International Money Markets and Flexible Exchange Rates

Stanley W. Black

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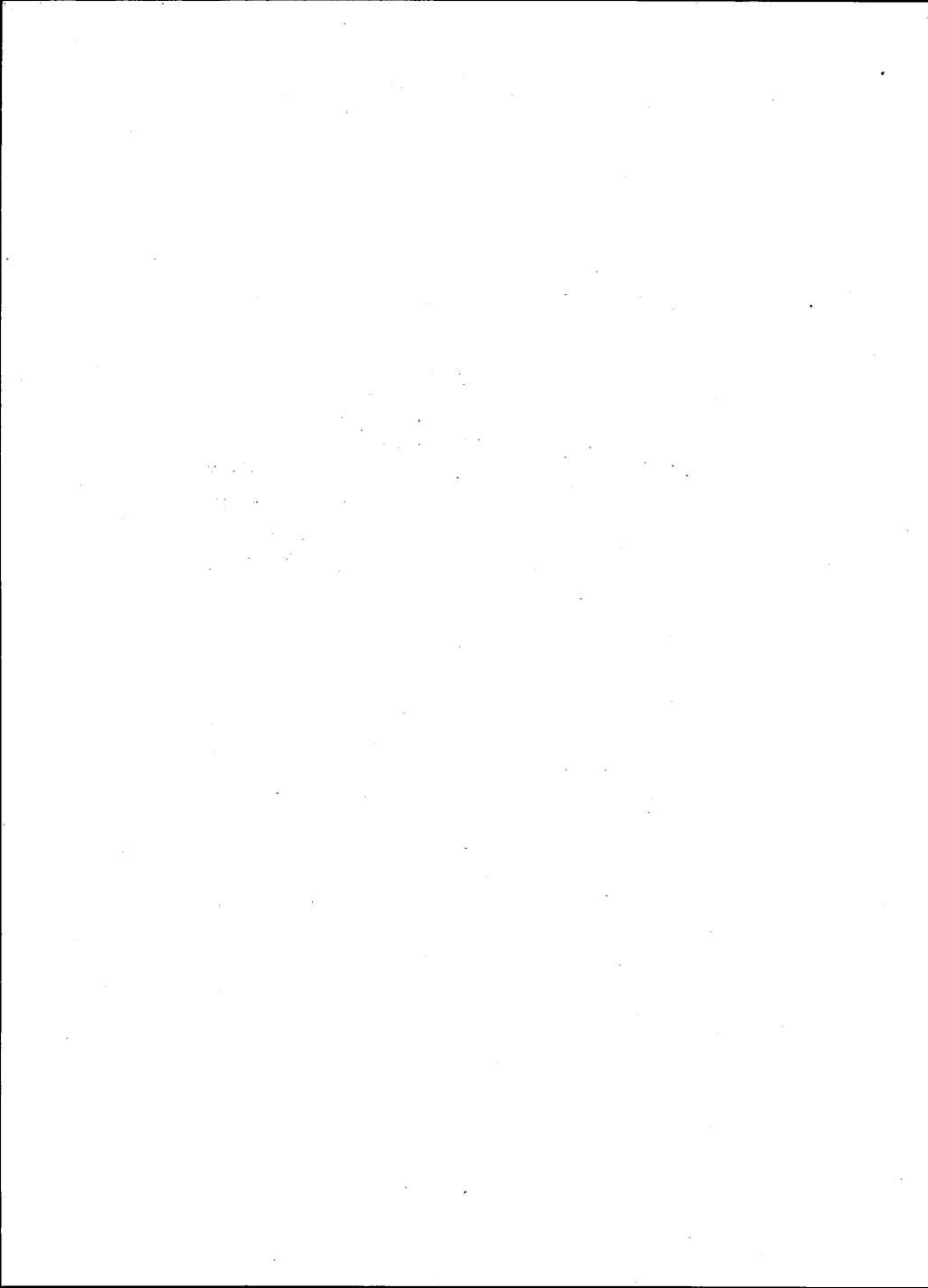
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ERRATA

The definition of the covered interest differential on page 36 as $z = NYB - LB + u$ should be corrected to $z = LB - NYB - u$.

In the Glossary of Symbols, z should be defined as $R_f - R_d - u$ instead of $R_d - R_f + u$.

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I. INTRODUCTION

The international monetary crises of the 1960's and 1970's have raised hard questions concerning the inherent stability of the monetary system based on the Bretton Woods Agreement. Many economists now believe that the combination of independent national monetary policies, pegged exchange rates, and unrestricted international capital movements is unstable in principle.[1]

The instability principle can be stated for the "dilemma" case of a country with a balance-of-payments deficit and high unemployment. Low interest rates encourage short-term arbitrage funds to flow toward countries with high interest rates, with the arbitrageurs protecting themselves against exchange loss by selling foreign exchange forward at the same time they are buying it spot. Under flexible exchange rates, the resulting pattern of forward rates would approximate those indicated by the interest-parity theory: the currencies of countries with high interest rates would be at discounts forward and those of countries with low interest rates at a premium, and covered interest differentials would tend to disappear. The operation of interest arbitrage would be self-limiting. At the same time, speculators with diverse views on expected future spot exchange rates would tend to be long forward in the currencies of high-interest-rate countries and short forward in the low, engaging in stabilizing speculation. Under a regime of pegged exchange rates, by contrast, the loss of reserves implied by the flow of funds out of countries with low interest rates can instill doubts about the ability of the authorities to maintain the pegged rate. The famous "one-way bet" on devaluation replaces dispersed expectations with the politician's nightmare — a bear attack by speculators and businessmen seeking to avoid the effects of devaluation. The currency of the low-interest country can move to a discount forward, not a premium, providing an incentive to additional arbitrage flows toward high-interest countries and accelerating the loss of reserves.[2]

[1]See, for example, Halm (1969). For an earlier statement, see Meade (1951, Chap. XVII).

[2]For a discussion of this case that omits forward exchange markets, see Halm (1969, pp. 12–15).

There are, broadly, three possible remedies for this kind of instability: (1) greater international coordination of monetary policies, tantamount to abandonment of independent national monetary policies; (2) controls on international money markets, tantamount to restrictions on convertibility; and (3) resort to flexible exchange rates, including such variations as wider bands and the crawling peg. Economists have a responsibility to bring all available evidence to bear on the crucial questions of this debate, especially the roles of arbitrage and speculation under fixed and flexible exchange rates.[3]

This study presents a theoretical and empirical analysis of a two-country model of international money markets with flexible spot and forward exchange rates. The theoretical model provides a framework for understanding the interrelationships among the many variables in the empirical data. There is an underlying symbiosis between the theoretical and empirical parts of the study: indeed, I can confidently state that neither part would have been completed without the stimulus of the other.

The empirical portion of this study uses the only body of data that gives commitments in *both* spot and forward exchange markets for a period of flexible exchange rates — the U.S. Treasury Department's *Statistics of Capital Movements between the United States and Foreign Countries* for the late 1930's. These data are used to test hypotheses that are the basis of the properties of the theoretical model. Other hypotheses tested relate to the extent of covering in forward markets and the stabilizing or destabilizing nature of speculation. The results should help to resolve conflicting assertions made about the forward exchange market and flexible exchange rates. In the absence of direct empirical evidence, such assertions have run all the way from Sohmen's (1969) belief that the forward market removes all uncertainty caused by flexible exchange rates[4]

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[3]For a general discussion of the dilemma and its possible resolutions, see Cooper (1968). The flexible-exchange-rate alternative is discussed by Lanyi (1969).

[4]Sohmen believes that, because the volume of purchases equals the volume of sales in any market (spot or forward), the average price agreed on in forward contracts is the same as the average spot price that would occur on the given day without forward dealings. Thus insurance against exchange risk is provided free, on average, by the forward market. The argument assumes that traders know perfectly in advance the dates at which they will need domestic or foreign currency. In actual fact, they will undoubtedly have unexpected needs arising from time to time and so will not be able to anticipate fully their exchange requirements. This uncertainty leads traders to hold transactions and precautionary balances of foreign exchange that cannot be perfectly covered because the date of their future use is not known. Thus forward markets are only a partial answer to the problem of exchange risk.

to Kindleberger's (1970, pp. 93–108) view that the forward market can be ignored.

The study is organized in the following way. Chapter II develops a two-country model in which the money markets and spot and forward foreign-exchange markets determine interest rates and spot and forward exchange rates. This model is a substantial generalization of my previous (1968) model[5] in the following respects: (1) interest rates in both countries are endogenous; (2) the trichotomy of speculators, arbitrageurs, and hedgers has been dropped, in response to criticism by Kenen (1965) and Leamer and Stern (1972); (3) speculation is allowed in both spot and forward exchange markets; (4) *stock* equilibrium conditions determine the various rates, instead of flow conditions; (5) the monetary sector of one country is developed fully. The complete comparative static properties of the model are derived in the Appendix and presented in Chapter III, including the effects of monetary policies under conditions of pegged and flexible exchange rates, the mechanics of pegging and of sterilizing capital flows, and government intervention in the forward exchange market.

Chapter IV extends the theory of rational expectations to a model with both spot and forward exchange markets. The response of the model to exogenous shocks affecting expectations suggests a way to specify dummy variables used in the empirical work. These are needed to represent expectations concerning the exchange rates. After a discussion of sources of data and methods of estimation in Chapter V, Chapter VI turns to empirical equations based on the theoretical model and using data on the short-term claims and liabilities of the United States vis-à-vis the United Kingdom for the period January 1936 to September 1939. Equations are also presented — for the first time, as far as I know — relating bank and nonbank positions in the forward market, as shown in *Statistics of Capital Movements*, to spot foreign-exchange holdings and trade commitments. The results show that forward covering was widely practiced.

Chapter VII presents equations for spot and forward commitments using dummy variables to represent expected future spot exchange rates based on the rational-expectations hypothesis. These variables allow tests of hypotheses that certain claims or liabilities were covered sufficiently in the forward market so that changes in expected future spot exchange rates did not significantly affect them. The findings corroborate the results obtained from direct estimates of equations for the forward market.

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[5]That model was an extension of Tsiang's well-known work (1959). For a different extension, see Sohmen (1969).

Chapter VIII examines numerous hypotheses concerning the specific events represented by the dummy variables and draws conclusions on the stabilizing or destabilizing nature of speculation and on the division of speculative activity between spot and forward markets. (Stabilizing behavior is defined here as behavior tending to reduce the variance of exchange rates around their equilibrium levels.)[6]

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[6]The reader of Chapter VIII will have to decide for himself whether my use of the equilibrium concept is acceptable (for guidance, see Machlup, 1958).

II. A TWO-COUNTRY MODEL

The model is designed to explain the behavior of domestic and foreign interest rates and spot and forward exchange rates. The domestic economy is disaggregated into a banking sector, a monetary authority, and a private nonbank sector, while the foreign economy remains aggregated. Eight assets are introduced: high-powered money, dollar (domestic-currency) deposits, dollar loans, domestic government securities, sterling (foreign-currency) deposits, sterling loans, gold, and sterling deposits for future delivery. As deLeeuw (1965, p. 482) explains in a similar context, "It is convenient to begin a verbal description of this model by comparing it with a simpler hypothetical model. In this simpler model, one demand and one supply function for each market would determine the amount outstanding and the interest rate in that market." In a model with N markets, the wealth identity (analogous to Walras's Law) shows that one of the markets is redundant, so that only N-1 interest rates could be determined, and one would be set at zero. DeLeeuw continues, "In some cases a supply relationship could be replaced by defining a supply or interest rate as exogenous." In the model developed in this paper, the rate of interest on high-powered money is arbitrarily set at zero. In addition, yields on three other assets are taken as fixed: gold, dollar deposits, and dollar loans. The fixed yields imply an infinitely elastic demand for dollar loans and an infinitely elastic supply of dollar deposits by banks, as well as an infinitely elastic demand for gold by the monetary authority as a consequence of a pegged gold price. The remaining five markets will generate five excess-demand functions, only four of which will be independent because of the wealth identity. The four independent excess-demand functions will suffice to determine two interest rates and the spot and forward exchange rates. With this preview, the model will now be set out.

The model consists of four sectors — three domestic and one foreign. The sectors, with their symbols following in parentheses, are: the domestic monetary authority (m), the domestic banking system (b), the domestic nonbank private sector (p), and the foreign sector (f). The United States and the United Kingdom are identified with the domestic and foreign

countries, respectively. The foreign sector includes the gold and sterling assets of the British Exchange Equalization Account (e).[1]

There are four domestic financial instruments, with their symbols following in parentheses: U.S. short-term government securities (S); bank dollar deposits, both demand and time (DD); high-powered money, consisting of total bank reserves (TR) and domestic currency (C); and, finally, bank dollar loans and acceptances (DL).

There are two foreign financial instruments: sterling bank deposits and other liabilities of British banks (SD) and sterling loans and acceptances (SL).

There are also an international asset, gold (G), and a contingent asset, the volume of outstanding contracts for the forward sale (FS) or purchase (FP) of foreign currency. Nonbanks or foreigners are on the selling side of forward sales, and domestic banks on the buying side; nonbanks or foreigners are on the buying side of purchases, and domestic banks on the selling side.[2] Since nothing is known about the maturity structure of these contracts, the three-month forward contract is taken to be representative. The quantities of *all* these financial instruments are measured *in dollars* at the *end of a specific period*, the *week*, for this model is to be applied to weekly data. The spot exchange rate, x dollars per pound, is used to convert sterling assets to dollars. Time subscripts are omitted when all variables relate to the same period. Thus a three-month forward contract calls for the delivery of a specified quantity of sterling on a date three months from the week in which the contract is concluded at a price agreed upon at the time it is concluded. This price is the forward exchange rate (y dollars per pound for delivery in thirteen weeks).

The resulting structure can best be illustrated by displaying the T-accounts of the sectors and the banks' foreign-exchange position sheet. Exogenous variables are shown with a bar on top (for example, $\bar{S}$, the total stock of domestic government securities). Where it is necessary to identify the sector owning a claim or owing a liability, that is shown by a subscript (for example, S_p, the private sector's holdings of government

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[1]The Account's operations are represented by exchange of sterling for gold. Prior to the collapse of the gold bloc in September 1936, many day-to-day operations were in French francs. The francs were always immediately exchanged for gold with the Bank of France, since the Account's charter did not allow the holding of positions in foreign currencies. After the conclusion of the Tripartite Monetary Agreement and its Protocol, dealings in dollars were frequent, but again positions were not maintained. Many dealings were directly in gold, since the fixed dollar price of gold provided an indirect influence on the dollar-sterling exchange rate via the gold price (see Waight, 1939).

[2]The data used in the empirical section are net of transactions among banks.

securities). The net worths of the private sector and the foreign sector are denoted as $\overline{P}$ and $\overline{B}$, respectively, while the banks' net foreign-exchange position is assumed to be zero.[3]

The banks hold reserves against a required ratio (k) applied to dollar and sterling liabilities, plus some excess reserves (ER). They supply loans (DL) and deposits (DD) in any amount demanded at a fixed interest rate (zero for demand deposits). The loan rate may be changed from time to time to regulate demand but is assumed to be fixed on a short-term (week-to-week) basis. The nonbank private sector borrows from the banks (DL_p) and invests its portfolio in accordance with considerations of diversification and yield. Exporters are likely to have sterling deposits (SD_p). Importers have sterling liabilities (SL_p), which may show up, however, as bank-acceptance liabilities (SL_b) offset on the balance sheet by a corresponding loan to the importer (DL_p). Exporters and importers are usually the main source of nonbank demand for purchase and sale of sterling forward.

(2.1)
$$TR \equiv k(DD + SL_b) + ER$$

(2.2)

Domestic Banks (b)

TR	DD
S_b	
DL	SL_b
SD_b	

(2.3)

Foreign (f)

DD_f	DL_f
SL_f	$\overline{SD}$
S_f	$\overline{B}$
$\overline{G}_e + G_f$	
$\overline{SD}_e + SD_f$	

(2.4)

Nonbank Private (p)

DD_p	DL_p
S_p	SL_p
C	$\overline{P}$
SD_p	

[3]A less detailed model of this sort is given in Hendershott (1968). His model contains only one interest rate and no exchange rates.

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(2.5)   *Banks' Position Sheet*

SD_b	SL_b
	BFP

The foreign sector is consolidated, and the money supply is assumed for simplicity to be a fixed stock of sterling deposits $(\overline{SD})$.[4] Thus a substantial proportion is held by the foreign sector (SD_f). Foreign exporters and importers have dollar loans and deposits. Their covering of exchange risk is done in the London forward market, which of course affects the New York market through British banks' adjustment of their positions. The Banks' Position Sheet contains the domestic banks' spot and forward foreign-exchange commitments.

In addition to the four identities implied by the balance sheets given above, there are eight equations balancing supply and demand, one for each of the financial instruments in the model:

		Instrument	*Yield*
(2.6)	$TR + C = \overline{G_m + S_m}$	High-powered money	0
(2.7)	$\overline{S} = S_b + S_p + S_f$ $+ \overline{S_m + G_m} - G_m$	Government securities	R_d
(2.8)	$DL = DL_p + DL_f$	Dollar loans	fixed
(2.9)	$DD = DD_p + DD_f$	Dollar deposits	fixed
(2.10)	$\overline{SD} = SD_p + SD_b$ $+ SD_f + \overline{SD}_e$	Sterling deposits	R_f
(2.11)	$SL_p + SL_b = SL_f$	Sterling loans	R_f

[4]Polly Allen has pointed out that, for $\overline{SD}$ to be exogenous, the foreign government must fix the *dollar* value of sterling deposits. To avoid this assumption, the *foreign* demand and supply functions can be defined in terms of sterling. All the variables with suffix e or f in equations (2.7) to (2.12) would be preceded by x, to convert them from sterling into dollars. In (2.10) and (2.14) $\overline{SD}$ and $\overline{B}$ would likewise be preceded by x. The left-hand side of the balance-of-payments equation would become $x_{t-1}\Delta B_t$, since valuation effects are excluded from the balance-of-payments statistics. The same modifications would carry through to equations (2.33) to (2.38). See section 1 of the Appendix for the role of valuation effects in this case.

		Instrument	*Yield*
(2.12)	$\overline{G} = G_m + G_f + \overline{G}_e$	Gold	0
(2.13)	$FS = FP + BFP + \overline{H}$	Forward sterling	—

Note that the domestic monetary authority is assumed to offset gold flows (G_m), so that its open-market portfolio (S_m) is an endogenous variable (equal to $\overline{S_m + G_m} - G_m$). In equilibrium the high-powered money stock is equal to the monetary authority's holdings of gold and government securities.[5] The market for forward sterling matches forward sales by nonbanks and foreigners (FS) with forward purchases by the same groups (FP) and with net forward purchases of the domestic banks (BFP) and the British Exchange Equalization Account ($\overline{H}$).

By substituting the three private balance-sheet identities into equation (2.7) and solving equations (2.7) through (2.12), one may verify that there is an additional dependent equation implied by the model, the wealth identity:

$$(2.14) \qquad \overline{P} + \overline{B} \equiv \overline{G} + \overline{S} \ .$$

Since claims on real capital have been ignored in this model, world net *private* worth ($\overline{P} + \overline{B}$) is the sum of gold and claims on the domestic government.

The balance-of-payments equation (2.15) states that import deliveries (IMD) minus export deliveries (EXD) in period t equals the increase in net worth of the foreign sector in period t:

$$(2.15) \qquad \overline{B}_t - \overline{B}_{t-1} = IMD_t - EXD_t = IMO_{t-1} - EXO_{t-1} \ .$$

It is assumed that these deliveries are predetermined by *orders* for exports (EXO) and imports (IMO) in earlier periods.[6] *Current* orders for exports and imports are endogenous variables in the current week, however. The first difference of the foreign-sector balance sheet (2.3) shows that the trade deficit $\Delta \overline{B}$ is equal to the short-term capital inflow plus gold outflow from the domestic country.

Including orders for exports and imports and the variables in equations (2.1) to (2.14), twenty-six endogenous quantity variables have been introduced so far. There are four rate variables, measured as averages over the

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[5]Therefore, equation (2.6) is *not* an identity. (For a similar approach, see Tobin, 1969, or deLeeuw, 1965.)

[6]For the dynamics of orders, deliveries, and payments in foreign trade, see Hansen (1961.)

week: the domestic short-term rate of interest (R_d), the foreign short-term rate of interest (R_f), the spot exchange rate expressed in dollars per pound (x), and the three-month forward exchange rate expressed in dollars per pound for delivery in thirteen weeks (y). These thirty variables are explained by five independent identities, eight balance equations, and seventeen behavior equations.

The behavior equations, with assumed signs, are provided in Table 2.1.[7] The basic assumption about behavior is that holdings of an asset depend positively on the asset's own yield and negatively on the yields of competing assets, as well as depending on certain quantity variables that measure the implicit services yielded by the asset.

TABLE 2.1

SIGNS OF PARTIAL DERIVATIVES OF BEHAVIOR EQUATIONS [a]

Asset	Variable	R_d	R_f	x	$w(x)$	y	$EXD - IMD$	SL_p	SD_p
(2.16) Sterling deposits	SD_b	−	+	−	+	+			
(2.17) Sterling deposits	SD_p	−	+	−	+	+	+		
(2.18) Sterling deposits	SD_f	−	+	−	+	+			
(2.19) Dollar loans	DL_p	+	+	−	+	+			
(2.20) Dollar loans	DL_f	+	+	−	+	+	+		
(2.21) Dollar deposits	DD_p	−	−	+	−	−			
(2.22) Dollar deposits	DD_f	−	−	+	−	−	−		
(2.23) Sterling loans	SL_b	+	−	+	−	−			
(2.24) Sterling loans	SL_p	+	−	+	−	−	−		
(2.25) Domestic securities	S_f	+	−	+	−	−			
(2.26) Currency	C	−							
(2.27) Excess reserves	ER	−	−	+	−	−			
(2.28) Forward purchases[b]	FP				+		−	+	
(2.29) Forward sales[b]	FS				−	+	+		+
(2.30) Gold	G_f	−	−	−			+		
(2.31) Export orders	EXO				+	+			
(2.32) Import orders	IMO				−	−			

[a]One equation has been left as a residual equation in each balance sheet, ensuring that the "adding-up" restrictions on each balance sheet are satisfied. This is equivalent theoretically to specifying all equations and then specifying the "adding-up" restrictions separately (see Brainard and Tobin, 1968). The residual variables, whose coefficients just balance out the coefficients in the nonresidual variables, are S_b, SL_f, S_p, and BFP.

[b]In these equations, the trade variable is $EXO - IMO$.

[7]All behavior equations are assumed to be continuous and differentiable functions of their arguments.

In the case of foreign assets, the yields to domestic residents must be corrected for changes in exchange rates. Suppose that holdings of foreign assets are covered through forward sale of foreign exchange. Under the simplifying assumption of zero transactions costs, a dollar is exchanged for $1/x$ units of sterling at the spot exchange rate and invested in the foreign asset to yield R_f in three months. Covering the foreign-exchange position is accomplished by selling the anticipated foreign-exchange receipts forward, for delivery on maturity of the investment, obtaining in consequence y dollars per pound. Thus covering converts a dollar today into y/x dollars in the future at a cost of $400(x - y)/x$, measured in per cent at an annual rate. The covered foreign interest rate is then $R_f - 400(x - y)/x$.

If the foreign asset is *not* covered, the sterling will be repatriated at the spot rate ruling at maturity of the asset. The expected future spot rate is defined as $w(x)$, an increasing function of the current spot rate, with elasticity less than unity. The *expected* yield on the uncovered foreign asset is then $R_f - 400(x - w)/x$.

The general form of the demand equations in this model can now be expressed for any asset A as $A = A(R_d, R_f - 400(x - y)/x, R_f - 400(x - w)/x, EX - IM)$. Holdings of sterling deposits, for example, respond negatively to the domestic interest rate and positively to the covered and uncovered foreign rates. An increase in the level of exports would increase desired holdings of sterling deposits. Dollar loans and deposits may appear from Table 2.1 to be exceptions to the rule that asset holdings respond positively (and liabilities negatively) to their own yields, but in fact the "own yields" on these instruments are fixed. The domestic interest rate is therefore the yield on a *substitute* asset, government securities, and has the usual negative effect on holdings of dollar deposits (positive effect on loans).

Note that dollar loans to foreigners should increase with an increase in exports. Increased imports are assumed to raise desired holdings of dollar deposits by foreigners and desired sterling loans to domestic residents.

Currency is assumed to be a substitute for domestic securities, and excess reserves are substitutes for either domestic or foreign securities. Foreign gold holdings are substitutes for foreign security holdings (uncovered) or domestic security holdings (covered).

In the forward market, the outstanding volume of nonbank and foreign contracts to *purchase* forward foreign exchange from banks (*FP*) is assumed to depend on the stock of sterling liabilities and the flow of import orders that is available to be covered through forward purchases. The speculative purchase of forward exchange is based on a profit calculation.

The purchase of three-month forward exchange at y dollars per pound implies that, for every dollar of commitment, one obtains $1/y$ pounds for future delivery. If these can be sold for dollars at the expected future spot rate w, the expected profit per dollar of commitment is $400(w-y)/y$ per cent at an annual rate. From this profit one would deduct the interest cost of any margin required by the contracting bank as security. Speculative purchases are taken to be an increasing function of the expected rate of profit. Symmetrically, the outstanding volume of contracts to *sell* forward foreign exchange to banks (FS) is assumed to depend positively on the volume of sterling deposits and the flow of export orders. The expected rate of profit on forward sales, $400(y - w)/y$, has a positive effect on forward sales.

The final two equations in Table 2.1 relate export and import orders to the expected future spot exchange rate or the forward rate, depending on whether the anticipated foreign-exchange receipts or payments havě been covered forward or not.

The model may now be solved by ignoring three of the eight markets, gold, dollar loans, and dollar deposits, since they have fixed yields. There remain five excess-demand and -supply functions in the four unknown rates: R_d, R_f, x, y. Setting any four of these excess demands and supplies equal to zero provides the solution to the model. The net excess-demand function for domestic government securities (D) is obtained by substituting into equation (2.7) the equations for S_p and S_b implied by the balance sheets of the private and bank sectors. The result, after cancellations and substitutions, is defined as the excess-demand function and is set equal to zero in (2.33):

$$(2.33)\ D(\overset{+}{R_d},\overset{-}{R_f},\overset{+}{x},\overset{-}{y}) \equiv G_f + S_f + DD_f + SL_b + SL_p - DL_f - SD_b$$
$$- SD_p + \overline{G}_e - k(DD_p + DD_f + SL_b) - ER - C + \overline{P} - \overline{G} - \overline{S}$$
$$+ (\overline{S_m + G_m}) = 0\ .$$

The signs of the partial derivatives shown above the arguments of the function D ( ) are based on Table 2.1, with one additional assumption. With domestic loan and deposit rates fixed, an increase in the rate of interest on domestic securities causes foreigners to hold fewer dollar deposits, to borrow more dollars, and to switch out of gold ($DD_f - DL_f + G_f$ falls). It is assumed that nonbank and foreign demand to hold domestic securities rises more than enough to offset these switching effects. This assumption is also required to obtain the sign in equation (2.35), but not for the signs in equations (2.34), (2.36), or (2.37). The ex-

cess-demand function for foreign securities (F) comes from equation (2.10):

$$(2.34) \qquad F(\overset{-}{R_d},\overset{+}{R_f},\overset{-}{x},\overset{+}{y}) \equiv SD_p + SD_f + SD_b + \overline{SD_e} - \overline{SD} = 0 \;.$$

The net domestic assets held by foreigners less net foreign assets held by domestic residents is obtained by substituting into equation (2.11) the expression for SL_f given by the foreign-sector balance sheet (2.3), and represents the excess-supply function for spot foreign exchange (X):[8]

$$(2.35) \quad X(\overset{+}{R_d},\overset{-}{R_f},\overset{+}{x},\overset{-}{y}) \equiv G_f + DD_f + SL_b + SL_p + S_f - DL_f -$$
$$SD_p - SD_b + \overline{G_e} - \overline{B} = 0 \;.$$

The excess-supply function for forward foreign exchange (Y) comes from equation (2.13), after substituting terms from the banks' Position Sheet (2.5):

$$(2.36) \qquad Y(\overset{-}{R_d},\overset{+}{R_f},\overset{-}{x},\overset{+}{y}) \equiv FS - FP + SD_b - SL_b - \overline{H} = 0 \;.$$

Finally, the excess-demand function for high-powered money is obtained from equation (2.6):

$$(2.37) \quad L(\overset{-}{R_d},\overset{-}{R_f},\overset{+}{x},\overset{-}{y}) \equiv C + ER + k(DD_p + DD_f + SL_b)$$
$$- (\overline{G_m + S_m}) = 0 \;.$$

All five of these equations contain only exogenous variables or variables for which behavior equations have been provided in Table 2.1. Nevertheless, only four of these five equations are independent, since

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[8]Basevi (1972) uses a different framework for analysis of the spot exchange market. The balance-sheet approach of equation (2.35) is equivalent, by (2.15), to using the balance-of-payments account as a statement of sources and uses of spot foreign exchange. Basevi, on the other hand, states that ". . . supplies and demands coming into the foreign exchange market do not coincide with the credit and debit items of the balance of payments." On exports under tied foreign-aid grants, I agree with him. But to delete ". . . all purchases and sales of goods and services for which there is a lag between the time of order and the time when payments are due . . ." seems mistaken to me. Under his treatment, such items are treated as covered in the forward market, hence removed from the spot market. Thus the covering of hedgers' commitments does not affect the spot market. Speculators' covering, on the other hand, does affect the spot market. Why the difference? Basevi has also pointed out that the foreign-sector balance sheet cannot be simply related to the market for foreign exchange if there are deposits denominated in domestic currency held in foreign banks (i.e., Eurodollars).

(2.38) $\qquad D(\quad) + L(\quad) - X(\quad) \equiv \bar{P} + \bar{B} - \bar{G} - \bar{S} \equiv 0 \,,$

by the wealth identity (2.14).

The subsequent analysis will deal only with equations (2.33) to (2.36), a choice that amounts to adoption of a loanable-funds approach to the determination of the domestic interest rate. An alternative liquidity-preference approach would include only equations (2.34) to (2.37). Substituting from the behavior equations into (2.33) to (2.36), we have four equations in four unknowns, R_d, R_f, x, y. It is assumed that these equations have a positive solution (R_d^*, R_f^*, x^*, y^*).

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III. PROPERTIES OF THE MODEL:
COMPARATIVE STATICS AND STABILITY[1]

A graphical picture of the solution of the model will facilitate the presentation of its comparative static properties. Consider first the two money-market equations, (2.33) and (2.34). For a given set of exchange rates, one can trace out the combinations of domestic and foreign interest rates (R_d, R_f) that will maintain equilibrium in each money market. Let D_i, F_i $(i = 1,2,3,4)$ represent the partial derivatives of equations (2.33) and (2.34) with respect to R_d, R_f, x, y. Total differentiation of equation (2.33), holding x and y constant, yields the equation of the DD curve, which represents those combinations of domestic and foreign interest rates that maintain equilibrium in the market for domestic government securities: $D_1 dR_d + D_2 dR_f = 0$. The slope of the DD curve, $dR_d/dR_f = -(D_2/D_1) > 0$, is positive, since an increase in the "own interest rate" requires an increase in the competing interest rate to maintain a state of zero excess demand. Similar results follow for the FF curve, representing combinations of interest rates that maintain equilibrium in the market for foreign securities: $F_1 dR_d + F_2 dR_f = 0$, with the slope $dR_d/dR_f = -(F_2/F_1) > 0$.

I now make a key assumption concerning the excess-demand functions (2.33) to (2.36), the dominant-diagonal assumption, which is shown in section 2 of the Appendix to be a sufficient condition for local stability of the model. Under this assumption, the slope of the FF curve exceeds unity, and the slope of the DD curve is less than unity $(D_1 > -D_2, F_2 > -F_1)$.[2] The curves are shown in Figure 3.1. For any given values of the exchange rates x and y and hence the discount $x-y$, Figure 3.1 determines the values of R_d and R_f and hence the differential $R_f - R_d$.[3] An increase in the

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[1] A mathematical treatment of the properties of the model is given in the Appendix. The reader who is interested only in the empirical results of the paper may omit Chapter III.

[2] See section 1 of the Appendix. The assumption implies that the coefficient of the own rate, D_1 for the DD curve, exceeds the sum of the absolute values of the "cross rate" coefficients, $-D_2 + D_3 - D_4$. Then $D_1 > -D_2$, since $D_3 > 0 > D_4$. Similarly, $F_2 > -F_1 - F_3 + F_4$, so $F_2 > -F_1$. The Appendix makes an additional assumption, Uekawa's condition, to guarantee exact comparative-static results from Figures 3.1 and 3.2.

[3] Only the discount $x - y$ matters, under the key simplifying assumption that $D_3 = -D_4, F_3 = -F_4$. The assumption does not affect any of the properties of the model, while enabling four equations to be dealt with in two dimensions. The Appendix does *not* rely on this assumption.

FIGURE 3.1

MONEY-MARKET EQUILIBRIUM*
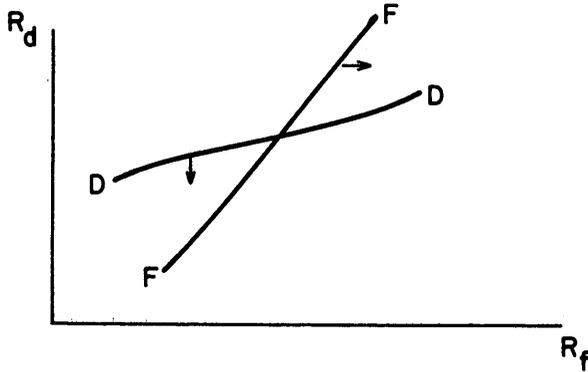
*Arrows show effects of increased forward discount.

spot exchange rate x (or decrease in the forward rate y) will cause the DD curve to shift down, as shown by the arrow, because the higher discount on forward exchange reduces the attractiveness of foreign securities. To maintain equilibrium in the market for domestic securities, the domestic interest rate must fall for any given value of the foreign rate. At the same time, the FF curve would shift to the right, as shown by the arrow, since the reduced attractiveness of foreign securities requires an increase in the foreign interest rate to maintain the level of demand in the foreign market, for any given value of the domestic interest rate. The result is that an increase in the forward discount $x - y$ must raise the interest differential $R_f - R_d$, if equilibrium in the money markets is to be maintained. Thus the combinations of $x - y$ and $R_f - R_d$ that maintain equilibrium in money markets can be traced out on a positively sloped curve called the MM curve, shown in Figure 3.3 below. The slope of the MM curve is less than unity.[4]

Similarly, given interest rates, one can use equations (2.35) and (2.36) for the exchange markets to trace out the combinations of spot and forward exchange rates that will maintain equilibrium in each exchange market (see Figure 3.2). Again the slopes of these curves, labeled XX and YY, will both be positive. For the XX slope, $dy/dx = -(X_3/X_4) > 0$; for

[4]See section 4 of the Appendix for the proof.

FIGURE 3.2

EXCHANGE-MARKET EQUILIBRIUM*
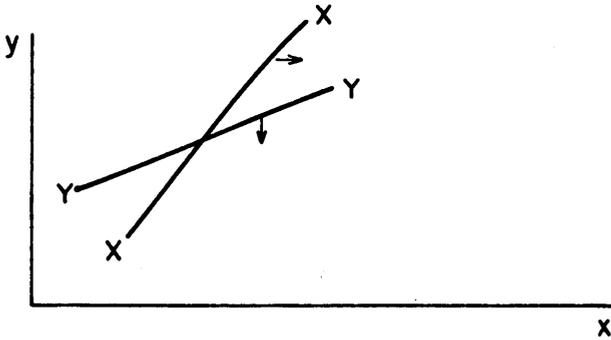
*Arrows show effects of increased interest differential.

the YY slope, $dy/dx = -(Y_3/Y_4) > 0$. In this case, the slope of the XX curve exceeds unity, and the slope of the YY curve is less than unity, since $X_3 > -X_4$ and $Y_4 > -Y_3$ from the dominant diagonal assumption. Given the interest rates R_d and R_f and the differential $R_f - R_d$, these curves determine the exchange rates x and y and the discount $x-y$.[5] An increase in the foreign interest rate R_f (or decrease in the domestic rate R_d) will cause the XX curve to shift to the right, as shown by the arrow. The reason is that the resulting increased demand for foreign exchange can be checked only by raising the spot exchange rate for any given forward rate, thus increasing the cost of cover. The same change in interest rates would cause the YY curve to shift down, as shown by the arrow, since the desired additional purchases of spot foreign exchange would be covered by additional forward *sales* of foreign exchange. The increased forward supply can be checked by a fall in the forward rate, given the spot rate. Therefore, maintenance of equilibrium in the exchange markets requires that an increase in the interest differential $R_f - R_d$ be matched by an increase in the forward discount $x - y$. Again, a positively sloped curve called the EM curve is traced out in Figure 3.3, in this case with slope greater than unity.[6]

[5]Only the interest differential matters, under the simplifying assumption that $X_1 = -X_2$, $Y_1 = -Y_2$.
[6]See section 4 of the Appendix.

FIGURE 3.3

EXCHANGE- AND MONEY-MARKET EQUILIBRIUM
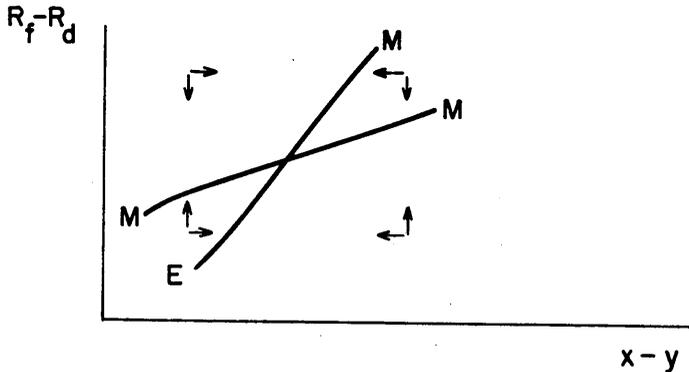
Over-all equilibrium in the model is determined by the interaction of the MM and EM curves. Given the differentials, Figures 3.1 and 3.2 then determine the levels of the interest rates and exchange rates.[7] The simplest demonstration that the MM curve is steeper than the EM curve follows from the stability analysis in section 2 of the Appendix. It is assumed that excess demand in each security market causes the own interest rate to fall ($\dot{R}_d = -D$, $\dot{R}_f = -F$), while excess supply in each exchange market causes the own exchange rate to fall ($\dot{x} = -X$, $\dot{y} = -Y$). These assumptions imply the following behavior for the interest differential and the forward discount: $\dot{R}_f - \dot{R}_d = D - F$, $\dot{x} - \dot{y} = Y - X$. The dynamics of Figure 3.3 may now be examined using these two statements.

Vertically above the MM curve in Figure 3.3, the foreign interest rate R_f has risen relative to the domestic rate. Therefore, the excess demand for domestic securities D has become negative and the excess demand for foreign securities positive. When $D - F$ is negative, however, the interest differential tends to fall. By similar reasoning the differential tends to rise

[7]If the spot exchange rate $x = 1$, a 45° line in Figure 3.3 (not shown) would represent interest parity, since $R_f - R_d = (x - y)/x$. There is no need for the curves to intersect on the 45° line, unless $X_1 = -X_2 = X_3 = -X_4$ and $X(0) = 0$, in which case equilibrium in the exchange market *requires* interest parity. To make this argument rigorous, plot $(1 + R_f)/(1 + R_d)$ against x/y.

below the *MM* curve. These conclusions are shown by the vertical arrows in Figure 3.3.

To the right of the *EM* curve, the spot rate has risen relative to the forward rate, so that $Y - X$ becomes negative, putting downward pressure on the discount. To the left of the *EM* curve, the discount tends to rise. These conclusions are shown by the horizontal arrows.

Because all the arrows point inward to the equilibrium point, the model is stable in this case. If, on the contrary, the *MM* curve were steeper than the *EM* curve, some of the arrows would point away from the equilibrium point, showing the model to be unstable in that case.

We may now proceed to a discussion of the comparative static properties of the model. The mathematical results are derived in section 1 of the Appendix and shown in Table A.1. These short-run results hold the trade balance constant, since $\bar{B}$ is predetermined. As time passes, movements in exchange rates will affect the trade balance and modify the results obtained here.[8]

Domestic Open-Market Purchase

An open-market purchase of securities over and above purchases required to offset gold flows will increase $\overline{S_m + G_m}$ and the high-powered money stock $TR + C$. The reduced supply of domestic securities shifts the *DD* curve down in Figure 3.1. Given exchange rates, the domestic interest rate falls relative to the foreign rate. In Figure 3.3, the *MM* curve shifts up, so that the forward discount and interest differential both rise. These results imply additional shifts in all four curves of Figures 3.1 and 3.2, in the directions of the arrows. The outcome is a decline in both interest rates, a rise in the spot exchange rate, and a decline in the forward rate. From Figure 3.3, the interest differential rises more than the cost of cover; there is a tendency for capital to flow out in response to an easier monetary policy.

Trade Deficit or Long-Term Capital Outflow

An increase in the trade deficit or exogenous capital outflow will raise $\bar{B}$, net short-term assets of foreigners. This affects both the domestic money market and the spot exchange market directly. The fall in domestic net worth lowers the domestic demand for domestic securities and shifts the *DD* curve up. The domestic interest rate rises relative to the foreign rate, given exchange rates, so the *MM* curve shifts down. In

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[8]For a thorough analysis of such effects in a model with exogenous interest rates, see Black (1968, sec. V).

the exchange markets, the increase in the demand for spot foreign exchange shifts the XX curve out, raising the spot rate and shifting the EM curve to the right. From Figure 3.3, the interest differential falls, while the discount rises. The result is that the curves of Figure 3.1 shift in the directions of the arrows, while those of Figure 3.2 shift in the opposite directions. All interest rates and exchange rates rise. The deficit is financed by an accommodating capital inflow.

Foreign Government Debt

If the foreign government increases the supply of foreign securities $(\overline{SD})$, the FF curve shifts to the right and the MM curve shifts up. The increased interest differential $R_f - R_d$ makes the spot exchange rate rise and the forward rate fall, as all curves in Figures 3.1 and 3.2 shift in the directions of the arrows. The net effect, from Figure 3.3, is an increase in the covered differential, inducing a capital flow toward the foreign country.

Intervention in the Spot Exchange Market

If the foreign government buys spot foreign currency for gold $(d\overline{SD}_e + d\overline{G}_e = 0)$ in an attempt to "manage" the flexible exchange rate, the supply of foreign securities falls, shifting the FF curve left, and the demand for spot foreign exchange rises, shifting the XX curve right. The EM curve shifts right and the MM curve down. The result is a decline in both interest rates and a rise in both spot and forward exchange rates. The decline in the interest differential and the rise in the forward discount would induce a capital flow toward the domestic country.

Forward Intervention

When the foreign government buys forward foreign currency $(\overline{H})$, the YY curve shifts up and the EM curve shifts left. The interest differential and the forward discount both decline, so the curves shift in the directions opposite to the arrows. Both spot and forward exchange rates rise, the latter by more than the former. The fall in the forward discount attracts funds to the foreign country, causing its interest rate to decline and the domestic interest rate to rise.

A Digression on Pegged Exchange Rates[9]

Suppose the two governments agree to peg the exchange rate between the limits $(\underline{x}, \overline{x})$. Whenever the rate is at one of the pegs, gold flows be-

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[9]See section 3 of the Appendix for these and other results.

come an integral part of the model. Using equation (2.12) to substitute for $G_f + G_e$ in equation (2.35), the excess-supply function of spot foreign exchange is rewritten as

$$(2.35') \quad X(R_d, R_f, G_m, y) \equiv \overline{G} - G_m + DD_f + SL_b + SL_p + S_f - DL_f$$
$$- SD_p - SD_b - \overline{B} = 0 \, .$$

The other equations of the model remain unchanged, although the spot rate x is no longer a variable, its equilibrating role having been taken by the gold flow G_m. It is still assumed that gold flows are sterilized by the domestic government, so that $G_m + S_m$ is exogenous in equation (2.33).

A graphical picture of the results of pegging is obtained by replacing the XX curve of Figure 3.2 with vertical segments at the upper and lower pegs, $\overline{x}$ and $\underline{x}$ (see Black, 1968, pp. 19–23). When the YY curve intersects a vertical segment, the spot exchange rate is at the relevant peg. A given increase in the interest differential can only cause the YY curve to shift down in this case. Since the spot rate does not rise, a smaller change in the forward discount $x - y$ is registered, compared with the flexible-rate case. Therefore, the EM curve has a steeper slope in the pegged-rate case than under flexible exchange rates. Recall that an open-market purchase of domestic government securities causes the MM curve to shift up. Since the EM curve is steeper when the spot exchange rate is at a peg, a given shift in the MM curve results in a *smaller* increase in both the interest differential and the forward discount than when the spot rate is free to move. A smaller rise in the forward discount means a smaller shift in the DD and FF curves in the directions of the arrows. Therefore, the domestic interest rate declines by less when the spot rate is pegged than when it is free to vary.

Notice that intervention in the forward market will have a smaller effect on the forward exchange rate in the pegged case. An upward shift in the YY curve generates a smaller effect on the forward rate y when the spot rate is at the peg.

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IV. RATIONAL EXPECTATIONS IN EXCHANGE MARKETS

Up to this point, the model's comparative-static and market-period-stability properties have been derived under a simplified assumption concerning expected future exchange rates. A better approach to expectations in exchange markets requires an explicit theory linking current and expected future prices. One approach that has been successfully applied to this problem is the rational-expectations hypothesis of Muth (1961). It is assumed that all participants in the market behave as if they know exactly the parameters of the (linear, dynamic) model that generates market outcomes. Given current information, the model can be used to generate the expected value of each price in the future. This expected value is assumed to be the single-valued expectation of all participants in the market, who are then said to be acting rationally.

The model developed in Chapter II will be simplified by assuming exogenous interest rates, linear demand functions, and a one-period lag of foreign-trade deliveries behind orders. Equations (2.35) and (2.36) for the excess supplies of spot and forward foreign exchange may then be written as

$$(4.1) \quad X(\bar{R}_d, \bar{R}_f, x, y, w) = \alpha(x_t - y_t) + \beta(x_t - w_t) - B_t = 0$$

$$(4.2) \quad Y(\bar{R}_d, \bar{R}_f, x, y, w) = -\alpha(x_t - y_t) + \gamma(y_t - w_t) = 0 .$$

Here the net foreign demand to hold domestic assets (X) has been separated into two parts, that covered in the forward market (α) and that left uncovered (β). In the forward market, arbitrageurs' net demand for forward exchange to cover their net spot holdings of domestic assets are matched by speculators' supply of forward exchange (γ). The final equation required to close the model is equation (2.15), which relates the change in the net worth of the foreign sector to the balance of trade deliveries, and hence to the lagged balance of trade orders.

$$(4.3) \quad \Delta B_t = IMD_t - EXD_t = IMO_{t-1} - EXO_{t-1} = -\delta w_{t-1} .$$

Trade orders are assumed to depend on the expected future spot exchange rate.[1] We now redefine all variables in equations (4.1) to (4.3) as *devia-*

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[1] Thus equations (2.31) and (2.32) have been simplified by leaving out the forward exchange rate. Including the forward rate complicates the model; it still leads to two positive real roots, one greater and one less than unity, but the roots are no longer reciprocals.

tions from (stationary) equilibrium values, in order to concentrate on fluctuations. Muth's approach to his model of commodity markets (without futures trading) is to add stochastic disturbances and then to derive the relationship between expected and actual prices under various conditions on the properties of the disturbances. But my intention is to show the effect on current and future prices of (1) perfectly anticipated future disturbances and (2) completely unanticipated future disturbances. In this case, the disturbances are not stochastic. The rational-expectations hypothesis implies that the spot price currently expected to rule one period in the future is equal to the expected value of the actual spot price one period in the future. In the absence of unanticipated disturbances, the expected value of the actual spot price is exactly the spot price that will come to pass. In symbols, $w_t = \mathcal{E}x_{t+1} = x_{t+1}$, where $\mathcal{E}$ is the expected-value operator.

By solving equations (4.1) and (4.2) to eliminate y_t, one obtains

(4.4) $$\left(\frac{\alpha\gamma}{\alpha + \gamma} + \beta\right)(x_t - w_t) = B_t .$$

Taking the first difference and using (4.3) yields

(4.5) $$\left(\frac{\alpha\gamma}{\alpha + \gamma} + \beta\right)(\Delta w_t - \Delta x_t) = \delta w_{t-1} .$$

Substituting $w_t = x_{t+1}$, one finds

(4.6) $$\Delta x_{t+1} - \Delta x_t = \epsilon x_t ,$$

where $\epsilon = \delta/[\alpha\gamma/(\alpha + \gamma) + \beta]$. This can be rewritten as

(4.7) $$x_{t+1} - 2x_t + x_{t-1} = \epsilon x_t .$$

The equation is solved by letting $x_t = A\lambda^t$, which yields the characteristic equation

(4.8) $$\lambda^2 - (2 + \epsilon)\lambda + 1 = 0 \quad \text{or} \quad \lambda + 1/\lambda = 2 + \epsilon .$$

The roots of this equation are real and positive, and occur as a reciprocal pair, $\lambda_1, \lambda_2 = \lambda_1^{-1}$. Therefore, the solution for the spot exchange rate over time takes the form

(4.9) $$x_t = A\lambda_1^t + B\lambda_2^t = A\lambda_1^t + B\lambda_1^{-t}, 0 < \lambda_1 < 1 ,$$

23

where A and B are arbitrary constants, depending on the initial conditions. The solution has two branches, one going backward in time and one forward. For example, an *anticipated* disturbance at time $t = 0$, denoted by η_0 and added to equation (4.1) or (4.2) will affect previous and future exchange rates in the form $x_t = A\lambda_1^{|t|}\eta_0$, or

$$(4.10) \qquad x_t = \begin{cases} A\lambda_1^t\eta_0 & \text{for } t \geqq 0 \\ A\lambda_1^{-t}\eta_0 & \text{for } t \leqq 0 . \end{cases}$$

An *unanticipated* disturbance, on the other hand, can affect only current and future exchange rates, as shown in

$$(4.11) \qquad x_t = \begin{cases} A\lambda_1^t\eta_0 & \text{for } t \geqq 0 \\ 0 & \qquad t < 0 . \end{cases}$$

The response of the model to a perfectly anticipated disturbance is best shown by working out a specific example.[2] Suppose the domestic government announces far ahead of time that at a specific future date all domestic residents will have to reduce their holdings of foreign assets below some ceiling. At the specified date (say, $t = 0$) there will be a once-for-all repatriation of capital η_0 that can be subtracted from the normal trade deficit, so that $\Delta B_0 = -\delta x_0 - \eta_0$. Solving equation (4.2), one finds that the forward rate reflects only partially the anticipated future spot rate:

$$(4.12) \qquad y_t = \frac{\alpha}{\alpha + \gamma} x_t + \frac{\gamma}{\alpha + \gamma} w_t = \frac{\alpha}{\alpha + \gamma} x_t + \frac{\gamma}{\alpha + \gamma} x_{t+1} .$$

Therefore, we can write down for any period the currently held stock of arbitrage and speculative capital and the corresponding volume of forward contracts as functions of the change in the spot rate:

$$(4.13) \qquad \alpha(x_t - y_t) = -\frac{\alpha\gamma}{\alpha + \gamma}(x_{t+1} - x_t) \quad \text{arbitrage capital,}$$

$$(4.14) \qquad \beta(x_t - w_t) = -\beta(x_{t+1} - x_t) \quad \text{speculative capital,}$$

$$(4.15) \qquad \gamma(y_t - w_t) = -\frac{\alpha\gamma}{\alpha + \gamma}(x_{t+1} - x_t) \quad \begin{array}{c} \text{speculative} \\ \text{forward sales,} \end{array}$$

$$(4.16) \qquad \Delta B_t = -\delta x_t \qquad \text{net imports.}$$

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[2]See Black (1972) for a more thorough analysis of this model.

The solution to the model for a required repatriation of capital, the disturbance η_0 in this instance, can be obtained by setting $x_t = \lambda^{|t|}x_0$, $w_t = x_{t+1}$ and substituting into equation (4.5) at $t = 0$ to get:

$$(4.17) \qquad \left(\frac{\alpha\gamma}{\alpha + \gamma} + \beta\right)(\lambda x_0 - 2x_0 + \lambda x_0) = \delta x_0 + \eta_0 \,,$$

$$(4.18) \qquad \left[\left(\frac{\alpha\gamma}{\alpha + \gamma} + \beta\right)(2\lambda - 2) - \delta\right]x_0 = \eta_0 \,,$$

$$(4.19) \qquad (2\lambda - 2 - \epsilon)x_0 = [2\lambda - (\lambda + 1/\lambda)]x_0 = \frac{\lambda^2 - 1}{\lambda}\,x_0$$
$$= \eta_0 \Big/ \left(\frac{\alpha\gamma}{\alpha + \gamma} + \beta\right),$$

$$(4.20) \quad x_0 = -\lambda\eta_0 \Big/ \left[(1 - \lambda^2)\left(\frac{\alpha\gamma}{\alpha + \gamma} + \beta\right)\right] = [-(1 - \lambda)\eta_0]/(1 + \lambda)\delta \,.$$

The decline in the spot rate at time zero shown by (4.20) compares with the larger decline $-\eta_0/\delta$ that would have had to occur in the absence of accommodating capital inflows. The spot rate on the foreign currency will be declining prior to $t = 0$ and rising after that date. From (4.13) to (4.16), as pictured in Figure 4.1, it can be seen that, prior to time zero, covered and uncovered capital will flow into the domestic country, being matched by increased net imports. In the forward market, the covered capital inflow generates forward purchases of foreign exchange, matched by speculative forward sales.

The accommodating capital inflow permits the repatriation to be made with minimal disturbance to current trade flows, spreading the trade implications of the capital transfer over many periods. After the date of the required repatriation, the spot rate rises back toward its equilibrium level. Speculative and arbitrage capital flows out at the time of the required inflow, and then slowly returns to normal.

This kind of model, when applied empirically to a period such as the late 1930's (or the late 1960's and early 1970's, for that matter), suggests the use of dummy variables to represent the effects on exchange rates of anticipated future disturbances. The dummy variables would take the form . . . λ^4, λ^3, λ^2, λ, 1 , λ, λ^2, λ^3, λ^4, . . . , centered on the known date of given disturbance, and would represent the movement of *expected* exchange rates around the date of the disturbance. This pattern would look like the spike in line two of Figure 4.1. The dummy would be entered into a regression equation like (4.1). *Unanticipated* disturbances, following (4.11), would have dummy variables of the form . . . , 0, 0, 0, 1, λ, λ^2, λ^3,

FIGURE 4.1

Spot exchange rate x

Net imports ΔB

Speculative and
arbitrage capital Δx

Total
capital inflow B

$\}\eta_0$

$-$ 0 t $+$
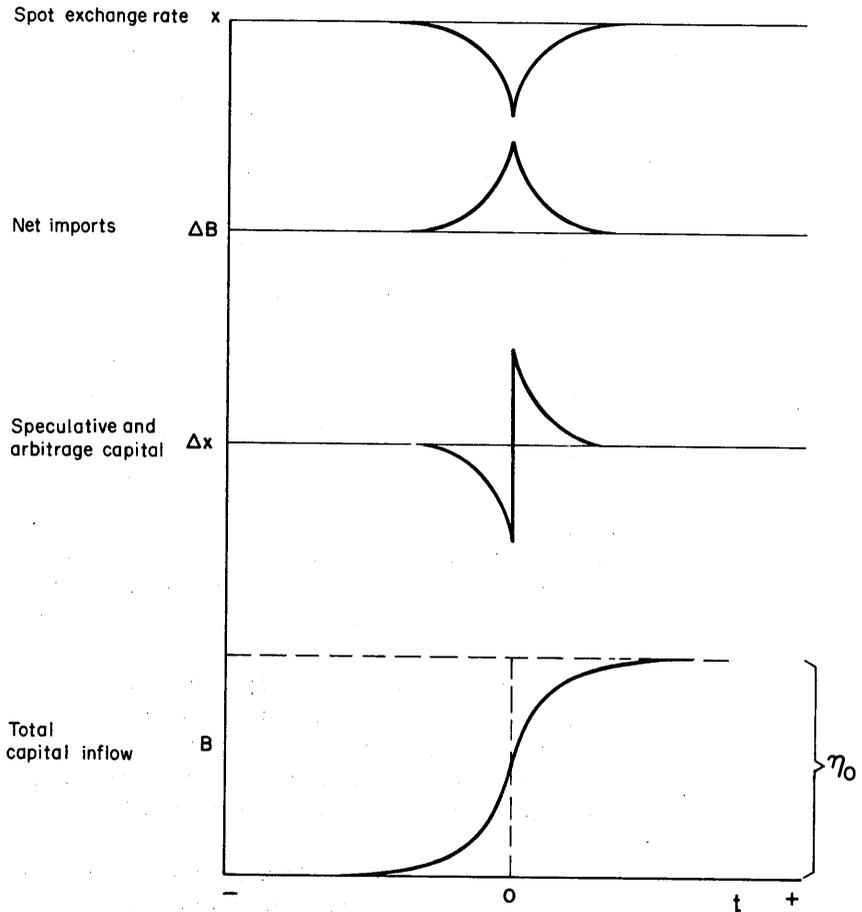
λ^4 , . . . , omitting the first half of the spike. A more flexible approach, which allows the data to determine whether or not the disturbances were anticipated, is to introduce *two* dummy variables, a Prior dummy of the form . . . , $\lambda^4, \lambda^3, \lambda^2, \lambda, 1, 0, 0, 0, \ldots$ and a Post dummy of the form . . . , $0, 0, 0, 1, \lambda, \lambda^2, \lambda^3, \lambda^4 , \ldots$. In this case, each half of the spike is independent. If both dummies are significant, the hypothesis that the disturbance was not anticipated would be rejected. Usually, one will have some

hypothesis on the sign of the dummy variable associated with a specific disturbance. The exact set of dummy variables used in this study is discussed in Chapter VII.

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V. DATA AND METHODS OF ESTIMATION

The Period

The data for this study come from the U.S. Treasury Department's *Statistics of Capital Movements between the United States and Foreign Countries* for the late 1930's.[1] A capsule review of the period covered is perhaps in order for readers like myself whose consciousness emerged after World War II. The international monetary arrangements of this period were heavily influenced by the backwash from the devaluation of the dollar in 1933 and the pegging of gold at $35 an ounce in January 1934. The other major influence was the rising threat of World War II. Sterling was devalued in 1931, the dollar in 1933. The "gold bloc" currencies of France, Switzerland, the Netherlands, Belgium, Italy, and Poland were left high and dry by the (excessive) devaluation of sterling and the dollar. Their fall was inevitable, and its postponement by means of internal deflation was another example of the effects of unrealistically pegged exchange rates. Although Belgium went off gold in March 1935, the rest held out with the French until September 1936. The Tripartite Monetary Agreement and its Protocol, which followed the collapse of the gold bloc, established a degree of cooperation among the Exchange Stabilization Funds of the United States, Britain, and France. The Agreement permitted modest fluctuations in the sterling-dollar exchange rate and did not interfere with the ensuing prolonged slide of the franc. The decline of the franc was related both to internal developments and to the increasing inconvertibility of the Italian lira and the Reichsmark, not to mention the threat of war. According to Yeager (1966, p. 327), during this period "the British Exchange Equalization Account kept the dollar-sterling rate fairly stable but not rigid," until January 1939, when the rate was pegged at $4.68.[2] In fact, the mean spot sterling-dollar exchange rate from January 1936 tó September 1939 was $4.86, with a standard deviation of 37.5 cents. The forward rate had the same standard deviation and a mean of $4.85. Thus the period was largely one of "flexible" but not "freely fluctuating" exchange rates.

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[1] *Statistics of Capital Movements between the United States and Foreign Countries and Purchases and Sales of Foreign Exchange in the United States*, U.S. Treasury Dept., quarterly, 1935–1938. Subsequent data in *Bulletin of the Treasury Department*, monthly, 1939.

[2] Yeager's Chap. 17 is a valuable summary of the events of the period.

The Data

In *Statistics of Capital Movements* economists have access to detailed weekly statistics by country of the amounts of short-term dollar and foreign-currency claims and liabilities of American banks, as well as statistics of transactions in outstanding long-term domestic and foreign securities. In addition, similar detailed data are available on purchases and sales of spot and forward foreign currencies by American banks and on outstanding forward contracts for delivery or receipt of foreign currencies. No comparable current source of data on forward-exchange commitments and transactions exists, as the collection of these data was discontinued after the war. Anyone truly interested in forward exchange should be fascinated by this unique opportunity to analyze the behavior of actual commitments. Yet the data have been strangely neglected. The best-known study of the period, Kindleberger's *International Short-Term Capital Movements* (1937) states in an Appendix: "The present monograph . . . has not dealt with the problem in statistical terms, however . . . the published data available to the student are still inadequate for a thorough-going statistical treatment of the subject" (p. 241).[3] On the other hand, Bloomfield's (1950) masterly *Capital Imports and the American Balance of Payments, 1934–39* carefully analyzed the Treasury data on flows of short-term and portfolio capital, as well as the data on forward positions. Bloomfield extracted a large number of conclusions from his study relating to the stabilizing nature of speculation in particular episodes, the factors influencing short-term capital flows, and interrelations among capital flows of all types. More recently, Glahe (1967) attempted to use these data to determine whether banks speculated on the forward market. He compared banks' forward purchases of sterling (less sales) to the covered interest differential between New York and London. The data Glahe used show *changes* in banks' commitments and hence cannot be used to infer anything about the *levels* of the banks' net forward commitments, which are the figures of interest. Furthermore, Glahe's tests are not very well designed.

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[3]Kindleberger's reasons for doubting the usefulness of the data were (a) "the problems of estimating what part of the international traffic in outstanding securities is speculative and hence essentially short-term in nature" (pp. 246–247), and (b) when funds for redemption or refunding of foreign bonds "are acquired in New York in the form of balances some time ahead of the actual redemption . . . the operation is reflected in weekly capital-movement data as (1) an inflow of short-term funds and later (2) an inflow of long-term capital balanced by an outflow of short-term funds." There were no such type (b) transactions to distort the flows between the United States and Great Britain during the period studied here.

The data provided in *Statistics of Capital Movements* enable one to estimate equations for the short-term claims and liabilities of American banks vis-à-vis various foreign countries. Since by far the largest volume of transactions took place between the United States and the United Kingdom, this study concentrates on those claims and liabilities, due account being taken of third-country effects. The data consist of dollar and sterling claims and liabilities, all measured in thousands of dollars, as of Wednesday of each week. This study uses the data from January 1, 1936, to August 30, 1939. The exact variables and their counterparts in the theoretical model are given below. The subscripts will be dropped in the rest of the paper.

Sterling deposits: $SD_p + SD_b$, consisting of (1) U.S. banks' deposits abroad, (2) deposits for account of domestic clients, (3) sterling bills to finance American exports.

Sterling loans: $SL_p + SL_b$, consisting of (1) borrowings by American banks from British banks, (2) acceptances made by British banks to finance American imports.

Dollar loans: DL_f, consisting of (1) loans to British banks, (2) acceptances made by American banks to finance American exports.

Dollar deposits: DD_f, consisting of (1) deposits for foreign account, (2) bills held for foreign account, (3) short-term U.S. Government obligations held for foreign account.

There are also data on nonbanks' and foreigners' outstanding contracts to purchase forward sterling from banks (FP) and their contracts to sell forward sterling to banks (FS). The difference between them provides the banks' forward position (BFP).

The short-term interest rates are the three-month Treasury-bill rates in London and New York, quoted weekly in *The Economist* and the Federal Reserve System's *Banking and Monetary Statistics* (1943). These are denoted LB and NYB, respectively. The percentage change in Standard and Poor's common-stock price index, $PCSP$, was taken from the same source. The bankers' acceptance rate in Paris, denoted PB, was also obtained from the same source on a monthly-average basis. It was converted to a weekly basis by entering for each week the corresponding monthly average and computing a five-week centered moving average.

Data for the weekly average spot and three-month forward sterling-dollar exchange rates come from records of the First National City Bank.[4]

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[4] As reported in the Appendix of Glahe (1967). The data on spot and forward rates were converted into the percentage annual rate of discount on forward sterling by the formula $u = 400(x - y)/x$.

Export and import data are monthly figures from the U.S. Department of Commerce's *Business Statistics*, smoothed to a weekly basis by entering for each week the corresponding monthly average and computing a five-week moving average centered two weeks after the current week. The data give exports and imports vis-à-vis the whole world, not just the United Kingdom.

The equations estimated for loans and deposits take the following form:

$$(5.1) \quad A = a_0 + a_1 LB + a_2 NYB + a_3 u + a_4 EX + a_5 IM + a_6 PB \\ + a_7 PCSP + e_1 .$$

The expected signs of coefficients a_1 to a_5 are those given in Table 2.1, depending on whether A represents dollar or sterling loans or deposits. The term e_1 represents random errors. The coefficient on the Paris acceptance rate should have a positive sign for American claims and a negative one for American liabilities, assuming that it represents the flow of funds between London and Paris. Such flows were quite large in the late thirties as the franc went through a series of devaluations and stabilizations. When funds are pulled back from London to Paris, the resulting shortage in London is expected to draw funds from New York, raising American claims on Britain. The reverse is expected to happen when funds flow from Paris to London. The percentage change in common-stock prices is included to try to pick up switching between money-market and stock-market investments.

The export and import variables are not very close to the theoretical variables introduced earlier. Being smoothed monthly averages of deliveries, they may combine both orders and deliveries for the week in question. Also, U.S. trade with Latin America, Europe, Canada, and Asia should not directly affect capital movements vis-à-vis the United Kingdom. On the other hand, to the extent that U.S. trade with third countries was financed in London, total trade would be the proper variable.

The nonbank forward-market equations follow quite closely the theoretical specification given in equations (2.28) and (2.29), except that forward purchases by the British Exchange Equalization Account ($\overline{H}$) are included in total nonbank forward purchases:

$$(5.2) \qquad FS = b_0 + b_1 SD + b_2 EX + b_3 v + e_2 ,$$

$$(5.3) \qquad FP = c_0 + c_1 SL + c_2 IM + c_3 v + \overline{H} + e_3 .$$

The banks are assumed to keep their position sheet balanced, following equation (2.5):

$$(5.4) \qquad BFP = d_0 + d_1 SL + d_2 SD .$$

The expected signs are all positive, except b_3 and d_2, which are negative. The terms e_2 and e_3 represent random disturbances. Lack of data on expected future exchange rates prevents the inclusion of the variable v, the expected rate of profit on speculation in forward exchange, except in equations using the dummy variables of Chapter IV. Therefore, the following procedure is used to eliminate v. The above three equations, together with the identity $BFP = FS - FP$, can be solved to determine v and the forward rate through the definition $v = 400 \, (w - y)/y$. Ignoring the constants and error terms, the solution for v is

$$(5.5) \quad v = \frac{b_1 - d_2}{c_3 - b_3} SD - \frac{c_1 + d_1}{c_3 - b_3} SL + \frac{b_2}{c_3 - b_3} EX - \frac{c_2}{c_3 - b_3} IM$$
$$- \frac{1}{c_3 - b_3} \overline{H} .$$

Assume that $c_3 = -b_3$, so that the coefficients of speculation are equal for purchases or sales. This is a maintained hypothesis, an untested part of the statistical model, which can be tested only by the inclusion of dummy variables in Chapter VII. Substitution of the solution for v into the equations for FP and FS yields the reduced-form equations:

$$(5.6) \quad FS = \frac{b_1 + d_2}{2} SD + \frac{c_1 + d_1}{2} SL + \frac{b_2}{2} EX + \frac{c_2}{2} IM + \frac{1}{2} \overline{H} ,$$

$$(5.7) \quad FP = \frac{b_1 - d_2}{2} SD + \frac{c_1 - d_1}{2} SL + \frac{b_2}{2} EX + \frac{c_2}{2} IM + \frac{1}{2} \overline{H} .$$

When the reduced-form equations are estimated, the structural coefficients can be identified from the relationships between the coefficients shown in (5.6) and (5.7). Note that forward purchases of sterling by the British Exchange Equalization Account will affect the two reduced-form equations about equally.

Estimation Techniques

The disturbances assumed to enter the equations for claims and liabilities and those for the forward market should interact through the

entire model to affect all the endogenous variables. It has been shown previously (Black, 1965, Chap. 4; Bryant and Hendershott, 1970) that the simultaneous-equations problem biases the estimated coefficients downward in this kind of model. Therefore, a simultaneous-equation technique such as two-stage least squares would help to purge the endogenous variables of their relation to the disturbances. Unfortunately, weekly data are not available for a sufficient number of instrumental variables to allow the use of such methods. Errors of measurement in the variables will also bias the estimated coefficients downward.

The disturbance terms are expected to be autocorrelated over time and intercorrelated between equations. Both will occur because of the movement of variables left out of the equations, such as expected future exchange rates. The Cochrane-Orcutt technique (see Johnston, 1963, p. 194) has been used to estimate the first-order autocorrelation coefficient r and transform the equations to reduce the autocorrelation; the regression coefficients presented below are therefore those obtained using transformed data. Zellner's technique for dealing with intercorrelated disturbances (see Goldberger, 1964, pp. 262–265) does not seem called for here, as the same variables enter each of the equations for claims and liabilities. The same variables were also included in estimating the forward-market equations. Under these circumstances, nothing can be gained by using Zellner's technique.

Since the equations are estimated from weekly data, substantial lags are expected. These are estimated either by using successive lagged values of the independent variables, or by using the Almon (1965) method of assuming that the lag coefficients lie on an unconstrained second-degree or fourth-degree polynomial.[5] The variables for exports and imports, as well as the Paris bankers' acceptance rate, are in the form of five-week moving averages. A distributed lag is built into these variables.

An examination of the residuals from the estimated equations did not reveal evidence of heteroscedasticity.[6] There is therefore no statistical reason to scale the quantity variables by dividing through by some sort of net-worth variable. Several authors (Bryant and Hendershott, 1970; Leamer and Stern, 1972) have argued recently that such scaling is necessary on theoretical grounds. The theoretical proposition states that the quantity of an asset held should be proportional to the size of the total

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[5]Different lengths of lags, as well as fourth-degree polynomials, were experimented with, to ensure that the shapes of the lag distributions were determined by the data and not by a priori assumptions.

[6]Specifically, the residuals did not appear to increase in absolute value through time, according to the nonparametric "peak" test (see Goldfeld and Quandt, 1965).

portfolio, for a given structure of interest rates. But there is no reason why we cannot interpret equations estimated from unscaled data as if they were homogeneous of degree one in net worth. The question of scaling is an empirical one.

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VI. EMPIRICAL SPOT AND FORWARD EQUATIONS

The three equations below give the results of regressing sterling loans and deposits and dollar deposits on the components of the covered interest differential. Quantity variables are measured in thousands of dollars, rates in per cent per annum. The components of the differential are used separately to test whether or not their coefficients are identical. Equations for dollar loans (not shown) were uniformly nonsignificant without the use of dummy variables.

(6.1) $SL = 56{,}419 + 37{,}755 \; \Sigma \; \alpha_i NYB_{-i} - 23{,}209 \; \Sigma \; \alpha'_i LB_{-i}$
$\qquad\qquad (10.2) \qquad (3.1) \qquad\qquad\qquad (3.2)$

$\qquad\qquad\qquad\qquad\qquad + \; 21{,}712 \; \Sigma \; \alpha''_i u_{-i} - 2{,}141 \; PB - 27 \; PCSP$
$\qquad\qquad\qquad\qquad\qquad\qquad (5.6) \qquad\qquad\quad (1.7) \qquad (0.6)$

$\quad R^2 = .94, \; s = 2{,}837, \; d = 2.28, \; r = .88$[1]

$\quad \alpha_i = .103, \; .163*, \; .195*, \; .199*, \; .175*, \; .122*, \; .043$
$\quad \alpha'_i = .125*, \; .143*, \; .154*, \; .157*, \; .154*, \; .143*, \; .124$
$\quad \alpha''_i = .218*, \; .179*, \; .147*, \; .125*, \; .112*, \; .107*, \; .112$

(6.2) $SD = 76{,}286 + 7{,}945 \; \Sigma \; \alpha_i LB_{-i} - 15{,}444 \; \Sigma \; \alpha'_i u_{-i}$
$\qquad\qquad (6.7) \qquad (0.7) \qquad\qquad\qquad (2.4)$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad - \; 17{,}873 \; NYB - 2{,}169 \; PB$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (1.6) \qquad\qquad (1.0)$

$\quad R^2 = .94, \; s = 4{,}659, \; d = 2.30, \; r = .95$
$\quad \alpha_i = .550*, \; .396, \; .253, \; .121, \; -.001, \; -.112, \; -.212$[2]
$\quad \alpha'_i = .598*, \; .271*, \; .071, \; .001, \; .059$

(6.3) $DD = 452{,}561 - 47{,}547 \; \Sigma \; \alpha_i LB_{-i} + 51{,}203 \; \Sigma \; \alpha'_i u_{-i} + 2{,}291 \; PB$
$\qquad\qquad (3.9) \qquad (2.2) \qquad\qquad\qquad (3.0) \qquad\qquad\qquad (0.3)$

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[1]R^2 is the square of the multiple-correlation coefficient, s is the standard error of estimate, d is the Durbin-Watson statistic of the transformed equation, r is the first-order autocorrelation coefficient, and t-ratios are given in parentheses. Starred values of distributed-lag weights have t-ratios greater than 2; the distributed-lag weights begin with $i = 0$.

[2]The t-ratio on the first term of this distributed lag is 2.3, on the second term 1.7.

$$R^2 = .99, s = 13{,}725, d = 1.86, r = .99$$
$$\alpha_i = .347^*, .278, .216, .159$$
$$\alpha_i' = .398^*, .239^*, .170, .192$$

In these equations, the components of the covered interest differential $(z = NYB - LB + u)$ have the expected effects of increasing American liabilities to Britain or decreasing American claims. Thus a rise in the discount on the pound (u) will raise sterling loans and dollar deposits, while reducing sterling deposits. Only minor lags appear on sterling and dollar deposits. Very substantial lags, averaging three weeks, appear on sterling loans. The difference probably arises because the majority of sterling loans are acceptances made by British banks to finance American imports. It apparently takes an average of three weeks for shifts in trade finance to occur as a result of changes in relative interest rates. Sterling deposits respond quickly; they consist in large part of American banks' own deposits abroad used for adjusting foreign-exchange positions. Note that the New York interest rate is not significant for dollar deposits, since most of these deposits do not yield interest. If lags as long as six weeks are allowed in the equation for dollar deposits, a secondary peak appears in the distributed lag about five weeks after the primary peak. This appears to be a monthly cycle in dollar deposits.

Exports and imports were added to each of the equations above, but only for sterling loans did they appear significant, again confirming the trade-finance role.

(6.4) $SL = 20{,}100 - 23{,}746 \, \Sigma \, \alpha_i z_{-i} + .101 \, \Sigma \, \alpha_i' IM_{-i} + .081 \, \Sigma \, \alpha_i'' EX_{-i}$
$\qquad\quad (2.2) \qquad (10.0) \qquad\qquad (2.8) \qquad\qquad (2.5)$

$$- \, 2{,}796 \, PB - 18 \, CSP$$
$$(3.2) \qquad (0.3)$$

$$R^2 = .95, s = 2{,}730, d = 2.12, r = .73$$
$$\alpha_i = .145^*, .185^*, .180^*, .162^*, .149^*, .133^*, .086^*, -.039$$
$$\alpha_i' = .745, .556^*, .108, -.181, -.152, .100, .222, -.396$$
$$\alpha_i'' = -.057, .377^*, .644^*, .438, -.186, -.820, -.696, 1.300$$

The positive sign for exports in equation (6.4) calls for some comment. This puzzling result may be a consequence of the inclusion in sterling loans of American bank borrowing from British banks. From equation (6.7) below, increased exports lead nonbanks to sell sterling forward to banks. One result will be a decline in the forward exchange rate (see row

1 of Table A.1). But, at the same time, American banks will make part of their adjustment by increasing their spot sterling liabilities by borrowing in London to offset their forward purchases of sterling.

Table 6.1 shows the total estimated effects on claims and liabilities of a 1 percentage point increase in each component of the covered interest differential. Thus a 1 percentage point increase in the covered London bill rate relative to the New York bill rate leads to about an $80 million flow from the United States to the United Kingdom, which is a 30 per cent drop in the net stock of funds held in New York, excluding dollar loans.

TABLE 6.1

ESTIMATED INTEREST-RATE IMPACTS

(*in thousands of dollars*)

	LB	*NYB*	*u*	*PB*	*Mean of Dependent Variable*
SD	7,945	−17,873	−15,444	−2,169	59,017
SL	−23,209	37,755	21,712	2.291	60,010
DD	−47,547		51,203	2,141	262,735
SD-SL-DD	78,701	−55,628	−88,359	−6,601	−263,728

The following equations show the results of regressing nonbank and foreign commitments to purchase forward sterling (FP) and commitments to sell forward sterling (FS) on sterling loans and deposits, exports, and imports. Note that the coefficients of the covered interest differential (z_i) are nonsignificant.

(6.5) $\quad FS = 147,505 + .911 \, SL + .393 \, EX + .139 \, IM - .268 \, SL_{-1}$
$\qquad\qquad (3.4) \quad (3.2) \qquad (2.7) \qquad (0.9) \qquad (0.9)$
$$- 6,342 \, \Sigma \, \alpha_i z_{-i}$$
$$(0.4)$$
$$R^2 = .90, \, s = 10,614, \, d = 1.99, \, r = .91$$
$$\alpha_i = .30, \, .45, \, .44, \, .29, \, -.01, \, -.47$$

(6.6) $\quad FP = 139,018 + .615 \, SD + .469 \, SD_{-1} + .747 \, SL + .290 \, EX$
$\qquad\qquad (3.1) \quad (3.6) \qquad (2.7) \qquad\quad (2.5) \qquad (2.1)$
$$+ .176 \, IM - .074 \, SL_{-1} - 10,660 \, \Sigma \, \alpha_i z_{-i}$$
$$(1.3) \qquad (0.3) \qquad\qquad (0.6)$$
$$R^2 = .91, \, s = 11,044, \, d = 1.91, \, r = .87$$
$$\alpha_i = .33, \, .49, \, .49, \, .30, \, -.04, \, -.57$$

As expected, the omission of a variable for expected future exchange rates causes exports and imports to have approximately equal coefficients in both equations. The relations derived in equations (5.6) and (5.7) can be used to identify the coefficients of the variables in the assumed structural equations. The results are

$$(6.7) \qquad FS = 1.08\,SD + .68\,EX$$

$$(6.8) \qquad FP = 1.31\,SL + .32\,IM$$

$$(6.9) \qquad BFP = -.03\,SL - 1.08\,SD\,.$$

The coefficients of sterling deposits in equations (6.7) and (6.9) are the same except for sign, because sterling deposits were not significant in equation (6.5). This finding is a bit peculiar; if banks cover sterling deposits, why should the same deposits be covered by nonbanks also? The coefficient of sterling loans in the equation of forward purchases (6.8) seems a little on the high side, but the other coefficients seem reasonable. The implication of equation (6.9) is that the banks' forward position, BFP, just offsets their spot position, which is mostly in the form of sterling deposits. It appears that both banks and nonbanks covered their sterling positions pretty completely.[3] The failure of imports to be significant is probably due to imports' being financed by sterling loans, as shown by equation (6.4). The sterling loans are then covered, as in equation (6.8).

Using these results together with the interest-rate impacts of Table 6.1, one may compute the estimated effect on net forward purchases of a 1 percentage point rise in the discount on forward sterling, holding constant the London and New York bill rates. The result is $1.08\,(-15,444) - 1.31\,(21,712) = \$45.1$ million. Thus, of the $80 million that was previously estimated to flow to London, $45 million-worth would be covered by forward sales in New York.

Reference

Bloomfield, Arthur I., *Capital Imports and the American Balance of Payments*, *1934–39*, Chicago, University of Chicago Press, 1950.

[3]This coincides with Bloomfield's (1950, p. 65) conclusion ". . . the bulk of the forward speculation in foreign currencies vis-à-vis the dollar appears to have been undertaken by foreign, as contrasted with American, non-banking parties."

VII. EFFECTS OF EXPECTATIONS

Up to this point, capital flows between the United States and the United Kingdom have been explained by market exchange rates and trade flows. But when expectations of future events shift markedly, market rates may not always provide good measures of future expectations. The period with which this study deals was swept by many political and economic disturbances, leading to shifts in expectations and to frequent flows of "hot money" from country to country to avoid devaluation or confiscation.

The "rational expectations" approach suggested in Chapter IV can be used to argue that many of the major participants in the market correctly perceive future events and act on their perceptions, even if the market as a whole does not fully reflect their views. To this end, a set of dummy variables of the form described in Chapter IV has been constructed to represent the movement of the expected future spot exchange rate, w, in the neighborhood of each known major political and economic disturbance during the period. For the purposes of this study, twenty-eight major disturbances were identified and dated from historical sources. Of these, thirteen were discarded as being insufficiently important or too close in time to more important disturbances. For each of the remaining fifteen, Prior and Post dummies were constructed with $\lambda = .7$. This value provides a reasonable spreading of information over adjacent periods; the dummy is 35 per cent of its maximum value three periods before the event, then 49, 70, 100 per cent. Some experimentation with $\lambda = .49$ suggested that .7 was a more reasonable value.

The events chosen are listed in Table 7.1. Some discussion of these events is in order. The Nazi moves, A, H, J, N, and O, would be expected a priori to result in dollar and gold flows to the United States, hence higher dollar deposits and higher dollar loans to finance the gold shipments.[1] It appears from the empirical results that the main flows in the early episodes, A and H, were from the Continent to England, as the first port available in the storm. In these cases, the resulting increase in British liquidity would ease monetary conditions in England and *reduce* dollar loans. The first two French episodes, B and C, generated large flows of

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[1]Gold arbitrageurs borrowed dollars in New York to finance the purchase of gold in London and its shipment to New York. Of course, dollar loans were also used frequently by British banks to adjust their liquidity positions. On the effect of gold flows, see Kindleberger (1937, pp. 250–251).

TABLE 7.1

DUMMY VARIABLES FOR MAJOR EVENTS

	Date	Event
A	3/7/36	Hitler's march into the Rhineland
B	6/5/36	Popular Front takes office in France
C	9/26/36	Franc devalued, Gold Bloc ends
D	4/15/37	Start of Gold Scare
E	6/30/37	End of Gold Scare
F	8/15/37	Start of American recession
G	10/1/37	Start of Dollar Scare
H	3/11/38	Hitler's occupation of Austria
I	5/5/38	Daladier stabilizes franc
J	9/28/38	Munich Agreement on Czechoslovakia
K	11/12/38	French austerity measures
L	1/5/39	Britain strengthens E.E.A., forbids speculation
M	2/1/39	British peg sterling
N	3/14/39	Hitler's occupation of Czechoslovakia
O	9/1/39	Invasion of Poland, war begins

"hot" money from Paris to London, again easing monetary conditions in England, with resulting secondary flows to the United States. The latter two French episodes, I and K, were in many respects the opposite of the first two, tightening money in London and pulling funds from New York. Events D and E of the "Gold Scare" were connected with an irrational belief that the American authorities would reduce the price of gold. Such fears became widespread after the 1936 *Annual Report* of the Bank for International Settlements, appearing in April of 1937, made some incautious statements about excessive gold production. During the Scare, gold flowed to the United States to be sold against dollars, raising dollar deposits and also dollar loans to finance the gold movements. Event F, the American recession of 1937, was brought on in large part by tight money and was therefore accompanied by a significant easing of American monetary policy. The "Dollar Scare," event G, was basically the reverse of the Gold Scare, since it arose from fears that the dollar price of gold would be raised. The rush to buy gold led to an embargo on financing of gold shipments by New York banks and the breaking of the "gold points." The British actions, L and M, came in response to heavy speculation against the pound in the aftermath of Munich and the French stabilization plan.

Tables 7.2A to C present the equations for sterling loans and dollar deposits and loans, including the dummy variables.[2] Results for sterling deposits are not shown, as no dummies were significant in that case. Tables 7.3A to C present the equations for nonbank forward purchases and sales and for banks' net forward purchases of sterling, including dummy variables.

TABLE 7.2A

Spot Equations with Dummy Variables, Sterling Loans (SL)

Constant	6,645 (1.0)	
$\Sigma \, \alpha_i z_{-i}$	−15,790 (7.9)	
EX	.091 (4.0)	
IM	.097 (4.4)	
PB	− 2,014 (2.2)	
PCSP	− 42 (0.8)	

Event	Prior	Post
A	− 1,070 (0.2)	− 281 (0.1)
B	− 1,308 (0.3)	− 1,806 (0.4)
C	4,408 (1.1)	4,035 (1.0)
D	5,702 (1.3)	4,042 (0.9)
E	9,292 (2.0)	6,303 (1.4)
F	846 (0.2)	3,808 (0.9)
G	− 7,383 (1.7)	− 1,083 (0.2)
H	3,189 (0.8)	4,376 (1.1)
I	− 2,335 (0.6)	2,657 (0.6)
J	− 464 (0.1)	− 7,287 (1.7)
K	724 (0.2)	− 148 (0.1)
L	16,909 (4.0)	12,534 (2.9)
M	10,369 (2.4)	11,245 (2.7)
N	3,477 (0.8)	8,100 (2.0)
O	− 4,564 (1.0)	. . .

α_i	.27*, .20*, .15*, .11*, .08*, .06*, .06, .07
R^2	.95
s	2,848
d	2.14
r	.65
F for dummies	1.14

*t-ratio exceeds 2.

[2]In these equations, the components of the covered interest differential are combined into the single variable z.

TABLE 7.2B

SPOT EQUATIONS WITH DUMMY VARIABLES, DOLLAR DEPOSITS (*DD*)

Constant		1,293,226 (2.2)
$\Sigma \alpha_i z_{-i}$	−	33,953 (2.6)
EX		.361 (1.4)
IM	−	.070 (0.2)
PB	−	12,363 (1.5)
PCSP		. . .

Event	Prior	Post
A	− 1,725 (0.1)	−11,364 (0.5)
B	61,272 (2.4)	79,224 (3.1)
C	51,050 (2.2)	48,819 (2.1)
D	13,771 (0.6)	− 1,485 (0.1)
E	7,055 (0.3)	54,192 (2.3)
F	−12,306 (0.5)	−13,975 (0.6)
G	5,443 (0.2)	4,189 (0.2)
H	− 9,138 (0.4)	−10,688 (0.5)
I	− 3,447 (0.1)	1,518 (0.1)
J	46,280 (2.0)	− 2,336 (0.1)
K	− 1,772 (0.1)	− 2,678 (0.1)
L	−17,458 (0.6)	−14,771 (0.5)
M	3,197 (0.1)	2,976 (0.1)
N	−24,577 (1.0)	−39,587 (1.6)
O	−59,567 (1.7)	. . .

α_i	.36, .13, .13, .38*
R^2	.99
s	12,917
d	1.79
r	1.00
F for dummies	1.75

*t-ratio exceeds 2.

It is important to test whether the entire set of dummy variables adds significantly to the explanatory power of each regression equation. An F-test (with 29 degrees of freedom in the numerator and 150 degrees of freedom in the denominator) is used to test whether the addition of the dummy variables reduces significantly the residual sum of squares obtained for the equations in Chapter VI. As the 95 per cent confidence level for F with 30 and 150 degrees of freedom is 1.54, the F statistics shown in Tables 7.2 and 7.3 indicate that the dummies are significant as a group in the equations for nonbank forward purchases and sales and in the equation for dollar deposits. The dummies are *not* significant as a group in the equations for sterling loans or sterling deposits. No test statistic could be computed for the equations for dollar loans and banks' net forward purchases, as there were no comparable equations without

TABLE 7.2C

SPOT EQUATIONS WITH DUMMY VARIABLES, DOLLAR LOANS (*DL*)

Constant	19,936 (3.7)	
$\Sigma \, \alpha_i z_{-i}$	3,127 (1.9)	
EX	.050 (2.2)	
IM	. . .	
PB	. . .	
PCSP	. . .	

Event	Prior	Post
A	− 4,296 (0.9)	− 9,552 (2.0)
B	− 4,718 (1.0)	1,923 (0.3)
C	−11,092 (2.5)	−11,767 (2.7)
D	− 2,180 (0.4)	11,902 (2.5)
E	17,304 (3.7)	20,755 (4.3)
F	9,572 (1.9)	− 3,463 (0.7)
G	−16,718 (3.2)	−11,036 (2.1)
H	−14,278 (3.1)	4,161 (0.9)
I	6,029 (1.3)	13,438 (3.0)
J	22,257 (5.0)	19,186 (4.0)
K	5,280 (1.1)	12,721 (2.7)
L	13,702 (2.8)	10,688 (1.6)
M	15,404 (2.3)	9,594 (1.7)
N	1,645 (0.3)	4,023 (0.8)
O	− 491 (0.1)	. . .

α_i	no lags
R^2	.62
s	5,928
d	0.80
r	. . .
F for dummies	. . .

dummies. The small number of significant *t*-ratios in the equation for banks' net forward purchases suggests that the dummies are not significant as a group in that equation.[3]

These results suggest that speculation played an important role in the determination of dollar loans and deposits and of nonbank purchases and sales of forward sterling. On the other hand, sterling loans and deposits were *not* affected by speculation during the upheavals of the late thirties, nor were banks' net forward positions. These findings are consistent with the conclusion that sterling loans and deposits were largely covered in the forward market.

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[3]The *t*-ratios in the equation for dollar loans are biased upward, since the correction for autocorrelated residuals could not be obtained for that equation. The computer refused to compute!

TABLE 7.3A

FORWARD EQUATIONS WITH DUMMY VARIABLES, FORWARD PURCHASES (FP)

Constant	250,698 (3.9)
$\Sigma \alpha_i z_{-i}$	$-$ 2,214 (0.2)
EX	.081 (0.4)
IM	.142 (0.6)
SD	.280 (1.5)
SL	.469 (1.6)

Event	Prior	Post
A	19,259 (1.0)	32,102 (1.7)
B	17,739 (0.9)	33,644 (1.7)
C	1,528 (0.1)	16,233 (0.8)
D	46,421 (2.4)	40,920 (2.1)
E	$-$36,833 (1.9)	$-$22,098 (1.1)
F	$-$20,496 (1.1)	$-$20,316 (1.0)
G	$-$ 5,203 (0.3)	11,156 (0.6)
H	266 (0.1)	8,180 (0.4)
I	10,222 (0.5)	14,430 (0.7)
J	2,579 (0.1)	$-$10,622 (0.5)
K	13,609 (0.7)	30,432 (1.5)
L	$-$ 578 (0.3)	$-$ 179 (0.1)
M	11,480 (0.5)	$-$ 2,313 (0.1)
N	$-$14,308 (0.7)	12,400 (0.6)
O	70,194 (2.7)	. . .

α_i	*
R^2	.93
s	10,708
d	2.13
r	.96
F for dummies	1.73

*Nonsignificant.

One should observe that the nondummy coefficients in the equations for sterling loans and dollar deposits are not very different from the results of Chapter VI. The only exception is a reduction in the coefficients of the covered interest differential, which probably loses some explanatory power to the dummy variables. The distributed-lag coefficients on the covered interest differential appear to show the effects of the monthly cycle in the data mentioned in Chapter VI, following equation (6.3).

The nondummy coefficients of the forward-market equations can be used as before to estimate the structural coefficients. Using equations (5.6) and (5.7),[4] we get equations (7.1) to (7.4).

[4]Since the dummies represent only the *exogenous* part of the function $w(x, \ldots)$, the omission of the *endogenous* part of the function still implies the reduced-form equations (5.6) and (5.7). Furthermore, the dummy coefficients in Tables 7.3A and B do not reject the hypothesis that $c_3 = -b_3$, made in Chapter V.

TABLE 7.3B

FORWARD EQUATIONS WITH DUMMY VARIABLES, FORWARD SALES (FS)

Constant	169,460 (2.8)
$\Sigma\, \alpha_i z_{-i}$	2,794 (0.3)
EX	.376 (1.9)
IM	.129 (0.6)
SD	— .416 (2.4)
SL	.709 (2.5)

Event	Prior	Post
A	19,399 (1.0)	28,123 (1.4)
B	22,506 (1.2)	37,079 (2.0)
C	− 3,393 (0.2)	8,279 (0.4)
D	41,123 (2.2)	41,128 (2.2)
E	−35,790 (1.9)	−29,145 (1.6)
F	−10,871 (0.6)	− 9,041 (0.5)
G	− 1,819 (0.1)	27,105 (1.5)
H	− 9,960 (0.5)	552 (0.1)
I	659 (0.4)	12,350 (0.7)
J	7,120 (0.4)	− 723 (0.1)
K	16,568 (0.9)	30,970 (1.6)
L	2,255 (0.1)	2,736 (0.1)
M	19,414 (1.0)	9,264 (0.5)
N	22,851 (1.1)	1,350 (0.1)
O	61,155 (2.4)	. . .

α_i	*
R^2	.92
s	10,150
d	2.10
r	.95
F for dummies	1.67

*Nonsignificant.

(7.1) $$FS = -.14\,SD + .46\,EX$$

(7.2) $$FP = 1.18\,SL + .27\,IM$$

(7.3) $$BFP = .24\,SL - .70\,SD$$

(7.4) $$BFP = .12\,SL - .78\,SD\ .$$

Equation (7.2) is in good agreement with the earlier finding (6.8). The equation for nonbank forward sales (7.1) has a very different coefficient for sterling deposits than shown in (6.7). Since these deposits are largely bank-owned deposits, a coefficient near zero for nonbanks is more plausible than a coefficient near unity. Both trade coefficients are some-

TABLE 7.3C

FORWARD EQUATIONS WITH DUMMY VARIABLES, BANKS' FORWARD PURCHASES (*BFP*)

Constant	$-$20,192	(1.3)
$\Sigma \alpha_i z_{-i}$	135	(0.1)
EX	.055	(1.1)
IM	.033	(0.8)
SD	$-$ .777	(11.0)
SL	.124	(1.0)

Event	Prior	Post
A	$-$ 3,164 (0.4)	$-$ 4,243 (0.6)
B	7,226 (1.0)	4,785 (0.6)
C	$-$ 311 (0.1)	$-$ 1,633 (0.2)
D	$-$ 8,449 (1.1)	$-$ 3,031 (0.4)
E	$-$ 8,190 (1.1)	$-$16,443 (2.2)
F	$-$ 4,274 (0.6)	$-$ 2,627 (0.4)
G	$-$ 2,709 (0.4)	13,121 (1.8)
H	$-$ 9,228 (1.3)	$-$ 7,221 (1.0)
I	$-$ 7,126 (1.0)	$-$ 6,225 (0.9)
J	$-$ 4,631 (0.6)	$-$ 1,902 (0.2)
K	$-$ 9,658 (1.3)	$-$ 5,401 (0.8)
L	4,804 (0.6)	$-$ 1,669 (0.2)
M	6,245 (0.8)	2,846 (0.4)
N	4,277 (0.6)	$-$ 3,367 (0.5)
O	$-$ 9,918 (1.2)	. . .

α_i	*
R^2	.96
s	4,364
d	2.31
r	.80
F for dummies	. . .

*Nonsignificant.

what reduced from the earlier results, although the coefficient for exports retains its significance. The banks' equation (7.3) is computed from the nonbank equations of Tables 7.3A and B via equations (5.6) and (5.7). Equation (7.4) comes directly from the bank equation in Table 7.3C. It is reassuring that the direct and indirect estimates are so close. These results in equations (7.3) and (7.4) confirm the earlier finding that banks appear to balance out their spot and forward positions. They are consistent, moreover, with the lack of influence of speculative variables on the banks' position.

Reference

Kindleberger, Charles P., *International Short-Term Capital Movements*, New York, Columbia University Press, 1937.

VIII. SPECULATIVE BEHAVIOR AT SPECIFIC EVENTS

The specific dummy variables in Tables 7.2 and 7.3 enable one to examine the effects on spot and forward markets of the major disturbing events of the period. Changes in the measured exchange rates are not independent of the dummy variables, as shown in Chapter IV. Nevertheless, the speculative flows associated with the dummy variables should be in addition to the arbitrage flows associated with the covered interest differential. Since the equation for dollar loans has autocorrelated residuals, inferences drawn from that equation must be regarded cautiously.

A. It would appear from the relationship of Prior and Post dummies that Hitler's march into the Rhineland was not anticipated. This event seems, moreover, to have reduced dollar loans to Britain. As the influx of funds from the Continent eased British monetary conditions, British banks repaid loans from American banks (they also reduced discounts and advances from the Bank of England) (Board of Governors, 1943, Table 164, pp. 639–640). There is some evidence that nonbanks bought sterling forward in reaction to the event, thus reducing the forward discount. This was stabilizing speculation, since the discount on forward sterling was quite large at the time.[1]

B. Since Leon Blum's Socialist Popular Front government was widely regarded as a catastrophe for France, there was a heavy flow of funds from Paris to London when the Socialists took office. A substantial amount of this money made its way from London to New York, according to the significant dummy variables for dollar deposits. The dummies show that the event was anticipated, which is consistent with the fact that the election was held two months earlier. In the forward market, sterling was sold by nonbanks at a substantial discount. Although this appears at first glance to be destabilizing speculation, the spot rate was abnormally high at this time and was expected to decline. It actually did fall by substantially more than the discount on forward sterling. From this perspective the forward rate was too high, and forward sales were stabilizing. By increasing the size of the discount, forward sales encouraged arbitrage funds to leave London, which of course was flooded with French funds (see Bloomfield, 1950, pp. 57–58).

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[1]The forward discount is not independent of speculative activity, as noted above. But when speculation *reduces* a large discount, the large size of the discount must be unrelated to the speculative activity.

C. The devaluation of the franc and the collapse of the Gold Bloc in September 1936 led to another large flow of French capital to London, which spilled over into dollar deposits in New York. The event was widely anticipated, as confirmed by the dummy variables. Dollar loans declined as British banks reduced their borrowing in response to the influx of foreign funds.

D. From April to June 1937, the view was widespread that the United States would counteract the growing inflow of gold by reducing the dollar price of gold, and the Gold Scare began. The equations reflect the beginning of the scare; there was a rise in dollar loans to finance gold flows, accompanied by substantial public purchases and sales of forward sterling. The forward purchases probably represented destabilizing speculation on a devaluation of the dollar (which never came), but it is interesting to see that almost matching forward sales were forthcoming, in a stabilizing counteraction.

E. Throughout the summer, indeed until the onset of the American recession in the fall of 1937, forward sterling remained at a substantial discount, while spot sterling was rising. Thus arbitrage considerations were strongly in favor of flows to New York from London, and dollar deposits rose sharply over the period. The gold-market counterpart to these developments in the exchange markets was a low price of gold in London, leading to substantial gold shipments to New York (Bloomfield, 1950, pp. 144–146). According to Table 7.2, dollar deposits were sharply higher at the end of the Gold Scare, reflecting the dollar counterpart of the gold shipped to New York. Dollar loans, of course, rose to finance the gold flows. These flows were clearly destabilizing. Sterling loans do not appear to have fallen before the end of the Scare as much as arbitrage considerations would have implied. Thus American importers may have been speculating for a decline in sterling, in a stabilizing manner. At the same time, the end of the Scare brought a reduction of nonbank purchases and sales of forward sterling, back to more normal levels. Their sales appear to have dropped by more than their purchases, leading to an increase in the net long position, matched by a substantial net short position by the banks (after allowing for the banks' holdings of spot sterling). This is one of two cases in which the banks appear to have speculated in the opposite direction from their customers. The banks may have been burned in the process, as the spot rate rose considerably more before falling with the onset of the U.S. recession.

F. The recession beginning in August and September of 1937 was in large part due to monetary stringency caused by the unwise 33⅓ per cent increase in member-bank reserve requirements in the spring of 1937.The

only apparent effect shown in Table 7.2 was a prior rise in dollar loans. On closer inspection, this turns out to reflect a sharp *decline* in dollar loans after the recession began, from what was an abnormally high level (no doubt associated with the financing of gold flows). Thus the recession may really date the end of the Gold Scare.

G,H. The recession was in fact responsible for starting the rumor that the dollar price of gold would be increased by the U.S. government. The so-called "Dollar Scare" lasted from November 1937 until Hitler forced the "Anschluss" of Germany and Austria in March 1938, bringing the markets back to their senses. During this period, represented by event G and the prior dummy on event H, dollar loans were abnormally low. The gold flows to New York simply ceased, so the need to finance such movements also ceased. Apparently, the U.S. Stabilization Fund even exported gold during this period (Bloomfield, 1950, pp. 165–166). Curiously, the banks appear to have gone long on forward sterling, in response to their customers' going short at this time. Since sterling remained high for over four months, the banks probably made money, but this would have to be classed as destabilizing speculation.

I. Daladier's stabilization of the franc led to a reverse flow of funds from London to Paris, together with sharply tighter money in London. British banks increased their borrowing in New York as a result.

J. The Munich crisis of September 1938 generated a large flow of funds to New York, matched by gold flow. Both factors are reflected in the rise in dollar deposits and dollar loans. It can be seen that the crisis was anticipated, which is corroborated by the fact that the original demands on Czechoslovakia came in July. Note that dollar deposits rose prior to the crisis by an amount estimated at $46.3/.3 = $154 million, and that the funds did not flow back out after the crisis (indicated by the non-significant Post-crisis dummy). This is in addition to the inflow induced by the covered interest differential, which swung to favor New York at this time. The volume of dollar loans required to finance the gold inflow seems to match quite closely in magnitude, if not in time pattern, the increase in dollar deposits. This could reflect the fact that foreign central banks and arbitrageurs supplied some of the dollar deposits initially, and then restored their positions by shipping gold to the United States.

K. In November 1938, the French government took strong austerity measures, including higher taxes and a revaluation of gold (which was widely hoarded domestically in France). The ensuing relative strengthening of the franc had the effect of accentuating the weakness of the pound, which had been falling since June in the steadily worsening atmosphere. The consequence was tight money in London, which increased dollar

loans from American banks to British banks. At the same time, British banks increased borrowing from the Bank of England (Board of Governors, 1943, pp. 639–640). There was an associated upswing in forward-market activity, with neither side of the market being stronger (both dummies are about the same magnitude for FS and FP). Interestingly, the banks may have gone short sterling a bit, although the t-ratio is too low for much confidence in this conclusion.

It should be noted that from January to July 1938 there developed a rising excess of nonbank purchases of forward sterling over nonbank sales. This was probably caused by the sharp decline in American exports. Banks had to go heavily short in the forward market, and they compensated by building up a large long spot position in sterling. During this period, the discount on forward sterling was kept relatively small by the excess nonbank purchases of forward sterling. The sharp deterioration of sterling during the Munich crisis brought the British Exchange Equalization Account into the forward market in support of sterling for the first time since 1931–32 (see Waight, 1939, p. 122). Nonbanks closed out their net long positions at this time. Thereafter, the authorities were frequently in the market, buying sterling forward, and their actions must be considered as a part of nonbank forward purchases of sterling (FP). As shown in Chapter V, such purchases tend to raise FS and FP about equally.

L. Throughout November and December, the weakness in the pound degenerated into a full-fledged bear attack, which reached a peak in the first week of January. At that time, the British authorities undertook extraordinary measures, including a ban on speculative forward transactions and a bookkeeping revaluation of gold to provide the Exchange Equalization Account with additional funds. The covered interest differential in favor of New York reached a peak just prior to these announcements.

These events show up in the dummy variables primarily as a sharp increase in sterling loans, which were not previously very responsive to speculative operations. The change in behavior was undoubtedly due to the prohibition of forward speculation against the pound. In these circumstances, spot speculation was the only avenue left for those betting on the decline of the pound. Although sterling loans were normally bills of acceptance to pay for American imports, their volume on this occasion increased significantly as sterling payments were delayed through the operation of "leads and lags." This example clearly shows that a functioning forward market makes "leads and lags" unnecessary. When the forward market is constricted, "leads and lags" appear as a less efficient but still effective means for speculation. This speculation, by the way,

could not be described as "destabilizing," for it surely pushed the pound closer to a realistic exchange rate, based on the very real prospect of European war.

The other result of the bear attack on sterling was tight money in London, which induced British banks to borrow in New York, raising dollar loans. This is confirmed by the fact that discounts and advances from the Bank of England to the London Clearing Banks were high at this time.

M. The continued attack on sterling forced the British Exchange Equalization Account to request a further large increment to its resources in February 1939. With these funds, it began a firm policy of pegging spot sterling at $4.68, which lasted until the outbreak of war. The reactions to this event were identical to those of the previous event. "Leads and lags" developed in sterling liabilities, and dollar loans rose as British banks borrowed in New York. The large but nonsignificant dummy for non-bank forward sales may indicate short sales of forward sterling.

N. Hitler dropped the other boot on Czechoslovakia in March 1939, occupying the entire country. This led to a further increase in sterling loans as a vehicle for speculation against sterling. There may have been a drop in dollar deposits at the same time; certainly, dollar deposits were below trend at this point. The only explanation I can find for this result is that there were large shipments of U.S. currency to Europe, in anticipation of the outbreak of war and attendant difficulties in currency transactions due to exchange control (Board of Governors, 1943, p. 417).

O. The final event of this period was the invasion of Poland on the first of September and the declaration of general European war. The result was an upsurge of activity in the forward exchange markets, and an apparent decline in dollar deposits. The surprising aspect of the forward activity is that it was heavier on the long side than on the short. The surprise evaporates upon examination of the division of forward positions between domestic and foreign customers. According to Table 8.1, domestic customers were short forward sterling, while foreign customers were

TABLE 8.1

NONBANK FORWARD POSITIONS IN STERLING, AUGUST 1939

(in millions of dollars)

	Week Ended Wednesday			
	Aug. 9	*Aug. 16*	*Aug. 23*	*Aug. 30*
Net long position	18	19	25	30
Domestic customers	−2	−12	−25	−10
Foreign customers	20	30	50	41

heavily long. The major foreign buyer of forward sterling can confidently be identified as the British Exchange Equalization Account. The banks may have gone short a bit at this time.

There was also a considerable reduction in dollar deposits. This was probably due to the increase in the British Treasury bill rate, from less than 1 per cent per annum to over 3 per cent, just prior to the invasion of Poland. The covered interest differential moved from 1.20 per cent in favor of New York to 0.57 per cent in favor of London, a shift of 1.77 percentage points in one week, the largest recorded by far. The significant dummy may merely reflect a nonlinearity in the relation between dollar deposits and the covered differential.

References

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Board of Governors of the Federal Reserve System, *Banking and Monetary Statistics*, Washington, D.C., 1943.
Waight, Leonard, *The History and Mechanism of the Exchange Equalisation Account*, Cambridge, England, Cambridge University Press, 1939.

IX. CONCLUSION

In lieu of a summary, some of the major contributions and conclusions of this study will be listed. The theoretical model has a solid foundation in the portfolio behavior of banks, nonbanks, foreigners, and the monetary authority. On this basis, a model of equilibrium in money markets and exchange markets is developed and analyzed in terms of stability and comparative statics. The effects of government intervention in spot and forward exchange markets are compared. Intervention in the forward market is shown to be more effective when the spot exchange rate is flexible than when it is pegged. A new proof is given of the proposition that monetary policy is more powerful under flexible exchange rates than under pegged rates. This model is the first to explain interrelated movements in domestic and foreign interest rates and spot and forward exchange rates.

A dynamic theory of the relationship between current and expected future spot exchange rates and forward exchange rates is developed by an extension of Muth's model of rational expectations. The theory has empirical application in the formulation of a new type of dummy variable used to test the effect of anticipated market disturbances.

Perhaps the most important empirical finding is that the forward market was a significant and integral part of the foreign exchange market in the only period for which data exist on the forward market. It is shown statistically that nonbank sterling liabilities incurred in connection with imports were consistently covered by forward purchases of sterling. Anticipated export receipts seem to have been covered by forward sales of sterling. Banks kept their spot and forward positions approximately balanced.

Furthermore, most private speculative activities in the dollar-sterling exchange markets of the late 1930's must be described as stabilizing. The only cases of destabilizing speculation uncovered in Chapter VIII were connected with the Gold Scare and the Dollar Scare. These unfounded rumors of changes in the pegged dollar price of gold generated much speculation on both buying and selling sides of the market. In each case, the rumors were fed by incautious or ambiguous official statements. On balance, the flexible exchange markets of 1936 to 1938 were not destabilizing. In most cases, they facilitated the response of participants in the markets to the destabilizing political events of the period.

The pegging of sterling in February 1939 and the ban on speculative

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forward activity cannot be said to have contributed to the stability of the exchange markets. The pegged rate was not easy to maintain at the manifestly high level chosen. A "one-way bet" was arranged, and speculative activity was merely shifted from the forward market to more disruptive and less efficient vehicles available in the spot market. Day-to-day uncertainty about small rate changes was replaced by one big uncertainty — when would the peg be dropped? It was dropped in the last week of August 1939, prior to the outbreak of war and the imposition of exchange controls.

APPENDIX: A MATHEMATICAL TREATMENT OF THE PROPERTIES OF THE MODEL IN CHAPTER III

1. Comparative Static Multipliers

By totally differentiating equations (2.33) to (2.36), one can obtain the comparative static properties of the model.[1] The results of differentiating can be written in matrix form as (A.1):[2]

$$
(A.1) \quad
\begin{bmatrix}
D_1^+ & D_2^- & D_3^+ & D_4^- \\
F_1^- & F_2^+ & F_3^- & F_4^+ \\
X_1^+ & X_2^- & X_3^+ & X_4^- \\
Y_1^- & Y_2^+ & Y_3^- & Y_4^+
\end{bmatrix}
\begin{bmatrix}
dR_d \\
dR_f \\
dx \\
dy
\end{bmatrix}
=
\begin{bmatrix}
d\bar{B} - d(\overline{S_m + G_m}) \\
d\overline{SD} - d\overline{SD}_e \\
d\bar{B} - d\bar{G}_e \\
d\bar{H}
\end{bmatrix}.
$$

The notation D_1, D_2, etc., means the partial derivative of D with respect to its first, second, etc., argument. Thus $D_1 = [\partial D(R_d, R_f, x, y)/\partial R_d]$, and so on. The signs given at the upper right-hand side of each partial derivative are the same as those given above the arguments of equations (2.33) to (2.36).

The symmetrical pattern of minus signs in (A.1) suggests a transformation to make the matrix non-negative. Multiplying the second and fourth rows by -1 and redefining the second and fourth variables as $-dR_f$, $-dy$, one obtains (A.2), which has a positive Jacobian matrix:

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[1] In what follows, note that $-\bar{B}$ has been substituted into (2.33) for $\overline{P}\text{-}\overline{G}\text{-}\overline{S}$, using the wealth identity (2.14).

[2] The *foreign* demand and supply functions may be defined in terms of sterling, as in Chapter II, footnote 4. This would modify some of the partial derivatives in (A.1). Using primes to denote the new values of the partial derivatives in (A.1), the partial derivatives with respect to x would change as follows:

$$
\begin{aligned}
D'_3 &= D_3 + (SD_p + SD_b - SL_p - SL_b)/x - kDD_f \\
F'_3 &= F_3 - (SD_p + SD_b)/x \\
X'_3 &= X_3 + (SD_p + SD_b - SL_p - SL_b)/x \\
Y'_3 &= Y_3 \\
L'_3 &= L_3 + kDD_f .
\end{aligned}
$$

The additional terms are the valuation effects of a change in the spot exchange rate. Note that $D'_3 + L'_3 - X'_3 \equiv D_3 + L_3 - X_3 \equiv 0$, by (2.38). Nevertheless, it is a stronger assumption to require that $D'_3, X'_3 > 0$ instead of just $D_3, X_3 > 0$. Making this assumption, all the results of the study go through as before. The mean values of $SD_b + SD_p$ and $SL_b + SL_p$ are given in Table 6.1.

$$(A.2) \begin{bmatrix} D_1^+ & -D_2^+ & D_3^+ & -D_4^+ \\ -F_1^+ & F_2^+ & -F_3^+ & F_4^+ \\ X_1^+ & -X_2^+ & X_3^+ & -X_4^+ \\ -Y_1^+ & Y_2^+ & -Y_3^+ & Y_4^+ \end{bmatrix} \begin{bmatrix} dR_d \\ -dR_f \\ dx \\ -dy \end{bmatrix} = \begin{bmatrix} d\overline{B} - d(\overline{S_m + G_m}) \\ d\overline{SD}_e - d\overline{SD} \\ d\overline{B} - d\overline{G}_e \\ -d\overline{H} \end{bmatrix}.$$

Under certain assumptions, the inverse of the Jacobian matrix in (A.2) will have positive diagonal elements and negative off-diagonal elements. The first assumption, that the Jacobian matrix has a dominant diagonal, guarantees that the inverse has positive diagonal elements. Speaking loosely, the assumption is that the "own" effect of a rate change on the demand for the "own" asset is larger than the sum of the "cross" effects on demand for other assets.[3] It will later be shown that this assumption implies that the model is stable.

The second assumption, less easy to translate into economic terms, is made so that the comparative-static properties of a "well behaved" model of exchange markets and money markets may be studied. Uekawa (1970, Theorem 5) has shown that the off-diagonal elements of the inverse of the Jacobian matrix will be negative when one can make the following assumptions concerning any subset S of the four markets (and the associated subset of rates).[4] There exists a set of rate changes $(dR_d, -dR_f, dx, -dy) \geqq 0$ such that (a) the effects of changes in the rates included in set S on the market excess demands included in set S exceed the effects on those same market demands of changes in the rates omitted from set S, and (b) the effects of changes in the rates included in set S on the market excess demands omitted from set S are smaller than the effects of changes in the rates omitted from set S on these same market demands. These assumptions seem to generalize the dominant diagonal assumption.

We may now solve equation (A.2) by inverting the Jacobian matrix to obtain (A.3):

---

[3] See McKenzie, 1960. Formally, for an $n \times n$ matrix A, there exist $d_i > 0$ such that $|a_{ii}d_i| > \sum_{j \neq i} |a_{ij}d_j|$ for each i.

If $d_i \neq 1$ for some i, choose units of measurement for the rate variables so that all $d_i = 1$. Note that this definition in terms of the *rows* of A has the same implications for the properties of A used in this study as the definition given by McKenzie in terms of the columns of A, since $|A| = |A'|$.

[4] Formally, the condition can be written: for a non-negative $n \times n$ matrix A, choose a subset of rows S. For any k not in S, there exists x_j^k such that $\sum_{jES} a_{ij}x_j^k \geqq a_{ik}$ for i in S and $\sum_{ES} a_{ij}x_j^k \leqq a_{ik}$ for i not in S.

$$
(A.3) \quad \begin{bmatrix} dR_d \\ -dR_f \\ dx \\ -dy \end{bmatrix} = \frac{1}{|J|} \begin{bmatrix} C_{11}^+ & C_{21}^- & C_{31}^- & C_{41}^- \\ C_{12}^- & C_{22}^+ & C_{32}^- & C_{42}^- \\ C_{13}^- & C_{23}^- & C_{33}^+ & C_{43}^- \\ C_{14}^- & C_{24}^- & C_{34}^- & C_{44}^+ \end{bmatrix} \begin{bmatrix} d\overline{B} - d(\overline{S_m + G_m}) \\ d\overline{SD}_e - d\overline{SD} \\ d\overline{B} - d\overline{G}_e \\ -d\overline{H} \end{bmatrix}.
$$

The C_{ij} are the cofactors of the (i,j) elements of the Jacobian matrix, and $|J|$ is its determinant, which is positive because of the dominant diagonal. The comparative static results are shown in Table A.1 (page 58).

2. Stability

The local stability of the model in the neighborhood of an equilibrium point will now be demonstrated. The interest rate for domestic (foreign) securities is assumed to fall in response to excess demand for domestic (foreign) securities. The spot (forward) exchange rate is assumed to rise in response to excess demand for spot (forward) exchange.[5] The excess demand and supply functions will be approximated by the first two terms of the Taylor series expansion about the assumed equilibrium point (R_d^*, R_f^*, x^*, y^*). Using the notation $\dot{R}_d = dR_d/dt$ to stand for the time derivatives, these assumptions imply

$$
(A.4) \quad \begin{bmatrix} \dot{R}_d \\ \dot{R}_f \\ \dot{x} \\ \dot{y} \end{bmatrix} = - \begin{bmatrix} D(R_d, R_f, x, y) \\ F(R_d, R_f, x, y) \\ X(R_d, R_f, x, y) \\ Y(R_d, R_f, x, y) \end{bmatrix} \approx - \begin{bmatrix} D_1 & D_2 & D_3 & D_4 \\ F_1 & F_2 & F_3 & F_4 \\ X_1 & X_2 & X_3 & X_4 \\ Y_1 & Y_2 & Y_3 & Y_4 \end{bmatrix} \begin{bmatrix} R_d - R_d^* \\ R_f - R_f^* \\ x - x^* \\ y - y^* \end{bmatrix}.
$$

After the same transformation that was applied to (A. 1), this becomes

$$
(A.5) \quad \begin{bmatrix} \dot{R}_d \\ -\dot{R}_f \\ \dot{x} \\ -\dot{y} \end{bmatrix} = - \begin{bmatrix} D_1 & -D_2 & D_3 & -D_4 \\ -F_1 & F_2 & -F_3 & F_4 \\ X_1 & -X_2 & X_3 & -X_4 \\ -Y_1 & Y_2 & -Y_3 & Y_4 \end{bmatrix} \begin{bmatrix} R_d - R_d^* \\ -(R_f - R_f^*) \\ x - x^* \\ -(y - y^*) \end{bmatrix}.
$$

Since the matrix in (A.5) is the negative of the matrix in (A.2), it has a negative dominant diagonal. Therefore, its characteristic roots have negative real parts, and the model will return to equilibrium if disturbed (McKenzie, Theorem 2).

---

[5] Choose units of measurement of the quantity variables so that all speeds of adjustment equal unity.

TABLE A.1

COMPARATIVE STATICS — FLEXIBLE RATES[a]

	Effect on Endogenous Variables			
Change in Predetermined Variable	Domestic Interest Rate, R_d	Foreign Interest Rate, R_f	Spot Exchange Rate, x	Forward Exchange Rate, y
$d\overline{B}$, increased trade deficit	$C_{11} + C_{31} > 0$	$-(C_{12} + C_{32}) > 0$	$C_{13} + C_{33} > 0$	$-(C_{14} + C_{34}) > 0$
$d(\overline{S_m + G_m})$, open-market purchase of government securities	$-C_{11} < 0$	$C_{12} < 0$	$-C_{13} > 0$	$C_{14} < 0$
$d\overline{SD}$, increase in foreign-government debt	$-C_{21} > 0$	$C_{22} > 0$	$-C_{23} > 0$	$C_{24} < 0$
$d\overline{H}$, government purchase of forward foreign exchange	$-C_{41} > 0$	$C_{42} < 0$	$-C_{43} > 0$	$C_{44} > 0$
$d\overline{SD}_e = -d\overline{G}_e$, foreign-government purchase of spot foreign exchange	$C_{21} + C_{31} < 0$	$-(C_{22} + C_{32}) < 0$	$C_{33} + C_{23} > 0$	$-(C_{24} + C_{34}) > 0$

[a]All entries should be divided by $|J|$.

3. On Pegged Exchange Rates

Differentiating equations (2.33), (2.34), (2.35'), and (2.36) totally with respect to the variables R_d, R_f, G_m, y, one obtains the following result, analogous to (A.2):[6]

$$(A.6) \quad \begin{bmatrix} D_1 & -D_2 & 0 & -D_4 \\ -F_1 & F_2 & 0 & F_4 \\ X_1 & -X_2 & 1 & -X_4 \\ -Y_1 & Y_2 & 0 & Y_4 \end{bmatrix} \begin{bmatrix} dRd \\ -dR_f \\ -dG_m \\ -dy \end{bmatrix} = \begin{bmatrix} d\bar{B} - d(\overline{G_m + S_m}) \\ \overline{dSD_e} - \overline{dSD} \\ d\bar{B} \\ -\overline{dH} \end{bmatrix}.$$

The Jacobian determinant in this equation is just C_{33}, the cofactor of the element in the third row and column of the Jacobian matrix of the flexible rate case. The effect of an open-market purchase on the domestic interest rate is

$$(A.7) \quad \frac{dR_d}{d(\overline{G_m + S_m})} = -\frac{(F_2 Y_4 - F_4 Y_2)}{C_{33}} = -\frac{C_{11 \cdot 33}}{C_{33}} < 0 .$$

The notation $C_{11 \cdot 33}$ means the cofactor formed by striking out the first row and column and the third row and column from the Jacobian of (A.2). From Table A.1 the flexible-rate multipliers for open-market operations can be compared with (A.7).

$$(A.8) \quad \frac{dR_d}{d(\overline{G_m + S_m})\text{flex}} - \frac{dR_d}{d(\overline{G_m + S_m})\text{peg}} = -\frac{C_{11}}{|J|} + \frac{C_{11 \cdot 33}}{C_{33}}$$

$$= -\frac{C_{11} C_{33} - C_{11 \cdot 33} |J|}{C_{33} |J|} = -\frac{C_{13} C_{31}}{C_{33} |J|} < 0 ,$$

by Jacobi's Identity (see Samuelson, 1960). In the flexible-rate case, monetary policy has a stronger effect on the domestic interest rate.

Some other interesting results can be obtained:[7]

$$(A.9) \quad \frac{dG_m}{d\overline{H}} = \frac{C_{43}}{C_{33}} < 0 \qquad \text{and} > -1 .$$

Purchase of the domestic currency forward ($d\overline{H} < 0$) can prevent a gold loss, but on a less than one-for-one basis.

$$(A.10) \quad \frac{dy}{d\overline{H}} = \frac{D_1 F_2 - F_1 D_2}{C_{33}} = \frac{C_{33 \cdot 44}}{C_{33}} > 0 ,$$

---

[6]An alternative method of pegging is to make foreign official holdings of domestic government securities (S_e) an endogenous variable, instead of G_m. If sterilization is not assumed, there is a -1 in the first row, third column, of the Jacobian matrix.

[7]Results (A.9) to (A.12) generalize similar findings for the case of exogenous interest rates in Black (1968).

(A.11) $\dfrac{dy}{d\overline{H}}\text{ flex} - \dfrac{dy}{d\overline{H}}\text{ peg} = \dfrac{C_{44}}{|J|} - \dfrac{C_{33\cdot44}}{C_{33}} = \dfrac{C_{34}C_{43}}{C_{33}|J|} > 0$.

Jacobi's Identity shows that forward intervention is more effective in affecting the forward rate in the flexible-rate situation than under pegged rates.

(A.12) $-\dfrac{dG_m}{d\overline{B}} = \dfrac{C_{33} + C_{13}}{C_{33}} < 1$.

A trade deficit makes gold flow out, but on a less than dollar-for-dollar basis, because tighter money pulls capital in.

4. *The Slopes of the MM and EM Curves*

Assume that the Jacobian matrix (A.2) has a dominant diagonal and that $D_3 = -D_4$, $F_3 = -F_4$. Then the slope of *MM* is less than unity. Proof: The equation of *MM* is derived as follows:

$$\begin{bmatrix} D_1 & -D_2 \\ -F_1 & F_2 \end{bmatrix} \begin{bmatrix} dR_d \\ -dR_f \end{bmatrix} + \begin{bmatrix} D_3 & -D_4 \\ -F_3 & F_4 \end{bmatrix} \begin{bmatrix} dx \\ -dy \end{bmatrix} = 0$$

or $A\xi + B\eta = 0$, where $B = \begin{bmatrix} D_3 & 0 \\ 0 & -F_3 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} = Cee'$

and e is a vector of ones, C a diagonal matrix.

Then

$$\xi = -A^{-1}B\eta = -A^{-1}Cee'\eta ,$$

$$e'\xi = -e'A^{-1}Cee'\eta ,$$

$$-\frac{e'\xi}{e'\eta} = \frac{d(R_f - R_d)}{d(x - y)} = e'A^{-1}Ce .$$

But the dominant diagonal assumption implies $e'A^{-1} > 0$ and $Ae - Be > 0$, or $e'e > e'A^{-1}Be = e'A^{-1}Cee'e$; thus $e'A^{-1}Ce < 1$. A similar proof shows that the slope of *EM* is greater than unity.

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GLOSSARY OF SYMBOLS

b	subscript for domestic banking sector
B	net worth of foreign sector
BFP	banks' net contracts to purchase forward foreign exchange
C	domestic currency
D	excess demand function for domestic government securities
DD	domestic bank deposits
DL	domestic bank loans and acceptances
e	subscript for foreign-exchange equalization account
ER	excess bank reserves
EX	exports from the domestic country (EXO if orders, EXD if deliveries)
f	subscript for foreign sector
F	excess demand function for foreign securities
FP	nonbank and foreign contracts to purchase forward foreign exchange
FS	nonbank and foreign contracts to sell forward foreign exchange
G	gold
H	Exchange Equalization Account's contracts to purchase forward foreign exchange
IM	imports to the domestic country (IMO if orders, IMD if deliveries)
k	required reserve ratio on domestic bank liabilities
L	excess demand function for high-powered money
LB	three-month Treasury-bill rate in London
m	subscript for domestic monetary authority
NYB	three-month Treasury-bill rate in New York
p	subscript for domestic nonbank private sector
P	net worth of nonbank sector
PB	banker's acceptance rate in Paris
$PCSP$	percentage change in Standard and Poor's common-stock price index
R_d	domestic three-month bill rate
R_f	foreign three-month bill rate
S	domestic government securities
SD	foreign securities (including both deposits and government securities)
SL	foreign bank loans and acceptances
TR	total bank reserves
u	$400(x-y)/x$; annual rate of discount on three months' forward exchange
v	$400(w-y)/y$; expected rate of profit on forward exchange, uncovered
w	expected spot exchange rate for period 13 weeks in future
x	spot exchange rate in dollars per pound
X	excess supply function for spot foreign exchange
y	forward exchange rate for delivery in 13 weeks
Y	excess supply function for forward foreign exchange
z	$R_d - R_f + u$; covered interest differential
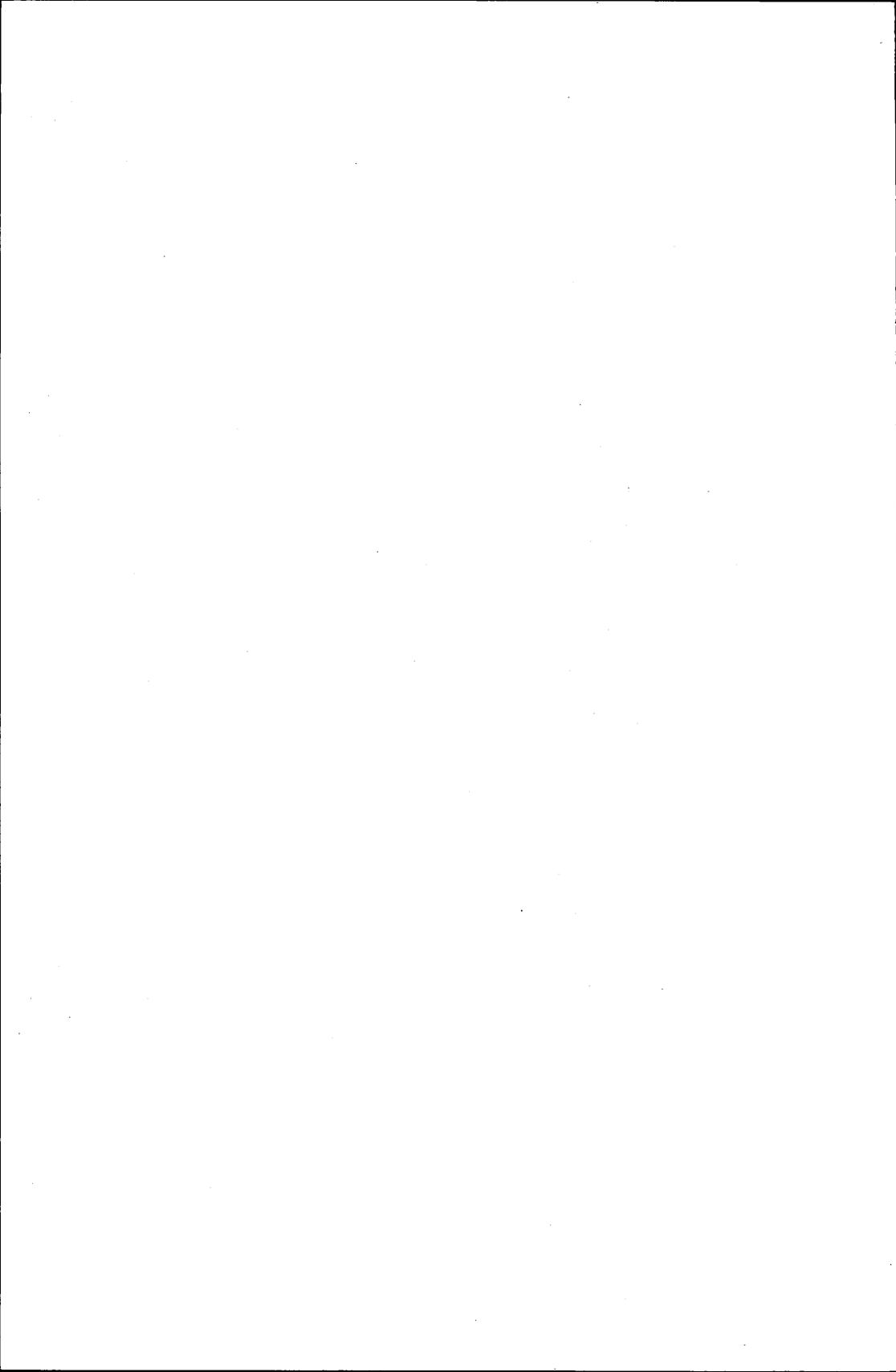
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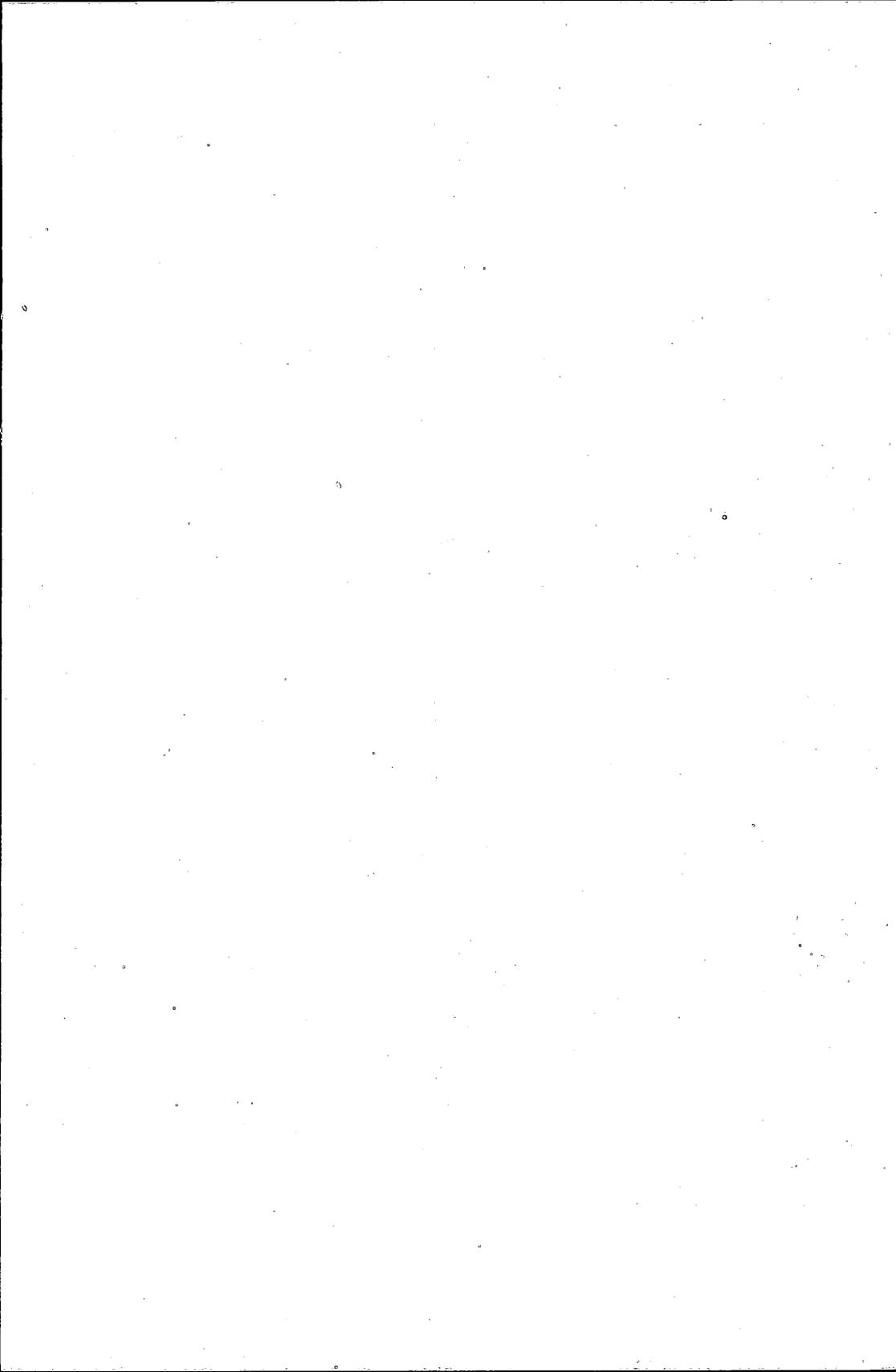

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* (1) Klaus Knorr and Gardner Patterson, eds., *A Critique of the Randall Commission Report.* (1954)
* (2) Gardner Patterson and Edgar S. Furniss Jr., eds., *NATO: A Critical Appraisal.* (1957)
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