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A Survey:
The Theory of International
Interest and Exchange Rates

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THE THEORY OF INTERNATIONAL INTEREST AND EXCHANGE RATES

The Structure Of International Interest Rates -or "Why Do International Interest Rates Differ?"

In the real world, both the student and practitioners of international finance are confronted by a bewildering array of interest rates. This information can be found in business papers such as The Wall Street Journal, The Financial Times , the Economist , or more specialized publications issued by major banks,[1] or advisory services. These rates change very frequently, often from one minute to the next. A table of representative interest rates reported for September 18, 1977, is reproduced in Exhibit 1 below.

The exhibit gives rates for ten industrialized countries for ten different types of instruments as well as spot and forward exchange quotations. The matrix of interest rates shown suggests two important observations. First, as should be well known to any student of finance, rates *within* each country are different for different types of credit instruments. Second, and more importantly from the point of view of *international* finance, the rates for similar instruments differ from one country to another. Central bank discount rates, for example,

[1] For example, Chase Manhattan Bank, International Finance (biweekly), Citibank, Foreign Exchange & International Money Markets (weekly); Harris Bank, Weekly Review - International Money Markets And Foreign Exchange Rates. Also, most major banks provide daily rate information to their corporate clients via computer time-sharing systems.

World Interest Rates

rates as of September 14, 1977, bond yields as of September 9 1977

in percent per annum	U.S.	Canada	Britain	Belgium	France	Germany	Italy	Netherlands	Switzerland	Japan
Central Bank Discount Rate	5.75	7.50	6.50	6.00	9.50	3.50	11.50 penalty rate 14 50	3.50	1.50	4.25
Day-to-Day Money	6.1875 Sept 15	7.50	6.125	3.55	8.375	4.00	12.00	3.625	1.50	4.75
Treasury Bills 91-day Middle Rates	5.84	7.13	5.8125	6.25 120-day	n. a.	n. a.	12.13	no dealing	no market	4.125 2-month
Commercial Paper prime 3 month asked	6.00 finance paper	7.467 finance paper 15% tax w/h	5.89 H P on discount basis	5.75 Certified	8.625	no market	no market	no market	no market	not traded
Bankers' Acceptances 3-month asked	6.15	7.40 15% tax w/h	5.875	5.75 Certified	not traded	5.15	no market	no market	3.75 not traded	no market
Government Bonds Long term new and old issues, average yield	7.65	9.10	11.64	8.90 20% tax w/h	8.95	5.71	11.32	7.73	3.98	6.91
Industrial Bonds prime long term, new and old issues average yield	7.95 Aa Industrials	9.40	13.43	10.11 20% tax w/h	11.67	6.04	11.76	7.68	4.69	7.04
Bank Short-Term Rate to Best Borrowers (prime rate)	7.25	8.25	8.50	8.75	10.10	6.75	17.00	6.00	6.00	4.50
Bank Sight Deposits	zero	zero	zero	0.50	zero	0.50	8.25-9.25	1.00-3.00 large deposits	0.50 residents only	zero
Bank Time Deposits 3 month	6.00 Cert of Dep	7.40 Cert of Dep	5.9375 Cert of Dep	6.25	8.6875	4.15	8.50-9.50	4.625 large deposits	2.25 residents only	3.75 15% tax w/h
Exchange Rates—in U.S.$ rates floating against the $	—	.9315	1.7440	.027875	.2025	.4295	.001131	.4053	.4137	.003747
Forward Exchange Cover 3 month in percent p a D = discount P = premium	—	.875 D	.50 P	.50 P	3.50 D	2.875 P	7.50 D	2.00 P	4.00 P	1.375 P

Eurodollar Deposits (London inter-bank, bid) Sept 15

Call	6.3125
1-month	6.4375
3-month	6.625
6-month	6.8125

International Arbitrage (3-month hedged) + in favor of U S. dollars

U S.-U.K. Treasury Bills	−.393
U.S.-Canada Treasury Bills	−.20
U.S.-Canada Finance Co. Paper	−.40
Eurodollars-U.K Local Auth. Deposits	+.375

Eurobonds

Straight debt of U.S. subsidiaries 6.85
average yield on seasoned issues

Convertible debt of U.S. subsidiaries
representative terms of most recent issues
coupon: 5.75
conversion premium: 14.83

Free Gold Price

London afternoon fixing

147.90
(per fine ounce)

The above interest rate quotations refer to the past week and may not be construed as offers by The Chase Manhattan Bank. The quotations for Bank Short Term Rate to Best Customers, while including customary commissions, reflect neither possible other fees nor varying compensating balance requirements

Source: The Chase Manhattan Bank, International Finance, Sept. 19, 1977.

EXHIBIT 1

World Interest Rates

vary from a low of 1.5 percent in Switzerland to 11.50 percent in Italy, with the United States being near the middle at 5.75 percent. Similarly, the prime rate ranges from as low as 4.5 percent in Japan to as high as 7.00 percent in Italy. In general, one can observe that rates differ widely from one country to another, although the term structure of interest rates within different countries exhibited a similar pattern at the specific period of time represented by our exhibit.

What explains the differences in rates and more importantly, what is the nature of the relationships that tie them together? It is these questions that we shall attempt to answer in the first part of this paper.

The students of international finance are faimiliar with some reasons for differences between rates on domestic versus external time deposits denominated in the same currency. From this base, we can begin to generalize.

First, rate differences <u>within</u> countries can be largely explained by (a) differences in default risk of the issuer of the respective financial claims, (b) factors related to market structure, and (c) maturity. The data in Exhibit 1 may be used to illustrate these variables using U.S. rates as examples. The discount rate, for instance, is available only to selected financial institutions -- the member banks of the Federal Reserve System -- and even these institutions do not have access to such funds in unlimited amounts. The probability of a default by these banks is very small and the funds are lent for very short periods of time, a few days in some instances. The Treasury bill (T-bill) rate, again, represents an interest rate that is quite unique; it is the short-term borrowing rate of the government. In most countries this rate tends to be the lowest rate in the money market because of the negligible default risk. Unlike private firms, government has the power to raise taxes in order to fulfill its obligations.

In the next category come the negotiable bank time deposits (called CD's) and notes issued by prime commercial borrowers (called commercial paper, or CP). These instruments carry a somewhat higher rate than T-bills for reasons of higher default risk and less marketability. These instruments are issued by private organizations who are known to default on their obligations occasionally. Also, the market for T-bills is much more extensive in terms of volume and number of participants as compared to the market for CD's and CP. A holder of CD's or CP runs a slightly higher risk of loss in case of an immediate need to convert these instruments into cash. Therefore, investors demand and obtain a slightly higher yield on these money market instruments than on T-bills.

In addition to differences in risk and market structure, tax factors can sometimes account for differences in yields. For example, in the United States, interest on T-bills is not subject to taxes imposed by individual states; the income from some securities is free from federal, and to a limited extent state income taxes, such as certain municipal bonds.

Observed interest differentials also reflect differences in the maturity of the claims involved. The long-term interest rates incorporate the expectations of future interest rate changes. If future interest rates are expected to be different from present rates, credit instruments of different maturities will have different yields. This effect is discussed fully in a later section of this paper.

All these factors affect interest rates for different instruments within a country. When it comes to explaining interest rate differences between countries, two additional factors complicate the picture. First, there are various barriers that impede international transactions and, therefore, arbitrage among credit instruments. Second, future exchange rate changes affect yields and therefore interest rates of securities denominated in different currencies.

In the domestic market, interest rates for similar securities are equalized through arbitrage: market participants sell and buy simultaneously different securities whenever yield differences do not reflect trader's perceptions of differences in risk, liquidity, and factors that cause yield differences. Such arbitrage for similar securities in different countries is impeded by factors that range all the way from various degrees of ignorance to taxes and other (actual or potential) government restrictions on financial transaction across international borders. Here, we shall focus on the relationship between exchange rate changes and interest rates, abstracting both from the factors that cause interest rates to be different within countries, as well as from those that cause interest rates to differ among countries because of actual or perceived barriers.

In this context, Eurocurrency rates are very important for both empirical and practical reasons: external time deposits in banks of the same standing tend to be the same in every respect, except currency of denomination.[2] Thus, when referring to interest rates in countries A and B, in practice we are talking about the respective Eurocurrency rates. They represent financial claims of the same risk, and the effect of restrictions on cross-border flows is minimized; such deposits are already outside the country where the currency of denomination is issued.

Interest Rates And Exchange Rate Changes

Having stripped away all extraneous factors, we can now focus on interest rates and exchange rates. As a first step, it is useful to recognize that exchange rate changes and interest rates are conceptually the same. This becomes clear when one compares, for example, a security denominated in Canadian dollars that yields 6 percent per annum with holding U.S.

[2] We neglect here risk differences that can be attributed to the possibility that some countries may be more likely than others to restrict nonresident convertibility.

dollars in the form of (non-interest-bearing) currency. Exhibit 2 compares the results of holding the Canadian dollar security versus U.S. currency when the Canadian dollar is expected to depreciate by 6 percent.

At time t(o), an investor has the choice of investing C$ 100 in a Canadian security with a terminal value at time t(1) of C $106 (yielding 6 percent). Our investor could have achieved the same results had he taken C$ 100, exchanged them for U.S. $100 at time t(o), and held the U.S. currency (a non-interest- bearing asset) until t(1). At that time, he would have obtained C $106 for U.S. $100, giving him the very same terminal value and, thus, the same yield.

This example is simply an illustration of the principle that whenever an asset (or liability) has a different value between two points in time, there is a rate of return (interest, yield) involved. But our simple example serves to make a further point; an investment in Canada, yielding 6 percent, will return zero on the basis of U.S.$, given that the C$ depreciates by 6 percent over the same period. Alternatively, investors are indifferent between the investment in Canada yielding 6 percent and an investment in the United States whose return is zero. And the same holds analogously for borrowings.

Thus, exchange rate changes are the exact equivalent to yield differences on claims denominated in the respective currencies.

	Time = t_o Exchange Rates: C$ 100 = U.S.$ 100 U.S.$ 100 = C$ 100	Time = t_1 Exchange Rates: C$ 100 = U.S.$ 94.34 U.S.$ 100 = C$ 106.00		
	Investment	Value of Investment	Rate of Return in C$	in U.S.$
Canadian Security	C$ 100 (= U.S.$ 100)	C$ 106 (= U.S.$ 100)	6%	0%
U.S. Currency	U.S.$ 100 (= C$ 100)	U.S.$ 100 (= C$ 106)	6%	0%

EXHIBIT 2

Investment in Two Currencies

with Changing Exchange Rates

This idea is, of course, the basis for international financial operations and interest arbitrage: whenever there is a discrepancy between exchange rate changes and interest rate differences, profit opportunities arise that can be exploited by selling (lending) in one market and buying (borrowing) in the other.

The introduction of uncertainty causes few problems, as long as care is taken to make consistent assumptions in the comparision of yields and yield equivalents caused by exchange rate changes. In our example, we can think of the investment as having an <u>expected</u> terminal value of C$ 106, just as the future spot rate of the C$ is <u>expected</u> to be C$ 106/$100, assuming the same probability distributions. Alternatively, we can think of the investment as a security issued by a reputable agency, whereby principal and interest have been contractually fixed at t(o). Such contractual arrangements also exist in the exchange market: by means of forward contract, concluded at t(o), the rate of the C$ can be fixed at C$ 106/US$100 for time t(1) .

<u>How Are Exchange Rates Determined?</u>

In a discussion of the foreign exchange market, demand and supply factors are stressed and related to various participants in the foreign exchange market: (1) <u>traders</u>, who wish to hedge their receivables and/or payables, (2) <u>interest arbitrageurs</u> who make decisions to invest or borrow on the basis of discrepancies between international interest rates and forward rates; and (3) speculators who take open positions whenever they feel that the forward rate, at which other market participants are willing to make commitments, is different from what they expect the future spot rate to be.

While this traditional classification serves well the purpose of introducing students of international finance to the mechanics of the foreign exchange market, knowledge of the interrelationship between exchange rates and interest rates permits us to refine the explanation of the determination of international rates.

First of all, the actions of commercial hedgers must be seen in the proper perspective: the exporter who has a foreign currency receivable must fund this receivable in his own currency. Hence, the asset and the liability is in different currencies, a fact that gives rise to exchange risk. Now, as far as hedging is concerned, there is, of course, an alternative to the use of the forward market. The exporter can borrow in the foreign country, exchange the proceeds of the loan through the spot market into his own currency, and reduce his domestic borrowings accordingly. As a result, the foreign currency receivable is offset by a liability in the same currency. Whether he uses the forward market or the foreign credit market to eliminate the exchange risk is a matter of comparing the differences in interest rates of the two credit markets with the equivalent difference between spot and forward rates in the respective currencies. But this makes the decision of the commercial hedger exactly equivalent to that of the interest arbitrageur who acts upon the same differences. The only distinction is that the decision of the trader is presumed to be prompted by a commercial transaction, while arbitrageurs are constantly on the lookout for profit opportunities. However, as far as the determination of interest differentials and forward premiums and discounts are concerned, neither commercial hedgers nor interest arbitrageurs have any influence once interest rates and foreign exchange markets are in equilibrium.

In fact, only people who act upon their expectations about future prices in these markets make rates move. And to the extent that these transactors "take a view" about the future, they can be considered speculators,[3] the negative connotation of this term notwithstanding. Indeed, this concept shows that the popular image of speculators as evil men, operating in a moral twilight is ludicrous. All people whose decisions to buy or sell goods and services, or to borrow and lend are influenced by expectations about exchange rates and/or relative interest rates are speculators. Thus, the concept of expectations, or more precisely, price determination via expectations, is at the core of the explanation of how international exchange rates and interest rate are determined.

The traditional theory of markets according to which the price of financial assets is determined by demand and supply can

[3] Speculari (Latin): to spy out, watch, examine, look forward.

easily be reconciled with the role of market expectations. What really matters are the expectations of market participants about future demand and supply, and all their determinants. It follows that in markets where prices are established in such a manner, current prices incorporate the expectations of market participants about future prices, such as exchange rates and interest rates.

In summary, we have shown that interest rate differences and expected foreign exchange rate changes are economic equivalents. It follows that both interest rates and exchange rates are simultaneously determined by the same set of expectations. Expectations must have some basis if we assume that market participants act rationally. Which factors determine the relevant expectations?

<u>The Determination Of Interest Rate Changes And International Interest Rate Differentials</u> [4]

The determination of the level of interest rates in an economy is a complex process and a number of competing explanations have been put forth to describe the processes by which interest rates are determined.[5] Here, we are concerned

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[4] This section relies on a synthesis by Ian H. Giddy, "An Integrated Theory of Exchange Rate Equilibrium," JOURNAL OF FINANCIAL AND QUANTITATIVE ANALYSIS , Dec. 1976, pp. 883-92.

[5] Theories of interest rate determination are associated with the works of Wicksell, Keynes, Hicks and Fisher. Any good introductory book on money and banking will bring the reader up-to-date.

primarily with relative <u>changes</u> of interest rates, and the monetarist framework provides a clear and consistent approach to draw the outline of complex relationships. Accordingly, the different rates of growth of money caused by varying monetary policies of governments are the cause of price level changes. This relationship is represented in Exhibit 3 by the link labeled 1. To be precise, it implies that the rate of change in the general price level ("inflation") in a country is determined by the difference between the rate of growth in real output and the growth in the supply of money.

The underlying idea is that when the rate of change in the money supply differs from the need for additional liquidity related to changes in real output, the general level of prices in the economy will change. The real need for money changes because of changes in the level of output of goods; if more goods are produced, then more money is needed to trade them at the existing price levels. If the money supply changes by an amount larger than the increase in output of goods, it can only be absorbed by an increase in prices such that the new output at new (higher) prices requires the new (higher) amount of money supply. As a consequence, an excessive increase in the money supply will cause prices to rise.

The second link identifies the relationship between changes in interest rates and changes in price levels. In a theory

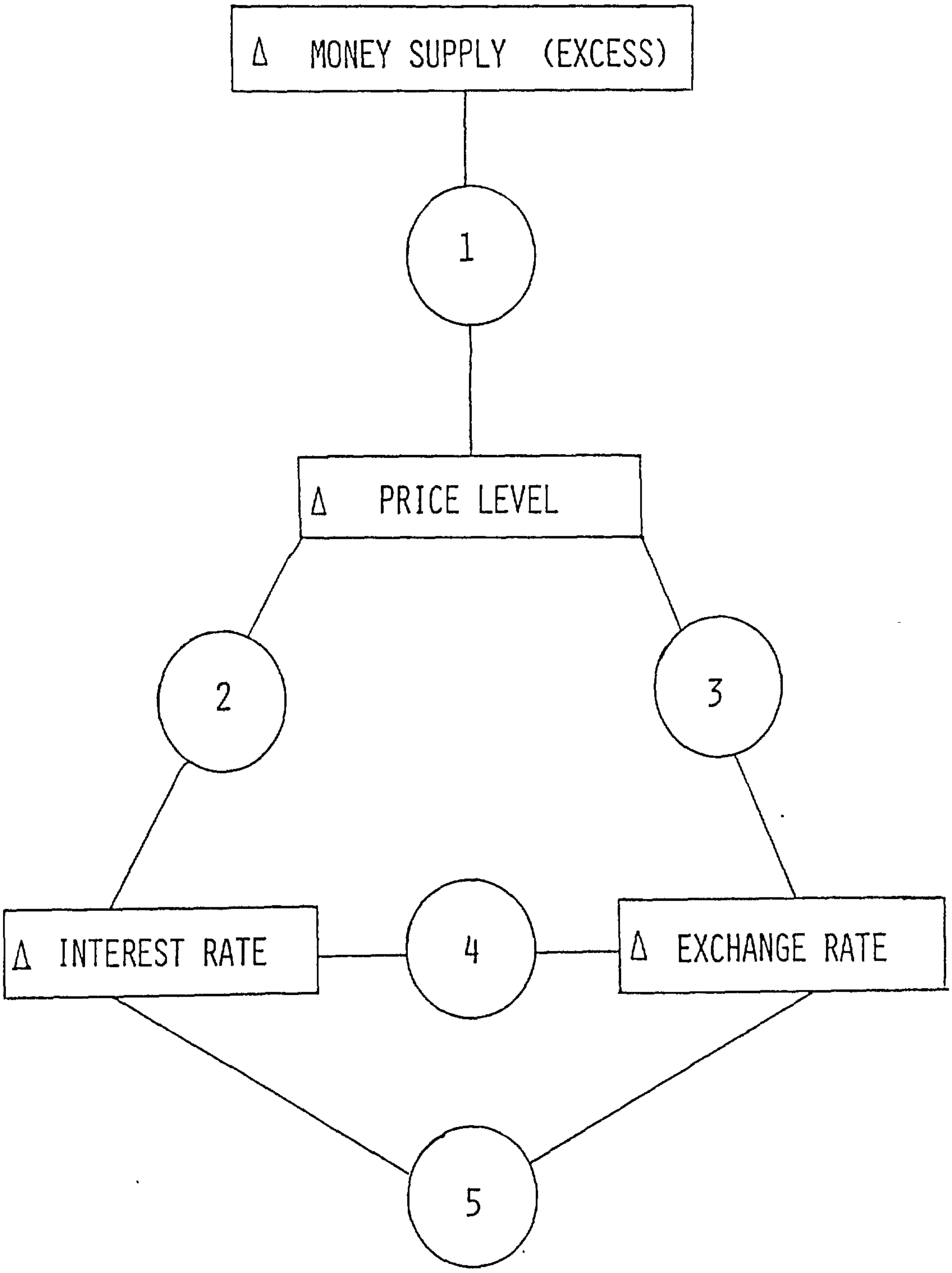

Δ MONEY SUPPLY (EXCESS)
1
Δ PRICE LEVEL
2
3
Δ INTEREST RATE
4
Δ EXCHANGE RATE
5

EXHIBIT 3

generally attributed to Irving Fisher,[6] interest rates have two components: a real return plus an adjustment for price level changes. If the holders of loanable funds are to be induced to give up their funds for a period of time, they must receive some compensation. This compensation takes the form of a higher purchasing power of the funds in the period in which they are returned. This compensation is necessary because without it the holders of funds will have no incentive to forgo current consumption and be exposed to take the risk of default. This compensation is termed the real return to the lenders of money.

If prices do not change, this return would represent the increase in the purchasing power of the loaned funds. But when prices are expected to rise, and when lenders are aware of that, they will demand compensation for inflation to protect the real rate of return. This will be done by including a factor for the expected rate of inflation in the interest rate. Thus, the interest rate will include a real return that increases the purchasing power of the loaned funds and a return that offsets the loss of purchasing powers due to inflation. The interest rate, then, can be represented formally by the equation:[7]

$$(1+i) = (1+r)\ (1+ \square P)$$

where i, the nominal rate of interest, provides a return on the investment equal to that given by a real rate of interest, r,

[6] THE THEORY OF INTEREST, (New York: the Macmillan Company , 1930).

[7] Throughout this paper, the symbol □ has been used to denote change in the value of a variable (usually denoted by the symbol delta). Thus, □P represents change in P from one period to another.

after the expected rate of inflation, πP, has been taken into consideration. Since the nominal interest rate must be determined before prices have actually increased, expected price change is incorporated in the nominal rate, rather than actual price change. Ex-post, the price change may not equal the expected value in most cases, but if the financial markets in the country are efficient, all the available information will be utilized and i will include the best possible estimate of πP.

Link 2 between price level changes and interest rate(s) implies that as price levels change (because of excessive money supply, as we saw above), the interest rate will change, so that changes in i completely offset the changes in πP, keeping r constant. The change in interest rates will thus be equal to the percentage change in price levels, which equals the rate by which the increase in the money supply exceeds the real needs of the economy.

It should be clear by now that if at the end of the time period prices have changed by more than was expected, the nominal rate of interest would have been underestimated and borrowers would have gained at the cost of lenders. Similarly, lenders would have gained if the price changes had been overestimated.

Given the process of determination of interest rate changes in a national economy, how do differentials in interest rates between different countries come about? Two additional relationships shown in Exhibit 3 as Links 3 and 4 will contribute to the explanation. The first of these relates price level changes in different countries and exchange rate changes; it is usually referred to as the "purchasing power parity theorem." The other link which relats differences in interest rates between different countries to expected changes in exchange rates is sometimes referred to as the "Fisher Open" effect to distinguish it from the relationship of price level changes and interest rates in a closed economy.

The purchasing power parity theorem can be stated in different ways, but the most common representation links the changes in exchange rates to those in relative prices:[8]

Rate of Change of the Exchange Rate
=
Difference in Respective Inflation Rates.

This relationship is derived from the basic idea that in the absence of trade restriction, the prices of the same goods in two countries must be equal. Under conditions of free trade, if the prices of similar commodities differ between two countries, arbitrageurs will be able to take advantage of such situations until price differences are eliminated. If at time t,

[8] For a more detailed discussion of this theorem, see Lawrence Officer, "The Purchasing- Power-Parity Theorem of Exchange Rate: a Review Article", IMF STAFF PAPERS, March 1976, pp. 1-60.

the prices in two countries are $P(1,t)$ and $P(2,t)$ and the exchange rate is $R(t)$, then

$$R(t) = P(1,t)/P(2,t).$$

Both $P(1,t)$ and $P(2,t)$ will change due to inflation such that:

$$P(1,t+1) = P(1,t) * \{1 + \square P(1)\}$$

$$P(2,t+1) = P(2,t) * \{1 + \square P(2)\}$$

and $$R(t+1) = P(1,t) * \{1 + \square P(1)\}/P(2,t) * \{1 + \square P(2)\}$$

or $$R(t+1)/R(t) = \{1 + \square P(1)\}/\{1 + \square P(2)\}.$$

Or

$$\{R(t+1) - R(t)\}/R(t) = \{1 + \square P(1)\} - \{1 + \square P(2)\}/\{1 + \square P(2)\}$$

$$= \{\square P(1) - \square P(2)\}/\{1 + \square P(2)\}.$$

If $\square P(2)$ is small, it can be neglected in the denominator, giving:

$$\{R(t+1) - R(t)\}/R(t) = \square P(1) - \square P(2).$$

Or, the rate of change in the exchange rate equals the difference in inflation rates. Thus, Link 3 in Exhibit 3 relates expected changes in exchange rates to the expected differences in inflation rates.

We have already discussed in general terms the relationship between the interest rates in two countries and the expected exchange rate changes. Now, we can treat the linkage between these rates more formally. In the absence of effective controls on capital flows, investors will employ their funds wherever the return is the highest. Thus, if the interest rates between two countries are unequal, investors will transfer their funds to the country where the interest rate is higher. Will the higher interest not come down under the influence of these flows? According to the Fisher Open effect, the interest rate differential will exist only if the exchange rate is expected to change in such a manner that the advantage of the higher interest rate is offset by the loss on the foreign exchange transactions. An investor in the low interest country can convert his funds into the currency of the high interest country and expect to earn a higher rate of interest, but his gain (in terms of higher interest rate) will be offset by his expected loss because of foreign exchange rate changes. This effect was illustrated by the example in Exhibit 2; it is stated more formally below.

This effect can be understood by equating the returns on equal in after taking the expected exchange rate changes into account. Thus, in equilibrium, the following holds:

The value at (t+1) of investment earning interest at a rate of i(d)
=
The value of an equal amount converted to a foreign currency at t, invested at an interest rate of i(f) and converted back into domestic currency at (t+1)

where i(d) = rate of interest in the home country and i(f) = rate of interest in a foreign country.

If the investment is of an amount of $100, then the left hand side is equal to:

$$100 * \{1 + i(d)\}.$$

If R(t) represents the exchange rate at time 0, then the right hand side is equal to:

$$\{100/R(t)\} * \{1 + i(f)\} * \tilde{R}(t+1);$$

the tilde ~ indicates that the exact value of the variable is unknown at the present time.

In equilibrium, the two sides will be equal.

$$\{100 * \{1 + i(d)\} = \{100/R(t)\} * \{1 + i(f)\} * \tilde{R}(t+1)$$

or $$\tilde{R}(t+1)/R(t) = \{1 + i(d)\}/\{1 + i(f)\}.$$

Or $$\{\tilde{R}(t+1)/R(t)\} - 1 = \{1 + i(d)\}/\{1 + i(f)\} - 1;$$

or $$\{\tilde{R}(t+1) - R(t)\}/R(t) = \{i(d) - i(f)\}/\{1 + i(f)\}.$$

If the time periods being considered are small, i(f) will be very small, and we can simplify and obtain:

$$\{\tilde{R}(t+1) - R(t)\}/R(t) = i(d) - i(f)$$

which is a formal representation of the Fisher Open effect stating that

> The Expected Rate Of Change Of The Exchange Rate = The Interest Rate Differential.

The above relationship is purely an <u>ex-ante</u> expectation because the value of $\tilde{R}(t+1)$ is unknown. The equality is supposedly to hold for a value of $\tilde{R}(t+1)$, that is the expectation of the market participants. Empirically, the relationship cannot be verified, because the variable $\tilde{R}(t+1)$ cannot be measured. However, it is possible to replace the expectational variable $\tilde{R}(t+1)$ with the forward rate for the period (t+1) given certain specific assumptions which will be discussed in the section on exchange rate forecasting. This forward rate is, just like interest rates, a contractual rate; hence, we obtain what is called the "interest rate parity theorem." According to this theorem, the observed differences in the interest rates will be equal to the premium or the discount on the exchange rate as reflected in the forward rate. This relationship is represented by the Link 5 in Exhibit 3.

In summary, interest rate differences and exchange rate changes are linked in two ways: first through the Fisher Open effect, which is based on expectations, and second, through the interest rate parity theorem which reflects an actual, ex-post, arbitraged relationship in the market.

The five links explained above represent an integration of the ideas that have been used in the previous sections of this paper and can be summarized as follows:

1. Monetary theory links different rates of excess money supply and changes in price levels.
2. Changes in price levels and changes in interest rates are linked by the Fisher (Closed) effect.
3. Changes in price levels and changes in foreign exchange rates are linked by the purchasing power parity theorem.
4. Changes in interest rates and foreign exchange rates are linked ex ante by Fisher Open effect.
5. Changes in interest rates and foreign exchange rates are linked ex post by the forward rate via the interest rate

parity theorem.

Anyone familiar with economic theory will recognize that the precise nature of each and everyone of these relationships has been the subject of considerable controversy. Questions can be raised about both the assumptions and the empirical verification of these relationships. If at all, these relationships only hold under the assumption that the markets for goods, capital, and currencies reasonably meet the requirements for perfect markets, especially in respect to governmental regulations and restrictions. However, our concern here is not with empirical validation but with presenting a simple, consistent, and comprehensive set of relationships that can serve as a point of departure for detailed analysis.

Maturity Structures And Forward Markets:

In the previous section we synthesized the relationships between changes in foreign exchange rates and interest rates and related the forward exchange rate to interest rates. Throughout it was implicit that our concern was only with two-periods; one in which the transactions were made, and the other in which the transactions matured. We now extend the theory beyond two-periods and consider what happens when exchange rate expectations have to be made for more than one period, given the structure of interest rates for more than one, that is n periods.

We have shown that the following relationship holds in a two-period situation:

The Difference in Interest Rates = The Expected Change of the Foreign Exchange Rate.

We saw previously that, when this equality is applied to forward rates, we find that the forward rate will have a premium equal to the difference in interest rates. When extended to n periods, the same formula holds in principle, though the exact mathematical representation becomes the following:

$$\frac{1 + {}_tI_{n,A}}{1 + {}_tI_{n,B}} = \left[\left\{1 + E({}_tr_1)\right\} \cdot \left\{1 + E({}_{t+1}r_1)\right\} \cdots \left\{1 + E({}_{t+n-1}r_1)\right\}\right]^{1/n}$$

where

${}_tI_{n,A}$ = interest rate in Market A, quoted at a time t for a maturity of n periods,

${}_tI_{n,B}$ = interest rate in Market B, quoted at time t for maturity of n periods,

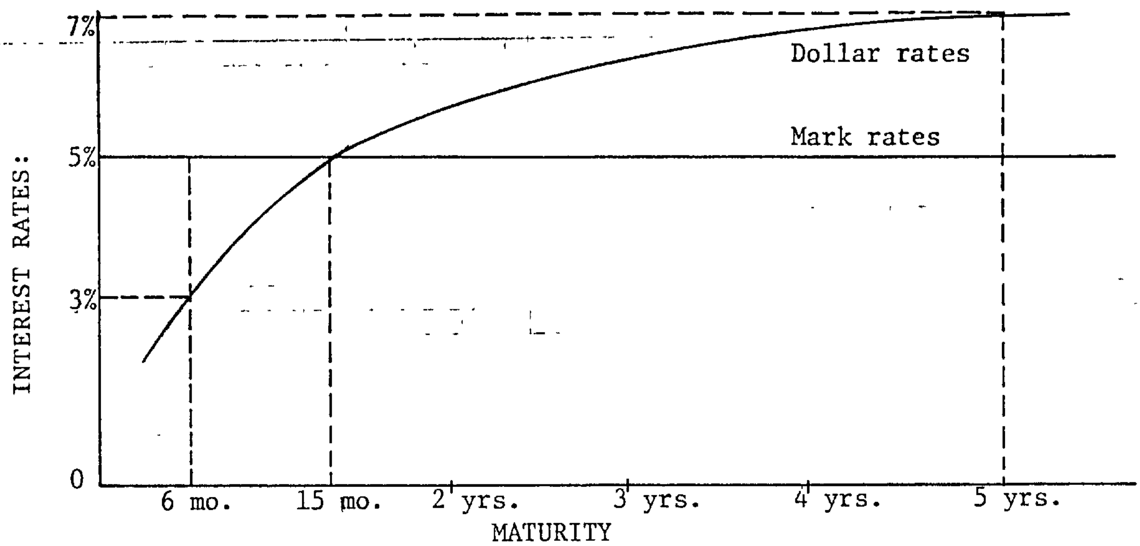
${}_{t+1}r_1$ = the expected change in foreign exchange rate from period (t+i) to (t+i+1), where i = 0,1,2,..., n-1.

The equation states that the ratio of interest rates in two markets will be equal to a geometric mean of expected changes in foreign exchange rates during each of the n periods. This equation implies a forecast about the exchange rate changes using the yield structure of the interest rates. The relationship between these two can be explained with the help of Exhibit 4, which shows hypothetical yield curves, or the term structure of interest rates for securities (for example, Eurodeposits) denominated in two currencies, dollars and marks.

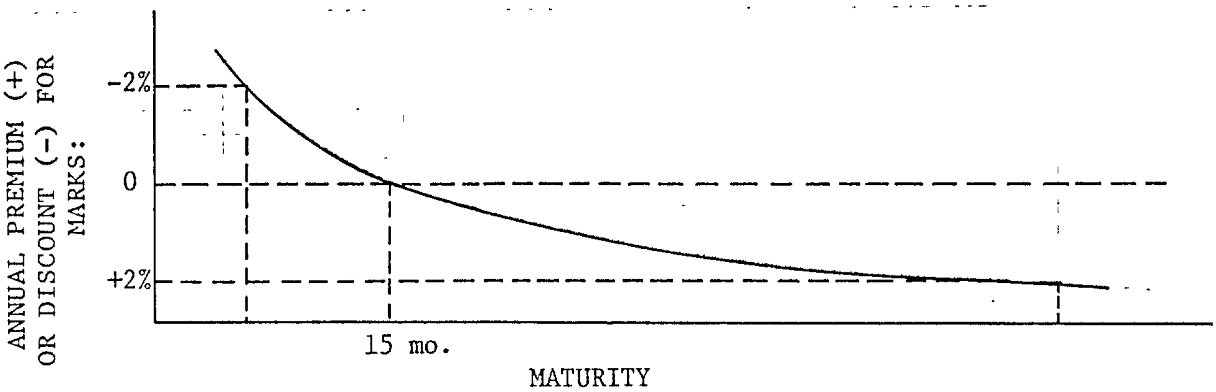
The first graph in the Exhibit 4 shows interest rates for various maturities prevailing in the market at the present time. These rates are contractual rates, or the rates at which lending and borrowing actually takes place in the market. The schedules, as shown, indicate that deposits in marks yield 5 percent, irrespective of the maturity of the loan. However, the rates for dollar deposits vary according to the maturity. A six-month dollar deposit can be obtained for only 3 percent, below the rate of 5 percent for a mark deposit of the same maturity. The rates for a fifteen-month deposit are the same in either currency at 5 percent. For maturities above fifteen months, the rate of interest on dollar deposits is above the rates for mark deposits. For example, a mark deposit of five years maturity will yield 5 percent p.a., but a similar deposit in dollars will bring 7 percent p.a.

These yield curves contain important information about future exchange rate changes and short-term interest rates. The yield curves for two currencies reflect the pattern of exchange rate changes expected by the markets. The implied exchange rate change for any particular period can be calculated by using the two-period interest arbitrage model explained in the previous section. To obtain the implied premium or discount on the

A. Term structure of interest rates in two different countries.



B. Term structure of exchange rate expectations based on the term structure of interest rates.



C. Expected spot exchange rates, based on expectations of Graph B.

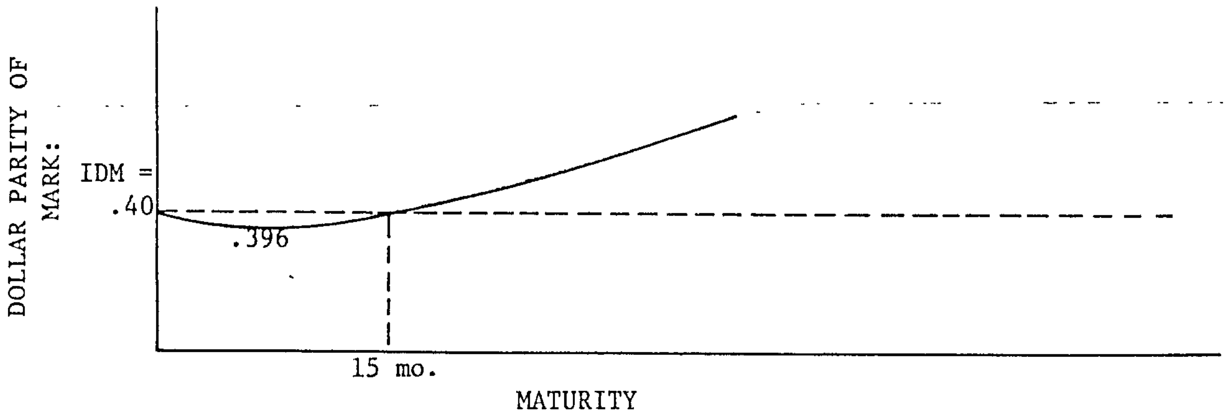


EXHIBIT 4

<u>Interest Rate Yield Curves and Implied Forecasts</u>

<u>of Exchange Rate Changes</u>

exchange rate that reflects the market expectation for any period, we simply calculate the interest rate differentials for that maturity. For example, to obtain the market expectation of the exchange rate change for a two-year period, we compare the inter for the maturity of two years. Graph A shows a difference of 1 percent per annum between the two currencies, with the mark interest rate at 5 percent being lower than the dollar interest rate. From the two-period interest arbitrage model, we know that this is equivalent to a 0.99 percent premium per annum on marks. Since the mark rate is below the dollar rate, the implied market expectation is that the mark will appreciate at a rate of 0.99 percent per annum with respect to dollar over a period of two years.

Let us now analyze the implied market forecast for the entire planning horizon. Graph A shows that the mark rate for all maturities is constant at 5 percent, whereas the dollar rate changes from a low of 3 percent for a maturity of three months to a high of 7 percent for the maturity of five years. What will the schedule depicting the market expectations of the exchange rate changes look like?

For the short-term maturities, the mark rate is above the dollar rate. This implies a market expectation that the mark will devalue with respect to the dollar over the short term. The exact amount of expected depreciation, or the market's expected value of the discount on marks, can be calculated from the interest rate differentials. According to the yield curves shown, the discount on marks persists for all maturities up to fifteen months. For a maturity of fifteen months, the interest rates for the two currencies are equal, which implies a market expectation that fifteen months from now, the present dollar/mark parity will prevail. If for all the intermediate maturities prior to the fifteenth month, the mark is expected to be below the dollar, but not for the fifteenth month itself, it also means that sometime before the fifteenth month is over, the discount on the mark will change to a premium. Moreover, the depreciation of the mark, during the time it is falling, will just equal its appreciation up to the fifteenth month from the time period it starts rising. But an expected appreciation of the mark implies a structure of interest rates wherein the mark interest rate is below the dollar interest rate.

This conclusion is consistent with our yield curves, because beside implying an expectation about exchange rate changes they also contain expectations about the short-term interest rates that will prevail in the future. In fact, the long-term interest rates are equal to the geometric mean of intervening short-term interest rates:

$$(1+{}_tI_n) = \left\{(1+{}_tI_1) \cdot (1+{}_{t+1}I_1) \cdot (1+{}_{t+2}I_1) \ldots (1+{}_{t+n-1}I_1)\right\}^{1/n}$$

Thus, the yield curves shown in Graph A imply that even though short-term rates on marks are now above those for dollars, they will sooner or later, but not later than fifteen months from now, change and drop below rates on dollar deposits. Accordingly, while at present the mark is at a discount with respect to the dollar for immediate short-term maturities, the expectation is that it will soon be quoted at a premium against the dollar for subsequent short-term maturities.

What is the market's expectation beyond fifteen months? For all maturities beyond fifteen months, the mark interest rates are below those for dollars, implying a market expectation that the mark will appreciate with respect to dollar after fifteen months. We saw in the example above that for a maturity of two years, the implied appreciation rate is 0.99 percent per annum. Market expectations regarding all exchange rate changes are shown in Graph B in Exhibit 4. When these expectations are applied to the present dollar/mark parity, we obtain Graph C which shows the market expectations of the exchange rates that will prevail at different times. This graph confirms what was said earlier about the change of discount to a premium on marks. As can be seen in Graph C, the spot price of mark with respect to dollar falls, though at a decreasing rate, for about the first six months and begins to rise after that time, until it reaches the present spot rate at the end of the fifteenth month. The shape of this schedule shows the time when the market expects the short-term rates for mark deposits to fall below the equivalent dollar rates. The market expectation is that in about seven months, the structure of short-term interest rates will be inverted.

It should be emphasized that the foreign exchange rate changes shown in Graph C may be merely implied. These expected foreign exchange rates may or may not be quoted in the market as forward rates. In other words, a market participant may not be able to make forward transactions at these rates, because no broker or banker will actually quote these prices. However, the interest rate structure being as it is, it will not be necessary for the transactors to actually enter into forward contracts, because the purpose of the forward transaction can be achieved merely by rearranging the debt instruments at the given structure of interest rates.

Forecasting Foreign Exchange Rates :[9]

Our discussion so far has been limited to the relationship between foreign exchange rates and interest rates. We stressed that both sets of rates were determined simultaneously, and we alluded in general terms to the forecasts implied by these rates. Now, we shall focus on forecasting specifically.

The material presented in this section is aimed at the user of foreign exchange forecasts; it shows how forecasts are made and what the assumptions behind the various forecasting models are.

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[9] This section relies primarily on Gunter Dufey and Ian H. Giddy, "Forecasting Foreign Exchange Rate in a Floating World," EUROMONEY, November 1975, pp.28-35, and Richard M. Levich, "Foreign Exchange Forecasting: Theory and Evidence" unpublished, New York University, March 1, 1976; (used with permission of the author).

The need for exchange rate forecasts is obvious. Spot rates prevailing at some point in the future are needed by all those whose economic decisions are affected directly or indirectly by changes in exchange rates, because these changes affect costs, prices, and effective interest rates. Those concerned with government policies will want to know future spot rates because they may provide clues about the impact of monetary policy on the rate of inflation, or about disequilibria in external accounts. For those concerned with planning and managing international business operations of any kind, foreign exchange rates prevailing in the future are important inputs into planning and decision making. Indeed, under certain conditions, those who can forecast foreign exchange rates can earn income directly through various forms of speculation, and it is, therefore, not surprising that much effort has been devoted to foreign exchange forecasting. The purpose of this section is to classify and critically review the prevalent methods used for exchange rate forecasting, to refine our understanding of foreign exchange markets and rates, and to explore the practical implications of "market efficiency".

Forecasting of economic data requires a "model", i.e., a set of relationships among variables, one of which is the variable to be forecast. Such models may be unspecified; they are simply engrained in the mind of a person who has been a long-term observer of the processes that generate the data. In the context of foreign exchange forecasting, this applies particularly to successful professional traders, who develop a "gut feel" for interpreting new pieces of economic and political information in terms of the future spot rate. Their models are so complex that they themselves are usually unable to describe them adequately, and their attempts to communicate how they arrive at certain opinions about future spot rates tend to yield answers that are either inconsistent or extremely naive at best. Nevertheless, their failure to make explicit the complex relationships that they have absorbed while dealing in the foreign exchange markets does not mean that their actions do not reflect a high degree of sophistication. Their success at surviving in a very competitive business is the best indicator of the quality of their respective "models."

Here, however, we are concerned primarily with formal, structured models. The widespread availability of computer facilities has promoted the development and use of forecasting models based on relationships that are stated in explicit mathematical terms. Because of the obvious usefulness of exchange rate forecasts, there have been numerous attempts at building formal foreign exchange forecasting models.[10]

For analytical purposes, all forecasting models can be

[10] In early 1978 there were several specialized firms offering foreign exchange forecasts: BI Metrics (Business International, New York) Conti Currency (Chicago), Predex (New York) and Forex (London). In addition, econometric forecasting services, such as Chase Econometrics and Data Resources, Inc. , generate and sell foreign exchange forecasts as part of their international models. Last, but not least, some of the large money center banks sell forecasts as part of their corporate foreign exchange advisory service. The annual subscription fees range somewhere between $10,000 and $20,000 (U.S.).

broadly divided into two - extrinsic and intrinsic. In "extrinsic" models, the underlying assumption is that there are some fundamental, causal factors which influence the variable of interest -- i.e., the future spot rate. In "intrinsic" models, a forecast of the future spot rate is based on information derived from its past values.

Extrinsic models can be further distinguished by the underlying theoretical framework. Such a theoretical framework is needed in order to identify the most appropriate factors, or variables, and in order to specify the precise nature of their interaction. Broadly, three subgroups of extrinsic models can be distinguished: models based on (a) balance of payments analysis, (b) national economic models focusing on changes in aggregate demand, and (c) so-called monetary models. Exhibit 5 contains a schematic presentation of the forecasting models analyzed here.

Models based on fundamental balance of payments analysis endeavor to forecast the individual items in a country's external accounts, such as the current balance, capital flows, and unilateral transfers, rationalizing that this analysis would capture the demand for and supply of foreign exchange, thereby providing indications as to its price, the exchange rate.

Balance of payments models are plagued by a number of inherent difficulties. One problem is founded on the fact that any change in the exchange rate tends to affect all the components of the balance of payments. Thus, while a deficit in

A. INFORMAL MODELS

B. FORMAL MODELS

EXTRINSIC MODELS

(Bases on Relationships of Foreign Exchange Rate with other Variables)

1. PARTIAL EQUILIBRIUM MODELS

(Balance of Payments Models)

2. EQUILIBRIUM MODELS

(Simulation Models)

AGGREGATE DEMAND MODELS

MONETARY MODELS

INTRINSIC MODELS

(Based on Past Values of Foreign Exchange Rate)

VARIOUS TIME SERIES MODELS

C. MARKET-BASED "MODEL"

(Based on the Assumption of Efficient Porcessing of Information)

EXHIBIT 5

Schematic Presentation of Foreign Exchange Forecasting Models the trade balance will put downward pressure on the exchange rate, the very change in the rate will in turn impact on the trade balance. And while some of those feedback effects are reasonably stable and can be built into the model, others are not. Further, there are interactions between the components in the balance of payments which are quite elusive. For example, a change in the trade balance may be supplemented or supplanted by various capital flows. By the same token, exchange rate changes may induce offsetting or compounding changes in various kinds of capital flows.

Last, but not least, the presumption behind this kind of forecasting is that it is easier to predict the components of the balance of payments rather than the exchange rate itself -- an assumption that is questionable. To illustrate, it may be possible to forecast with a reasonable degree of accuracy that a country will experience a deficit in its current account. However, a relatively small percentage of deviation in that forecast may lead to a substabtial difference between the actual and forecast spot rates in terms of percentage.

As long as there is <u>systematic</u> government intervention in the foreign exchange markets, as is the case when the rate is fixed, the feedback effects of changing exchange rates on the various components of the balance of payments can be neglected. But when exchange rates are changing in a system of free or managed floating, it is necessary to move toward so-called full equilibrium models,[11] where the predicted variable, the future exchange rate, is the result of the interactions of <u>all</u> those variables that are considered to be determinants of the future rate.

The usual approach, well developed in economic model building, is to construct a set of equations that describes the economy (or several economies) and can be solved simultaneously to yield the desired variable, here the exchange rate. In its simplest form, the exchange rate R is expressed as a function of endogenous (Y) and exogenous variables (X).

$$R = f\{Y(1),....,Y(n);\ \ X(1),....,X(m)\}.$$

The distinction is important because one set of variables (Y) is determined by the model, but the forecaster must provide an estimate of the exogenous variable.

Depending on the choice of variables and the specification of their interrelationships, one can distinguish between aggregate demand models and monetarist models. The former are more complex, because in models that rely on changes in output it is necessary to specify many different relationships. One such foreign exchange model, for example, specifies relationships involving such variables as trade balances, relative inflation rates, real growth rates, relative capacity utilization, short-term interest rates, government deficits, foreign exchange reserves of central banks, relative wage and

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[11] Partial equilibrium models neglect feedback effects.

price performance, and others.[12]

It is important to recognize that the various relationships are specified on the basis of past experience. And <u>one</u> of the crucial determinants for the success or failure of such a forecasting model is the stability of such relationships over time. In defense of model builders, it must be said that they pay a great deal of attention to problems which could stem from this source. Thus, the more sophisticated models of this kind have built into them an elaborate analysis of errors produced by each equation in the model in order to adjust as soon as possible for changes in the hypothesized economic structures. Still, with so many relationships interacting, it is easy for errors to occur because of "misspecification": a technical term which indicates that the model fails to represent reality properly, because either the wrong variables have been chosen or the interrelationships are not correctly stated.

Monetarist models, based on a more comprehensive view of exchange rate changes, try to avoid some of these problems by concentrating on considerably fewer variables. Indeed, the comprehensive equilibrium model presented earlier is the basis for this class of models. The fundamental notion is that an excess supply of money in the economy -- measured in relation to other economies[13] - will spill over in the external accounts

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[12] Michael K. Evans and John F. Norris, " International Business and Forecasting," <u>Columbia Journal of World Business</u>, Winter 1976, pp. 28-35.

[13] $(\square M(i)/\square Y(i)) \; / \; (\square M(j)/\square Y(j))$

and, therefore, into the exchange rate.

A simple forecasting model along these lines might be constructed as follows:[14]

$$M(i) = P(i)^{c(1)} * Y(i)^{c(2)} * R(i)^{c(3)} \qquad i=1,2 \tag{1}$$

$$R = P(1)/P(2) \quad \text{or} \quad \log R = \log\{P(1)/P(2)\} \tag{2}$$

where M(i) = nominal money supply

P(i) = price level

Y(i) = real income

r(i) = opportunity cost of money

R = exchange rate

c(1),c(2),c(3) = coefficients specifying the relationship between the money supply and the price level, income and interest rate, whereby $c(1), c(2) > 0$; and $c(3) < 0$. As a further simplification, we assume that the coefficients are the same in each country.

After some manipulations, equations (1) and (2) result in:

$$\log(R) = \log\{P(1)/P(2)\}$$
$$= \{1/c(1)\} * \log\{M(1)/M(2)\} - \{c(2)/c(1)\} * \log\{Y(1)/Y(2)\} - \{c(3)/c(1)\} * \log\{r(1)/r(2)\} \tag{3}$$

Thus equation (3) stipulates that the spot rate is positively

[14] Adapted from Richard M. Levich, "Foreign Exchange Forecasting: Theory And Evidence" pp. 5,6.

related to the money supply ratio and the interest rate ratio between the two countries, and negatively related to the income ratio.

Models such as these can be made even simpler, but they can also be made more complex and sophisticated, and when they are computerized they can impress many people. However, it is worthwhile to look critically at some of the features of these models when their use as forecasting tools is assessed. We have already referred to possible errors due to misspecification -- namely the failure to express the relationship between the different variables correctly because of wrong specification in the first place or because these relationships may have changed over time.

Secondly, the output of equilibrium models -- regardless of their theoretical base -- depends on an estimation, i.e. forecast, of the exogenous variable(s) that must be provided by the user of the model. Thus, to make such models useful for forecasting, it is necessary either to forecast the exogenous variables or to find a lagged relationship between the exogenous variable(s) and the exchange rate. Typically, aggregate demand models treat government spending, taxes, exports, and investment as exogenous variables, while monetarist models require either a forecast of the money supply, or specify a constant, lagged relationship between changes in the money supply and other variables.

The role of the government with respect to exchange rate forecasting models is particularly important because governmental actions can produce the crucial lags needed to make models that simulate the equilibrium exchange rate[15] into true forecasting models. Under a system of "fixed" but adjustable exchange rates(typical of the Bretton Woods system, or even a system of managed floating where the authorities "lean against the wind" by intervening in the foreign exchange market) it is government action that provides for the delays in the reaction of the exchange rate to changes in the economic fundamentals, and this permits forecasting.[16]

In fact, when government intervention is predictable, not only will econometric models be quite successful, but much cruder models will also yield successful forecasts. In such an environment, simple examination of balance of payments trends and other "fundamentals", such as relative rates of inflation and trade patterns, provides a measure of the pressure on the value of a currency. Then, changes in the level of foreign exchange reserves of the central bank as well as an analysis of the country's access to credit facilities by the IMF or the international markets indicate the time when a situation would become critical. The final and crucial step is to predict which of the limited policy options decision makers of the country

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[15] The exchange rate that would prevail for given exogenous variables, provided the model is correctly specified.
[16] A point clearly recognized in M. Murenbeeld, "Economic Factors For Forecasting Foreign Exchange Rate Changes", COLUMBIA JOURNAL OF WORLD BUSINESS, Summer 1975, p. 81.

involved will resort to in a crisis: reinforced attempts at internal deflation, imposition of additional exchange controls, or devaluation.

The success or failure of foreign exchange forecasting under such circumstances depends very much on that final step. An investment in analysis of the power structure and of the economic ideology of key decision makers in various countries could pay off in very successful forecasts.[17]

With the move toward a system of flexible exchange rates in the international financial environment, the so-called intrinsic class of formal forecasting models has attracted renewed attention.

Unlike extrinsic models, with their reliance on causal relationships between one or more exogeneous variables, intrinsic models rely on statistical relationships between the variable to be forecast and past values of the same series. The idea is to identify and extricate from the historical data series itself the underlying processes that generate new data.

Applied to exchange rate forecasting, this concept implies that the future exchange rate can be predicted from the behavior of the exchange rate in the past. Specifically, forecasting

[17] For a report by one of the most successful practitioners of the art of currency forecasting in this era see: Robert B. Shulman, "Are Foreign Exchange Risks Measurable?" COLUMBIA JOURNAL OF WORLD BUSINESS, June 1970, pp. 57-58.

models of this nature assume that there exists some pattern, or relationship, that can be identified and subsequently used for forecasting. This has led to the application of a number of time series techniques, each of which is designed to identify the "pattern," or statistical dependence, of foreign exchange rates over time. Essentially, such techniques range from naive fitting of trendlines to sophisticated time series models, where, through a sequence of filtering models and diagnostic analysis, the forecaster attempts to detect any dependencies that can be used for forecasting.

As an illustration of time series forecast, we will outline here foreign exchange forecasts based on autoregressive, integrated moving-average (ARIMA) processes, generally referred to as Box-Jenkins models.[18] Such ARIMA models incorporate many other time series techniques and are, therefore, representative of all forecasts based on such methods.

The first step involves the preliminary specification of a model that tentatively identifies the underlying process. Often, it is subsequently necessary to perform first order differentiation to obtain stationarity in the mean of time series, which is a prerequisite for the application of this

[18] For an illustration, see Ian H. Giddy and Gunter Dufey, " The Random Behavior Of Flexible Exchange Rates," JOURNAL OF INTERNATIONAL BUSINESS STUDIES, Spring 1975, pp. 17-19. For another application of Box-Jenkins techniques on foreign exchange forecasting, see John F.O. Bilson and Richard M. Levich, " A Test of the Forecasting Efficiency of The Forward Exchange Rate, " N.Y.U. Working Paper #77-61, June 1977.

technique. Once the model has been selected, its parameters are estimated, using non-linear least squares methods, for example. The autocorrelations of the residuals and the significance of the variables are then carefully checked. If the residuals show any autocorrelation, it indicates that systematic economic information remains in the series and the model must be adjusted. The final model, having filtered out of the time series all systematic relationships, leaving only random disturbances, or "white noise," can subsequently be used for forecasting by projecting it forward and computing the expected values of futures exchange rates.

Those who wish to apply this and similar methods will find detailed descriptions in the references cited. The application of such forecasting techniques is greatly facilitated nowadays by the many forecasting "packages" that are available in large scale computer systems. Here we shall focus on the assumptions that are crucial for the user of such exchange rate forecasts, who is contemplating venturing his own funds or those of his company's shareholders on the output of such models.

The attractiveness of Box-Jenkins forecasting techniques is that the sophisticated fitting of the model captures all information in the series of historical data. This is an improvement over extrinsic models, in which important information may be left out, because of the wrong choice of variables or mispecification of the interrelationships of variables. Unfortunately, like all time series models, Box-

Jenkins techniques, too, rely on information contained in the data of the past. And this information set may or may not hold for the future.

The Concept of Efficient Markets and Implications for Forecasting

Observers of markets where private, profit seeking transactors compete have long recognized that prices are determined by the anticipation of demand and supply, rather than by present supply and demand. The pursuit of profits in speculative markets requires that market participants take into account future prices in their current buying and selling decisions. They form opinions about future prices by continually searching for information and interpreting it in order to make predictions. The concept of market efficiency is based on the notion that current prices reflect all available information, including what market participants expect in terms of future prices, and that further, all new information that is received by the market is analyzed and immediately incorporated into expectations about future prices,from these expectations into decisions to buy and sell, and thus into current prices.

The implications of market efficiency for forecasting are rather far reaching. If markets are efficient, it is not worthwhile to forecast, because current prices, including forward rates, already reflect all available information, including any information contained in the past series of foreign exchange rates. In other words, the participants in the market include the forecast provided by the intrinsic models in their price setting.

The efficient market concept is anathema to many financial executives and foreign exchange traders because interpretation of information, anticipation of future prices, and acting upon such expectations is the essence of their jobs. The efficient market concept is powerful yet simple, and it is therefore necessary to look carefully at the assumptions and the conditions under which it applies.

In the context of the foreign exchange markets, the concept of market efficiency means that the exchange rates should be based on all currently available information. This set of information includes each and every factor that can possibly influence the exchange rates. Also included in this set are all the past prices and any information contained in these prices. The past prices 'contain' information in the form of trends and periodic fluctuations. If the present prices contain all this information, they should not present any possibilities for systematic profits arising from the analysis of the past data. Put differently, if knowledge of past exchange rates resulted in superior forecasts, we might be willing to buy such a 'consulting service'. [19]

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[19] The material in this and the following section is based on unpublished material provided by Rolf Mirus.

If, on the other hand, the foreign exchange markets are efficient, then the current exchange rate already conveys and reflects all economically useful information, including that contained in past prices. In this case the money spent on the "consulting service" would be spent unwisely. If all relevant information is contained immediately in the current exchange rate, then only unanticipated events are left to determine changes in the exchange rate. Since, however, unanticipated events are random in character, it follows that the exchange rate should follow a "random walk". The nature of such a random walk can perhaps more easily be expressed by hypothesizing that each day the exchange rate changes by $1 with probability .5 up and probability .5 down. The pattern that would result from this assumption is given in Exhibit 6.

Formally this can be expressed as

$$R(t) - R(t-1) = \tilde{u}(t)$$

where $\tilde{u}(t)$ is the random variable. Above, $\tilde{u}(t)$ was assumed to be

$$\tilde{u}(t) = \begin{cases} +1 \text{ with probability } p = 0.5 \\ -1 \text{ with probability } 1-p = 0.5 \end{cases}$$ with finite variances.

If the past history of the exchange rate is well described by this random walk model and we want to make a forecast for $\tilde{R}(t+1)$,

$$\tilde{R}(t+1) = R(t) + \tilde{u}(t+1), \qquad (4)$$

then the expected value is given by Equation (5):

$$E[\tilde{R}(t+1)] = R(t), \qquad (5)$$

because the expected value of $\tilde{u}(t+1)$ is zero, and the past history of R tells us nothing about the next independent outcome

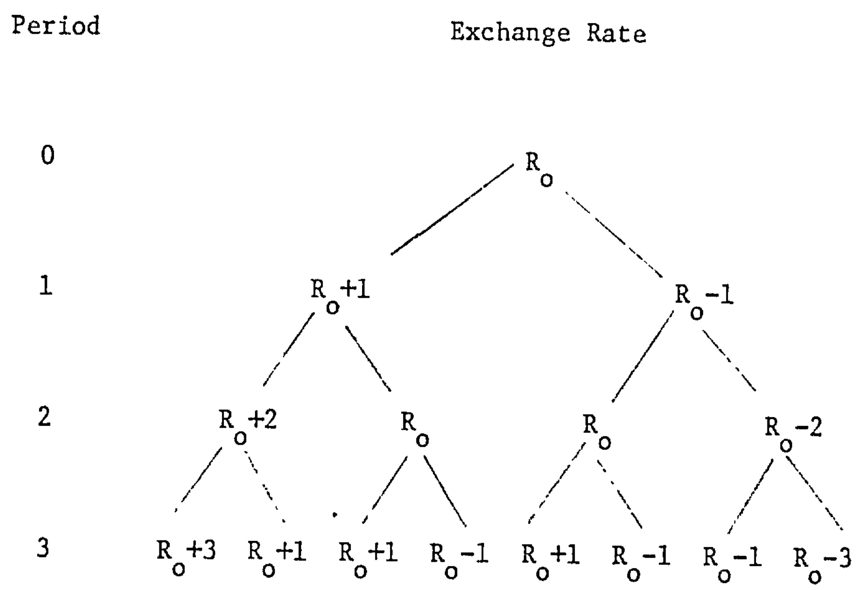

EXHIBIT 6

Random Walk of Exchange Rate

of $\tilde{u}$.

If the random variable, $\tilde{u}$, is normally distributed, with variance V^2, we can say that on the basis of the past history of R the distribution of $\tilde{R}(t+1)$ has the bell-shaped form centered on $E[\tilde{R}(t+1)] = R(t)$ {according to Equation (5)}, with 95 percent probability that $\tilde{R}(t+1)$ will fall within R(t) +1.96 V. The best single point forecast for $\tilde{R}(t+1)$ would be the expected value $E[\tilde{R}(t+1)] = R(t)$, which has the statistical property of being the minimum mean square error forecast. In similar fashion,[20] R(t) would be the best forecast of $\tilde{R}(t+2)$, $\tilde{R}(t+3)$, etc.

In fact some recent empirical work by a number of researchers[21] confirms the efficient market hypothesis for several currencies during the current period of floating, most notably for the Canadian dollar but also for the pound sterling and French franc. As in the situation at the New York Stock Exchange , the actions of market participants ensure that we cannot do better than the market when attempting to forecast exchange rates -- whether they be on spot or forward markets. No amount of internal information-gathering and charting and no

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[20] Cf. Charles R. Nelson, APPLIED TIME SERIES ANALYSIS FOR MANAGERIAL FORECASTING, San Francisco, 1973.

[21] Rolf Mirus, "Speculation In The Forward Exchange Market: The Canadian Dollar Since 1970", RECHERCHES ECONOMIQUES DE LOUVAIN, 41, No. 4 (1975): 303-11. Philip A. Cummins, Dennis E. Longue, Richard J. Sweeney And Thomas D. Willett, "Aspects Of Efficiency in the U.S./Canadian Foreign Exchange Market: A Preliminary Report," paper presented at the Allied Social Science Association, San Francisco, 1974. Ian Giddy And Gunter Dufey, "The Random Behavior Of Flexible Exchange Rates: Implications For Forecasting", JOURNAL OF INTERNATIONAL BUSINESS STUDIES, Spring 1975.

external consulting service will enhance our ability to predict exchange rates. That, at any rate, is the message from recent analysis for these currencies.

To put it into proper perspective, it is useful to remember that market efficiency does not come about by accident; it is a condition that exists because a competing group of profit-minded transactors acts as if the market was not efficient, constantly incorporating information into prices. Clearly, if nobody would make forecasts and act upon such forecasts, markets would surely not be efficient.

In the foreign exchange market, it is mainly the professional traders in the foreign exchange departments of banks who perform this function. During the trading day, they constantly monitor economic and political information coming to them via the newswires, nowadays flashed on big TV screens in the trading rooms. More important, they constantly exchange information among themselves and with those of their colleagues who deal in other sectors of the financial markets. Their memories, chartbooks, and computer files contain the past data series which they search for patterns and relationships. In general, they are intelligent, well-trained individuals who earn substantial incomes for themselves and their employers for obtaining and analyzing information related to exchange rate changes - and reacting quickly to it. Since they work in competition with others, their profits tend to be limited to the competitive economic return appropriate to the level of their considerable skills and the risks taken by the financial institution that employ them. Exchange rates are determined by the actions of these traders, adjusting their bid and ask prices as they attempt to increase or decrease their positions.[22]

The point here is that anyone who wishes to forecast exchange rates, by whatever technique, must ask whether his model can provide more accurate information about future exchange rates than the rates arrived at by the interaction of the professional traders.

To be precise, anyone engaging in a serious -- and therefore costly -- exchange rate forecasting effort should be able to answer the following question affirmatively: "Do I have unique and superior information about future exchange rates that is not available to the market as a whole?" Or, "Why do I believe that the current prices, including forward rates presently quoted, do not already reflect the information that I have?"

Very few corporate executives will be able to answer the first question affirmatively or the second question at all. In addition the very notions underlying these questions cast doubt on the motivations of those who sell the output of forecasting

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[22] For a good description of the foreign exchange trader's work see "Dealing With $150 Million a Day," INTERNATIONAL MANAGEMENT, January 1975, pp. 28-35. The Foreign Exchange Market.

models,[23] taking on all comers for a fee that is modest relative to the trading profits which could be gained if the forecasts could outperform the market. A further implication of the efficient market concept is that even if a model were to provide superior forecasts, the transactions of its users would quickly align rates with the rates which had been forecast, thus eliminating profit opportunities and, thereby, the value of the model. Thus, we are very critical of those who attempt to "mass market" foreign exchange forecasting models.

Some Further Theoretical and Empirical Issues

We have more empathy with those who want to put money and effort into building their own model, for it is very difficult to prove conclusively whether or not markets actually price foreign exchange "correctly"--i.e., whether or not they are efficient.

The fundamental problem in this respect is that all tests of market efficiency are really joint tests of two propositions: first, a test of the model that purports to generate exchange rates; secondly, a test of the proposition that transactors can set actual rates in accordance with the expected values generated by the model. Thus, when statistical analysis would lead one to reject the hypothesis that the market is efficient, it is impossible to say whether transactors processed information incorrectly, or whether the model was specified

[23] Unless they are interactive econometric models where the user can make his own mistakes by specifying the independent variables to be input.

incorrectly.[24]

All this leaves unresolved the discussion between many academics, who argue that markets tend to be efficient--unless specific evidence is present that market participants as a group do not interpret information correctly--and practitioners, who instinctively reject the implications of market efficiency.

On the issue of efficiency in the foreign exchange market, there exist further sources of confusion. On a very naive level, it is sometimes argued that whenever the actual spot rate differs from that predicted by the forward rate or the interest rate differential, this itself indicates that the market is not efficient. Such an interpretation reflects, of course, a gross misinterpretation of the concept. Market efficiency involves only the interpretation of known information, and since new information occurs randomly, there are bound to be differences between the forecast rate and the actual rate. One way to put it in perspective is to say that we know that the spot rate forecast by the forward rate, or interest differentials, is unlikely to occur, but we do not know ex ante whether the actual rate will be above or below the expected (forecast) rate.

A related issues is a bit more difficult to resolve. Given that the actual rate will deviate from the rate forecast, what

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[24] For thorough review of these issues and the empirical work performed to date see Richard M. Levich, "On The Efficiency of Markets for Foreign Exchange," NYU Working Paper #77-62 (revised October 1977).

can be said about the nature of the deviations? Especially, is there reason to believe, on theoretical or empirical grounds, that the forward rate is an "unbiased estimator" of the future spot rate, or are there any systematic differences?

Before we delve into an analysis of this issue, it must be clearly recognized that any such systematic deviations do not necessarily reflect market inefficiencies. To repeat, market efficiency refers to the processing of information in setting prices. And the relevant information set, we shall argue, may well contain factors that make for systematic deviations of predicted rates from actual rates.

One of those factors that can cause systematic differences is based on a technicality, known in the literature as the Siegel paradox. If residents of two countries consume a common basket of goods, the foreign exchange rate will lie in general between the expectation of the future rate defined in terms of one currency and the expectation of the future rate defined in terms of the other currency. However, the practical significance of the Siegel paradox is negligible when the variance of the exchange rate is not excessive.

More interesting is the possibility that the forward rate systematically under- or overestimates the expected rate--i.e. that forward rates (or interest rate differentials) are biased predictors, whenever significant transactions cost exists, or when the risk of intervention in international financial transactions by governments is significant. For example, we would expect the forward rate of the pound to be systemcatically lower than the expected rate if Her Majesty's government were prone to interfering with the disposition of non-residents' sterling assets. By the same token, U.K. interest rates would be systematically higher under these conditions.

Exhibit 7 presents some data illustrative of this point. In the context of forecasting, we can say that, given a $2 spot rate per pound sterling, the 12-month forward rate is $1.92, while the expected future rate is $1.94. Of course, the latter can not be observed directly.

What is important here is that in this case nothing is gained by forecasting unless one can show that the market prices the political risk incorrectly. Of course, the forecast rate is, statistically, a biased predictor of the actual future spot rate, whether or not political risk is priced correctly.

More difficult conceptually are deviations based on the riskiness of currencies as measured by the expected variance. While it is clear that risk-averse transactors will demand a risk premium for currencies with a high variance, when we allow for diversification, the existence of a systematic bias, or deviation of the forward rate from the expected spot rate is not altogether obvious. Virtually all those who construct international capital asset pricing models and derive risk premiums from them assume at least implicitly that risky

	United States (no risk of intervention)	U.K. (substantial risk of intervention)	U.K. (no risk of intervention)
Interest rates p.a.	5%	9%	8%
Forward discount on £, p.a.	...	4%	3%
Expected depreciation on £, p.a.	...	3%	3%

EXHIBIT 7

Bias in Forward Rate in Presence of Political Risk currencies are positively correlated with real world wealth, or real gross world product[25] and that risk is nondiversifiable. Only then does a risk premium exist. But these assumptions are not obvious,[26] and empirical work on this issue is inconclusive.

Be that as it may, the implications for forecasting remain unchanged; in a world of uncertainty, abnormal profits--as compared to random profits--through exchange rate forecasting can be earned only if and when current information is not properly incorporated in price and forecasting efforts provide superior information. The implications for management action are a bit more difficult, and we will take up elsewhere the case of specific market imperfections that will lead to a biased prediction by the forward rate or interest rate differential. We shall see that under certain conditions they can be used by companies who, for one reason or another, can overcome the market imperfection that causes the bias.

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[25] See, for example, F.Z.A. Grauer, R. H. Litzenberger and R. E. Stehle, "Sharing Rules and Equilibrium in an International Capital Market Under Uncertainty," JOURNAL OF FINANCIAL ECONOMICS, June 1976.

[26] Much of this section is based on a paper by Jeffrey A. Frankel, "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Rate Differentials", Massachusetts Institute of Technology, revised version October 17, 1977, Appendix A-1.

<u>Summary</u>

The analysis presented here has focused on the interrelationship between the two fundamental prices in international finance. The price of credit (interest) and the price of different monies in different countries (exchange rates). We explained the equivalence of international interest rate <u>differences</u> and exchange rate <u>changes</u>. It was shown that both reflect rates of return. The equivalence also holds in terms of a general equilibrium models, where interest rates and exchange rates are simultaneously determined by the same economic processes. The equivalence was shown to prevail also for different time horizons.

Interest rates and their equivalents--expected future exchange rates, or forward rates-- contain implicit forecasts. In our discussion of exchange rate forecasting we surveyed and analyzed the various methods currently used. On the basis of relationships between interest rates and exchange rates, and introducing the assumption of market efficiency, we developed a simple method to derive market generated forecasts of exchange rates. We concluded with a brief discussion of some of the empirical and theoretical issues that pertain to exchange rate forecasting.

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