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A MODEL OF ARBITRAGE AND SHORT-TERM CAPITAL FLOWS

by

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Introduction

Existing empirical work dealing with short-term capital movements in an adjustable peg exchange rate regime suffers from insufficient attention to exchange risk as a determinant of the timing and direction of short-term capital flows. Theoretical work on monetary policy in an open economy has highlighted the importance of the degree of capital mobility in determining the extent to which international flows of funds respond to divergent national monetary and fiscal policies. We conjecture that the dominant determinant of capital mobility, even in a narrow band exchange rate regime, is the risk of exchange rate changes. Following this conjecture we develop a model in which foreign bonds covered against exchange risk are perfect substitutes for domestic bonds, while uncovered foreign bonds are not good substitutes for domestic bonds.

These assumptions are incorporated into an integrated model of exchange rate determination and short-term capital flows. The exchange rate regime investigated is a fixed rate system, with narrow intervention bands, that is subject to occasional discrete parity changes. In such a system it is assumed that the current account and long-term capital account in the balance of payments are determined by factors other than exchange rate fluctuations allowed within the narrow bands. The private short-term capital account and the intervention policies of central banks are sensitive to exchange rate changes.

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In addition to analysis of recorded items in the balance of payments we investigate the importance of unrecorded transactions in a model of short-term capital flows. The unrecorded transactions considered are contractural trade obligations, forward exchange positions, and unrecorded capital flows. It is shown that each of these transactions presents a measurement problem which materially affects the interpretation of any model of the short-term capital account.

Existing empirical work on financial capital flows generally follow two divergent methodologies. Stock adjustment models, typified by Branson's work, [2] assume that what Aliber [1] calls political risk is an important determinant of the degree of substitutability among bonds issued in different countries. In such models, a change in the desired stock foreign assets depends upon changes in interest differentials, changes in wealth, and changes in risk parameters. Risk here is not exchange risk, but risk of default or of exchange controls peculiar to various countries, and is generally assumed constant. In order to measure the changes in desired stocks of foreign assets and liabilities due to changes in these determinants, it is assumed that the adjustment is spread over several time periods, so that a change in the interest differential or in wealth does not lead to full stock adjustment within a measured time period. Thus disequilibrium interest differentials are observable, and distributed lags of changes in interest differentials or changes in wealth give information about capital flows.

In a recent paper Kouri and Porter [6] have criticized this approach. Their contention is that given a change in the monetary base of a small open economy, capital flows will occur very quickly in order to satisfy a new stock portfolio equilibrium. In Kouri and Porter's view, changes in interest differentials in quarterly or monthly data reflect changes in equilibrium interest rates consistent with changing stocks of assets. Thus a change in the domestic part of the monetary base does not generate observed disequilibrium interest rates, but does generate an equivalent offsetting capital flow within the measured time period.

In this paper we test a quite different model. If we control for the effect of exchange risk as a deterrent to capital flows, then we expect that portfolio adjustment will occur very rapidly, since except for exchange risk, domestic and foreign bonds are perfect substitutes. But even in normal times exchange risk cannot be ignored. In order to explain capital flows it ~~is necessary to~~ first understand the factors which influence the supply of forward cover to those who wish to take advantage of interest differentials. Our hypothesis is that the timing of a stock portfolio adjustment which Kouri and Porter have assumed takes place very quickly, and which Branson assumes depends on an adaptive process, depends in large part on expectations concerning changes in exchange rates. In our model uncovered capital flows are assumed to follow a stock adjustment process. But we find the reasons for including lagged explanatory variables unpersuasive.

In our view lagged variables such as trade balance or changes in interest rates are important not because people adjust their portfolios slowly, but because changes in these variables affect expectations about changes in exchange rates, and thus desired speculative positions. We therefore assume that the uncovered part of portfolios are adjusted within the measured time period, which in our model is one month. Since exchange risk makes uncovered foreign bonds poor substitutes for domestic bonds, changes in the domestic part of the monetary base are not fully offset by uncovered capital flows. Thus foreign and domestic interest rates can diverge, and a change in the differential will be associated with an uncovered capital flow within a month.

Covered foreign bonds, however, are assumed perfect substitutes for domestic bonds. Thus the covered differential will not be bid away from the familiar interest parity condition.[1/] But in this case the capital flow necessary to maintain interest parity in the face of a domestic open market operation is not the one necessary to keep foreign and domestic interest rates equal, but the one necessary to change the forward exchange premium so that it offsets the change in the uncovered interest rate differential. Thus we encounter a simultaneity problem for covered capital flows. That is, the covered capital flow is motivated by opportunities for covered arbitrage, but the arbitrage itself influences the level of the covered differential.

1/ It is argued below that errors in measurement account for divergences from interest parity that seem to appear in the data.

It is necessary therefore to identify shifts in the demand and supply curves for covered foreign claims and liabilities which would tend to generate a covered interest differential in the absence of simultaneous stock adjustments. This necessitates the development of a model of exchange rate determination. It also implies that a model of capital flows must include variables which explain how much, and in what form, market participants trade exchange risk.

In order to introduce the problem, in the next section a very simple model of exchange rate determination and covered capital flows is developed. The effect of changes in exchange exposure of commercial traders is used as an example of a variable which shifts the demand curves for covered foreign claims and liabilities. This simple model is then expanded, and finally yields a testable hypothesis.

CHART I

A Sequential Analysis of Exchange Markets

Row	Time	Uncovered Export Trade Contracts (Net)	Trade Deliveries (Net)	Covered Flows (Net)	Uncovered Flows (Net)	Spot Dollars	Forward Dollar
(1)	t_0	Surplus	0	0	0	0	Excess Demand
(2)	t_0	Surplus	0	0	0	Excess Demand	Excess Deman
(3)	t_0	0	0	Inflow	Outflow	0	0
(4)	t_1	0	Surplus	Outflow	0	0	0
(5)	t_1	Surplus	0	0	0	0	Excess Deman
(6)	t_1	Surplus	0	Inflow	Outflow	0	0

Trade Flows and Covered Capital Movements

The first approximation to a model of exchange markets will imagine a world in which all trade and short-term capital flows are covered against exchange risk. Speculators may be active in spot and forward markets but do not, as a group, create any excess demands or supplies in any exchange market.[2/] We shall call country A's currency dollars; foreign exchange for A is called marks.[3/]

Assume initially that country A has for a long time had a trade balance and no net short- or long-term capital flows. Now in time t_0 assume that some exogenous shock generates an increase in export contracts with no change in import contracts. Further assume that all contracts entered into at time t_0 will result in payment and delivery of goods in t_1, where t_1 is 90 days after t_0. In row (1) Chart I this initial situation is depicted. The initial market disturbance is in the forward market, since by assumption A's exporters will attempt to purchase a greater quantity of forward dollars than A's importers are supplying in t_0.[4/] The initial effect

2/ These assumptions will be dropped later; at this point we wish to emphasize the difference between interest arbitrage and uncovered capital flows which are motivated by interest differentials with expectations about exchange rate changes held constant.

3/ We will assume that all trade contracts are denominated in marks. This does not affect the analysis but eases the exposition.

4/ Notice that the traders are not "financing" trade in the traditional sense; they are trying to insure the exchange value of future receipts. The exporter must of course finance production. But as is argued below this is not the place to look for a relation between international trade and international capital movements.

then will be a rise in the forward price of dollars. Since there are no speculators in the market, and trade payments are predetermined, it follows that the forward price of dollars will rise relative to the spot rate until interest arbitrage becomes profitable. Arbitragers will attempt to sell spot marks for spot dollars, invest the dollars for 90 days, and sell the dollar proceeds forward for delivery in t_1. But the attempt to buy spot dollars will of course put upward pressure on the spot rate. This leaves us in the situation depicted in row 2, Chart I. There is now excess demand in either the spot or forward markets for dollars. Obviously arbitrage is not an equilibrating force. The pressure on the spot rate will not in our model lead to any supply response in the spot market; thus the spot and forward exchange rate will tend to rise without limit.

In order to highlight the dual nature of the capital account assume that, in face of the contractural trade surplus and the desired covered capital inflow, the monetary authority buys domestic bonds in an effort to lower domestic interest rates. Notice that, given our assumptions, this will not eliminate the incentive for covered capital inflows. A reduction in the domestic interest rate will tend to reduce (or make more negative) the uncovered interest differential in favor of dollar assets But traders by assumption will bid up the premium on forward dollars in an attempt to induce arbitragers to purchase dollar assets and supply forward dollars.[5/]

5/ This assumption, which is different from many existing models, will be defended in the next section.

But the monetary authority's actions of reducing interest rates might induce an uncovered capital outflow. Row 3, Chart I, shows this situation. Notice that the conditional claim on forward marks of traders is now offset by a conditional forward liability of arbitragers, thus clearing the forward market. And the spot demand for dollars of arbitragers is just offset by a spot supply of dollars by uncovered capital traders. Another possibility, of course, is that the monetary authority could intervene directly in the spot market and supply dollars to arbitragers. This of course is an uncovered official capital outflow which may or may not be associated with a domestic open market operation. A third possibility is that an uncovered flow might result from the imposition of some sort of capital controls, which is equivalent to changing the implicit interest rate on uncovered foreign claims.

An important question is whether or not the same contractural trade surplus in the next time period will require an additional short-term capital inflow. We shall see that it does not; only a change in the trade balance will require additional short-term capital flows.

In t_1 assume that the surplus contracted for in t_0 is realized and payment is made. It will be convenient to first clean up the transactions made in t_0 which will occur in t_1. In row (4), Chart I, we see that traders who had sold their mark receipts forward in t_0 will be paid the marks in t_1 and will deliver them to fulfill the forward contract. The arbitragers will sell their dollar assets and transfer the proceeds to the traders. Since the surplus of trade deliveries is offset by an outflow of short-term capital, and the transfer is made of predetermined prices, neither of these actions have a direct effect on exchange rates.

Now suppose the same trade surplus contracted for in t_0 is again contracted for in t_1. Row (5), Chart I, is identical to row (1). But in this case the excess demand for forward marks by traders will be met if arbitragers roll-over (maintain at the same level) their arbitrage position; they need not be induced to increase that position. This is shown in row 6, Chart I. Excess demand in the spot market on the other hand must again be met by an uncovered capital outflow or by official intervention in the spot market.

Spot and Forward Speculation and the Nature of Interest Arbitrage

We have seen that the exchange risk generated by a trade contract initially leads traders to bid up the forward rate. Arbitragers might transfer the unbalanced position to the spot market if some market participant is simultaneously seeking an open spot position.

It is equally possible that traders could initially seek cover by bidding for spot foreign exchange. In this case traders could hold a spot position to offset their contractural risk. Arbitragers in this case might transfer this excess demand for spot exchange to the forward market if some other market participant preferred an open forward position.

which will happen seems a good deal less determinant than the traditional literature suggests. The common assumption is that "all speculation takes place in the forward market," since a given amount of speculative capital can be highly levered in this market. Further, traders are assumed to cover only in the forward market. These assumptions have a reputable background but suggest some disturbing analogies. First, no arbitrage flows will ever take place unless trade is sensitive to changes in the spot rate or central banks intervene in the spot market. Arbitragers will bid for spot funds as the forward rate is bid up or down, but there will be no takers in the spot market unless either the central bank or some speculator decides to take an open spot position. Second, an analogous assumption in other markets would lead us to believe that all stock market speculators buy or sell short rather than taking spot positions. This violates easily observable facts. In foreign exchange markets the facts are not obvious simply because no observable market exists where we can get an idea about typical speculative portfolios.

The problem with statements about "leverage" is that they give no information about which market is most advantageous for a given agent to obtain leverage. In fact, any agent who has any liability on his balance sheet is levering his net worth in order to acquire assets. In foreign exchange markets a speculator or trader will consider the possibility of borrowing funds, for example in the commercial paper market, and buying spot foreign exchange rather than buying forward exchange. If he does this the cost of covering exchange risk is the difference between his borrowing rate and what he can earn on a foreign currency asset. Or the trader or speculator can pay for avoiding exchange risk by paying the currently quoted forward premium. Exchange traders tell us that the trader or speculator will always choose the forward rate. This follows if the difference between the opportunity or borrowing costs of the foreign exchange bank and the rate which the bank can earn on foreign assets is smaller than the spread for anyone else in the economy. Any speculator or trader who has that combination of borrowing cost and investment opportunity which is narrower than that reflected by the market forward rate should in fact buy spot foreign exchange and invest it until it is needed to make payment.

One gets the feeling that someone is getting something for nothing in this model. The trader who bids for a forward exchange contract from a commercial bank is promising to deliver one currency for another in 90 days. On this basis the bank, in order to cover itself, has to make an offsetting agreement with some other market participant. Now if the exchange rate moves in such a way as to injure the trader, the bank must expect that the trader may not be able to meet its forward contract obligation. The bank therefore should, and generally does, consider the credit-worthiness of the trading firm when deciding the conditions under which it will offer the firm a forward contract.

This calculation is exactly the same calculation the bank would have to make if the trader requested a loan in order to allow him to cover his open position by purchasing spot foreign exchange. To make them exactly equivalent, we could assume that the foreign exchange assets purchased by the firm are offered as security for the bank loan. At the end of the 90-day period the firm would sell its foreign exchange assets and repay the bank loan. Again the bank would have to consider the overall financial position of the firm in deciding under what terms it would make the secured loan.

The forward exchange market then is not an added source of leverage for the trading firm. Rather it represents a convenient collapsing of negotiations into one transaction between the bank and the firm. There is no free lunch which attracts all market participants to the forward market. At the margin the forward premium represents the price at which some market participants will be indifferent between spot and forward speculation. The decision of a given firm to cover or speculate spot or forward might be influenced by a number of second order effects.

First, some individuals may find that they must make frequent foreign currency payments. Faced with uncertainty about when they will need foreign exchange it might be rational to hold a working balance in spot foreign exchange and replenish this balance when the spot rate appears favorable. Attempting to synchronize forward contracts with payments needs might involve prohibitive transactions costs.

Second, large transactors might find the forward market too thin to accommodate their needs of a fixed price. Such transactors might find that buying spot exchange at the market price and storing it until needed is less costly than buying forward exchange or waiting until the day when a large spot purchase is required.

Some multi-national corporations might find that within some range they are indifferent to the currency composition of their working balances. These spot balances might be switched into strong currencies directly, rather than adjusting their exposure through forward contracts.

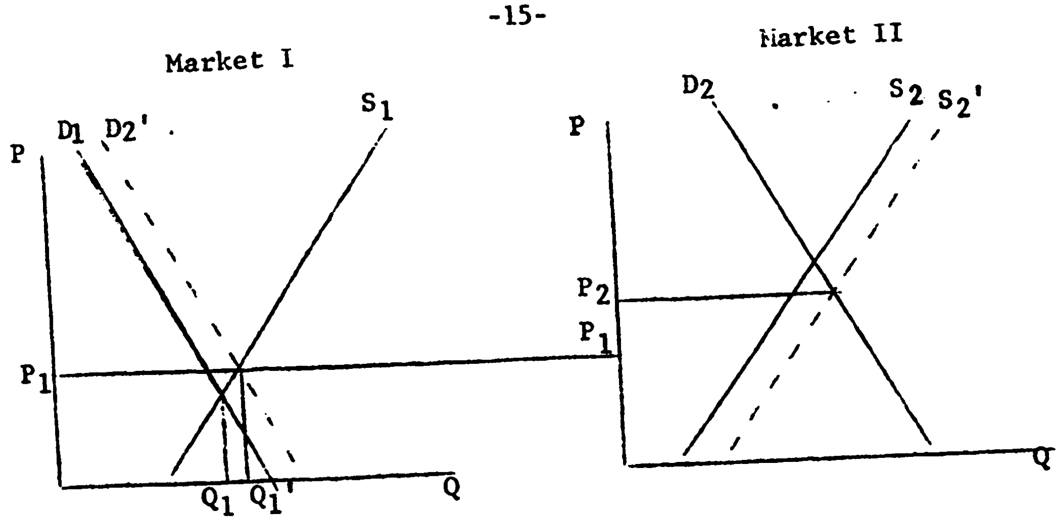
Finally, an important factor might be the type of exchange controls in force. These controls are most effective against the type of portfolio investments that a commercial bank would make in the process of arbitrage. If commercial banks cannot earn interest on portfolio investments in a given currency then the interest parity forward premium will be substantial, reflecting the difference between the opportunity costs of the bank on domestic assets and a zero rate of return on foreign currency assets. A trading firm, on the other hand, may be in a better position to beat the exchange controls since most authorities have tried to disrupt the business of "legitimate" foreign trade as little as possible. Thus the trading firm, when faced with a substantial forward premium, may well find it optimal to buy spot exchange and invest it in a foreign currency asset which is not available to commercial bank arbitragers.

To these we could add other secondary factors. Some market participants apparently are excluded from the commercial bank forward market because banks consider "speculators" bad risks or unpatriotic. These individuals will speculate in the spot market. These participants face a market imperfection which might make spot speculation preferable.

In any case, it seems likely that the very narrow reasons given in traditional models for why speculators operate only in the forward market may not in fact hold. As a theoretical construct the assumption that all speculation is forward speculation is not objectionable. But, as we will show below, this theoretically useful assumption may generate incorrect inferences from empirical evidence.

Arbitrage and Short-term Capital Flows

Essentially we view spot and forward exchange markets as two markets for the same good. The markets are separated by storage and transactions costs. In the diagram below the two markets are initially isolated from one another. In each market a price and quantity are determined. Now arbitragers are told that they can buy or sell in either market. The only constraint is that they must pay a positive storage cost to get the goods from market I to market II. The arbitrager will buy in market I, pushing the demand curve in market I to the right, and sell in market II, pushing the supply curve right, until the difference P_2-P_1 just equals the storage costs. If we call market I the spot market for dollars and market II the forward market for dollars, and call the transport costs the interest differential

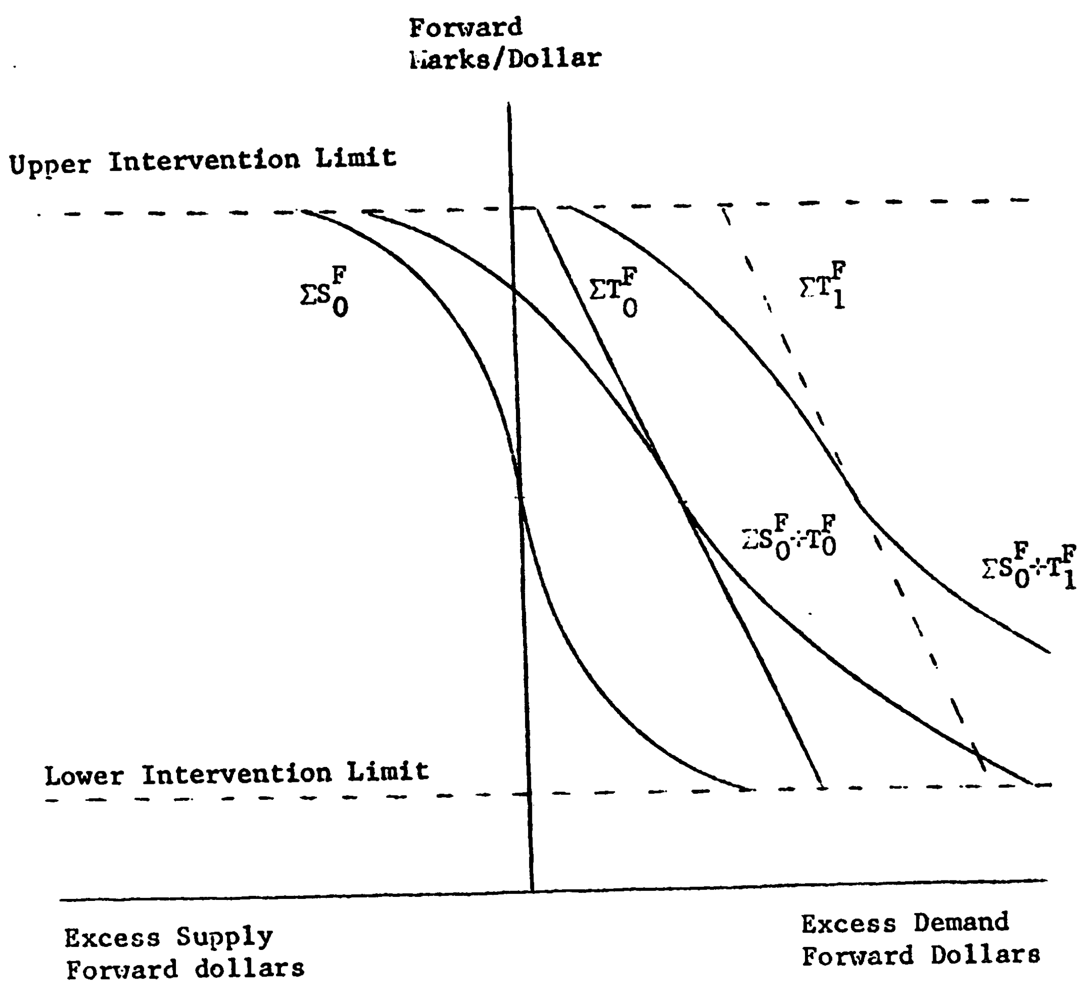


between marks and dollars, then arbitrage is the difference between Q_1 and Q_1'. Notice that the amount of arbitrage, $Q_1'-Q_1$, depends upon the elasticity of supply of spot speculation, that is, the movement along S_1, as compared to the elasticity of demand for forward speculative positions.

The difference between P_1 and P_2 might reflect, in addition to the interest rate, the fact that spot and forward dollars are not the same goods. Thus as $Q_1'-Q_1$ grows, arbitragers might demand a price differential greater than that implied by the interest rate. This is, of course, the slope of the arbitrage schedule with respect to the implicit (interest adjusted) premium on forward dollars.

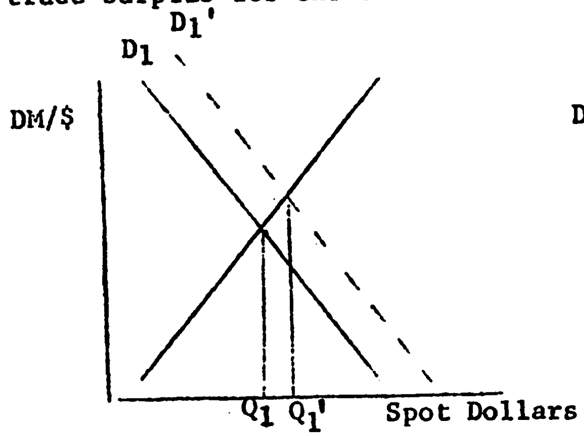
If a stable relation between the implicit premium and the volume of arbitrage existed, one could simply estimate the volume of arbitrage flow as a function of the implicit premium. If this is not a stable relation, or if the arbitrage schedule is perfectly elastic, then one can try to estimate arbitrage flows by regressing them against variables which shift one of the four curves in markets I and II.

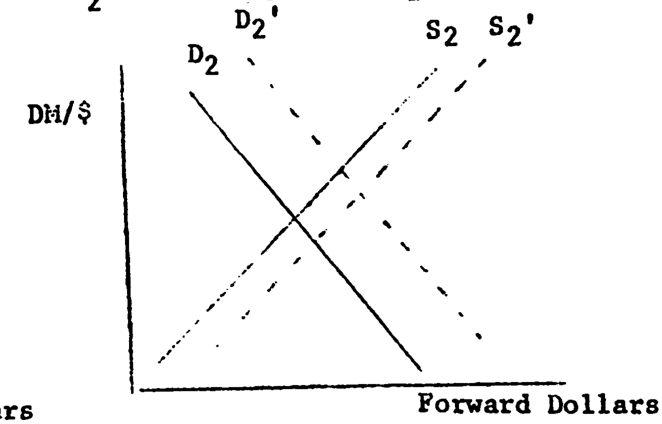
CHART II



Forward Marks/Dollar
Upper Intervention Limit
ΣS_0^F
ΣT_0^F
ΣT_1^F
$\Sigma S_0^F + T_0^F$
$\Sigma S_0^F + T_1^F$
Lower Intervention Limit
Excess Supply Forward dollars
Excess Demand Forward Dollars

For example, we have argued that a change in the contractural trade surplus for the U.S. will shift D_2 to the right to D'_2





Arbitragers will then buy spot pushing D_1 to D_1' and sell forward pushing S_2 to S_2'. Given the elasticities of the curves as drawn here, we should observe an arbitrage inflow to the U.S. of $Q_1'-Q_1$.

A Diagramatic Model of An Adjustable Peg System

In order to be relevant for empirical work the simple demand supply analysis of arbitrage has to be modified to fit the adjustable peg system as it existed until very recently. The primary complication is government intervention. The existence of intervention limits considerably alters the simple demand and supply relations for foreign exchange.

The existence of intervention limits makes the behavior of private speculators particularly difficult to model. It will be useful to break speculators into two conceptual groups, differentiated by the degree of risk aversion and by the parameters which determine the volume of activity of each group in exchange markets. One group consists of traders who are assumed very risk averse in that they will cover most of their foreign exchange receipts and expenditures regardless of where within the band the exchange rate might be. Their excess demand or supply for forward cover is effected parametrically by the trade balance. The second group includes all other relatively risk-neutral speculators. The primary difference between the two groups, besides risk aversion, is that the size of the second group is determined, not by the trade balance, but by the profitability of the speculation business. In the next section we turn our attention to the formation of expectations and a description of the activities of this residual group of speculators as well as that of traders and arbitragers.

Non-trade Speculation

Speculative expectations are assumed to depend upon past patterns of exchange rate changes as well as past and projected changes in other variables such as the reserve position of the central bank defending the exchange rate. In order to facilitate graphical exposition we assume that the expected future spot rate is at parity. If the spot rate moves to an intervention limit, speculators must determine whether or not the central bank can successfully defend the intervention limit. That is, should they change their estimate of expected future spot rate? The rate of reserve accumulation or loss is an important parameter here. If speculators believe that the central bank will be unable or unwilling to defend the existing intervention limit, then the expected value for the exchange rate lies outside the intervention limit.

The demand and supply curves in the forward market in Chart II incorporate the above considerations. Within the bands speculation is assumed stabilizing in the sense that at a point away from the expected value (parity) speculators will on balance bet that the rate will move toward parity.[6/] At rates near parity there is, however, considerable room for disagreement, as long as the central bank is not directly active in the market. Thus, at a point mid-way between the par value and the upper limit, there is an excess supply of forward dollars, but the excess supply is small relative to the gross volume of speculation. As the forward rate moves close to the upper limit,

6/ In the empirical work to follow, the expected future rate will not be parity but will be the solution to an autoregressive expectations model.

the expectation that the central bank will not allow the rate to rise further will move a larger share of the speculative bets to the excess supply category. At the upper limit nearly all speculators will be betting that the rate will fall or at least go no higher. Notice here that the speculative game offers no extraordinary profits as long as the central bank is very likely to defend the upper limit. Thus the speculative excess demand curve ΣS^F, intersects the intervention limits and becomes perfectly inelastic at the limits since no new capital is attracted to the speculative game. The shape and position of this curve is independent of the trade balance.

If speculators decide on balance that the intervention limit will not be successfully defended, the forward exchange rate loses much of its significance. Speculators could take positions in the forward market, but this remains a fair game as long as the authorities do not intervene in the forward market. If everyone in the market has about the same information, the forward rate will move far outside the intervention limits cutting off any extraordinary profits. But there is a better game in town, an unfair game, in which speculators have the edge. The speculator can shift to the spot exchange market where the central bank is maintaining a pegged exchange rate. The often heard, and widely misinterpreted, statement that forward markets "dry up" during a speculative episode says nothing about the nature of forward markets themselves; it merely is another way of saying that when central banks are intervening in the spot market there is a better game to play.

Taking the extreme view that there is no net speculation in the forward market when the forward rate moves outside the bands, the demand and supply curves in the forward market discontinue at the upper and lower intervention limits as shown in Chart II.

Trade

If we assume that all trade is covered, then the behavior of traders in the forward market can be treated as parametric shifts in the curves already drawn for pure speculators. More realisitically, we assume that some traders behave in the same way as other speculators and some do not. Thus the slope of the demand and supply of forward exchange depends upon both traders' and speculators' response to changes in the exchange rate. But the position of the curves is shifted when the trade balance changes, since some traders are assumed to always seek cover at any exchange rate within the band.[7/]

7/ This specification of traders' behavior is contrary to views such as the following offered by White [9].

> The new element in the foreign exchange market, which made necessary a revision of previous opinion, was the restoration of confidence in the maintenance of the official parities: importers and exporters -- who have probably been the chief users of forward exchange contracts -- became confident in 1959 that, for example, the dollar price of the pound sterling would not move (within the next three months) outside the legal limits of \$2.78 and \$2.82. At the upper limit of \$2.82, the U.S. importer could never gain by covering forward, and he probably would lose; at this price, therefore, his demand for forward pounds would be zero.

The frequency in parity changes since the introduction of "certainty" in 1959 implies at any point in time a non-zero probability that the legal limits will be breached. There must be some level of risk aversion on the part of some traders which will insure that even a very small probability of a large exchange loss due to a parity change will lead them to seek cover in the forward exchange market.

Arbitrage

No arbitrage schedule is drawn on this axis, since arbitrage is not a function of either exchange rate, but rather the difference between the exchange rates generated in the two markets. We will assume that the interest parity condition holds continuously; that is, covered foreign bonds are perfect substitutes for domestic bonds. For any given spot rate then, the forward arbitrage excess demand is the negative of the $\Sigma S + \Sigma T$ curve. In the spot market it is the same as the $\Sigma S + \Sigma T$ curve.

An Algebraic Description of a Model of an Adjusted Peg Exchange Rate System: Normal Period

Normal periods will be identified in the empirical work to follow as those time periods in which the forward exchange rate is within the intervention bands.

Forward Market

(1) $S_t^F = S^F(R^F - R^*)$

(2) $T_t^F = (1-\gamma)\alpha TB_{t+1} + (1-\alpha) TB_{t+1} S^F (R^F - R^*)$

(2a) $T_t^F = (1-\gamma)\alpha TB_{t+1}$

Equation (1) states that the excess demand for forward speculative positions in period t, S_t^F, is a function, S^F, of the divergence between the current forward exchange rate, R^F, and the expected future spot exchange rate R^*.

Equation (2) states that the excess demand for forward exchange by traders in period t is equal to some constant, α, of the contractural trade balance in period t. The uncovered portion of the contractural trade balance, $(1-\alpha)TB$, is a change in a speculative position. For simplicity we assume that such decisions are the same as for changes in speculative positions unrelated to trade. In (2a), therefore, we include only those traders who always cover either spot or forward, and subsume trader-speculators in equation (1). The (1-γ) parameter is the share of trade which is covered in the forward market. The time dimension of TB reflects the fact that trade contracts do not show up as recorded trade flows until some subsequent time period.

Spot Market

(3) $S_t^s = S^s\ (R^s - R^*)$

(4) $T_t^s = \gamma\ \alpha\ TB$

(5) $LTC_t^s = \overline{LTC}_t$

(6) $STC_t^1 = C(i_D - i_w)$

(7) $G_t = [S_t^s + T_t^s + LTC_t^s + STC_t^1]$ if $R^{UL} < R^s$ or $R^s < R^{LL}$

$= \overline{G}_t$ if $R^{UL} > R^s > R^{LL}$

Equation (3) states that S_t^s, the excess demand for spot speculation, is a different function of the same expected exchange rate, R^*, and the current spot rate, R^s.

Equation (4) states that the excess demand for traders' spot positions, T_t^s, is equal to the share of trade covered, α TB, times the share covered in the spot market, γ.

Equation (5) states that the excess demand for spot speculative positions due to long-term capital flows is equal to the exogenously determined change in the stock of net long-term liabilities to foreigners.

Equation (6) states that some part of the change in short-term liabilities to foreigners, are uncovered, and are a function of the change in the difference between "the" domestic interest rate, i_D, and the world interest rate, i_w.

Equation (7) states that official excess demand in the spot market G_t^s is the negative of all other excess demands in the spot market if the spot exchange rate is of the lower intervention limit, R^{LL}, or the upper intervention limit, R^{UL}, or it is equal to exogenously determined level, $\overline{G}$, if the exchange rate is not at a limit.

Identities

$$(8)\quad A^F + S^F + T^F \equiv 0$$

$$(9)\quad A^S + S^S + T^S + LTC^S + G^S + STC'^S \equiv 0$$

$$(10)\quad A^S = - A^F$$

Substituting $-A^S$ for A^F and solving for A^S we have:

$$(11)\quad 2A^S = S^F(R^F-R^*) - S^S(R^S-R^*) - (1-2\gamma)\alpha\, TB_{t+i} - LTC^S - G^S - C(i_0-i_w)$$

We assume that S^F and S^S are not the same functions. That is, speculators have preferences for either spot or forward speculative positions when R^F and R^S are at interest parity. Even though, at the margin, arbitrage will insure that spot positions and forward positions are equivalent in terms of interest rate yields, speculators for secondary reasons have preferences for either spot or forward open positions. If, for some reason, R^F were to move away from interest parity, then we would expect speculators to move into one market or the other.

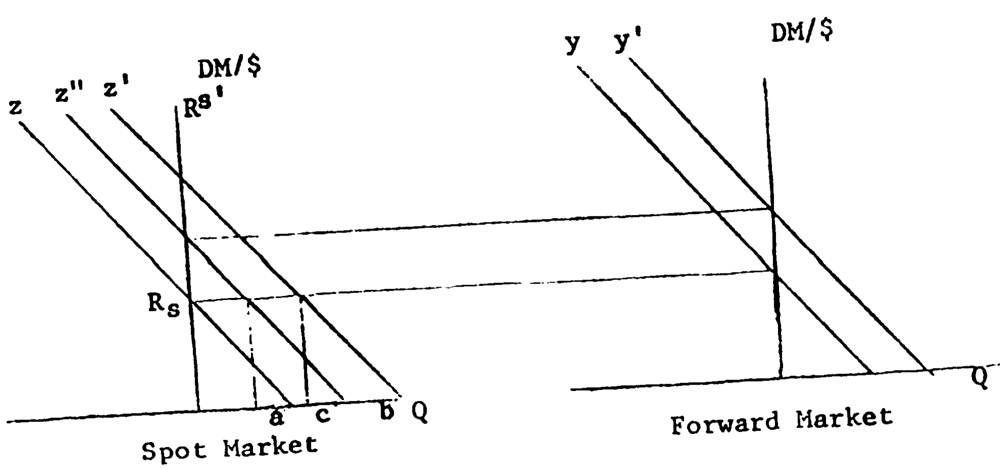
We will assume, however, that interest parity always holds in "normal" periods, since arbitragers are willing to substitute covered foreign bonds for domestic bonds at a small fixed covered premium. In these circumstances $R^F - R^S$ simply reflects an exogenously determined interest differential. Speculators then can look at either the spot rate or the forward rate when determining their total speculative position. The allocation of this total speculative position between spot and forward speculation depends on secondary effects mentioned in the preceding section. In (12) we substitute the interest parity forward exchange rate, R^I, for R^F and R^S in the S^F and S^S functions in equation (11).

$$(12)\quad 2A^S = S^F(R^I - R^*) - S^S(R^I - R^*) - (1-2\gamma)\alpha\, TB_{t+1} - LTC^S - C(i_D - i_w)$$

In order to get an intuitive feeling for (12), assume that speculative responses to changes in $(R^I - R^*)$ are evenly divided between spot and forward speculative positions, so that $S^F = S^S$. Then (12) becomes:

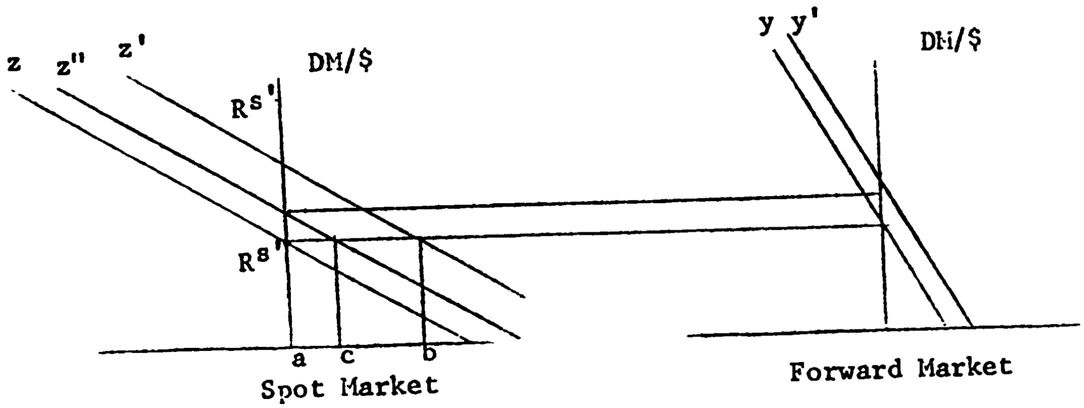
$$(13)\quad 2A^S = -(1-2\gamma)\alpha\, TB_{t+1} + LTC^S + G^S + C(i_D - i_w)$$

Suppose there is a long-term capital inflow which shifts the excess demand curve for spot marks to the right by an amount ab from z to z'



This will force R^S up to $R^{S'}$ and thus R^F to an implicit discount. Arbitragers will sell spot, shifting z' to the left to z'' and buy forward, shifting Y to the right to Y', until the implicit discount disappears. Since z and y have the same slope by assumption, the long-term capital inflow of ab will result in a negative excess demand for spot arbitrage equal to cb, where cb = $\frac{ab}{2}$.

Now suppose preferences changed so that $S^S = 2S^F$. Again a



long-term capital inflow equal to ab shifts z to z'. Again R^S is forced up creating an implicit discount. Arbitragers sell spot and buy forward until the implicit discount disappears. But in this case the arbitrage cb = 2/3 ab. As long as S^S is not the zero function, a long-term capital inflow will generate an arbitrage inflow.

A change in the contractural trade balance, measured by a change in trade flows in t + i, will generate an arbitrage flow if Y is not equal to $S^S/(S^F+S^S)$. Notice that the sign arbitrage flow can change as Y, the share of trade cover sought in the spot market, varies from zero to one. The usual assumption is that traders always cover forward, or that Y = 0. If so, our model shows that an increase in the trade surplus will generate an arbitrage inflow.

A change in the interest differential (i_D-i_W) has an indirect effect on arbitrage flows. First we have argued that the speculative functions S^F and S^S are not influenced by changes in the interest parity spread between R^S and R^F. Given a change in the interest differential, arbitragers will bid so that the two exchange rates change, but no other excess demand in either the spot or the forward market will be generated by this type of change in the exchange rates. But the change in the interest rate will have some direct effect on the demand for spot exchange not caused by the change in the spot exchange rate necessary to re-establish interest parity. This is due to the change in the interest rate compensation for taking open spot positions. While uncovered foreign bonds are assumed not good substitutes for similar domestic bonds, they are substitutes, and a change in their prices due to changes in national interest rates will cause some uncovered capital flow. This has an effect on arbitrage flows essentially the same as that of shifts in the z function due to official intervention or long-term capital inflows, which are assumed not sensitive to interest differentials.

<u>An Algebraic Description of a Model of an Adjustable Peg Exchange Rate System: Speculative Period</u>

We have hypothesized that speculative expectations are bimodel. The model value of the expected exchange rate is within the band or well outside the band due to expectations of a discrete parity change. Our hypothesis is that the probability attached to these two model values is subject to very large variations over short time periods. Further, economic theory cannot tell us when this change in probabilities will occur. This depends on private views of central bank behavior which are not predictable. We therefore will use an observed variable to tell us after the fact when private market participants attached a high probability to R**, the predicted future spot rate if a parity change occurs.

The observed variable is the forward rate when it is outside the intervention limits.[8/] If the forward rate moves outside the limits, a weak assumption is that the excess demand for forward exchange by those who expect R** to occur is greater than the excess supply of those who expect some R* to occur. We will use as a working hypothesis a stronger assumption that when the forward rate is observed to be outside the limits all private market participants expect that R** will occur.

Under these conditions the forward rate will be bid toward R**, while the spot rate is constrained from moving outside the intervention limits by central bank intervention. The S^F function still exists, but since the interest parity condition is violated, all speculators will prefer spot speculation. Traders for the same reason will cover in the spot market. In the forward market then all excess demands are zero.

8/ See Leamer and Stern [7] for a discussion of this assumption.

Spot Market

In the spot market we have:

$$(14) \quad S^S = S^S(R^S - R^{**})$$

$$(15) \quad T^S = T^S(R^S - R^{**})$$

$$(16) \quad LTC^S = \overline{LTC}$$

$$(17) \quad STC' = C(i_D - i_W)$$

$$(18) \quad G = -(S^S + T^S + LTC + STC')$$

Equations (14) and (15) state that both traders' and speculators' excess demand for open spot positions are functions of the difference between the current spot exchange rate, R^S, and the expected future rate, R**, when R** is outside the intervention limits. Equations (16) and (17) are the same as in non-speculative periods, although their quantitative importance is probably swamped during speculative periods. Finally, (18) states that government excess demand in the spot market is equal to the negative of all other excess demands.

Since there are no excess demands in the forward market to be transformed through arbitrage to the spot market, there is no arbitrage during a speculative period.

Arbitrage and Recorded Short-Term Capital Flows

The dependent variable in (12), A^S, includes only short-term capital flows which are a result of interest arbitrage. We have emphasized the role of arbitrage in short-term capital flows but certainly available data on short-term capital flows also include changes in spot speculative positions which are not the result of interest arbitrage.

For example, we have shown above that if γ, the part of a contractural trade balance covered in the spot market, is equal to $S^S/(S^F + S^S)$, then no arbitrage is generated by a change in the contractural trade balance. But the spot position taken directly by traders and speculators might be recorded as a short-term capital flow. In fact, regardless of whether traders initially seek cover in the spot or forward markets, the sum of the direct effect on S^S and T^S, and the arbitrage effect, will be the same. In general, any change in the demand or supply for spot or forward exchange will generate the same change in speculative spot positions, regardless of the market in which the change in excess demand is initially registered. In the empirical work to follow we will see that interpretation of recorded short-term capital flows depends critically on whether or not a given statistical aggregate represents arbitrage positions, speculative spot positions, or some combination of the two.

A Digression on Trade Flows and Implicit Premium Calculations in Existing Models

Starting with Kenen's [4] work on short-term capital flows in the U.S. balance of payments, trade variables have been included in several empirical studies of capital flows, and have been found to be a statistically significant variable in explaining capital flows, particularly models of the U.S. capital account. A typical justification for including trade variables can be found in Branson and Hill: [3] "Several modifications of the basic portfolio stock-adjustment equation ... must be made in order to apply it to changes in U.S. short-term claims on private foreigners, ... First, it is necessary to recognize the trade credit nature of a large portion of U.S. short-term lending. To account for this factor, we have added changes in current and lagged merchandise exports (to the equation for short-term claims on foreigners)." Branson recognizes that there is no logical link in his model between trade and capital flows "since claims on foreigners should depend on interest rates R at home and abroad, <u>just as would the increase in the effect on an increase in total assets w.</u>" (Emphasis mine.) The scale variable, w, in Branson's analysis is meant to capture the effect of an increase in the scale of U.S. wealth, part of which might be allocated to acquiring claims on foreigners. It is correct to say that an increase in exports from New York to Boston, which results in an increase in U.S. wealth, will have the same effect on the demand for claims on foreigners as a similar export from New York to Frankfurt. If so, there is no reason to add trade variables to a model which has a wealth variable, and certainly no reason to believe that changes in the trade balance are a good proxy for changes in U.S. wealth. The analysis in this paper differentiates between foreign trade and domestic trade because one necessarily generates exchange risk, while the other does not. The exchange risk generated by international trade drives the model of capital flows; there is no need to rely on relationships which are incorrect "in theory."

Another argument for including trade variables has been offered by Willett [10].

> "When we move from the comparative static exercise of the changes between equilibrium positions, and look at the dynamics of portfolio adjustment, we find that the methods by which trade is financed do take on importance since they will affect the timing of private return flows. To the exporter the I.O.U. of the importer and cash balances are not perfect substitutes. Though for balance of payments accounting purposes the exporter's holdings of the importer's I.O.U. is a short-term claim, it cannot be repatriated (converted into domestic currency) as easily. As a consequence the exporter is in general constrained in his ability to reduce this foreign held part of his portfolio until final payment comes due, i.e., until his I.O.U. is converted into a more liquid asset. Thus if incentives exist for repatriation the timing though not the magnitude will be determined by the method by which exports are financed."

In a footnote, Willett recognizes that "of course discounting is possible, but will have no effect on aggregate net private flows unless undertaken with a party of another country." But this is exactly the point which is important. As shown in Table I, a significant part of acceptances made by U.S. banks are held by non-residents. A trade acceptance is a very liquid money-market instrument which finds its way into foreign and domestic portfolios just as any other financial claim does. The largest single category of acceptances according to transaction for the survey dates were generated by third country trade, while U.S. exports are, except in the 1964 data, the least important. This data is only suggestive, since not all trade finance takes the form of acceptances, but it does cast considerable doubt on the proposition that exports affect in any direct way the stock of claims on foreigners held by U.S. residents. Perhaps some authors have failed to distinguish between accepting and discounting bills; in fact for the survey dates shown only about one-third of acceptances made were discounted by the accepting bank.

Implicit Premiums and Speculation

The difficultyin obtaining a useful proxy for speculation has plagued empirical work on capital flows. It is clear that speculation concerning parity changes has the power to swamp all other determinants of capital flows, but it is not clear what simple indicator might be used to measure the existence or the severity of

Table I: Bankers Dollar Acceptances - United States Banks

According to Transaction

Date	Total	Exports	Imports	Third Country Trade	Other
2/28/71	6,984	1,520	2,618	2,621	225
2/29/68	4,266	1,029	1,091	1,979	167
5/31/64	3,049	941	576	1,426	106

According to Ownership

		U.S. Banks		Non-Residents				
Date	Total	US Banks Own bills	US Banks Bills of Others	Total	Off	Banks	Other	Unallocated
2/28/71	6,984	2406	783	2,529	425	2,055	48	1,266
2/29/68	4,266	1329	479	1,567	381	1,126	60	891
5/31/64	3,049	1105	313	917	434	443	41	714

Source: Press Release, Federal Reserve Bank of New York "Bankers Acceptances - United States."

speculative activity. Several authors have used variants of the implicit forward premium or discount. This is the difference between the interest parity forward rate and the observed forward rate. A primary difficulty of this approach is that the implicit premium is actually a measure of the elasticity of the interest arbitrage schedule rather than a direct measure of speculation. We have argued, however, that as long as there are no expectations of a parity change, the arbitrage schedule is perfectly elastic. If this is true, then implicit premiums should never be observed unless the forward rate has moved outside the intervention limits. In summarizing empirical work of several authors in which interest parity conditions were tested as determinants of forward exchange premia, Spraos [8] found that deviations from interest parity were quite small in models which controlled for speculative episodes. Our guess is that the remaining deviations of market forward rates from interest parity are due to errors in variables.

Particularly important in this respect is the possibility that the imposition of capital controls leads to consistent bias in implicit premium calculations employed in existing studies. Suppose, for example, that a relatively restrictive monetary policy, along with expectations of an appreciating exchange rate, has generated a capital inflow to Germany. In various ways the German authorities will penalize these inflows: through direct controls, reserve requirements on non-resident deposits of German banks, taxes, gentlemen's agreements, and so forth. All such factors tend to drive a wedge between the rate a resident and a non-resident can earn on a DM asset in Germany. As the rate which a non-resident can earn in Germany falls, the true interest parity forward rate for the mark moves to a smaller discount or larger premium than what prevailed before the imposition of the capital controls. But if the German money market interest rate is used to find interest parity conditions, the calculated interest parity rate will not change. Thus a measured implicit premium will show up in the data which is entirely due to changes in capital controls.

Eurocurrency interest rates represent a "clean" measure of the opportunity cost which a non-resident suffers by not holding a part of his portfolio in foreign claims. For example, a Euro-DM deposit at a Swiss bank is probably a very close substitute for a DM deposit at a German bank to a non-German resident. Normally then these two rates would be very nearly the same. Given speculative pressure on DM for example the German central bank can be expected to penalize non-resident placements in German money markets. In this case the Euro-DM would reflect what non-residents can earn in German money markets, while German domestic rates represent what German residents can earn in German money markets. The interesting aspect of Eurocurrency deposits is that the market works out the effect of capital controls for us. If we assume that the only difference between a Euro-DM and a German DM deposit is the location in terms of national borders, then any differences in these rates must reflect national capital controls.[9] This implies that the bias introduced into measures of speculative activity by controls can be eliminated by using Eurocurrency rates in calculating interest parity forward rates.

A brief example might help clarify this point. In June 1971 the Bundesbank imposed a 40% reserve requirement on non-resident deposits in German banks. Up to this time this had been the primary means by which non-residents had acquired DM claims. A Swiss Eurobank had up to this time offered a deposit rate on Euro-DM deposits equal to what the Swiss bank could earn in Germany plus a small intermediation fee. With the imposition of the reserve requirement, German banks found that deposits by the Swiss bank were only worth 60% of the face value in terms of usable reserves, and therefore could offer 1/.6th of the interest rate offered to domestic deposits. In turn the Swiss Eurobank could offer a commensurately lower Euro-DM rate. Of course there were other ways in which the Swiss bank could utilize the DM obtained through its Euro-DM deposits. It soon became evident that the Swiss Eurobanks could lend directly to German corporations and thus bypass the established intermediation channel, the controlled German banks. This eventually led the Bundesbank to impose a reserve requirement on the borrowings from non-residents by German firms. But we need not attempt to identify the impact of specific capital controls; we need only realize that the Swiss Eurobank does the best it can in

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9/ Of course we must assume that Swiss authorities do not interfere with the Euro-DM activities of Swiss banks. The market also insures this since the Eurocurrency business will move to an unconstrained center if one central bank attempts to regulate the market.

penetrating the German money market, and pays a Euro-DM deposit rate which reflects how successful it can be in avoiding the Bundesbank's efforts to curtail this penetration. An arbitrage schedule drawn with reference to Eurocurrency interest rates eliminates exchange risk and the effect of controls and reflects only the factors which make covered DM claims less than perfect substitutes for otherwise similar domestic currency claims. If we are right in assuming that covered foreign bonds are perfect substitutes for domestic bonds, then Eurocurrency rates should always be at interest parity. If so, any calculated implicit premium represents noise in the data and in a regression analysis of capital flows should not add explanatory power to the regression results.

Empirical Tests

In order to proceed with a test of the model developed in (1-17) we first explicitly make the endogenous spot and forward exchange rates functions of the exogenous variables in the model. For the spot rate in non-speculative[10/] periods from (3-7) we have:

$$(19)\quad R^S = r^S\ (\Delta TB_{t+1}, LTC^S,\ STC^S,\ G^S,\ R*)$$

for the forward exchange rate, R^F, from (1, 2a) we have:

$$(20)\quad R^F = r^F(TB,\ R*)$$

Substituting 19 and 20 into 12 we have:

$$(21)\quad 2A^S = S^F(r^F - R*) - S^S(r^S - R*) + (1 - 2\alpha) \sum_{t=1}^{3} \alpha\ TB_{t+1} - LTC^S - G^S - C(i_0 - i_w)$$

Taking changes, assuming a linear form, and that $\gamma = 0$:[11/]

$$(22)\quad \Delta A^S = (S_1^F\ r_1^F + 1)\ \alpha \sum_{t=1}^{3} \Delta\ TB_{t+1} - S_2^F\ \Delta R* - S_1^S\ r_1^S\ 0 - (S_1^S\ r_2^S + 1)\ \Delta\overline{LTC} - C(S_1^S\ r_3^S + 1)\ \Delta(i_D - i_w) - (S_1^S\ r_4^S + 1)\ \Delta G + S_2^S\ \Delta R*$$

10/ During speculative periods it is expected that speculative purchases of spot exchange will swamp the other variables. The model tested will utilize a dummy variable in an attempt to capture the effects of speculation generated by expected parity changes.

11/ The notation S_1^F is the partial derivative of the S^F function with respect to its first argument.

The structural and reduced form coefficients are presented in Table II.

TABLE II

Variable	Reduced Form	Structure	Expected Sign
$\sum_{t=1}^{i} \Delta TB_{t+i}$	α_1	$\alpha(S_1^F r_1^F + 1)$	(+)
ΔLTC	α_2	$-(S_1^S r_2^S + 1)$	-
$\Delta(i_D - i_w)$	α_3	$-C(S_1^S r_3^S + 1)$	-
ΔG	α_4	$-(S_1^S r_4^S + 1)$	-
ΔR^*	α_5	$(S_2^S - S_2^F)$	(+,-)

An increase in the contractural trade surplus, as measured by subsequent changes in the recorded trade balance, first generates a positive excess demand for forward cover and a change, r_1^F, in the forward exchange rate. Some part of this excess demand, $S_1^F r_1^F$, is met in the forward market by an excess supply of forward speculation. The part not met in the forward market by forward speculation, $(S_1^F r_1^F + 1)$, is transferred via arbitrage to the spot market. We expect that $-1 < S_1^F r_1^F < 0$ so that some part of an increase in the contractural trade surplus will generate an excess demand for spot arbitrage positions. Or in more familiar terms arbitragers demand spot dollars in order to accommodate spot speculators and thus generate an arbitrage inflow.

A long-term capital inflow initially generates excess demand in the spot exchange market and a change, r_2^S, in the spot exchange rate. Some part of this excess demand, $S_1^S r_2^S$, is met by an excess supply of speculative spot positions. The part not met in the spot market, $(S_1^S r_2^S + 1)$, is transferred via arbitrage to the forward market. In this case an arbitrage excess supply, or an outflow of arbitrage funds, is implied, equal to $-(S_1^S r_2^S + 1)$.

An increase in the interest differential in favor of the U.S. generates an excess demand for spot dollars equal to $c\Delta (i_D - i_W)$. The impact on arbitrage flows is essentially the same as the case for long-term flows discussed above. Official intervention is another type of exogenous uncovered capital flow and has comparable effects on arbitrage flows.

A change in the expected exchange rate is somewhat more difficult to interpret since it is not an observed variable. We assume that speculators utilize a model which generates values for the exogenous variables in (13) and (14) based on autoregressive patterns of past changes in these variables. Using this model, speculators generate values for the expected exchange rate, R_t^*, which will prevail at the end of the current month. After comparing R_t^* with R_{t-1}^*, speculators decide what change in their spot and forward speculative position they desire to make during the month according to the S_2^S and S_2^F functions. If $S_2^F > S_2^S$, and if both are positive functions, then a given rise in R^* will generate a larger excess demand in the forward market than in the spot market. In order to keep the forward rate from rising to an implicit premium with respect to the spot rate, arbitragers will supply spot and demand forward generating and arbitrage inflow. If there is any truth to the statement that speculators prefer forward positions, then we can tentatively expect a positive coefficient on α_5, but there is no strong motivation for such expectations.

Conclusions:

Before entering into some important qualifications of the above model due to data limitations, the thrust of the argument to this point is as follows. If we look at a number representing short-term capital flows we must keep in mind that a significant part of such flows might represent arbitrage positions. Arbitrage positions are only indirectly influenced by variables ordinarily found in regression analysis of short-term capital flows. Exchange rate expectations, interest differentials, and changes in the trade variables drive the arbitrage model, but identification of structural relationships among arbitrage flows and these variables depends on a string of guesses on the part of the analyst. Hopefully the reader can, using the model developed here, test his own priors against the evidence presented below.

Data Limitations

The primary difficulty in testing the arbitrage model is that statistics on pure arbitrage flows are not available. Data on total short-term capital flows certainly in part include uncovered positions sensitive to changes in interest rate changes and exchange rate expectations. If the dependent variable tested contains all interest-induced short-term flows, as well as all spot speculative positions, then we have from (22) that the change in net short-term liabilities to foreigners is:

$$(23)\ \Delta STLN = (S_1^F r_1^F + 1)\ \alpha \sum_{t=1}^{3} \Delta TB_{t+i} - S_2^F \Delta R^* + 2S_2^S \Delta R^*$$

$$- C\ \Delta(i_0 - i_w) - \Delta LTC - \bar{G}$$

Table III presents the structural and reduced form coefficients for this model.

TABLE III

Variable	Reduced Form	Structure	Expected Sign
$\sum_{t=1}^{3} \Delta\ TB_{t+i}$	$\alpha_1 =$	$\alpha(S_1^F r_1^F + 1)$	+
Δ LTC	$\alpha_2 =$	-1	-
$\Delta(i_D - i_w)$	$\alpha_3 =$	0	
ΔG	$\alpha_4 =$	-1	-
ΔR^*	$\alpha_5 =$	$2S_1^S - S_2^F$	(+, -)

There is no change in the interpretation of α_1, since a change in the contractural trade balance has no direct effect on spot speculative positions. This is true following the assumption that $\gamma=0$, or that traders do not speculate in the spot market, thus the only effect on spot positions is through arbitrage.

The impact of a change in long-term capital or a change in official balances on changes in short-term liabilities to foreigners is unity. That is, in the case of long-term capital the arbitrage effect, $-(S_1^S r_2^S + 1)$, plus the direct change in speculative spot positions, $S_1^S r_2^S$, must be equal to the change in long-term capital in order to clear the spot market.

A change in the interest differential will generate no net capital flow if all interest-induced funds, all speculative spot positions, and all arbitrage positions take the form of measured short-term capital flows.

A change in R* will generate a direct change in speculative spot positions, S_2, plus the arbitrage effect $(S_2^S - S_2^F)$ for a total effect of $2S_2^S - S_2^F$. There is, of course, a somewhat stronger presumption that this is positive.

In each case a further set of assumptions is now necessary. The data set used below as the dependent variable is the change in net short-term liabilities to foreigners reported by U.S. banks and non-financial corporations. If these data represent primarily arbitrage flows, then the set of structural coefficients in Table II is relevant. If these data also include all other speculative and interest-induced spot positions, then the structural relations in Table III are relevant. We suspect that the true structural coefficients lie somewhere between those in Table II and Table III. Obviously much of the interesting part of the distinction between arbitrage flows and other short-term capital flows evaporates if all such flows are lumped together in the same aggregate. We suspect that positions *vis-a-vis* foreigners reported by banks, which are reported promptly and widely interpreted as indicators of responses to interest differentials and exchange rate expectations, do contain an important and potentially confusing element of arbitrage transactions. The positions of non-financial corporations are probably incomplete, since not all corporations are required to report their positions.

The Data

An important problem in dealing with the U.S. capital account is choosing a measure of foreign interest rates and foreign exchange rates. The exchange rate for the U.S. is a particularly difficult variable to quantify. Several studies have used the single dollar-foreign currency cross exchange rate, or have tried several individual cross rates, in capital flow equations. This would be reasonable if foreign currencies tended to move against the dollar in unison over the sample period. Even casual inspection of those data reveal, however, that this was not the case over the sample period considered here. Triangular arbitrage insures that cross exchange rates are consistent; it does not insure that foreign currencies will move in unison against the dollar unless it is assumed that the foreign currencies cross rates with respect to one another do not change. A particularly striking aspect of this assumption not holding is that very often during the sample period one foreign currency, for example sterling, moved to its intervention floor against the dollar, while another, for example the French franc, moved to its intervention ceiling.

It was decided, therefore, that some weighted average of exchange rates was more appropriate in measuring the exchange value of the dollar. Six major foreign currencies were chosen, including the Canadian dollar, German mark, French franc, Swiss franc, Dutch guilder, and sterling.

The range of plausible weighting schemes is almost infinite, and since we have already given a weight of zero to most of the currencies in the world, further refinements of the weighting scheme seemed arbitrary and for simplicity a simple arithmetic average is used.

Since in "normal" periods the model assumes that speculators are predicting movements in the exchange rate within the intervention band, we purged the data of changes in rates due to parity changes. During periods of temporary floating, a prorated monthly change in the parity from the previous parity to the new parity was subtracted from the observed change in the exchange rate. In the case of the Canadian dollar, where no new parity was established before the end of the period, changes in the exchange rate were measured as deviations from a linear time trend.

In order to obtain a value of the expected change in the exchange rate free of simultaneous influence of arbitrage and other short-term capital flows, we regress the exchange rate on exogenous and predetermined variables in the model. The regression of R^s on a set of these variables yields (24)

$$\text{(24)}\quad E\Delta R_t = \underset{(-1.36)}{-.19}\,\Delta R_{t-1} \underset{(-2.85)}{-.37}\,\Delta R_{t-2} \underset{(-4.03)}{-.48}\,\Delta R_{t-3} \underset{(-3.16)}{-.55}\,\Delta R_{t-4}$$

$$- .0049\Delta G_{t-1} \underset{(-2.76)}{-.066}\,\Delta G_{t-2} \underset{(0.99)}{+.025}\,\Delta G_{t-3} \underset{(0.09)}{-.0023}\Delta G_{t-4}$$

$$\underset{(0.17)}{+.029}\,\Delta TB_{t-1} \underset{(0.74)}{+.17}\,\Delta TB_{t-2} \underset{(0.54)}{+.12}\,\Delta TB_{t-3} \underset{(-0.20)}{-.03}\,\Delta TB_{t-4}$$

$$\underset{(-0.88)}{-.0093}\Delta ID_{t-1} \underset{(0.56)}{-.068}\,\Delta ID_{t-2} \underset{(-0.87)}{-.10}\,\Delta ID_{t-3} \underset{(0.58)}{+.067}\,\Delta ID_{t-4}$$

The foreign interest rate variables are also arithmetic averages of national money market rates of Eurocurrency rates. Detailed information on the remaining variables is contained in Appendix I.

The variables are defined as follows:

$\Delta STLN$ = Change in net short-term liabilites to foreigners reported by banks and non-financial corporations in the U.S.

$E\Delta R$ = Expected change in the weighted average U.S. exchange rate.

ΔID = Change in three-month U.S. Treasury bill rate less constructed foreign interest rate.

ΔED = Change in three-month Eurodollar deposit rate less constructed Eurocurrency rate.

ΔTB_{t+i} = Change in U.S. trade surplus in ith month after t.

$\Delta LTLN$ = Change in net long-term liabilities to foreigners reported by banks and non-financial corporations in the U.S.

SD_1 = Speculative dummy = Number of foreign currencies whose forward exchange rate is over the upper intervention limit divided by six.

SD_2 = Speculative dummy = Number of foreign currencies whose forward exchange rate is below the lower intervention limit divided by six.

SD_3 = Speculative dummy = Number of foreign currencies whose forward exchange rate is over the interest parity forward rate and over the upper intervention limit divided by six.

SD_4 = Speculative dummy = Number of foreign currencies whose forward exchange rate is below the interest parity forward rate and below the lower intervention limit divided by six.

D_1 = Window dressing dummy = - 1 in December

+ 1 in January

0 otherwise

ΔG = Change in U.S. net official reserve position.

EIP = Average implicit premium on the dollar calculated using Eurodollar and Eurocurrency interest rates.

IP = Average implicit premium on the dollar calculated using U.S. Treasury bill rate and foreign money market rates.

Regression Results

The results of several regressions suggested by the model developed above are presented in Table IV. Even given the qualifications on interpreting the reduced form coefficients developed in the above discussion the data offer some interesting insights into the determinants at short-term capital flows. The discussion of the results will concentrate on equations one through four which do not contain government intervention as an independent variable, equation five will be considered separately. The first four regressions differ in that alternative specifications of interest rate variable and the speculative dummy variables are employed.

The regression coefficient for $E\Delta R$, the instrumental variable which measures expected exchange rate changes other than parity changes, had the expected sign and was significant in all the regressions. According to these point estimates an expected one percent appreciation of the weighted average dollar exchange rate within one month generates a short-term capital inflow of between \$1.80 billion and \$2.09 billion during the month.

The regression coefficients for led changes in the trade balance have the expected sign and are significant in period t+1. The size of the sum of the coefficient is greater than expected, in that it implies that a one billion dollar increase in the contractural trade surplus generates about a 2-1/2 billion dollar capital inflow. However, a test

TABLE IV

Regression Results for ΔSTLN
(billions of dollars)

ΔSTLN \ Independent Variables	ΔG	EΔR	ΔTB t+1	ΔTB t+2	ΔTB t+3	ΔLTLN	ΔED	IEP	ΔID	IP	SD_1	SD_2	SD_3	SD_4	D_1	C	R^2	DW	S^e
1		2.09 (3.43)	1.20 (2.36)	1.08 (1.79)	0.44 (0.91)	-0.909 (-0.85)	0.085 (0.94)	-0.19 (-1.65)			5.287 (4.53)	-0.352 (-0.47)			-0.701 (-2.58)	-2.43 (-1.62)	0.50	1.69	.808
2		2.02 (3.45)	1.21 (2.49)	1.14 (1.99)	0.47 (1.02)	-1.651 (-1.51)			0.25 (0.75)	0.34 2.49)	3.956 (3.36)	-0.315 (-0.51)			-0.654 (-2.52)	0.061 (0.31)	0.54	1.83	.773
3		1.85 (2.67)	1.46 (2.51)	1.48 (2.18)	0.56 (1.01)	-0.680 (-0.56)	0.077 (0.72)	0.13 (0.96)					3.166 (1.73)	0.241 (0.18)	-0.786 (-2.56)	-0.090 (-0.63)	0.34	1.37	.923
4		1.80 (2.84)	1.38 (2.60)	1.41 (2.28)	0.54 (1.06)	-1.76 (-1.46)			0.15 0.43)	10.46 (3.27)			1.695 (1.00)	0.048 (0.04)	-0.627 (-2.22)	0.329 (1.75)	0.45	1.52	.844
5	0.458 (8.88)	1.31 (3.23)	0.65 (1.93)	0.29 (0.74)	0.01 (0.03)	-2.65 (-3.68)	0.10 (1.57)	0.05 (0.61)			2.550 (3.11)	-0.425 (-0.93)			-0.614 (-3.47)	0.061 (0.59)	0.79	1.51	.525

of a linear constraint on the sum of the coefficients shows that their sum is not significantly different from one at a five percent confidence level.

In regressions one and three Eurocurrency rates are used as measures of the effective yield available to non-residents on assets denominated in various currencies. Positive values for ΔED measure increases in the differential in favor of Eurodollars as compared with other Eurocurrency rates. Remember we are assuming the Eurocurrency rates are tied to corresponding domestic money market rates, with divergences reflecting only capital controls. The regression coefficients in equations one and three imply that an increase in the differential in favor of Eurodollars generates an uncovered demand for dollar denominated assets. This directly leads to an increase of U.S. net short-term liabilities to non-residents, and perhaps an arbitrage outflow. In any case the net value of the structural coefficient for changes in the interest differential in Tables I or Table II is positive. While the regression coefficients have the expected sign they are not significantly different from zero.

The covered differential in favor of Eurodollars over other Eurocurrencies is measured by IEP. As argued above this variable is not expected to add any explanatory power to the regression since it was expected to show no systematic variance. The regression coefficients are not significantly different from zero which is consistent with this expectation.

The same regressions were run using domestic interest rates as measures of the effective yield available on assets denominated in various currencies. The regression coefficients in regressions two and four for increases in the differential in favor of U.S. domestic short-term interest rates have the same expected sign and can be interpret in the same way as the coefficients for changes in the differential in favor of Euro-dollars in regressions one and three.

The measure of the covered differential in favor of dollar denominated assets using domestic money market rates, IP, has the expected sign and is significant in both regressions two and four. Remember this is not because a covered differential in favor of dollars actually persists long enough to be measured, but because the imposition of capital controls leads to a consistent bias in this <u>measure</u> of the covered differential in favor of dollar denominated assets. Positive values of IP in the model developed here are possible only when capital controls distort domestic interest rates as measures of the effective yield that a non-resident can earn on assets denominated in various currencies. Thus an apparent covered differential in favor of dollar denominated assets occurs when the U.S. imposes restrictions on capital inflows or foreign countries impose penalties on capital outflows. Since the intensity of such restrictions is correlated with speculative demands for dollar denominated assets, we would expect that positive values for IP would be correlated with net short-term capital inflows to the U.S.

If the regression coefficient on IP in equations two and four is compared with that of IEP in equations one and three, it can be seen that if we are right in assuming that the difference between these two measures of the covered differential in favor of dollar deconimated assets is the distortion generated by capital controls, then the significance and size of the coefficients on IP must be due completely to the correlation of speculative demands for uncovered positions and the intensity of capital controls.

The speculative dummy variables, SD_1 and SD_2, in regressions one and two do not have the expected sign. A positive value for SD_1 implies that the forward rate for one or more foreign currencies is over its upper intervention limit. Other things equal, we would expect that the implied expected dollar devaluation would generate a net fall in the demand for dollar assets. The near zero value for SD_2 was also not expected since an expected depreciation of a foreign currency was expected to generate a capital inflow to the U.S. A clue to this apparent puzzle might lie in the key currency status of the dollar, and to the asymetrical behavior of foreign central banks. When one foreign currency was weak and its forward rate below the lower limit, it was generally true that more than one other foreign currencies appeared very strong with forward rates over the upper limit. This did not reflect expectations that these currencies would be revalued against the dollar, but that the weak non-dollar currency would be devalued. These expectations led market participants to sell the weak currency and buy dollars and other foreign currencies. Thus SD_1 is capturing the expected devaluation of sterling, for example, by measuring the appreciation of other foreign currencies as sterling is sold off.

The regression coefficients for speculative dummies SD_3 and SD_4 in regressions three and four show similiar behavior as do those for SD_1 and SD_2. They are however not significient and smaller than SD_1 and SD_2. The difference between these two sets of dummy variables is that SD_3 and SD_4 do not sort out periods where parity changes are expected unless the forward rate is outside the intervention limits and outside the interest parity forward rate. As such it makes the conditions under which we presume that parity changes were expected more rigerous and it does not appear that this is a useful refinement of our identification of speculative periods.

The D_1 dummy variable captures the effect of so called year end window dressing opperations which result in U.S. net short-term liabilities falling in December and returning to their former level in January.

The regression coefficient for changes in the stock of net long-term liabilities to foreigners has the expected sign but is not significient in the first four regressions.

Equation five is the same as equation one with the addition of a measure of net official purchases of dollars. Official intervention is clearly endogenous to the system and adding it to the regression as an exogenous variable introduces specification errors. It is encouraging however that the speculative dummy variable seems to have captured some of the effect of government intervention. Attempts to create an instrument for ΔG were not successful. We plan to attempt to construct a series which excludes intervention by central banks whose currencies are at an intervention limit as a possible way to identify more nearly exogenous spot demand for dollars by central banks.

REFERENCES

[1] R. Z. Aliber, "Attributes of National Monies and the Independence of National Monetary Policies" (mimeo, 1973).

[2] W.H. Branson, Financial Capital Flows in the U.S. Balance of Payments, North-Holland Publishing Company, Amsterdam 1968.

[3] W.H. Branson and R.D. Hill Jr., Capital Movements in the OECD Area, OECD Economic Outlook, Occasional studies, December 1971.

[4] P. Kenen, "Short-term Capital Movements and the U.S. Balance of Payments," Joint Economic Committee, U.S. Balance of Payments, Hearings, 88th Cong., 1st sess., Washington 1963, pp. 153-91.

[5] C.P. Kindleberger, "The Case for Fixed Exchange Rates, 1969" in The International Adjustment Mechanism, Federal Reserve Bank of Boston, Conference Series No. 2, 1969, pp. 93-108.

[6] P. Kouri and M. Porter, "International Capital Flows and Portfolio Equilibrium" International Monetary Fund Memorandum (mimeo, 1972).

[7] E.E. Leamer and R.M. Stern, Quantitative International Economics, Allyn and Bacon, Inc., Boston 1970, Ch. 4.

[8] J. Spraos, "La fonction d'arbitrage" in Le Change A Terme; Technique, Théoric, Politique, Centre d'Economic Bancaire Internationale, Université de Paris, Paris 1972, pp. 43-51.

[9] W.H. White, "Interest Rate Differences, Forward Exchange Mechanism, and the Scope for Short-Term Capital Movements," IMF Staff Papers, Vol. X (Nov. 1963), pp. 485-501.

[10] T.D. Willett, "The Influence of the Trade Balance and Export Financing on International Short-Term Capital Movements: A Theoretical Analysis." Kyklos, Vol. X, Fasc. 2 (1969), pp. 314-26.

VARIABLE NAMES and DATA SOURCES

STLB	Short Term Liabilities to Foreigners Reported by Banks	FRB
STLNF	Short Term Liabilities to Foreigners Reported by Non-Financial Institutions	FRB
STCB	Short Term claims on Foreigners Reported by Banks	FRB
STCNF	Short Term claims on Foreigners Reported by Non-Financial Institutions	FRB
IUS	3-month U.S. Treasury bill rate	FRB
IUK	3-month U.K. Treasury bill rate	FRB
IFR	French Day-to-day money on private securities	FRB
ISW	Swiss 3-month deposit rate	FRB
ICAN	3-month Canadian Treasury bill rate	FRB
IGR	German 3-month interbank loan rate	DBMR
INET	3-month Dutch Treasury bill rate	FRB
E(country)	Eurocurrency 3 month deposit rates	SBC
LTLB	Long Term Liabilities to Foreigners Reported by Banks	FRB
LTLNF	Long Term Liabilities to Foreigners Reported by Non-Financial Institutions	FRB
LTCB	Long Term claims on Foreigners Reported by Banks	FRB
LTCNF	Long Term claims on Foreigners Reported by Non-Financial Institutions	FRB
R(country)	Spot exchange rate at end of period in dollars per unit of foreign currency	IFS
FR(country)	3 month forward exchange rate at end of period in dollars per unit of foreign currency	IFS

Variable Name	Description	Source*
$\bar{R}$(country)	Par value for spot exchange rate in dollars per unit of foreign currency	IFS
TB	U.S. trade balance	USEI
ΔG	Change is U.S. net official reserves	FRB

$$LTLN = LTLB + LTLNF - LTCB - LTCNF$$

$$STLN = STLB + STLNF - STCB - STCNF$$

$$RUS = - \left(\frac{RUK - \bar{R}UK}{\bar{R}UK} + \frac{RCAN - \bar{R}CAN}{\bar{R}CAN} \ldots /6 \right)$$

$$ID = IUS - (IRK + ICAN + INET + IGR + ESW + IFR) /6$$

$$IP = - \left[\left(IRK - IUS + \frac{(RUK - FRUK) 4}{RUK} + \ldots /6 \right] \right.$$

$$ED = EUS - (EUK + ENET + EGR + ESW + EFR) /5$$

$$EIP = -- \left[EUK - EUS + \frac{(RUK - FRUK) 4}{RUK} \right] + \ldots /5$$

<u>* Source</u>

FRB = Federal Reserve Bulletin

DBMR = Deutsche Bundesbank Monthly Review

IFS = IMF, International Financial Statistics

USEI = Ceneus, U.S. Imports and Exports

SBC = Swiss Bank Corporation, Internal Records