An Econometric Analysis
of
The Eurodollar Market

by

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1. Introduction

This paper challenges the present-day validity of Rich's model of the Eurodollar market. Georg Rich tested a theoretical model of the market by analysing the relationships between Eurodollar interest rates and exogenous shocks in the global economy, under a fixed exchange rate regime. These relationships ultimately affect the demand for Eurodollar assets and the size of the Eurodollar market. This model used principles of portfolio selection and financial intermediation. Rich's 1971 econometric analysis has been re-estimated with more current data. However, the current analysis will test the relevance of Rich's model in a flexible exchange rate world. The modern parameter values will be compared to the original values, which generally corresponded to the model's theoretical conclusions. If the new study concurs with the first one, then we can conclude that the Eurodollar market has not significantly changed. Otherwise, the result of the analysis will reveal that the Eurodollar market has been altered somewhat over more recent years. If the Eurodollar market has changed, the causes of these deviations will be examined.

1.1 Description

The Eurocurrency market is the world's largest money market. About 58 percent of this market was denominated in U.S. dollars in 1989.[1] Although other currencies, such as the German Deutschemark,

have gained ground on the U.S. dollar, the dollar is still dominant in this market. The gross size of the market at this time was $6.1 trillion dollars, and the net size was $2.6 trillion.[2] In comparison, the net size of the market in 1970 and 1980 was $65 billion and $755 billion respectively. The difference between the net and gross size of the market is due to fractional reserve banking. This concept will be analyzed in detail in chapter two.

The Eurocurrency market is characterized by currency being held in banks outside of the country that issues the currency.[3] More specifically, the Eurodollar market is one where U.S. dollars are held in banks outside of the United States. The Eurobanks hold an advantage over the regular U.S. commercial banks because they are not subject to as restrictive reserve and capital requirements.[4]

A reserve requirement is a controlled percentage of a bank's total deposit liabilities. It must be deposited in the national central bank interest free, in order to repay depositors if necesssary. Without a minimum reserve constraint, the portion of deposit liabilities that are available to a bank for investment purposes increases. Eurobanks are not subject to a reserve requirement, although many of them do hold some precautionary reserves.

Capital requirements involve the holding of a certain amount of equity capital against the bank's assets in order to maintain its solvency.[5] Previously, an Eurobank could be established in a country where the capital requirement is smaller than in the bank's

home nation. The Eurobanks could then offer more competitive interest rates and more accessible credit to their customers, than can domestic banks with tighter regulation. However, the "Basle Supervisors' Committee, which consists of the G-10 countries and Luxembourg, have agreed on an eight percent minimum capital requirement by 1992.[6] Countries outside of this group are not legally bound to the same requirements. The Eurobanks strengthen banking competition in all of the domestic markets in which they operate. The disadvantage of this system is an overall increase in the risk of default in the market.

The risk of being unable to cover deposits is greater without sufficient deposit insurance and reserves. Loans in the Eurodollar market are made to an increasing number of developing countries with tremendous balance-of-payments deficits. These borrowers increase the overall risk for default in the Euromarket.[7] This situation is similar to the case of junk bonds.[8] With junk bonds, the investor receives a very high yield on an equally risky bond. However, in the Eurodollar case, a rational Eurobank will hedge its default risks by diversifying its portfolio. This is an over-the-telephone market, which provides a strong and instantaneous link between the major global financial centres in the world.[9]

1.2 Participants

The major players in the Eurodollar market are commercial banks, corporations, governments, and international institutions.[10]

Commercial banks form the heart of the Eurodollar market, by operating as both a lender and a depositor, outside of the United States. These organizations could be foreign banks or subsidiaries of U.S. banks. Of these, the largest ones dominate the market, and in doing so, also control the interbank market. The interbank market is comprised of the banking operations that take place among Eurobanks. The larger banks get a disproportionate amount of the low interest credits from depositors, and subsequently lend these funds to the smaller banks, at a higher rate. Major corporations and international institutions are the primary borrowers in the Eurodollar market.

Governments, and government-controlled corporations, are primarily longer term borrowers, but they are now becoming significant depositors as well. Private individuals are minor participants due to the fact the Eurodollar market is largely a wholesale market.[11]

1.3 Background

Although there is some controversy as to the origins of the Eurodollar market, the main consensus will be listed below. The Eurodollar market's beginning can be traced back to just after World War II.[12] The Soviet Union, Eastern Europe, and China all placed deposits in Western Europe, in order to avoid possible political complications in the United States, due to the Cold War.

When funds were invested in Western Europe, it secured otherwise unattainable U.S. dollar loans for these Communist countries.

In 1957, the British placed controls on the international availability of the Pound Sterling.[13] Banks in the United Kingdom began to do their foreign business with the U.S. dollar, which was not controlled by British authorities. At the same time, many other European countries started to allow for the easier conversion of the U.S. dollar. "Continental banks discovered that they could be more competitive outside their countries of residence", and established themselves as Eurocurrency banks.[14]

In the United States in the mid 1960's, a number of circumstances led to phenomenal growth in the Eurodollar market.[15] The U.S. balance of payments deficit had become very large, so the government implemented some restrictions in order to control it. The interest equalization tax of 1963 made it less profitable to invest directly in the foreign market than in the domestic market.

Regulation Q lowered the U.S. deposit rates that commercial banks could offer. This regulation drove U.S. dollars out of the country and into Eurobanks. In 1969 and 1970, further U.S. contractionary monetary policy continued to help expand the Eurodollar market. These factors led to a tripling of the Eurocurrency market in this decade.[16]

In the 1970's there were many factors that contributed to the growth of the Eurodollar market.[17] There was a large increase in the demand for loans by the non-OPEC third world countries. Industrial nations required more funds in order to service their

growing deficits. Various controls were placed on the European banking sector, which encouraged them to increase their Eurodollar activity. Central banks were depositing large amounts of foreign currency reserves in the system.

The Eurodollar market was expanded further in the 1980's and 1990's, owing to the ever increasing globalization of financial markets.[18] Information and telecommunications technology continue to increase the speed of transactions exponentially. New financial instruments also broaden the appeal of the Eurodollar market.

1.4 Problems

The Eurodollar market, appealing as it seems, does have some apparent drawbacks. The three major problems with the market are: its greater probabilty of loan default, its weakening of national monetary policy, and its supposed role in increasing global inflation.[19]

As was mentioned earlier, the Eurodollar has no central bank-like authority. There are no lender-of-last-resort facilities, no deposit insurance facilities, and limited market supervision. These deficiences lead to some risk factors that are larger in the Eurodollar market, than in domestic markets. Risk is added to the market because lenders may not know the ultimate use of the loaned funds. The market's participants, however, accept the increased risk in order to enjoy a higher return on their investment.

In the interbank market, a loan is made by one Eurobank, and

it may be subsequently reloaned to any number of other banks before leaving the Eurocurrency market. The bank which made the initial loan might not know the final destination of those funds, and hence there would be greater risk due to a lack of investment information.

In the earlier years of the market's existence, the majority of the participants in the market were banks and corporations with very high credit ratings. However, in more recent years, there have been large increases in the amount of loans to Third-World countries that are unable to pay back their debts. These loans are not tied to conditions, like much of the IMF and World Bank lending, so there is not much supervision as to the use of the funds. Such countries can borrow money from the Eurodollar market with much more freedom than from a supervising lender. Most Third-World countries have much lower credit ratings than the original participants in the market, so they increase the overall risk of default.

Due to the lack of a minimum reserve requirement, when there are term differences with time deposits and loans, a problem could arise due to the lack of reserves to cover payments in an Eurobank at a given point in time. This dilemma may also occur when a chain of depositors lose confidence in their bank and demand that their deposits be returned. Confidence may be lost if depositors do not believe that the bank can pay their deposits on demand. This case is a variation of the free banking controversy.[20]

There have been suggestions to set up a type of central bank

to govern the Eurocurrency market. Such an institution would remove the freedom from the Eurodollar system. An ideal choice would be an organization such as the Bank for International Settlements, the World Bank, or the IMF. However the market can only be controlled by "the central bank responsible for the marketplace in which the individual Eurobank operates", or "each and every central bank regulating the access to the international market by its own banks and corporations".[21] So far, neither of these conditions have been fulfilled.

It is evident that a large international money market, independent of national control, could pose a problem to monetary policy. The central banks' policies can be weakened somewhat if they unexpectedly cause agents in the domestic market to enter the Eurodollar market. Emminger states that domestic monetary policies can be affected by "...the consequence of freedom of international money movements as such - magnified however by the enormous size of the funds concentrated in the Europool."[22] Obviously, the size and strength of the Eurodollar market warrants careful consideration by the monetary authorities when planning monetary policy.

Has the Eurodollar market added to global inflation? The market has expanded the credit base somewhat, but in order fully to answer this question, some of the mechanics of the Eurodollar market must be understood. The Eurodollar mechanism, and an answer to the inflation question, are illustrated in chapter two.

2. Mechanism of Eurodollar Market

In order to fully appreciate the model that will be analysed, some principles of financial intermediation and portfolio selection must be understood. There are two technical devices which must be described in order to realize the mechanism through which the Euromarket operates. Fractional reserve banking in the interbank market is a process by which Eurodollar balances are transferred from one bank to the next. Most economists attribute "credit expansion" in the Eurodollar market to this feature, of which the Eurocurrency multiplier is a measure. In this chapter, these two characteristics will be described using fractional reserve banking, and one answer to the question of global inflation raised in chapter one will be given.

2.1 Eurobank Portfolio Options

A Eurodollar bank is involved in the lending and borrowing of U.S. dollars. It receives an initial deposit from some nonbank, be it a private depositor or some other type of investor. This deposit becomes a portion of the bank's portfolio. The process of portfolio selection involves the analysis of the following options.[23]

First of all, Eurobanks could participate in the foreign exchange market in order to "adjust their day-to-day liquidity

position or to obtain loanable funds in their own currencies."[24] The ease of convertibility of the dollar with other national currencies makes this option attractive. An important arbitrage tool is the swap, which is defined as a "...simultaneous spot purchase and forward sale of a currency."[25] Two important exchange rates need to be defined when considering swaps.

The spot exchange rate is the immediate price of a currency. The forward rate is a price agreed upon today for delivery and payment of a currency at some future date. The premium or discount on the forward exchange rate represents the buyer/seller's expectations as to the appreciation or depreciation of the currency, taking into account international interest rate differentials. The Eurobank could convert the dollars into its domestic currency and lend the money to local borrowers. These types of transaction would take the money out of the Eurodollar market immediately.

Secondly, the bank could loan all or a part of the money to a borrower who demands U.S dollars. The Eurobank can generally loan the money at a lower rate than a U.S. bank could, since "Eurodollar rates track domestic rates almost perfectly, but differ from U.S. rates by small, fairly consistent margins."[26] The fact that Eurobanks are not subject to reserve requirements, and that they incur relatively lower transaction costs are two reasons why Eurodollar interest rates are lower. These banks have a larger percentage of their deposits available to them to make loans, although they will still hold minimal reserve funds. The amount of

reserves that an Eurobank will hold depends in part on the ratio of time deposits to demand deposits.

A time deposit is one that becomes due after a certain period of time has elasped. A rational bank will try "to 'marry' its liability to a claim."[27] To "marry" in this context describes the matching of the maturities of deposits(liabilities) with the maturities of equal-sized claims(loans) by the Eurobank. This type of deposit requires practically no reserve balance. In comparison, demand deposits can be claimed at any time, and hence they cannot be "married". The greater the value of demand deposits, the larger the amount of reserves held by the Eurobank.[28]

The last option that an Eurodollar bank has arises when the dollars are redeposited back into the Eurocurrency market. The sum of these occurrences is referred to as the interbank market. The interbank market consists of arrangements where banks with excess reserves lend these funds for short periods to other banks.[29] The interbank market contains a large portion of the Eurocurrency market's resources. The portion of Euromarket assets which are tied up in interbank activity is 71.6 percent, and 86.1 percent of its liabilities are in the interbank market.[30]

2.2 Fractional Reserve Banking

The mechanism through which most interbank transactions take place in the Eurodollar market is fractional reserve banking. This mechanism is an important financial intermediation tool. When an

exchange is made between banks, it is recorded in their books. More often than not, no actual dollars are transferred. Through this method of accounting, one sum of money may be multiplied many times before it actually exits the Eurodollar market permanently. "Credit creation in the Eurodollar market refers to the creation of credit to (and deposits by) nonbanks, not to the piling up of interbank assets and liabilities."[31] The Eurodollar multiplier is designed to measure the net expansion of credit in the Euromarket.

An example of a typical Eurodollar lifecycle that was adapted from Clendenning and Friedman can be found in the appendix.[32,33] This cycle demonstrates both options two and three, and consists of seven accounting stages. Any mention of dollars in the following refers to U.S. dollars.

In Stage one we have a typical domestic banking transaction, where a foreign Depositor A places $100 in a U.S. bank. The deposit could have been converted from a foreign currency. This transaction is recorded in the books as a $100 asset for the depositor, and a $100 liability for the domestic bank. For any of the explanations previously offered, this investor could find it more appealing to deposit these dollars in an Eurobank.

Stage two provides the accounting entries that would occur when Eurodollars are created. Depositor A wishes to open an account with Eurobank X. The depositor would now claim its assets against Eurobank X and 100 Eurodollars are created. Eurobank X holds a U.S dollar deposit with the American bank and a liability to Depositor A. The domestic bank now has a liability of $100 with

the Eurobank, and is no longer directly dealing with Depositor A.

In stage three, Eurobank X chooses to participate in the interbank market by depositing dollars into another Eurobank. In our example, we will assume that the Eurobanks will maintain a ten percent reserve ratio. Eurobank X will hold $10 in the U.S. bank and have $90 available to it to loan to Eurobank Y. The $10 held for reserves represents a leakage from the interbank market.

A leakage occurs when some funds leave the Eurodollar market for any number of reasons, some of which include the holding of reserves, the paying of taxes, or the purchase of foreign currency.[34] This does not affect Depositor A's claim against Eurobank X. The U.S bank now has a liability of $10 to Eurobank X and a $90 liability to Eurobank Y. The total liability of the U.S. bank is still $100. Eurobank X now has a $10 claim against the American bank and a $90 claim against Eurobank Y. Eurobank Y has a $90 claim against the U.S bank and a liability of the same amount to Eurobank X.

In step four, Eurobank Y holds a $9 reserve amount with the U.S. bank and lends the remaining $81 to Borrower B. The U.S. bank now has liabilities of $10, $9 and $81 to Eurobanks X and Y, and borrower B respectively. Its total liability is still $100. Eurobank Y now has a $9 claim against the U.S. bank and a $81 claim against Borrower B. Although there are $190 worth of gross Eurodollar deposits in the system, the net deposits still total $100, since the deposit between the Eurobanks will cancel each other out. At this point the world supply of dollars is $81 higher

and the interbank deposits are $19 higher. The U.S. money supply, and the balance-of-payments position are unchanged. Thus, the Euromarket transactions have added $100 to global money supply.

In Step five Borrower B pays the $81 to Company C for goods. This transaction will shift Borrower B's claim against the U.S. bank to Company C, even though Borrower B is still responsible for repayment of the loan to Eurobank Y. This will end the interbank cycle, unless company C redeposits their dollars into the Eurodollar system.

In step six, Company C deposits its $81 into Eurobank Z. Eurobank Z now holds a claim against the U.S. bank and the interbank transactions are allowed to continue. Borrower B's position in the remainder of the exercise is unchanged, so it is not recorded in step six or seven.

In step seven, Eurobank Z holds $8 in the U.S. bank as reserves and loans the remaining $73 to Borrower D. Borrower D does not return any of the dollars to the Eurodollar system and the cycle ends. At this time, we can analyze the total expansion of credit.

The "net credit expansion" includes the $81 to Company C, as well as the $73 to Borrower D. This $154 is the amount of nonbank dollars in the system. The gross Eurodollar deposits now total $271, and interbank deposits now total $27. The U.S. bank's liability of $100, the U.S. money supply and the balance-of-payments position have remained unchanged. Therefore, the World's supply of dollars has increased by $154, so the Eurodollar market

has caused some global inflation, according to Friedman's monetary theory of inflation. Friedman states that "the Eurodollar market almost surely raised the world's nominal money supply and has thus made the world price level higher than it would otherwise be."[35]

2.3 Global Inflation

The severity of inflation caused by the Eurodollar market hinges on a debate between the Post-Keynesians and the Monetarists.[36] The Friedman(Monetarist) view assumes that the Eurodollar market has a fixed leakage and reserve ratio. Furthermore, the reserve ratio is assumed to be small. These factors will allow for a large multiplier and hence, the Eurodollar market has caused global inflation. For reasons already discussed, the leakage ratio can vary for a few reasons. According to Klopstock, the leakage ratio will most likely be extremely large.[37] The Post-Keynesians believe that this large leakage ratio will lead to a very small Eurodollar multiplier. In this case, there will not be any credit expansion or inflation in the global market. This debate will not be discussed any further in this paper. The reserve ratio is not a requirement in the Euromarket, and will in all probability differ from bank to bank.

There are three factors which influence the size of the reserve ratio.[38] If the probability of withdrawal is high or the potential borrowers are too risky, then Eurobanks will naturally hold more reserves. If the interest rates are low, then the

opportunity costs of holding reserves will likewise be low. In this case, Eurobanks will also hold more reserves. These factors diminish the accuracy and probably the size of the Eurodollar multiplier. The Hewson and Sakakibara multiplier makes use of flexible leakage and reserve ratios.[39] This is probably the best available multiplier, although due to the limited size of this paper, it will not be discussed any further. Instead, the next chapter will describe the model to be used in the econometric analysis of the Eurodollar market.

The Eurodollar market's interest rates will have an effect on the leakage ratio and consequently on the size of the market. However, there are some other factors that will also have an effect on the Eurodollar market. International and U.S. interest rates, exchange rates and the balance of payments position can all have an effect on the Eurodollar asset interest rates. In the following chapters we shall analyze a model that deals with the effects of these factors on the growth of the Eurodollar market.

3 The Model

3.1 Description

The model that will be used in this analysis is one of portfolio selection and financial intermediation, which is taken from Georg Rich.[40] Rich borrows portions of his model from Brainard's financial intermediation model.[41] Other parts of this model are adopted from Tobin's portfolio selection model.[42]

In Rich's model we have an incomplete financial relationship between the United States and the United Kingdom. In this model, a relationship between the demand for Eurodollars and changes in the U.S.-U.K. financial position vis-à-vis one another was sought. An increase in the demand for Eurodollars is representative of growth in the Eurodollar market. Rich found that there was a signifcant relationship between domestic interest rates in both countries and the demand for Eurodollar assets. The Sterling exchange rate and the U.S. balance of payments position also significantly affected the Eurodollar market.

U.K. residents can deal in both dollars and pounds. In this small subset of the world, only four financial instruments will be considered. These instruments include Eurodollar deposits, Eurodollar loans, U.S. short-term assets and U.K. short-term assets. These four assets are assumed to be substitutes. It is also assumed that U.S. and Sterling short-term asset interest rates are exogenous in order to simplify the simulation of the exchange

market. The analysis of the forward and spot exchange markets in this paper will rely on studies performed by Stein.[43]

Only three players are permitted to participate in Rich's world. Eurobanks can be U.K. banks or U.K. branches of American banks. The other two players are the U.K. nonbanks and residents of the United States. British nonbanks consist of residents and nonbank organizations. In this model, domestic U.S. banks will not be considered in order to maintain consistency with Rich's analysis. The following listing will more clearly define each players' jurisdiction:

Eurobanks	- hold Sterling and U.S. assets - accept Sterling and Eurodollar deposits - grant Eurodollar loans - grant Sterling loans
U.S. residents	- hold U.S. and Sterling assets - have Eurodollar deposits - Borrow $U.S., Sterling - Borrow Eurodollars from Eurobank
U.K. nonbanks	- hold U.S. and Sterling assets - have Eurodollar deposits - Borrow $U.S. and Sterling - Borrow Eurodollars from Eurobank

3.2 Structural Equations

In this model, there are two major excess demand functions. There is an excess demand function for Eurodollar deposits and one for Eurodollar loans. These excess demand functions are assumed to be affected by the interest rates of our four assets. The U.S. short-term interest rate will be used as a numeraire. All other rates will now be described as follows:

x_D = | Eurodollar deposit rate - U.S. short-term rate |
x_L = | Eurodollar loan rate - U.S. short-term rate |
y = | Sterling short-term rate - U.S. short-term rate |
g = forward premium(discount) on the spot rate of the pound
P^* = expected rate of appreciation(depreciation) of the spot rate of the pound

Using these relationships, we can derive an excess demand function for Eurodollars as follows:

(1) $D(x_D, x_L, y+g, y+p^*) = 0$[44]

$dD/dx_D > 0$, $dD/dx_L < 0$, $dD/d(y+g) < 0$, $dD/d(y+p^*) < 0$

Here, $y+g$ can be defined as the yield on covered Sterling assets in terms of American short-term assets and $y+p^*$ as the yield on uncovered sterling assets, from an U.S. perspective. A covered Sterling asset has its future value protected against fluctuations in the exchange rate between the dollar and the pound. The value of an uncovered asset changes when there are changes in the exchange rate. In other words, the future value of an uncovered asset purchased today is not guaranteed. In this model, it is assumed that the excess demand for Eurodollar deposits is negatively related to the U.S. short-term rate. Using the original interest rate identities, we find that an increase in the U.S. short-term rate leads to a decrease in x_D, x_L, $y+g$ and $y+p^*$.[45] In order for the negative relationship between D and the U.S. short-term rate to be true, we must have the following condition:

(1a) $dD/dx_D + dD/dx_L + dD/d(y+g) + dD/d(y+p^*) > 0$

Hence, equation (1) must satisfy equation (1a).

From the first derivatives in (1), it is clear that an increase in the Eurodollar deposit rate will lead to an increase in

the Eurodollar deposit excess demand function. If the yield on any of the three substitutes for Eurodollar deposits increase, then the demand for Eurodollar deposits will decrease. If there is to be a negative relationship between the U.S. short-term rate and the excess demand for Eurodollar deposits, the Eurodollar deposit rate must have a greater effect on the excess demand for Eurodollar deposits than the interest rates of the three substitutes combined.

So far, we have discussed the demand side of Eurodollar deposits. The supply of Eurodollar deposits is negatively related to the Eurodollar deposit rate and positively related to the interest rates of its substitutes from the perspective of the Eurobanks. If the Eurodollar deposit rate differential (x_D) increases, then the U.K. banks will naturally want to decrease the amount of its Eurodollar deposits and promote the relatively cheaper substitutes.

The excess demand for Eurodollar loans are handled in the same manner as Eurodollar deposits. This function is illustrated as follows:

$$(2) \qquad L(x_D,\ x_L,\ y+g,\ y+p^*) = 0$$

$$dL/dx_D > 0,\ dL/dx_L < 0,\ dL/d(y+g) > 0,\ dL/d(y+p^*) > 0$$

If there is an increase in the Eurodollar loan interest rate, then borrowers will become less interested in Euroloans and more interested in the substitutes.

In this simple model, we must solve for the Eurodollar deposit (x_D) and loan differentials (x_L) in terms of the short-term Sterling interest rate differential (y), the forward premium of the pound

(g) and the expected appreciation of the pound (p^*). However, due to the high multicollinearity between the forward premium (g) and Sterling-U.S. interest rate differential (y) found by Rich, we must treat g and p^* as endogenous variables to maintain consistency.[46] For simplicity, we will treat the Sterling differential yield (y) as an exogenous variable. In order to solve this problem, we must provide four equations which supplement equations (1) and (2). These equations are included to illustrate the effects of exchange-rate speculation and of changes in the U.S. balance of payments position on the Eurodollar interest rates.

The four equations which will be derived include the excess demand functions for spot and forward pounds, an equation that determines the expected spot rate, and an expression that illustrates the U.S. net debt to foreigners other than official institutions. The resulting six endogenous variables are x_D, x_L, g, p^*, p and N. The current spot rate is represented by p and the current American net debt to foreigners is denoted by N.

The first of the four supplemental equations that will be analysed is the balance-of-payments constraint. Since only two countries are being considered in this world, Rich argues that this equation may also be called the excess demand for spot pounds.

$$(3) \quad -(N_t - N_{t-1}) - B(p_t, T_t) + (Z_t - Z_{t-1}) = 0, \qquad dB/dP_t > 0$$

N: U.S. net debt to foreigners, other than official institutions (negative for credits)
B: surplus(+) or deficit(-) of U.S. balance of payments on current account
Z: U.S. official holdings of gold and foreign exchange less U.S. liabilities to foreign official institutions

This equation implies that any change in the net liabilities to foreigners(N) will signal some action that took take place in the foreign exchange market. The current account surplus in this model is positively related to the current spot rate of the pound, and an exogenous disturbance variable (T). If the spot rate of the pound increases then U.S. goods will become relatively cheaper than U.K. goods. The excess demand for U.S. goods will increase the U.S. current account surplus. In Rich's model, it is assumed that the current spot rate (P_t) and the current net debt to foreigners (N_t) will be endogenous and U.S. reserve assets (Z) will be exogenous. In this paper, the exchange rates will be defined as dollars/pounds.

Next, the U.S. net debt to foreigners must be calculated. The function that will be used is described as follows:

$$(4) \quad N = N(x_D,\ x_L,\ y+g,\ y+p^*)$$

$$dN/dx_D < 0,\ dN/dx_L < 0,\ dN/d(y+g) < 0,\ dN/d(y+p^*) < 0$$

This equation is based on Rich's assumption that the international interest rate differential (y) determines the stocks of foreign assets. For example, if the Eurodollar deposit rate rises, then the demand for that instrument increases. This will increase the amount of U.S. claims against foreigners, or equivalently, decrease the U.S. net debt to foreigners (N).

We must now derive an excess demand function for forward pounds. In practice, there are two situations that can lead to the purchase and sale of forward pounds.[47] An increase in the U.S. net debt to foreigners will cause an increase in the demand for forward

pounds. This situation occurs because investors usually wish to cover their assets against changes in the spot market.

The other means by which transactions in the forward pounds market may take place is through speculation. Investors speculate if they think that they can make a profit from a perceived discrepancy in the spot or forward exchange rates. In this model, the amount of uncovered assets in a portfolio is directly related to the difference between the yields of uncovered and covered Sterling assets ($p^* - g$). For example, if the expected appreciation of the spot rate (p^*) increases relative to the forward premium (g), then one of two situations may occur. Either U.S. investors will purchase uncovered Sterling or U.K. nonbanks will sell uncovered dollars in the spot market. Whichever scenario occurs will result in an increase in the excess demand for forward pounds.

Speculators may also deal in the forward market in order to profit from discrepancies in the expected spot rate and the corresponding forward rate. The expected profit(in dollars) associated with an one pound forward purchase is illustrated by the function [E(p) - f]. Here, E(p) represents the expected spot rate and f represents the corresponding forward rate.

Theoretically, investors do not need any capital to speculate in the forward market. However, in practice a small deposit is usually required.[48] We will denote this capital expenditure as k. In this model we will use a fixed k and propose the new expression:

$$[E(p) - f] / kf = (p^* - g).(p/f) / kf$$[49]

In this expression, we can see that speculation increases with an increase in the covered-uncovered yield differential. Thus, the excess demand for forward pounds is positively related to (p^*-g). We can now write an excess demand for forward pounds function (F) as follows:

$$(5) \quad F[N, (p^* - g)(p/f)] = 0$$

$$dF/dN > 0, \; dF/d(p^*-g) > 0$$

Lastly, an expression must be derived for the expected appreciation of the spot rate. For this model, changes in the expected appreciation of the spot rate (p^*) are due in part to the current spot rate and partly by exogenous disturbances in the economy. Hence, we can use the following regressive expectations expression to describe the expected appreciation in p^*:

$$(6) \quad p^* = p^*(p, e)$$

$$dp^*/dp < 0$$

Here, we can consider e to represent an exogenous change in the short-term expected appreciation of the spot rate of the pound (p^*). The six equations used in our model can be summarized as follows:

$$(1) \; D(x_D, x_L, y+g, y+p^*) = 0$$
$$(2) \; L(x_D, x_L, y+g, y+p^*) = 0$$
$$(3) \; -(N_t - N_{t-1}) - B(p_t, T_t) + (Z_t - Z_{t-1}) = 0$$
$$(4) \; N = N(x_D, x_L, y+g, y+p^*)$$
$$(5) \; F[N, (p^*-g)(p/f)] = 0$$
$$(6) \; p^* = p^*(p, e)$$

3.3 Impact of the Exogenous Disturbances

In this model, there is a problem with identification which

hinders us from testing the structural equations. Instead, we must determine if the model can be substantiated by the observed changes in the endogenous variables. If the observed yields on the four assets are consistent with the theoretical model, then the model can be considered to be corroborated.

According to Rich's model, any exogenous disturbance will affect the Eurodollar rates, the forward premium and the expected rate of appreciation on the spot rate. From an American viewpoint, a change in the forward premium and a change in the expected rate of appreciation on the spot rate of the pound, respectively, represent a change in the covered and uncovered yields on Sterling assets. Our test must be performed from this perspective.

In order to perform such a test, we must analyze the effects of a change in the interest rate differential between the Sterling and U.S. short-term rate (y), an exogenous change in the expected appreciation of the spot rate (e) and an exogenous increase in U.S. exports (T). This test consists of two steps. The first step will involve the solving of the equillibrium values of x_D and x_L, given $y+g$ and $y+p^*$. In the second step of our testing, equations (3) - (6) will be solved.

First, the excess demand for Eurodollar deposits (DD) and loans (LL) curves must be derived. These curves are initially assumed to be in equilibrium. This analysis was borrowed from Hick's General Equilibrium model.[50] Using implicit differentiation on equations (1) and (2), we can derive the slope of the excess demand for Eurodollar deposits and loans respectively as follows:

DD: $dx_D/dx_L = -(dD/dx_L) / (dD/dx_D) > 0$

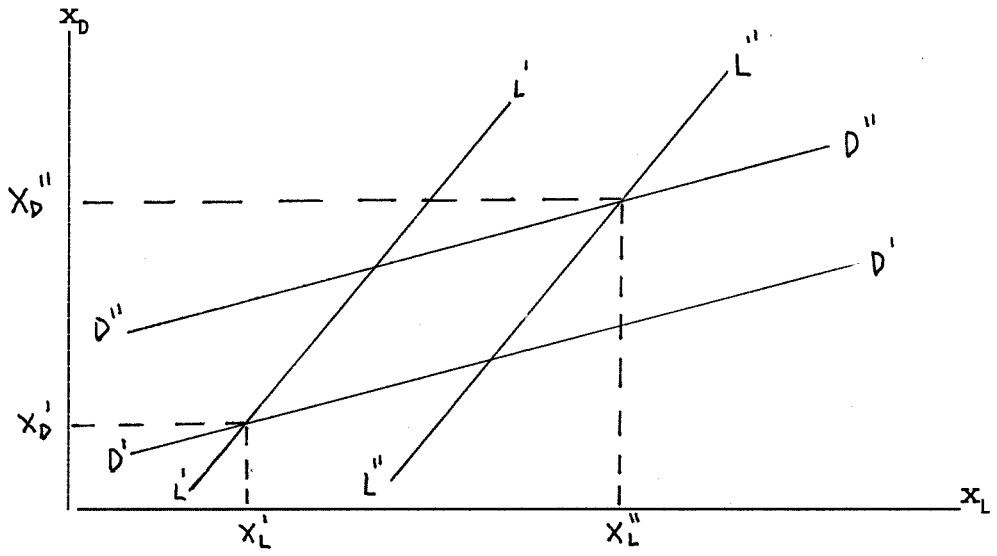
LL: $dx_D/dx_L = -(dL/dx_L) / (dL/dx_D) > 0$

This inequality comes from the relationship that we deduced in expression (1a):

(1b) $dD/dx_D > -dD/dx_L - dD/d(y+g) - dD/d(y+p^*) > -dD/dx_L > 0$

A similar relationship can also be found for equation (2). Although both curves are upward sloping, the LL curve is steeper than the DD curve.[51]

Diagram 1: Eurodollar Rate Adjustment[52]



We will now analyze the effects of an increase in covered yield differential on Sterling assets (y+g) and the uncovered yield differential on Sterling assets ($y+p^*$), on the Eurodollar deposit rate. By implicit differentiation we can obtain the following two expressions:

$$DD: \mathbf{dx_D/d}(y+g) = -(dD/d(y+g)) \;/\; (dD/dx_D) > 0$$

$$LL: \mathbf{dx_L/d}(y+g) = -(dL/d(y+g) \;/\; (dL/dx_L) > 0$$

From these relationships, we can illustrate the effect of a change in y+g on the Eurodollar rates. From the above expressions, an increase in the covered Sterling differential (y+g), given a fixed $y+p^*$, will increase the Eurodollar deposit rate. Using equation (1), the higher Eurodollar deposit rate will increase the excess demand for Eurodollar deposits and shift the Eurodollar deposit demand curve D'D' up to D"D". From equation (2), the same increase in y+g will simultaneously increase the Eurodollar loan rate and decrease the demand for Euroloans. This decrease in Euroloan demand will shift the Euroloan demand curve down from L'L' to L"L". The Eurodollar deposit and loan rates will rise relative to the U.S. short-term rate. An identical result will be obtained for an increase in the yield on uncovered Sterling assets ($y+p^*$).

The second step in this analysis requires us to solve equations (3) - (6). Assuming that the Eurodollar market is in equilibrium, only y+g and y+p* will affect the U.S. net debt to foreigners(N) in equation (4). The variables x_D and x_L may be taken as parameters. The covered and uncovered yield differential on Sterling assets changes N both directly and indirectly. An increase in y+g or $y+p^*$ will cause N to decrease directly, from our derivation of equation (4). Indirectly, an increase in y+g or $y+p^*$ will increase x_D and x_L, which will lower the U.S. net debt to foreigners as well. The previous manipulation of equation (4) will

give us a new expression:

(4a) $N = N^*(y+g, y+p^*)$ $\qquad dN^*/d(y+g) < 0,\ dN^*/d(y+p^*) < 0$

Here we have eliminated x_D and x_L from equations (3) - (6). It is now possible to solve (3), (4a), (5) and (6) for four endogenous variables. These variables are the expected appreciation of the spot rate for the pound (p*), the forward premium on the spot rate of the pound (g), the current spot rate (p) and the U.S. net debt to foreigners other than official institutions (N). This discussion can be divided into three parts based on each exogenous variable: a change in the differential yield on Sterling assets (y), an exogenous change in the expected spot rate (e) and an exogenous increase in exports (T).

An increase in the yield differential on Sterling assets will induce a capital outflow from America. This outflow is represented by a decrease in the net U.S. debt to foreigners (N) and will increase the demand for spot pounds. The rise in the demand for spot pounds will increase the current spot rate (p). In Rich's model, a higher spot rate will cause the expected appreciation (p^*) and forward premium (g) of the pound to decrease. However, $y+g$ and $y+p^*$ are increased because y rises by more than either g or p^* decreases.[53] This increase in the covered and uncovered differential yield on Sterling assets leads to an increase in both x_D and x_L from the analysis in step one.

If the increase in y is mostly offset by the decrease in g or p^*, then it would follow that the Eurodollar rates would change very little, relative to the U.S. short-term rate. However, if an

increase in the Sterling yield differential is caused by a decrease in the U.S. short-term rate, then y+g, y+p* and the Eurodollar loan and deposit rates will fall, but less severely than the U.S. short-term rate. If the decrease in the U.S. short-term rate is offset by a decrease in the g or p^*, then the fall in the Eurodollar rates will approximately equal the fall in the U.S. rate.[54] Hence, the greater the reaction of g and p* to exogenous disturbances, the greater the connection between the Eurodollar and U.S. rate, and the weaker the connection between the Eurodollar and Sterling rates.

Secondly, an exogenous increase in the expected appreciation of the spot rate (e) will increase the U.S. demand for pounds. The resulting capital outflow from the United States will cause the current spot rate for pounds (p) to increase, due to the greater demand for them. The increase in the expected appreciation of the spot rate will allow for speculation in the forward market for pounds, which will raise the forward premium of the pound (g). The increase in g and p* will lead to an increase in x_D and x_L as we discussed earlier. Speculators will switch from dollar and Eurodollar assets to Sterling assets in order to gain a higher return from the expected future appreciation of the pound.

Lastly, an exogenous increase in U.S. exports (T) will lead to an outflow of capital (N) from America, since U.K. importers will demand more U.S. dollars in order to purchase these goods. The spot rate of the pound (p) will decrease due to the increased demand for U.S. dollars. The decrease in the spot rate of the

pound will lead to an increase in p^* and g, which will ultimately lead to an increase in x_D and x_L.

In the next chapter, this model will be tested empirically. The new results will be compared to Rich's results and to the theoretical model. In addition, any limitations of Rich's model to current data will be highlighted.

4. Empirical Results

In the statistical tests, Rich only considers the Eurodollar deposit demand and not the Eurodollar loan demand function. Structural equations will not be used since monthly Eurodollar deposit data were unavailable for the entire period. Instead we will measure the effect of the domestic interest rates, the U.S. balance-of-payments position and the U.S. reserve asset positon on the Eurodollar deposit rate, the spot rate and forward premium of the pound. Our results will be compared to the theoretical results, as well as to Rich's empirical findings. This study will update Rich's regressions by adhering to his contraints.

4.1 Regression Equations

The regression equations in this empirical model are based on the actual interest rates of the instruments analysed, and not on the differentials as in the theoretical model. Although it has been argued that interest rate differentials produce better results, we will use the actual rates in order to maintain consistency with Rich's analysis. The three endogenous variables to be studied are the three-month Eurodollar deposit rate (X_D), the three-month forward premium of the pound (g) and the current spot rate of the pound (p). The exogenous variables that Rich used include the three-month U.S. short-term rate (X), the three-month U.K. short-term rate (Y), the exogenous changes in the spot rate

(DZ), the U.S. commodity trade balance (B*) and the U.S. net debt to foreigners other than official institutions (N_{t-1}) lagged by one month.[55] We use capital letters to denote the interest rates since these are actual rates and not differentials. For consistency, we will also consider the previous variables to be exogenous. Any complications that occur because of these variables will be discussed throughout the remainder of the paper.

The variable DZ represents the change in total U.S. reserve assets. Rich attempts to use this variable to measure exogenous changes in the spot rate of the pound. The relevance of this variable will be discussed shortly.

Although the statistical model has already been simplified from the theoretical model, a number of difficulties still arise. First and foremost, there has been a change in the exchange rate regime since the time period that the Rich study covered. The Bretton Woods System was fully operational from 1964 to 1969, when the original study was researched. This system was essentially a fixed-exchange regime with exchange rates permitted to fluctuate only one percent (+/-) away from parity.[56] Reserves were adjusted to stabilize exchange rates and to finance a country's balance-of-payments deficit.[57]

In Rich's study, DZ was used to determine exogenous changes in the spot rate of the pound. Under the Bretton Woods system, which relied heavily on the adjustment of reserves, this may have been a marginally acceptable measure of exogenous changes in the spot rate of pounds.

From 1971 to 1973, the Bretton Woods system collapsed in favour of a managed floating rate regime.[58] Under this system, Rich's measure of exogenous changes in the spot rate of the pound (DZ) is no longer valid. A floating exchange system continues to operate today between the United Kingdom and the United States, so we can expect some changes in the Eurodollar market as a result.

In order to test for changes empirically, three periods must be compared to Rich's conclusions. The period from January 1970 to March 1973 will illustrate the effects of the dismantling of the Bretton Woods System. The floating rate regime's effects on the Eurodollar market will be measured from April 1973 until August 1976. This period was highly irregular in that heavy exchange controls were utilized by the U.S. Treasury for part of the interval.[59] After the Second Amendment to the IMF's Articles of Agreement, the exchange rate techniques used post-1973 were legalized.[60] We test a fairly normal period (February 1983 - February 1987) with respect to economic shocks. We did not cover the period from September 1976 until January 1983 due to two factors. Firstly, there were serious exogenous disturbances such as a global recession and the OPEC crisis. Secondly, we were not able to collect various data for portions of this time period.

The 1970-1973 data should be more closely related to the original data since the Bretton Woods system was in limited use during this period. The 1973-1976 data should move away from Rich's result and toward the more recent data. Conclusions from the 1983-1987 period should fully illustrate any changes that have

occurred in the Eurodollar market, since the transformation from fixed to floating exchange rates in the international market has been completed in this interval.

A problem arose when more modern data(1983 - 1987) were obtained. There is no longer any attainable measure of short-term liabilities apart from long-term liabilities to foreigners, as was used by Rich.[61] Before 1978, these data could be found in the Federal Reserve Bulletin. In order to use modern data, an equation that solves for the short-term liabilities net of short-term claims must be derived. When using the period from May 1973 to August 1976, the following expression was obtained:

(14) NSTL = 12956 + 0.98405NTL
(92.70) (t-values)

R^2 = .9994 se = 136.9

NSTL: short-term liabilities to foreigners other than official institutions - short-term claims
NTL: total liabilities to foreigners other than official institutions - total claims

This relationship substantiates our discussion from chapter two. Net short-term liabilities are approximately equal to net total liabilities, so it is clear that banks attempt to "marry" their liabilities to their claims in a consistent fashion. A closer view of the data has further emphasized this point. This equation will be applied to 1983-1987 data in order to find a value for the net short-term liabilities to foreigners. The U.S. short-term interest rate and lagged variables did not prove to be significant in other regressions, and as a result, these variables were not considered.

This study will disregard any exogenous changes in the U.S. current account (T) as Rich does. In order to further simplify the analysis, the U.S. commodity trade balance (B*) will be considered exogenous. According to Rich, these two restrictions may cause problems to the study.

If part of an observed change in the U.S. commodity trade balance (B*) is caused by a change in the spot exchange rate (p), then a positive relationship between p and B* should be evident.[62] In Rich's study, a negative relationship between p and B* is found. However, in this study an insignificant relationship is found in all three periods.

This relationship can be explained by the fact that the portion of U.S. trade done with Great Britain has decreased over the years. The U.S. currently trades with many other countries such as Germany, Japan and Canada. The portion of the U.S. commodity trade balance (B*) that is related to the pound exchange rate (p) is minimal. Therefore, no significant relationship between the spot rate of the pound and the U.S. commodity trade balance can be found.

Secondly, we have no measure of the exogenous changes in the expected spot rate. Rich uses the total U.S. reserve assets - net liabilities to foreign official institutions and total non-marketable U.S. Treasury notes and bonds (DZ) to find any exogenous change in the spot rate. When the Bretton Woods system was in effect, DZ may have been an acceptable measure of exogenous spot rate changes. Rich used the following multiple linear regression

to find DZ:

(14b) $DZ = 239.49 + 75.07X - 20.96Y - 0.15B^* - 0.14N_{t-1}$[63]

Rich proposes that because the spot exchange rate fluctuates by only a small amount, DZ should be endogenous.[64] However, from equation (14b), Rich could only find the U.S. net short-term liabilities to foreigners to be barely significant(t=2.419). In our study, we found DZ completely independent of these explanatory variables, using multiple linear regression analysis, in all three intervals. In a floating-rate regime, this scenario is to be expected. However, since DZ is not a feasible measure of the exogenous changes in the spot rate of the pound, we only include this variable to remain consistent with Rich in our regressions.

4.2 Parameter Estimates[65]

Rich accepted a high degree of positive autocorrelation in all of the estimates used in the original study. However, we are able to eliminate this problem with first-, second- and third-order autoregressive equations. The type of each equation is specified in Table three. Once again, Rich's conclusions will be compared with our results from January 1970 to March 1973, April 1973 to August 1976 and February 1983 to February 1987. When the Chow test was applied to the three intervals that we used, we found that the three periods were statistically significantly different.

In Rich's analysis, a positive relationship between the Eurodollar rate (X_D) and the U.S. short-term rate (X) was found.

In the 1970-1973 and the 1983-1987 periods, we find the same relationship. An especially strong positive relationship was found in the latter period. However, in the 1973-1976 interval, an insignificant relationship was found. In general, the U.S. short-term rate has had a strong positive effect on the Eurodollar deposit rate.

Contrary to Rich's work, we find a negative relationship between the Eurodollar deposit rate (X_D) and the U.K. short-term rate (Y). This negative relationship between X_D and Y also contradicts the theoretical conclusions. If accepted at face value, this result indicates that there is a negative relationship between the U.S. and U.K. interest rates on short-term assets; however, the results may simply reflect a number of econometric problems. In the modern financial market, U.K. interest rates must be considered with the interest rates of at least two other dominant currencies, namely the Japanese Yen and the Deutschemark.

In Rich's econometric analysis, there is a positive relationship between the forward premium of the pound (g) and the U.S. short-term rate (X). However, in later periods, this relationship becomes insignificant. These results are questionable since the regressions on the forward premium did not have any explanatory power in the 1973-1976 and 1983-1987 periods. The forward premium is no longer strongly affected by the U.S. short-term rate. The relationship between the forward premium (g) and the U.K. short-term rate (Y) flows from a negative one in the sixties to a positive one in the eighties. Modern data provide us

with evidence which supports the fact that the British Monetary Authority can control the exchange rate with interest rate manipulation. This result is correct from the perspective of a floating exchange rate system. Again, our data have deviated from the theoretical framework.

The spot rate (p) has become less related to the U.S. short-term rate (X) through each period, with the exception being the 1973-1976 interval. Here, there was a strong positive relationship between X and p. On the contrary, the relationship between Y and p became stronger over the years. This trend further supports the U.K. monetary authority's ability to affect short-run exchange rates by altering its interest rates.[66]

When the Brettons Woods system fell, the manipulation of reserves to adjust the balance of payments position and exchange rates decreased drastically. In Rich's study, the net U.S. reserve asset position was used to determine the expected appreciation of the spot rate of the pound. When the Bretton Woods system was still in limited operation(1970-73), DZ did have a negative relationship with the Eurodollar deposit differential (x_D). However, this instrument is no longer useful in measuring the expected appreciation, as is illustrated in the equations. Today, instruments such as open market operations can be used to achieve monetary goals.[67]

Rich finds a significant relationship between X_D and the U.S. commodity trade balance (B*). However, we no longer find any relationship between these two variables. Rich also finds a

significant relationship between p and B*, but no relationship between g and B*. We cannot find any relationship between either p and B* or g and B*. As mentioned earlier, pound transactions are no longer significant in the U.S. commodity trade balance account. Rich found a relationship between p and the U.K. commodity trade balance (B**) but we could find no such trend.

Rich compares the signs of B* and N_{t-1}, in their relationship with p, and finds them to be opposite. Since we cannot find any significant association between p and these two variables, we cannot draw any conclusions. A conclusion is not necessary in our analysis because neither B* or N_{t-1} is related to the spot rate of the pound (p).

5. Conclusions

In this paper, a detailed description of the Eurodollar market and its adjustment mechanism was provided. An empirical analysis of the market and changes that have occurred over the last 20 years has been done. These findings will be highlighted and suggestions for future models will be provided.

Over the periods which were covered, there was a change in exchange rate regime. The industrial nations moved from a mechanism by which exchange rates were fixed to gold and/or the U.S. dollar, through a mechanism with extreme exchange controls, to a system of relatively free floating exchange rates. As a result of these monumental shifts in international monetary policy, it would have been very surprising if our results corresponded to the original study.

In Rich's model, exchange rate speculation was the major adjustment mechanism. However, in our model speculative relationships could not be identified, due to the fact that we did not have the appropriate speculative variable. Moreover, the U.K. pound is no longer an important currency by which to measure speculative changes. "The capital markets of the United Kingdom and France have limited significance internationally."[68] This is not to say that speculation no longer occurs. In today's market, exchange rate speculation can lead to much larger gains and losses because many currencies fluctuate very freely. In any future

models, other dominant currencies must be considered in order to observe speculative activities in the Eurodollar market. Of these, the Japanese Yen and the Deutschemark are the most important.

The Eurodollar rate does follow the trend of the U.S. short-term interest rate very closely. The domestic market does play an important role in determining the Eurodollar deposit rate, and in doing so, also controls the demand for Eurodollar deposits. In this respect, the model is correct.

The U.K. short-term interest rates no longer have a significant effect on the Eurodollar rate. In future models, a two-country world will not be applicable. At the very minimum, the world must consist of a North American block (ie. $U.S.), a European block (ie; ECU and Deutschemark) and an Asian block (ie. Japanese Yen). Possibly, all other countries should be added as a fourth participant. A more complicated model will be inevitable since additional exchange and interest rates will have to be simultaneously considered.

In order to determine the expected value of the spot rate of any foreign currency, a new measure of pressure in the exchange rate market will have to be derived. It was shown that DZ is an inappropriate measure of the expected appreciation of the pound. The net U.S. Treasury reserve assets are no longer a major instrument by which to measure speculative movements.

The short-term net liabilities to foreigners no longer accurately describes capital movements that are attributable to the Eurodollar market. If this result is so because the amount of

capital movements of the Eurodollar market are relatively small, then a new measure must be found. If this relationship is so because of the impact of long-term liabilities, then a new model must be derived.

The Rich model provided reasonable results for the Bretton Woods system. It is not, however, relevent in today's system of floating exchange rates. Accordingly, our results are mainly negative or critical, rather than confirming and positive. In future models, the previously discussed observations will have to be considered.

Appendix - Table 1

Outline of Eurodollar Transactions[13]

Step 1:

Depositor A		U.S. Bank	
dep. at U.S. bank 100			dep. due to: A 100

Step 2:

Depositor A		U.S. Bank		Eurobank X	
dep. at Eurobank X 100			dep. due to X: 100	dep. at U.S. bank 100	dep. due to A: 100

Step 3:

Depositor A		U.S. Bank		Eurobank X	
dep. at Eurobank X 100			dep. dut to X: 10 Y: 90 100	dep. at U.S. bank 10 dep. at Eurobank Y 90 100	dep. due to A: 100

Eurobank Y	
dep. at U.S. bank 90	dep. due to: Eurobank X: 90

Appendix - Table 1

Outline of Eurodollar Transactions[13]

Step 4:

Depositor A	
dep. at Eurobank X 100	

U.S. Bank	
	dep. due to: X: 10 Y: 9 B: 81 100

Eurobank X	
dep. at U.S. bank 10 dep. at Eurobank Y 90 100	dep. due to A: 100

Eurobank Y	
dep. at U.S. bank 9 loan to Borrower B 81 90	dep. due to: Eurobank X 90

Borrower B	
dep. at U.S. bank 81	loan payable to Eurobank Y 81

Step 5:

Depositor A	
dep. at Eurobank X 100	

U.S. Bank	
	dep. due to X: 10 Y: 9 C: 81 100

Eurobank X	
dep. at U.S. bank 10 dep. at Eurobank Y 90 100	dep. due to A: 100

Eurobank Y	
dep. at U.S. bank 9 loan to Borrower B 81 90	dep. due to: Eurobank X 90

Borrower B	
goods from Company C 81	loan due to: Eurobank Y 81

Company C	
dep. at U.S. bank 81 goods to Borrower B -81	

Appendix - Table 1

Outline of Eurodollar Transactions[13]

Step 6:

Depositor A	
dep. at Eurobank X 100	

U.S. Bank	
	dep. due to X: 10 Y: 9 Z: 81 100

Eurobank X	
dep. at U.S bank 10 dep. at Eurobank Y 90 100	dep. due to A: 100

Eurobank Y	
dep. at U.S. bank 9 loan to Borrower B 81 90	dep. due to: Eurobank X 90

Company C	
dep. at Eurobank Z 81	

Eurobank Z	
dep. at U.S. bank 81	dep. due to C: 81

Step 7:

U.S. Bank	
	dep. due to X: 10 Y: 9 Z: 8 D: 73 100

Eurobank X	
dep. at U.S. bank 10 dep. at Eurobank Y 90 100	dep. due to A: 100

Eurobank Y	
dep. at U.S. bank 9 loan to Eurobank Y 81 90	dep. due to: Eurobank X 90

Company C	
dep. at Eurobank Z 81	

Eurobank Z	
dep. at U.S. bank 8 loan to Borrower D 73 81	dep. due to C: 81

Borrower D	
dep. at U.S. bank 73	loan payable to: Eurobank Z 73

Appendix - Table 2[65]

(16a) $x_D = 1.66 + 0.6064X + 0.0999Y - 0.0003DZ$ (ols)
(10.27) (2.42) (2.36)
se = 0.26 R^2 = 0.61 F = 36.31 DW = 0.78

(16b) $x_D = 1.6372 + 1.242X - 0.1974Y - 0.0002DZ$ (ols)
(11.40) (-2.072) (-4.027)
se = 0.6294 R^2 = 0.8317 F = 55.99 DW = 2.1365

(16c) $x_D = 25.879 + 3.871X - 5.066Y - 0.016DZ$ (ols)
(0.487) (-0.813) (-1.849)
se = 57.48 R^2 = 0.1028 F = 1.413 DW = 2.1428

(16d) $x_D = 2.1633 + 1.04X - 0.1207Y - 0.0000DZ$ (ols)
(23.17) (-2.563) (-0.6287)
se = 0.5165 R^2 = 0.9013 F = 206.96 DW = 1.995

(16) chow test F = -22.3038

(17a) $x_D = 1.57 + 0.6142X + 0.0793Y - 0.0003DZ + 0.0003B^*$ (ols)
(10.65) (1.91) (2.55) (2.12)
se = 0.26 R^2 = 0.63 F = 29.78 DW = 0.89

(17b) $x_D = 2.3736 + 1.1243X - 0.207Y - 0.0000DZ + 0.0005B^*$ (ols)
(9.136) (-2.248) (-3.726) (1.845)
se = 0.6083 R^2 = 0.8474 F = 45.82 DW = 2.317

(17c) $x_D = 30.18 + 2.017X - 4.086Y - 0.015DZ - 0.012B^*$ (ols)
(0.249) (-0.652) (-1.802) (-1.123)
se = 57.28 R^2 = 0.1332 F = 1.383 DW = 2.0561

(17) chow test F = -17.4805

(17d) $x_D = 1.8897 + 1.071X - 0.1114Y - 0.0000DZ + 0.0000B^*$ (ols)
(19.17) (-2.311) (-0.5016) (0.9345)
se = 0.517 R^2 = 0.9026 F = 155.15 DW = 2.007

(18a) $x_D = 1.57 + 0.596X + 0.0956Y - 0.0003DZ + 0.0001N_{t-1}$ (ols)
(9.77) (2.28) (2.04) (0.75)
se = 0.26 R^2 = 0.60 F = 27.19 DW = 0.76

(18b) $x_D = 1.689 + 1.218X - 0.196Y - 0.0002DZ + 0.0000N_{t-1}$ (ols)
(7.837) (-2.016) (-3.956) (0.2116)
se = 0.6385 R^2 = 0.8319 F = 40.83 DW = 2.1422

Appendix - Table 2[65]

(18c) $x_D = -56.376 + 22.65X - 9.995Y - 0.015DZ - 0.005N_{t-1}$ (ols)
(1.789) (-1.519) (-1.904) (-1.868)
se = 55.638 R^2 = 0.1820 F = 2.003 DW = 2.112

(18) chow test F = -17.5176

(18d) $x_D = 2.076 + 1.052X - 0.122Y - 0.0000DZ + 0.0000N_{t-1}$ (ols)
(20.45) (-2.576) (-0.5758) (0.4899)
se = 0.5194 R^2 = 0.9016 F = 153.55 DW = 2.015

(19a) g = 0.60 + 0.7167X - 0.9133Y - 0.005DZ (ols)
(6.34) (11.53) (2.11)
se = 0.50 R^2 = 0.79 F = 87.64 DW = 0.92

(19b) g = 0.0026 + 0.0017X - 0.0022Y - 0.0000DZ (AR1)
(2.458) (-5.856) (-0.1462)
se = 0.0024 R^2 = 0.6972 F = 26.10 DW = 2.047
RHO = 0.5357

(19c) g = -0.2037 - 0.0121X + 0.0331Y - 0.0001DZ (ols)
(-0.2036) (0.7107) (1.796)
se = 0.4296 R^2 = 0.0987 F = 1.351 DW = 2.157

(19d) g = -0.0171 + -0.0022X + 0.0038Y - 0.0000DZ (ols)
(-1.623) (2.616) (-0.974)
se = 0.016 R^2 = 0.13 F = 3.49 DW = 2.00

(19) chow test F = -3.2625

(20a) g = 0.64 + 0.7125X - 0.9023Y - 0.0005DZ - 0.0002B* (ols)
(6.26) (11.01) (2.06) (0.57)
se = 0.51 R^2 = 0.79 F = 65.14 DW = 0.92

(20b) g = 0.0043 + 0.0013X - 0.0022Y + 0.0000DZ + 0.000B* (AR1)
(1.864) (-5.513) (0.1705) (1.204)
se = 0.002 R^2 = 0.71 F = 20.12 DW = 2.08
RHO = 0.4985

(20c) g = -0.24 + 0.002X + 0.026Y + 0.0001DZ + 0.0001B* (ols)
(0.0032) (0.55) (1.75) (1.14)
se = 0.43 R^2 = 0.13 F = 1.35 DW = 2.07

Appendix - Table 2[65]

(20d) $g = -0.006 + 0.0035X - 0.0001Y - 0.0001DZ - 0.0000B^*$ (ols)
(-2.062) (2.308) (-1.134) (-1.264)
se = 0.0157 R^2 = 0.1535 F = 3.037 DW = 2.049

(20) chow test F = -3.875

(21a) $g = 0.12 + 0.6562X - 0.9377Y - 0.0003DZ + 0.0002N_{t-1}$ (ols)
(5.81) (12.08) (1.43) (2.27)
se = 0.49 R^2 = 0.80 F = 71.16 DW = 0.99

(21b) $g = 0.004 + 0.0012X - 0.022Y - 0.0001DZ + 0.0000N_{t-1}$ (AR1)
(1.374) (-5.817) (0.0825) (1.027)
se = 0.0024 R^2 = 0.7062 F = 19.83 DW = 2.003
RHO = 0.5126

(21c) $g = 0.425 - 0.156X + 0.071Y + 0.0001DZ + 0.0000N_{t-1}$ (ols)
(-1.646) (1.441) (1.853) (1.914)
se = 0.4149 R^2 = 0.1820 F = 2.002 DW = 2.12

(21d) $g = -0.013 - 0.003X + 0.004Y - 0.0000DZ - 0.0000N_{t-1}$ (ols)
(-1.820) (2.660) (-1.04) (-0.8323)
se = 0.0158 R^2 = 0.1422 F = 2.776 DW = 1.998

(21) chow test F = -4.5824

(22a) $p = 282.7 - 0.5957X + 0.0312Y - 0.0000DZ - 0.0019B^*$ (ols)
(3.96) (0.29) (0.01) (4.42)
se = 0.67 R^2 = 0.30 F = 8.53 DW = 0.46

(22b) $p = 2.5611 - 0.0263X + 0.0036Y + 0.0000DZ + 0.0000B^*$ (AR1)
(-1.535) (0.6013) (0.1029) (0.8935)
se = 0.0394 R^2 = 0.7756 F = 28.51 DW = 1.714
RHO = 0.8512

(22c) $p = 1.1722 + 0.032X + 0.124Y - 0.0000DZ - 0.0000B^*$ (AR3)
(0.961) (6.863) (-1.534) (-1.482)
se = 0.1196 R^2 = 0.9265 F = 113.44 DW = 1.8218
RHO1 = 1.523 RHO2 = -0.734 RHO3 = 0.211

(22d) $p = 1.9156 + 0.0049X - 0.3201Y - 0.0000DZ - 0.0000B^*$ (AR2)
(0.2703) (-3.795) (-0.9197) (-0.055)
se = 0.041 R^2 = 0.955 F = 355.47 DW = 1.854
RHO1 = 1.141 RHO2 = -0.158

(22) chow test F = -14.1872

Appendix - Table 2[65]

(23a) $p = 282.91 - 0.6118X - 0.0019B^*$ (ols)
(4.94) (4.55)
se = 0.66 R^2 = 0.30 F = 17.51 DW = 0.46

(23b) $p = 2.5691 - 0.0234X + 0.0000B^*$ (AR1)
(-1.478) (0.8360)
se = 0.0385 R^2 = 0.7731 F = 59.63 DW = 1.7457
RHO = 0.8459

(23c) $p = 0.5199 + 0.255X + 0.0000B^*$ (AR2)
(9.494) (0.721)
se = 0.171 R^2 = 0.8404 F = 100.05 DW = 1.5846
RHO1 = 0.841 RHO2 = -0.158

(23d) $p = 1.7251 - 0.022X + 0.0000B^*$ (AR2)
(-1.146) (0.5108)
se = 0.0444 R^2 = 0.9458 F = 602.03 DW = 1.9175
RHO = 1.259 RHO2 = -0.296

(23) chow test F = -24.3349

(24a) $p = 283.08 - 0.5765X - 0.0018B^* + 0.0054B^{**}$ (ols)
(4.25) (4.32) (2.09)
se = 0.64 R^2 = 0.34 F = 13.72 DW = 0.53

(24b) $p = 2.5699 - 0.0238X - 0.0000B^* - 0.0000B^{**}$ (AR1)
(-1.475) (-0.8323) (-0.2078)
se = 0.039 R^2 = 0.7734 F = 38.68 DW = 1.7714
RHO = 0.8451

(24c) $p = 0.512 + 0.2530X + 0.0000B^* - 0.0000B^{**}$ (AR2)
(9.009) (0.8532) (-0.360)
se = 0.1736 R^2 = 0.8407 F = 65.09 DW = 1.5789
RHO1 = 0.830 RHO2 = -0.14842

(24d) $p = 1.7303 - 0.0219X + 0.0000B^* - 0.0000B^{**}$ (AR2)
(-1.138) (0.7732) (-0.9105)
se = 0.0445 R^2 = 0.9464 F = 400.2 DW = 1.9129
RHO1 = 1.266 RHO2 = -0.301

(24) chow test F = -17.7647

(25a) $p = 280.87 - 0.6572X - 0.0011B^* + 0.0005N_{t-1}$ (ols)
(5.32) (2.74) (4.23)
se = 0.59 R^2 = 0.46 F = 20.56 DW = 0.47

Appendix - Table 2[65]

(25b) $p = 2.5795 - 0.01522X + 0.0000B^* - 0.0000N_{t-1}$ (AR1)
(-0.9472) (0.9811) (-1.632)
se = 0.0377 R^2 = 0.7887 F = 65.32 DW = 1.876
RHO = 0.809

(25c) $p = 0.4496 + 0.264X + 0.0000B^* - 0.0000N_{t-1}$ (AR2)
(8.560) (0.922) (-0.569)
se = 0.1734 R^2 = 0.8412 F = 65.33 DW = 1.5825
RHO1 = 0.824 RHO2 = -0.154

(25d) $p = 1.7172 - 0.0208X + 0.0000B^* - 0.0000N_{t-1}$ (AR2)
(-1.06) (0.4886) (-0.3573)
se = 0.0447 R^2 = 0.9459 F = 396.31 DW = 1.9115
RHO1 = 1.258 RHO2 = -0.295

(25) chow test F = -17.8559

Endnotes

[1]Gordon F. Boreham and Ronald G. Bodkin, Money, Banking and Finance: The Canadian Context, 4th ed. (Toronto: Holt, Rhinehart and Winston of Canada, Limited, 1993) 500.

[2]Boreham and Bodkin 500.

[3]Ronald I. McKinnon, The Eurocurrency Market. (New Jersey: Princeton University, 1977) 2.

[4]M. Friedman, "The Euro-dollar market: Some First Principles," The Morgan Guaranty Survey. (Federal Reserve Bank of St. Louis, 1969) 20.

[5]Giddy 5.

[6]Bank For International Settlements, 59th Annual Report. (Basle, 12th june 1989) 90-91.

[7]Boreham and Bodkin 503.

[8]Frank Graaf, Euromarket Finance: Issues of Euromarket Securities and syndicated Eurocurrency loans. (The Netherlands: Kluwer Law and Taxation Publishers, 1991) 213.

[9]Boreham and Bodkin 499.

[10]Giddy 10-11.

[11]Frank E. Morris and Jane S. Little, "The Eurodollar market today: Size, Scope and Participants," The Eurodollar, ed. Herbert V. Prochnow (Chicago: Rand McNally and Company, 1970) 53.

[12]Giddy 8.

[13]McKinnon 6.

[14]Boreham and Bodkin 499.

[15]Boreham and Bodkin 500.

[16]Giddy 8.

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[17]Boreham and Bodkin 500.

[18]Boreham and Bodkin 500.

[19]Otmar Emminger, "The Euromarket: A Source of Stability or Instability?," The Eurodollar, ed. Herbert V. Prochnow (Chicago: Rand McNally and Company, 1970) 109.

[20]Murray N. Rothbard, The Mystery of Banking (Richardson & Snyder, 1983) 111 - 113.

[21]Emminger 111.

[22]Emminger 119.

[23]Charles J. Scanlon, The Eurodollar, ed. Herbert V. Prochnow (Chicago: Rand McNally and Company, 1970) 24.

[24]Scanlon 28.

[25]Giddy 24-25.

[26]Giddy 24.

[27]Scanlon, 27-28.

[28]Friedman 20-32.

[29]Scanlon 23-24.

[30]Giddy 15.

[31]Alexander K. Swoboda, The Eurodollar, ed. Herbert V. Prochnow (Chicago: Rand McNally and Company, 1970) 299-300.

[32]E.Wayne Clendenning, The Euro-currency Markets and the International Activities of Canadian Banks. (Ottawa: The Economic Council of Canada, 1977) 16-20.

[33]Friedman 20-32.

[34]George W. McKenzie, The Economics of the Euro-currency System. (London: The Macmillian Press Ltd., 1976) 73.

[35]Friedman 22.

Endnotes

[36]John R. Hewson, Liquidity Creation and Distribution in the Eurocurrency Markets. (Lexington, Massachussetts: Lexington Books, 1975) 10 - 16.

[37]McKenzie 77.

[38]McKenzie 75-76.

[39]John R. Hewson and Eisuke Sakakibara, The Eurocurrency Markets and their implications. (Lexington, Massachussetts: Lexington Books, 1975) 124-28.

[40]Georg Rich, A Theoretical and Empirical Analysis of the Eurodollar. (Ottawa: Carleton University, 1971) 1-50.

[41]William C. Brainard, "Financial Intermediaries and a Theory of Monetary Control,"Financial Markets and Economic Activity, eds. Donald D. Hester and James Tobin (New York: John Wiley & Sons, 1967) 94-143.

[42]James Tobin, "Liquidity Preference as Behaviour Towards Risk," Review of Economic Studies, (25, Feb., 1958) 65-86.

[43]Jerome L. Stein, "International Short-term Capital Movements," American Economic Review (March 1965) 40-66.
Jerome L. Stein, "The Simultaneous Determination of Spot and Futures Prices," American Economic Review (Dec. 1961) 1012-1025.

[44]In this analysis, d will represent partial derivatives and **d**(in bold print) will represent total derivatives.

[45]If the U.S. short term rate(numeraire) increases, then
x_D = Eurodollar deposit rate - numeraire,
x_L = Eurodollar loan rate - numeraire and
y = U.K. short-term rate - numeraire all decrease.

[46]Rich 12.

[47]Rich 15.

[48]Rich 17.

Endnotes

[49] $g = (f - p) / p$ and $p^* = [E(p) - p] / p$

We find that $[E(p) - f]/f = (p^*-g)[(p-f)/f + 1]$
$= (p^*-g)(p/f)$

Rich's study was done while the Bretton Woods system was in operation and the U.K. spot rate could not fluctuate by more than 1%. Under this assumption, the forward rate should follow the same restrictions, so (p/f) should be very close to one. However, our study is post-Bretton Woods, so the ratio of (p/f) is expected to fluctuate widely. Therefore, we must take account of the ratio (p/f), although this ratio does not affect the sign of our relationship.

[50]John R. Hicks, Value and Capital (London: Oxford University Press, 1939) 67-71.

[51]From equations (1a) and (1b),

$$dD/dx_D > -dD/dx_L.$$
$$dx_D/dx_L = -(dD/dx_L) / (dD/dx_D) < 1$$

Similarly, we know that an increase in U.S. short-term rates will make foreign and Eurodollar loans relatively cheaper. Hence, we would expect a positive relationship between the U.S. short-term rate, and the excess demand for Eurodollar loans(L). For this to be true, we require the following relationships:

$$(2a) \quad dL/dx_L + dL/dx_D + dL/d(y+g) + dL/d(y+p^*) < 0$$

$$(2b) \quad dL/dx_L < -dL/dx_D - dL/d(y+g) - dL/d(y+p^*)$$

From (2b), $dL/dx_L < -dL/dx_D$ or $-dL/dx_L > dL/dx_D$
$dx_L/dx_D = -(dL/dx_L) / (dL/dx_D) > 1 > dx_D/dx_L$

Therefore, the slope of the LL curve is greater than the slope of the DD curve.

[52]Rich 20.

[53]$d(y+g)/dy > 0$ since $-1 < dg/dy < 0$. This is a drawn from Rich 42.

[54]Rich 24.

Endnotes

[55]Data on X, Y, p, g, N_{t-1}, were found in the Federal Reserve Bulletin(various issues). Data on f, g and x_0 were found in the Economist. Data on B* and B** were found in the OECD Main Economic Indicators.

[56]Boreham and Bodkin 544.

[57]Boreham and Bodkin 544.

[58]Boreham and Bodkin 546.

[59]Boreham and Bodkin 548.

[60]Boreham and Bodkin 570.

[61] In 1978, the Federal Reserve Bulletin ceased the printing of short- and long-term liabilities to foreigners. Instead, a total liability figure is now used.

[62]Rich 28.

[63] DZ = change in gold and foreign exchange held by the U.S. Treasury and by the Exchange Stabilization Fund + change in IMF net position(quota of U.S. less fund holdings of dollars) + SDR(Special Drawings Rights) - change in U.S. Banking liabilities to foreigners(other than official institutions) - change in U.S. Treasury nonmarketable notes and bonds issued to foreign institutions. We have included SDR's because they are a post-1969 reserve asset.

[64]Rich 29.

[65]Equations denoted with a: Rich's study
b: January 1970 to March 1973
c: April 1973 to August 1976
d: February 1983 to February 1987

[66]Harvey A. Poniachek, "The Determination of Exchange Rates," International Finance Handbook, 2 vols. (New York: John Wiley & Sons, 1983) 24.

[67]Boreham and Bodkin 213.

[68]Giddy 5.

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