market would find it profitable to shift funds out of euro-dollars into euro-deutschemarks. These arbitrage flows between euro-currencies would tend to push the euro-dollar rate above $i_{\$}^{e}$ or the euro-deutschemark rate below i_{ec}^{d}. But at these euro-currency interest rates, domestic banks will find it profitable to arbitrage with the euro-currency market—US domestic banks will supply funds to the euro-dollar market and West German domestic banks will demand funds from the euro-deutschemark market. In equilibrium, the euro-dollar rate cannot remain above its upper arbitrage limit of $i_{\$}^{e}$ nor the euro-deutschemark rate fall below its lower arbitrage limit of i_{ec}^{d}, and the forward discount on dollars cannot exceed F_d''. The demand for forward dollars will therefore become perfectly elastic at this rate.

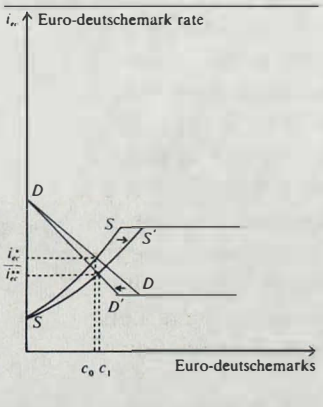
Similarly, the equilibrium forward discount on deutschemarks cannot exceed F_d'—the difference between US banks' lower arbitrage limit and West German banks' upper arbitrage limit. The demand for forward deutschemarks therefore must also become perfectly elastic at F_d''.

Between the forward discounts, F_d' and F_d'', movements in euro-currency interest rates are unconstrained by the arbitrage activity of domestic banks, and within this range euro-currency interest rates should adjust rapidly to a change in the forward discount. If the forward discount on dollars were to increase from its equilibrium level F_d^*, (say to F_d''' in diagram 3 of Chart D), suppliers of funds to the euro-dollar market would find it profitable, at the initial rates of interest on euro-dollars and euro-deutschemarks, to transfer these funds to the euro-deutschemark market and cover forward; and arbitrageurs would find it profitable to borrow euro-dollars to lend on a covered basis as euro-deutschemarks. The combined effect is therefore to shift the supply curve for euro-dollars to the left (from

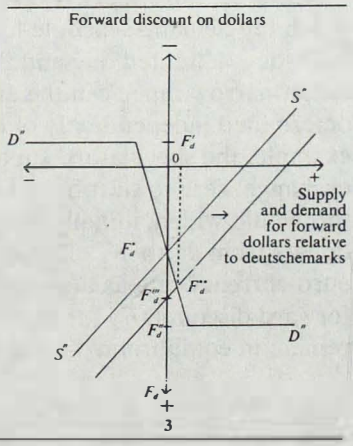
Chart D
The euro-dollar market



The euro-deutschemark market



The forward exchange market



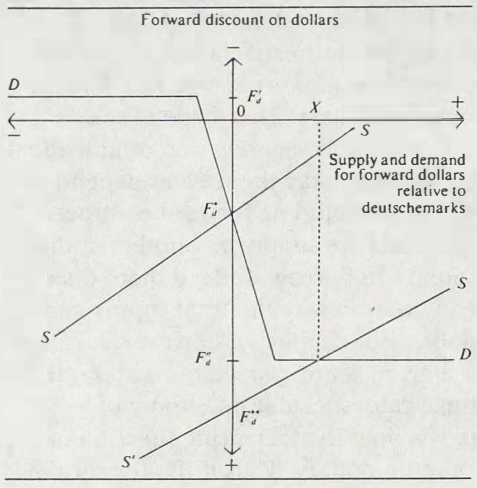
[1] 'Speculators' refers to any market operators taking an open position in the forward exchange market.

SS, to SS', see diagram 1 of Chart D), and the demand curve for euro-dollars to the right (from DD to DD' in diagram 1 of Chart D), sharply increasing the euro-dollar rate from $i_{e\$}^{\cdot}$ to $i_{e\$}^{\cdot\cdot}$ (see diagram 1 of Chart D), while shifting the supply curve for euro-deutschemarks to the right (from SS to SS' in diagram 2 of the chart) and the demand curve for euro-deutschemarks to the left (from DD to DD' in diagram 2) as banks which had previously borrowed euro-deutschemarks would now find it profitable to borrow euro-dollars instead and switch these into deutschemarks and cover forward. These shifts in the supply and demand schedules for euro-deutschemarks will sharply decrease the euro-deutschemark rate from $i_{ec}^{\cdot}$ to $i_{ec}^{\cdot\cdot}$ (see diagram 2 of Chart D). The movements in the euro-dollar and euro-deutschemark rates, combined with some subsequent narrowing in the forward discount on dollars (from $F_d^{''}$ to $F_d^{\cdot\cdot}$ in diagram 3 of Chart D), would re-establish equilibrium between the markets. At the new equilibrium, as Chart D shows, the euro-dollar rate is higher, the euro-deutschemark rate lower, and the forward discount on dollars somewhat wider.

Because both the supply and the demand curves shift in both euro-currency markets, however, the actual movement of funds between the markets need only be small to re-establish equilibrium—the shift out of euro-dollars is illustrated in the chart as d_0 to d_1;[1] the shift into euro-deutschemarks as c_0 to c_1—and therefore the arbitrageurs' demand curve for forward dollars is likely to appear to be nearly perfectly inelastic with respect to the forward discount on dollars between the points $F_d^{'}$ and $F_d^{''}$. It is the mobility of capital between euro-currencies, and the adjustment in euro-currency interest rates, which allows dealers to determine a euro-currency rate simply as the euro-dollar rate less the forward discount on dollars. If arbitrage between euro-currency markets were not perfect, and it took considerable time and movement of funds to remove disequilibrium between euro-currency interest rates, then other influences—the demand for the euro-currency by final users and the supply of the euro-currency by holders of funds—could determine a rate of interest on the euro-currency which was different from the euro-dollar rate less the forward discount on dollars, and covered differentials between euro-currency interest rates could emerge.

However, this model also shows that the range over which the demand schedule for forward dollars is inelastic is a limited one and therefore only over a rather narrow range can the euro-currency rate be determined independently of other influences. If, for example, the speculators' supply curve of forward exchange were to shift from SS to $S'S'$ (see Chart E), this would widen, initially, the forward discount on dollars from $F_d^{\cdot}$ to $F_d^{\cdot\cdot}$. If euro-banks determine the euro-currency rate as the euro-dollar rate less this forward discount, $F_d^{\cdot\cdot}$, then euro-currency markets remain in equilibrium—there is no arbitrage flow

Chart E



between euro-currencies—but euro-currency markets are now out of equilibrium with domestic currency markets. A forward discount of $F_d^{\cdot\cdot}$ forces the quoted euro-currency rate below the rate at which domestic banks find it profitable to borrow the euro-currency. Domestic banks would therefore find it profitable to borrow their domestic currency in the euro-market rather than in the domestic market or to borrow euro-dollars, swap these into the domestic currency and cover themselves forward; and they would continue to do so until the forward discount on dollars narrowed to $F_d^{''}$ (see Chart E)—the rate at which they no longer find it profitable to borrow euro-currency rather than domestic currency—or until domestic interest rates fell into line with the euro-currency rate. The net result would be that X forward contracts would have been made and that there would have been an inflow of X from euro-dollars into the domestic currency (see Chart E). This inflow would continue until either the forward rate or domestic interest rates adjusted. The main determinants of the euro-currency rate then comprise a wider set of variables than just the euro-dollar rate and the forward discount on dollars.

The euro-markets and short-term capital flows

An interesting question concerns the rôle of the euro-markets as a channel for short-term capital flows. Some observers have suggested that, because there are no restrictions on flows between currencies in the euro-market and because arbitrage is nearly perfect between euro-currencies but not between domestic currencies, euro-markets have increased the volume of short-term capital flows, aggravating exchange rate pressures and decreasing the effectiveness of countries' domestic monetary policies. However, to the extent that euro-banks determine euro-currency rates as simply the euro-dollar rate less the forward discount on dollars, there is never any incentive for covered arbitrage flows between euro-currencies within the euro-market. Indeed, even if there were, the above framework suggests that very small flows would bring euro-currency interest rates back into equilibrium.

The main reason for short-term capital flows which are channelled through the euro-currency market is the

[1] If, as is likely, banks are the main arbitrageurs between euro-currencies, then there need be no decrease in the size of the euro-dollar market when the forward discount on dollars increases above its equilibrium level. If banks only arbitrage in the euro-dollar market, only the demand curve for euro-dollars will shift and the size of the euro-dollar market would increase as banks borrow dollars to lend covered in deutschemarks. In segment 1 of Chart D the size of the euro-dollar market would increase from d_0 to at least d_1.

arbitrage activity of domestic banks when euro-currency interest rates are pushed to the margins at which they find it profitable either to lend to, or borrow from, the euro-currency market. These margins are *exclusively* a function of domestic interest rates, reserve requirements or other domestic capital controls and independent of the existence of the euro-currency market. The rôle that euro-banks play is one of intermediating between currencies, e.g. matching demands for deutschemarks with dollar deposits. Euro-banks are not the cause of short-term flows; this is to be found in the misalignment of domestic interest rates, reserve requirements and exchange rate expectations.

One final question is why, even in the absence of restrictions on capital flows, interest-rate parity appears to hold between euro-currency interest rates but not between nominal domestic interest rates. One reason may be that whereas country and default risk may be quite different between domestic markets they need not differ between euro-currencies.[1]

An alternative way of answering the question is to consider why, given that interest-rate parity does hold between euro-currencies, the supply of currency to the euro-market is not perfectly elastic at the nominal domestic interest rate. This may simply reflect the imperfect substitutability between domestic and euro-currency (or external) deposits for non-banks: while the supply and demand curves for external deposits by domestic banks become perfectly elastic at certain euro-currency interest rates, the supply of currency to the euro-market by non-banks is not perfectly elastic at the nominal domestic rate of interest. Rather it appears upward sloping (as illustrated as *SS'* in diagram 1 of Chart C), first because non-bank holders of funds are likely to have strong preferences, other than pecuniary ones, for holding domestic currency rather than euro-currency and secondly, because they may have limited sources of funds with which to arbitrage. In other words, while it seems appropriate to view banks as flow-adjusters freely borrowing funds on competitive terms, it seems more appropriate to view non-banks in general as stock-adjusters allocating a given portfolio between domestic and external assets of varying risk and return.

A simple test of the integrated model

As a test of this integrated model, it would be instructive to see whether the euro-currency interest rate on a strong currency, such as the deutschemark, has been determined, in the absence of controls on the free flow of capital to the domestic market, at the rate at which it would have been profitable for domestic banks to borrow from the euro-currency market. To investigate this, the nominal three-month euro-deutschemark rate and the nominal West German domestic three-month inter-bank rate have been plotted, [2] in Chart F, together with the differential between the rates, for the period January 1973 to end-March 1978.

While this chart suggests that there was a very close relationship between the rates from mid-1975 to end-1977, there were also considerable deviations, particularly in 1973 and 1974, and again in 1978. However, at different times during this period the West German authorities have imposed controls, of varying severity, in an attempt to reduce capital flows into Western Germany, and only between August 1975 and December 1977 were West German domestic reserve requirements the same on West German banks' domestic and foreign-owned deutschemark liabilities (see Table D). Only for this period would the extra costs of raising loanable funds to West German banks have been the same in the domestic and euro-market, and therefore only for this period would the model suggest that there should be a close relationship between nominal domestic and euro-deutschemark rates. For this period, the calculated mean and variance of the differential (see Table E) were, respectively −0.15 and 0.03 percentage points, suggesting that the relationship between the rates was in fact very close.[3]

Table D
Minimum reserve ratios on time liabilities of West German banks[a]

	Liabilities to residents	Liabilities to non-residents	On growth of liabilities to non-residents
Applicable from the first day of			
1972 July		30.00	60
Aug.	11.75		
1973 Mar	13.55		
July		35.00	60
Oct.		35.00	60
Nov.	13.95		
1974 Jan.	13.25	30.00	0
Sept.	11.90		
Oct.	10.95	27.60	0
1975 June	10.40		
July	9.35	24.85	0
Aug.		9.35	0
1976 May	9.85	9.85	0
June	10.35	10.35	0
1977 Mar.	10.45	10.45	0
June	9.95	9.95	0
Sept.	8.95	8.95	0
1978 Jan.	8.95	15.00	80
Mar.	9.65		
June	9.00	9.00	0

[a] Reserve class DM 1,000 million and over from December 1970 to February 1977; thereafter DM 100 million and over.

Table E
Three-month euro-deutschemark rate less West German three-month inter-bank rate[a]

	Mean	Variance	Number of observations
1 January 1973–end-December 1973	− 6.42	5.89	46
1 January 1974–end-July 1975:			
Unadjusted for reserve changes	− 0.23	0.27	87
Adjusted for reserve changes	− 0.21	0.24	87
1 August 1975–end-December 1977	− 0.15	0.03	120
Total sample	− 1.32	6.97	253

[a] The interest rates used were Monday middle closing rates, where available.

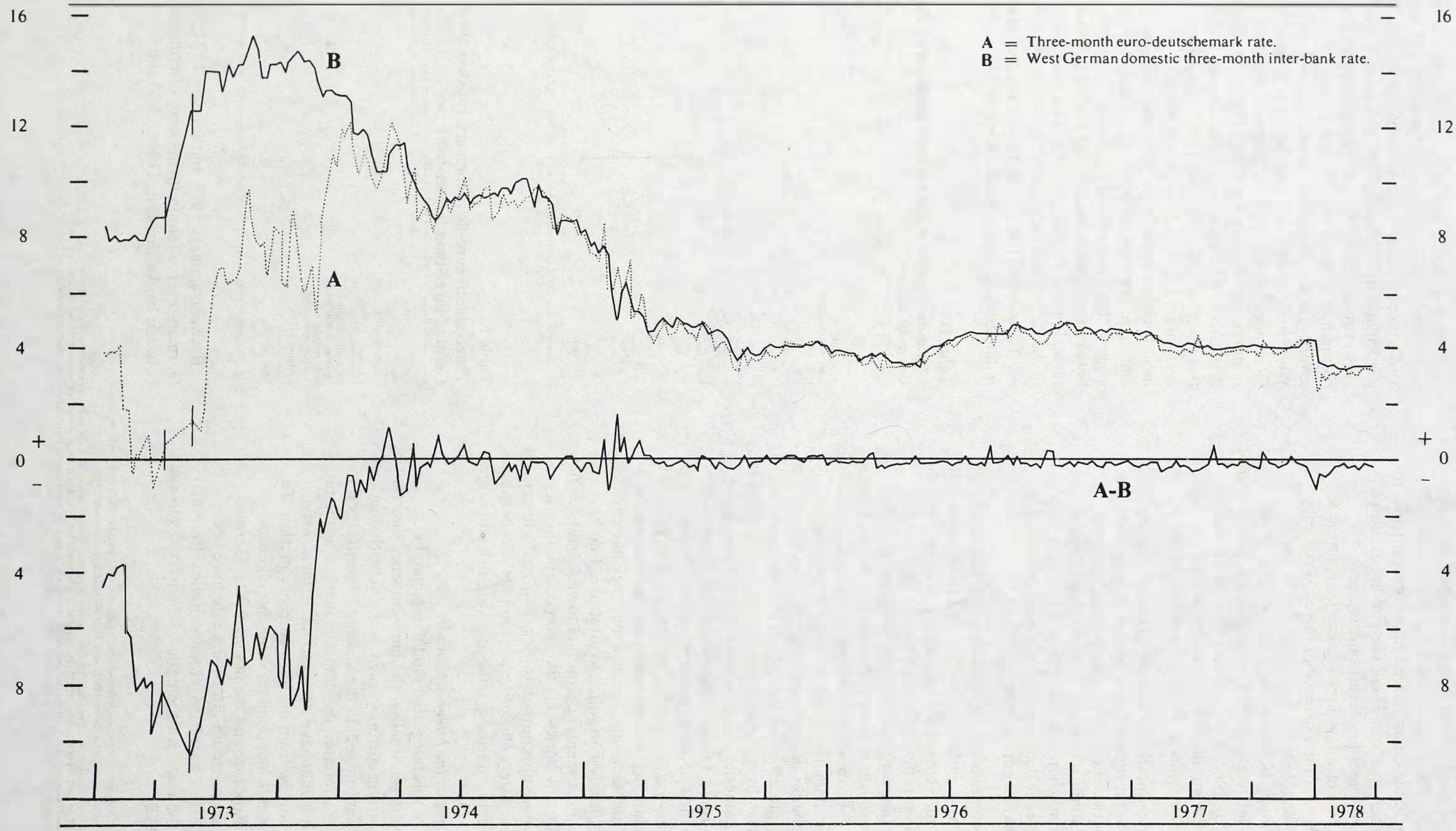
Between January 1973 and January 1974, West German reserve requirements were discriminatory as between banks' domestic (13%–14%) and foreign-

[1] For example, euro-dollar and euro-deutschemark deposits could both be made with the same London bank.

[2] The interest rates used were the middle closing rates on Mondays where available.

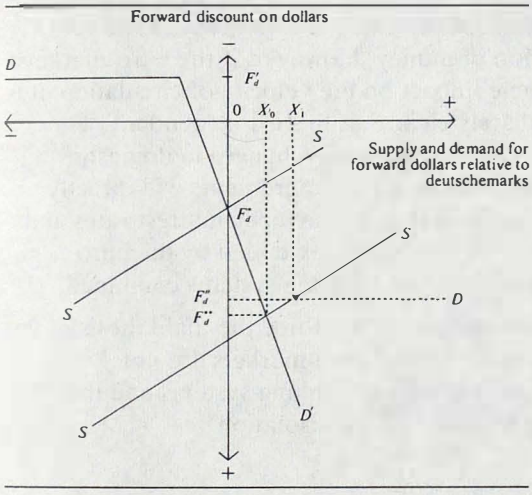
[3] However, these statistics again indicate, contrary to that expected from the model, that the population mean was statistically different from zero. This may only reflect the fact that no allowance has been made for bid/offer spreads in either of the markets. These would be expected to increase the mean differential, i.e. to make it less negative, by about 0.13 percentage points depending on the spread margin in the West German inter-bank market.

Chart F


A = Three-month euro-deutschemark rate.
B = West German domestic three-month inter-bank rate.
B
A
A-B
16
12
8
4
+
0
−
4
8
1973
1974
1975
1976
1977
1978

owned (35%) deutschemark liabilities. Further, a 60% reserve requirement was imposed on the growth of West German banks' time liabilities in deutschemarks to non-residents. Together these imposed a 95% reserve requirement on any increase in West German banks' time liabilities to non-residents and effectively discouraged West German domestic banks from borrowing deutschemarks from the euro-currency market. In terms of the model, these measures would remove the perfectly elastic segment of both the demand schedule for euro-deutschemarks and the demand schedule for forward dollars which would now become DD rather than DD (see Chart G). This latter

Chart G



schedule is now inelastic over a much larger range, which allows the forward discount on dollars to widen in equilibrium, beyond F_d''. The net effect is that the euro-deutschemark rate will fall below the rate at which domestic banks would have begun to find it profitable to borrow euro-deutschemarks in the absence of the discriminatory reserve requirement; the forward discount on dollars will widen to F_d^{**}; and there will be a smaller flow out of dollars into deutschemarks—X_0 rather than X_1 in the absence of the discriminatory reserve requirement (see Chart G).

Further, during the period February 1973 to February 1974 the West German Government under the Bardepot Law, imposed a 100% minimum reserve requirement (raised from 50% in February 1973; and subsequently reduced to 20% in February 1974 and removed in September 1974) against foreign loans contracted by West German companies, making it unprofitable for them to borrow externally. Together these measures appear to have effectively insulated the West German domestic market from short-term capital inflows during 1973, and there were very sharp deviations between the level of domestic and euro-deutschemark rates. The mean and variance of the differential during this period, −6.42 and 5.89 percentage points respectively, are sharply different from those in the 1975–77 period (see Table F).

In the immediate period after the removal of reserve requirements on the growth of West German banks' non-resident deutschemark deposits and the Bardepot regulations, the deviations between the rates were

Table F

Analysis of variance: euro-deutschemark/ domestic deutschemark differential

	1 January 1973–end-December 1973	1 January 1974–end-July 1975	
		Unadjusted for reserve changes	Adjusted for reserve changes
1 January 1974–end-July 1975:			
Unadjusted	$F_{45,\,86} = 22.3$[a]		
Adjusted	$F_{45,\,86} = 24.8$[a]	$F_{86,\,86} = 1.1$	
1 August 1975–end-December 1977	$F_{45,\,119} = 198.7$[a]	$F_{86,\,119} = 9.0$[a]	$F_{86,\,119} = 8.0$[a]

[a] Indicates that the variances, are significantly different at a 1% level of significance.

reduced, with the mean and variance of the differential narrowing to −0.23 and 0.27 percentage points respectively. However, these are still fairly large compared with the period after August 1975, possibly reflecting the discriminatory nature of reserve requirements on West German banks' foreign-owned liabilities.

In January 1978, when again faced with large capital inflows, the West German authorities once more imposed discriminatory reserve requirements on the level and growth of the deutschemark liabilities of West German banks to non-residents. A reserve requirement of 95% was once more effectively placed on any increase in West German banks' foreign-owned time liabilities. Following this, the euro-deutschemark rate dropped below the domestic inter-bank rate. However, it subsequently returned to a more 'normal' level. One possible reason may be that, in the absence of restrictions on foreign borrowing by West German companies, corporations may themselves have arbitraged between the domestic and euro-markets. The discriminatory reserve requirements were rescinded in June 1978.

These movements in the differential between the West German domestic and euro-deutschemark interest rates are broadly consistent with the model developed above. They suggest first that, in the absence of restrictions or discriminatory reserve requirements on foreign inflows, domestic banks will arbitrage with the euro-market to equalise the costs of borrowing in the two markets and consequently to place a lower limit on the euro-deutschemark rate and, when combined with the arbitrage activity of US banks, an upper arbitrage limit on the forward discount on dollars; and secondly that discriminatory domestic currency reserve requirements—particularly those which impose large penalties on the growth of foreign-owned liabilities—are effective in reducing flows to the domestic market, even though they may be, to some extent, circumvented by the arbitrage activities of corporations.

Some implications of the model

The above analysis has attempted to explain some of the systematic relationships which have been observed between domestic and euro-currency deposit rates. This has suggested that, in the absence of restrictions on the free flow of capital, domestic banks will arbitrage between the domestic and euro-currency markets so as

to equalise, at the margin, the effective cost of loanable funds to banks in the two markets. Recent empirical experience is broadly consistent with this hypothesis.

An implication of this analysis relates to the applicability of certain frameworks which have been used to analyse the credit-creating potential of the euro-markets. Some of these treat the euro-market as if it were an autonomous or closed banking system;[1] or at least one with an independent set of interest rates.[2] Others suggest that, because euro-banks are not legally obliged to hold reserves against their deposits, any shift of deposits to the external market could increase, by the size of reserve balances released, the volume of loans that may be made from a given deposit base.[3]

The analysis of this article, however, suggests that the euro-currency market is not independent of domestic banking systems and that, if capital flows are unrestricted, interest rates in the two markets are extremely closely related. Indeed in such circumstances the euro-currency market appears very much as an integrated part of domestic banking systems, with even small changes in liquidity in one market generating compensating flows from the other. Furthermore, it is not the case that flows channelled through the euro-market automatically escape the imposition of domestic reserve requirements. A sizable proportion of euro-currency deposits are supplied by banks from their domestic currency deposits—as a rough and rather conservative estimate these may represent 20% of the market's net sources of funds—and at least some proportion of foreign currency deposits are lent by euro-banks to banks in the country of issue of the currency or converted by euro-banks into the domestic currency of the country where they operate. In either of these cases, the flows which pass through the euro-markets will attract domestic reserve requirements. Indeed funds which are channelled through the euro-currency market will only avoid domestic requirements when euro-banks intermediate directly between non-banks, and even then euro-banks will hold prudential reserves against the non-bank deposits.

One possible impact that the market may have—though one that is not readily measurable—is, like any efficient financial intermediary, to increase the velocity of circulation of money. However, if the euro-markets do have some impact on the velocity of circulation, it is not immediately clear that this is independent of domestic monetary policies---changes in domestic interest rates and reserve requirements will directly influence the level of euro-currency interest rates and hence the amount of credit extended by the euro-currency and domestic banking systems combined.

These considerations reinforce the main thesis of this article which is that the euro-markets are not independent of domestic banking systems and that it is misleading to study them in isolation.

[1] For example, models which attempt to apply fractional reserve multiplier analysis.

[2] For example, general equilibrium or portfolio balance approaches. See J. Niehans and J. Hewson, 'The Eurodollar Market and Monetary Theory', *Journal of Money, Credit and Banking*, February 1976, pages 1–27, for a critical discussion of the various approaches.

[3] G. Dufey and I. H. Giddy, page 162 (see footnote [1] on page 35).