Foreign Exchange Market Efficiency, Speculators, Arbitrageurs and International Capital Flows

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ABSTRACT

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This study provides an economic rationale for Stein (1965) model which shows that the fulfilment of covered and uncovered interest parities is unnecessary for foreign exchange market efficiency, even without transaction costs, provided that economic agents hold different expectations concerning exchange and political risks. The results for six OECD countries [that covered interest differential (interest differential minus forward discount) tends to have an opposite sign to and vary inversely with interest differential] contradict Mundell-Flemming proposition concerning capital movements but is consistent with this proposition once the role of un-hedged arbitrageurs is recognised. Three reasons for the unexpected relationship between covered and uncovered interest differential are given. The first two involve the over-reactions by the government and the speculators in fixing the forward discount and predicting currency depreciation respectively and the third involves interest rate differential failing to keep pace with inflation differential.

Keywords: Foreign Exchange Market Efficiency; Speculative Efficiency; Speculators; Arbitrageurs; International Capital Movements.

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I. Introduction

There is an extensive literature on the “efficient markets hypothesis” for foreign exchange markets. The efficient markets hypothesis is the proposition that prices fully reflect information available to market participants, i.e. hedgers (hedged interest arbitrageurs) and speculators and there are opportunities neither for the hedgers nor for the speculators to make super-normal profits, i.e. both speculative efficiency and arbitraging efficiency exist. The speculative efficiency hypothesis (which some authors identify as the efficient markets hypothesis itself) is the proposition that the expected rate of return to speculation in the forward foreign exchange market conditioned on available information is zero (Hansen and Hodrick, 1980). The arbitraging efficiency hypothesis is the proposition that the expected rate of return to covered or uncovered interest arbitrage in the international capital market is zero. However, with transaction costs or risk premia, it can be shown that foreign exchange market efficiency does not imply covered or uncovered interest parity (as implicitly assumed in macroeconomics) or the optimality of the forward exchange rate as a predictor of the future spot rate (as implicitly assumed under the efficient-markets hypothesis).

To test for speculative efficiency, many authors test the hypothesis A that the forward price is the “best” forecast of future spot price (or, equivalently, the forward discount is the “best” predictor of the rate of depreciation). However, hypothesis A represents speculative efficiency only if the actual rate of depreciation is a good proxy for the expected rate of depreciation, since there is no unexploited sources of expected super-normal profits for speculators if the latter (not the former) is equal to the forward discount. In fact, hypothesis A can, just a well, represent rational expectations if the forward discount happens to be a good proxy for the expected rate of depreciation. It is useful for analytical purposes to use speculative efficiency and rational expectations as two distinct independent concepts, even though it is possible to argue that the latter is part of the former. Once again, one should stress that the rejection of hypothesis A does not imply speculative inefficiency (or irrational expectations) if transactions costs and risk premia exist.

To test for arbitraging efficiency, several authors test covered interest parity (CIP), i.e. the parity between the forward discount and the interest differential. Again, it has now been widely believed that a rejection of CIP does not imply a rejection of arbitraging efficiency again because of transactions costs and risk premia. However, it is important to note that the existence of transactions costs and risk premia are not the only reasons for arbitraging efficiency to be consistent with a deviation of the interest differential from its CIP. In the context of a simple forward market model, e.g. as given in Stein (1965), it can be shown that arbitraging efficiency can exist even if CIP does not hold and transactions costs and risk premia are absent. This happens if the elasticity of the hedgers’ demand for (or supply of) forward exchange is not infinitely large relative to that of the speculators’ supply of (or demand for) forward exchange. Unfortunately, apart from Stein (1965), there appears to be little in the literature on what determine these elasticities.

The interest differential is said to be in favour London (the domestic market) and against New York (the foreign market) if the interest rate in London (on assets denominated in £) is higher than that in New York (on the assets denominated in $). However, the net covered yield (defined as equal to interest differential minus forward discount) can still favour New York if the interest differential (in favour of £) is less than the forward discount (against £). From Figures 2.1-2.6 in section IV, it can be seen that, throughout the period 1982-1990 (with rare exceptions), the interest differential was in favour of London (against New York) and yet net covered yield was in favour of New York, i.e. the net covered yield and the interest differential had opposite signs. This means that the hedgers had profit incentives to move funds from London to New York and to buy forward £ and, presumably, the speculators had profit incentives to supply forward £, because they expected
that the expected rate of depreciation was less than the forward discount. The problem is that the net covered yield tended to vary negatively with the interest differential, because the forward discount varied proportionately more than the interest differential and this appears to suggest that a country, trying to reduce capital outflow by increasing its domestic interest rate, could end up increasing its outflow instead, in marked contrast to the standard prediction of macroeconomics (e.g. Mundell-Fleming model).

This paper has three main objectives. First, it aims to develop a forward market model (based on Stein’s model) and to provide the rationale for the assumption that the elasticities of demand and supply (with respect to the forward discount) are inversely related to political risk and exchange risk respectively. Second, it aims to provide a plausible explanation for the theoretically unexpected inverse relationship between the net covered yield and the interest differential. And Third, it aims to use daily data for six major industrialized countries to estimate the relationships between the forward discount and the interest differential.

Section II provides a brief critical review of the literature on speculative efficiency and arbitraging efficiency. Section III uses the daily data (provided by REUTERS) to present some statistical facts on the forward discount, the interest differential and exchange rate depreciation for three countries (Great Britain, Canada and Japan) for the period 1982-1996 and for two countries (Australia and New Zealand) for the period 1990-1996, with each of these countries taking turn to be the domestic market and the US as the foreign market. Section IV presents a revised version of the Stein model (Stein, 1967) and a number of reduced-form equations useful for testing purposes. Section V presents and discusses the regression results. Section VI gives a summary of the main conclusions.

II. Brief Review of Literature on Speculative and Arbitraging efficiency

For simplicity, let us discuss the issues underlying foreign market efficiency in terms of the case in which London and New York are the domestic and foreign markets respectively and £ and $ are the domestic and foreign currencies respectively. The following are the observed facts. Interest rate is higher in London than New York (i.e. the interest differential is in favour of London), the forward discount is against £ and net covered yield is in favour of New York. Let us, for convenience, follow Stein (1965) to define the gap between the expected rate of depreciation of £ vis-à-vis $ and the interest differential (the former minus the latter) as backwardisation. Since net covered yield favours New York, hedgers demand forward £. Let us assume backwardisation is positive so that speculators supply forward £, otherwise there would be no forward transactions.

According to Fama (1970), foreign exchange market efficiency exists only if there are no opportunities for market participants to make super-normal profits. There is no unexploited sources of super-normal profits for hedgers if covered interest parity (CIP) holds or for speculators in the domestic exchange market if the forward discount on £ is equal to its expected rate of depreciation (i.e. zero backwardisation). There is no unexploited profits for either hedgers or speculators if the uncovered interest parity (UIP) holds, i.e. if the interest differential is equal to the actual rate of depreciation. It should be noted that CIP (UIP) is a sufficient but not necessary condition for arbitraging efficiency (market efficiency).1

Three methods for testing foreign exchange market efficiency

There are at least three methods for testing market efficiency. Since information on the exchange rate (in the form of its past time-series) cannot be used to improve on profits if exchange rate

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1 CIP would be a necessary condition for arbitraging efficiency only if there are no transactions cost and no risk premia.
follows a random walk without drift, the first method for testing market efficiency is to carry out a simple test of the exchange rate for unit root. This method was quickly abandoned when it was realised that such a test of market efficiency is valid only if the interest differential is constant over time and, generally in practice, it is not.2

Since market efficiency implies an absence of profit opportunity, the second method for testing market efficiency is to test for the profitability of filter rules (e.g. a simple rule of buying a currency whenever it rises j-per cent above its most recent trough and selling the currency whenever it falls j percent below its most recent peak). This method has not been popular with economists because the results are highly sensitive to the sample periods chosen and the filter rules investigated. By far the most popular method for testing market efficiency has been the third method which involves regressing the logarithm of the spot rate onto the lagged logarithm of the forward rate (Frenkel, 1976; Turnovsky and Ball, 1983) or regressing the actual rate of depreciation against the forward discount (Tease, 1988) to avoid the bias, which would arise if the exchange rate happens to be non-stationary, as it in fact tends to be (Hansen and Hodrick, 1988; Mease and Singleton, 1982; McDonald and Taylor, 1987). Underlying this method is the hypothesis that forward price is the “best” forecast of the future spot price. The third method for testing market efficiency is essentially a joint test of two distinct propositions (i) that the forward discount is equal to the expected rate of depreciation and (ii) that the expectation is unbiased (i.e. rational expectations).

The third method’s null hypothesis of speculative efficiency can be rejected if the forward discount deviates sufficiently from the expected mean of the (actual) rate of depreciation and this can be the result of the fact that the supply of speculative funds is less than infinitely elastic with respect to backwardisation. Stein(1995, p.115) maintains that the sensitivity of the speculative net position to backwardisation, or “speculative elasticity”, is higher when expectations are held firmly than when they are subject to considerable doubt. It will be shown that speculative efficiency is consistent with the forward rate being equal to the expected future spot rate only if the speculators’ supply of forward £ is infinitely elastic (assuming that the hedgers’ demand is not infinitely elastic). But this is so only if (i) expectations are held firmly without doubt and (ii) all speculators hold an identical expectation concerning the future spot rate; neither of these conditions appears to hold in practice.

The joint hypothesis of rational expectations and speculative efficiency

As Bilson (1975) observes, the hypothesis that forward price is the “best” forecast of the future spot price often appears under the guise of rational expectations for economic analysis and market efficiency for financial analysis. A forecast may be considered “best” in the sense that it is unbiased and efficient.3 Let α and β be respectively the intercept and slope of the regression of the actual rate of depreciation on the forward discount and let the null hypothesis for testing rational expectations

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2 Generally, assuming rational expectations, the random walk model is inconsistent with the uncovered interest parity (UIP) condition, i.e. a non-rejection of the randomness of the spot rate implies a rejection UIP (Taylor, 1995, p. 14).

3 That is, it has a minimum variance within a class of unbiased forecasts. A biased forecast with a minimum variance around a biased mean may still be better than the best of the unbiased forecast, if its bias is sufficiently small. This suggests that a more appropriate criterion for measuring forecasting performance would be a measure such as the mean square error (MSE), where MSE = Bias² + Var, Var stands for the variance of the forecast. In terms of MSE, unbiasedness is not a necessary condition for “best” in this sense. Let x be a forecast variable with mean μ, then :

\[ \text{MSE} = \text{E}(x - \mu)^2 = \text{E}(x - \text{Ex})^2 = \text{Var} + \text{Bias}^2, \]

where \( \text{Var} = \text{E}(x - \text{Ex})^2 \) and \( \text{Bias}^2 = (\text{Ex} - \mu)^2 \).
and/or speculative efficiency be H0: \( \alpha = 0 \) and \( \beta = 1 \). On the assumption of speculative efficiency, the regression of the actual rate of depreciation on the forward discount (a proxy for the expected rate of depreciation) provides a valid test for rational expectations (i.e. that the expected rate of depreciation is the “best” forecast for the actual rate of depreciation). Similarly, on the assumption of rational expectations, the regression of the actual rate of depreciation (a proxy for the expected rate of depreciation) on the forward discount provides a valid test for speculative efficiency. The problem is that the rejection of the above H0 implies only that rational expectations and speculative efficiency cannot both be true, it does not say whether speculative efficiency or rational expectations is not true or both are not true. In fact, the above H0 is a joint hypothesis that the speculators are endowed with rational expectations and risk-neutrality (Taylor, 1995, p.14).

**Empirical evidence: Speculative efficiency**

It has been a common approach for researchers to assume that speculators are risk neutral when testing for speculative efficiency. As Taylor (1995, p.15) observes, empirical studies for a large variety of currencies and time periods and for the recent floating experience (e.g. Smith and Gruen, 1988; Thorpe et al, 1988 for Australia; Bilson, 1981; Longworth, 1981; Fama, 1984 for other countries) tend to report results which are unfavourable to the efficient market hypothesis under risk neutrality. The findings of these tests are often ambiguous, as the researchers are often unable to discern whether the rejection of market efficiency is due to irrationality, mis-specification of expected returns or a risk premium.

A number of authors also carry out the so-called ‘weak-form error orthogonality’ tests (Geweke and Feige, 1978; Frankel, 1981; Hansen and Hodrick, 1980; Tease, 1980). Using the gap between forward rate and the future spot rate as a proxy for the forecast error, they regress this proxy against one or more of its lagged values to test for speculative efficiency. What they in fact test is not really the hypothesis of speculative efficiency but the hypothesis of rational expectations in the sense that the forecast error has a zero mean (i.e. the forecast is unbiased) and is serially uncorrelated (i.e. the forecast is efficient), on the assumption that only lagged forecasting errors are included in the information set available to market participants. Note that for expectations to be rational, the forecast error should be orthogonal to all its lagged values (i.e. all the coefficients of the lagged values would be zero) and the constant term should also be zero.

For the inter-war period, Hansen and Hodrick (1980), using weekly data and one-month forward rates, reject the null hypothesis (that the forecast error is orthogonal to its lagged values) for the mark-£ and franc-£ but not for the US $-£. However, as they are rightly concerned, their results reflect in part the non-stationarity of the forecast errors, which do weaken their tests. For the period 1973 to 1979, Hansen and Hodrick (1980), using weekly data and three-month forward rates and carrying out tests involving the currencies of seven countries (Canada, France, Italy, Japan, Switzerland, United Kingdom and West Germany) versus US $, reject the null for three currencies (mark, franc and lire versus US $) but do not reject the null for the remaining four currencies. For about the same period, i.e. 1973 to 1978, Frankel (1980), rejects the null hypothesis for three currencies (£, mark and lire versus US$) out of six. For period 1972 to 1977, Feweke and Feige (1978) reject the null for only one currency (Canadian $ versus US $) out of seven.

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4 Note that \( \alpha = 0 \) implies zero transactions costs and risk premia. With the presence of transactions costs and risk premia, the null hypothesis should become H0: \( \beta = 1 \), since \( \alpha \neq 0 \), for reasons discussed earlier.

5 It makes no sense to assume hedgers to be risk-neutral, since by definition they are paying speculators to carry the exchange risk for them.

6 For example, forecast errors could be non-stationary because the mark was experiencing a rapid depreciation in the final weeks of the sample
currencies considered. For the period December 1983 to January 1986, Tease (1980) rejects the
null hypothesis for Australian $ vs US $.

In practice, the forward rate is expected to differ from the expected future spot rate for
reasons discussed in Section IV, which also shows that the gap between the forward rate and the
future spot rate (used as a proxy for the forecast error by the above authors) is equal to the true
forecast error plus a component which is related to the net covered yield and transactions costs. In
other words, the gap between the forward rate and the future spot rate is equal to the true forecast
error only if either (i) the elasticity of speculators’ supply of forward exchange is infinitely large or
(ii) CIP holds exactly and transactions costs are zero (see equation 8.3b, p. 20). Thus, unless (i) or
(ii) is true, the rejection of the null hypothesis of the orthogonality test does not even imply a
rejection of rational expectations.7

Empirical evidence: Arbitraging efficiency

Since transactions costs and risk premia exist in practice, as recognised by several authors (e.g.
Bilson, 1981; Fama and Farber, 1979; Frankel 1979), a departure from CIP does not necessarily
imply arbitraging inefficiency, just as a non-zero backwbrisation does not necessarily imply
speculative inefficiency. With transactions costs and risk premia, it can be shown that the null
hypothesis for testing CIP differs from that for testing arbitraging efficiency. Let α and β be the
intercept and slope of a regression of y on x (which is a reduced-form equation derived from a
forward market model), where y is the forward discount and x is the interest differential. On the
assumption that the hedgers’ demand for forward £ (the domestic currency) is infinitely elastic with
respect to the y [but the speculators’ supply is not] and that d (the expected rate of depreciation of
the £) is independent of x, then it can be shown that CIP require α=0 and β=1 simultaneously,
whereas arbitraging efficiency requires only β=1, since α can be shown to include the influence of
transaction costs and risk premia and is therefore not zero.8 However, it will be shown in this
paper that the elasticity of the demand by perfectly rational hedgers is inversely related to the
uncertainty concerning the future policies of the foreign governments9, i.e. political risk, and the
elasticity of the supply by perfectly rational speculators is inversely related to the uncertainty
concerning the future spot exchange rate, i.e. exchange risk.10 The non-rejection of β<1 may be the
result of political and exchange risks rather than arbitraging inefficiency.

Frequent failures of the tests of market efficiency, because the forward discount deviates
from either the interest differential or expected depreciation, have led researchers to postulate the
existence of a risk premium. Ibotson and Sinquefield (1976) have documented the existence of
large differences in the average holding returns on a variety of assets. The case for time-varying
risk premia has been made by Grauer et al (1976) and Lucas (1982). Researchers have often tested
for a risk premium as a function of the variance of forecast errors or of the exchange rate
movements (Domowitz and Hakkio, 1985; Giovanninini and Jorion, 1989). Rejecting the unbiased
and Hodrick and Srivastava (1984) find that a time-varying risk premia is present in several major
exchange markets. On the other hand, Frenkel (1982) fails to identify such a risk premium, using a

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7 This does not mean that, on the assumption that expectations are rational, the rejection of this null hypothesis means
a rejection arbitraging efficiency, since arbitraging efficiency is not inconsistent with autocorrelated net covered
yields which would be responsible for the serial correlation in the proxy for the forecast errors.
8 For simplicity, the discussion is in terms of the case in which the hedgers demand forward $ (the domestic currency)
and the speculators supply forward $. In practice, their roles can be reversed.
9 Especially concerning sudden exchange restrictions.
10 See Aliber, 1973, p.1453, for a discussion of these two types of risks.
six-currencies test and Domowitz and Hakkio (1985) provide empirical support for some but not all currencies.

CIP has been tested by a number of authors. While evidence from Stein (1965) for three pairs of countries (US/UK, US/Canada, UK/Canada) for the 1958-62 period is against CIP, that by Aliber (1973), Frenkel and Levich (1975, 1977) - for a number of major exchange rates during the 1970s and allowing for transaction costs - support CIP. For Australia for the period 1974-81, the results from Turnovsky and Ball (1983) support CIP for the quarterly data but not for the monthly data.

One major problem encountered in testing either speculative efficiency or arbitraging efficiency hypothesis is that $d$ (the expected rate of depreciation) is not directly observable and it is difficult to find a good proxy for it.\(^{11}\) It can be shown that the reduced form equation of a forward market model gives $y$ as a weighted sum of $x$ and $d$, i.e.

$$y = \lambda x + (1-\lambda)d + u_y$$  \hspace{1cm} (1.1)

where $u$ is a random residual and $\lambda$ (0<$\lambda$<1) is the weight (see Section IV). It will be shown in Section IV that $\lambda$ increases as the ratio of the elasticity of the hedgers' demand to the elasticity of the speculators' supply increases. To test for arbitraging efficiency (and CIP), $d$ is typically omitted and this would cause $\beta$ (the estimate of $\lambda$) to be biased towards unity to the extent that $x$ and $d$ are positively correlated. It can be shown that $\beta$ is an unbiased estimate of $\lambda$ only if $x$ and $d$ are uncorrelated but this implies a complete breakdown of UIP and a very high degree of market inefficiency. One possible solution is to follow Dornbusch (1976) to assume that $d$ adjusts to $x$ (via the change in the spot rate to reduce or eliminate excess un-hedged interest-arbitraging profit). If UIP holds only partially, because un-hedged-interest arbitrageurs are averse to exchange and political risks, then $d$ adjusts only partially to $x$, it can be shown that $\beta$ is larger than $\lambda$ but less than unity.

As it turns out, $\beta$ is consistently found to be greater than unity for all the cases in this study (see Figures 3.1-3.5) and there appears to be little from conventional economic theory to explain this result. Moreover, this result does appear to pose a tricky problem for monetary authority, desiring to reduce or reverse a capital outflow. For example, consider the case in which $y>x>0$. The hedgers will invest abroad, i.e. they sell spot £ and purchase forward £. To reduce capital outflow, the UK government may try to reduce the net covered yield in favour of the foreign market ($y-x$), say by increasing $x$ (i.e. raising the domestic interest rate). It will not succeed in reducing $y-x$, unless $\beta<1$. With $\beta>1$, an attempt to raise $x$ will result in increasing $y-x$, causing a further increase in capital outflow, i.e. the exact opposite to what is wanted. This seems to suggest that to reduce an outflow, $x$ has to be reduced (i.e. by reducing domestic interest rate relative to foreign interest), the opposite to the prescription of conventional macro theory (e.g. the Mundell-Fleming IS-LM-BP model).

One way to explain the fact that $\beta>1$ is to follow Nelson and Wu (1998, pp.1699-1700) to postulate that there is a large proportion of traders (the so-called noise traders) who tend to overreact to news, to display excess £ pessimism and to place excessive weight on the forward discount.

\(^{11}\) Obviously, the forward discount $y$ cannot be used as a proxy for the expected rate of depreciation ($d$) in equations in which the forward discount itself is included as a dependent or explanatory variable.
against £ when predicting changes in the exchange rate. In such a case, we can postulate the following relationship between \( d \) and \( x \):

\[
d = \gamma x + u_d \quad (\gamma > 1)
\]  

(1.2)

Substituting (1.2) into (1.1) gives:

\[
y = [1+(1-\lambda)(\gamma-1)] x + [u_y+(1-\lambda)u_d]
\]  

(1.3)

It can be seen from (1.3) that the coefficient of \( x \) would now be greater than unity if \( \gamma > 1 \).

III. Data and Facts on Interest and Exchange Rates

All the data used in this study are daily released data from Reuterlink sourced data (REUTERS Australia Pty Limited). Information on the data is from the Reuterlink Historical Data manual. The data received (in their original form) are defined by REUTERS as follows:

- **Spot rates.** The number of units of currency that may be traded for 1 US dollar. Rates are for lots of at least US $5 million. The most indicative spot rates are obtained from the markets where the currency is most actively traded (e.g. Europe, Asia, North America). Reuters’ definition of spot rate will be retained in this study, except for the case of the Japanese yen, whose spot rate is defined as the number of yen per US $.

- **Deposit rates.** The interest rate given on large sums on deposit for a specified time.

- **Forward rates.** The rate at which a currency can be purchased or sold for delivery in the future. The number returned by ReuterLink PC is an offset from the current US dollar spot rate, normally scaled by a factor of 10,000. For example, if this figure is 857, then add .0857 to the spot rate to obtain the forward rate. The periods available are: overnight, 1 week, 1, 2, 3, 6 and 9 months or 1 year.

A cursory look at the data show that there was a **forward premium** on the yen and a **forward discount** on the other four currencies (£, Canadian $, Australian $ and New Zealand $) vis-a-vis US $. Similarly, as expected, the deposit rate has been lower for assets denominated in yen but higher for assets denominated in the other four currencies than for assets denominated in US $. For convenience, the movements of the forward discounts and spot rates of each currency vis-a-vis US $ will be discussed in turn. To help to make the discussion in this section logically consistent with that in the next section, it is assumed that the currency on which there is a **forward discount** is the **domestic** currency and the other currency is the **foreign** currency. This means that the US $ is the **foreign** currency with respect to £, Canadian $, Australian $ and New Zealand $ but is the **domestic** currency with respect to the Japanese yen.

**Forward discount and currency depreciation**

12 Nelson and Wu (1998) review empirical evidence in support of their postulate concerning the noise traders from three studies Froot and Frankel, 1989; Frankel and Chinn, 1993; and Cavaglia et al (1994). The survey respondents were asked to provide forecasts at horizons of 3, 6 and 12 months into the future. They found that forecast errors are positively correlated with forward discount, with coefficient varying from 1.93 to 6.07 for 3 month forecast horizon and from 1.84 to 5.35 for 6 month horizon.
Since the current spot rate represents a very large component of both the forward rate and the future spot rate, it is expected that the forward rate would be highly correlated with the future spot rate and so testing for their relationship provides a poor test for the hypothesis of speculative efficiency. A more sensible test of this hypothesis is to test for the relationship between the forward discount and the rate of currency depreciation, i.e. to test that the former is a good predictor of the latter. It is clear from Figures 1.3-1.5 that, for the periods considered, there is hardly any statistical relationship between these two variables (this conclusion is confirmed by the fact that all the simple correlation coefficients between these two variables are less than .01.) However, as argued below, the absence of a relationship between the forward discount and interest differential is fully consistent with speculative efficiency.

It can be seen from Figures 1.1-1.5 that the forward discount is considerably more stable than the rate of change of the spot rate over a period of one month for all currencies vis-a-vis US $.13 Between January 1982 and February 1985, £ depreciated vis-a-vis US $ (Figures 1.1 and 1.6) and yet this was not reflected in a forward discount against £ (Figure 1.1), which was close to zero throughout this period. Between February 1985 and May 1988, £ appreciated against US $ and yet there was a significant forward discount against £, i.e. the forward rate failed to forecast even the direction of the change in the spot rate. The forward discount against £ remained large, with no apparent underlying trend in the £/$ spot rate in the period between May 1988 and October 1992 and gradually fell towards zero, subsequently, as the spot rate fluctuated narrowly around the 1.55 ($ per £) mark.

The spot rate for Canadian $ (vis-a-vis US $) has been considerably more stable throughout the period (January 1982 and June 1996) than the spot rate for £ (Figures 1.2 and 1.6). There appeared to be some very long cycles around a constant trend. Yet there was quite a substantial forward discount against the Canadian $ which tended to increase between July 1984 and July 1990 and decreased since this date. All this suggests that, for Canada, the forward discount is a poor predictor of the change in the spot rate.

For both Australia and New Zealand, there were no REUTERS data on the forward rates for period prior to 15 May 1990. The spot rates of both of these countries were a great deal more unstable before this date than subsequently. During the period May 1990 and June 1996, the underlying trend of the spot rates of Australian $ and New Zealand $ appeared to be about constant and yet a considerable forward discount persisted. The forward discounts on the Australian $ and New Zealand $ tended to decrease toward April 1994 and then increase again subsequently (See Figures 1.4-1.6.). The forward discount was a poor indicator of the change in the spot rate for either Australia or New Zealand.

The spot rate of the Japanese yen vis-a-vis US $ fluctuated considerably (from month to month) around a declining trend for the period January 1982 and June 1996. As expected, there was a sizeable forward discount on the US $ vis-a-vis the yen. Monthly changes in the spot rate of the yen is a great deal more violent than the monthly changes in its forward margin. (See Figures 1.3 and 1.6). However, for Japan, the forward rate did correctly forecast the underlying trend in the change in the spot rate.

**Forward discount and interest differential**

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13 Here, one month is taken to mean 20 working days or 4 weeks. Strictly speaking, one month is equal to 21.666 working days.
Since there would be no profit for the arbitrageurs when the covered interest parity holds (i.e. the interest differential is equal to the forward discount), many authors tested covered interest parity to test for arbitraging efficiency. Figures 2.1-2.5 and 3.1-3.5 clearly show that CIP held for none of the pair of countries considered. In fact, the forward discount tended to exceed the interest differential (whenever both are positive). Again, in the next section, we shall show that the failure of CIP to hold is perfectly consistent with arbitraging efficiency, if agents differ in their expectations concerning exchange and political risks.

The first important thing to note from Figures 2.1 is that a positive (negative) forward discount on £ tended to be greater (less) than the interest differential in favour of London (i.e. £-assets) and the larger is the absolute value of the latter the larger is the gap between it and the former (i.e. the covered interest rate differential or net covered yield, as it is commonly called). Thus, up to around January 1985, the interest differential was in favour of New York ($-assets) but the net covered yield was in favour of London (£-assets) and, subsequently, this situation was reversed. Moreover, as the interest differential (in favour of London) increased, the net covered yield against London also increased, making London less and less attractive than New York for hedged arbitrageurs to invest. Since, by definition, NCY = y-x, where NCY, y and x are the net covered yield, forward discount and interest differential respectively, NCY varies inversely with x if the derivative of y with respect to x (dy/dx), i.e. the slope of the regression of y on x, is greater than unity. From Figure 3.1, the scatter plot of y against x appears as a thick line with a slope clearly greater than unity, being steeper than the 450 (diagonal) line. Note that a point above (below) the 450 line indicates that the forward discount is greater (less) than the interest differential. It can also be seen from Figure 3.1 that the negative values of the forward discount were less than those of the interest differential (i.e. for those years in which interest rate is higher in the UK than in the US) and the positive values of the forward discount were greater than those of the interest differential confirms the finding that covered interest differential (x-y) has the opposite sign to uncovered interest differential (x), so that it paid to move funds away from the country with higher interest rate, because of the more than offsetting higher exchange risk or forward discount involved.

The tendency for the net covered yield to have an opposite sign to the forward discount and vary inversely with the interest differential was also true for all the other countries included in this study (i.e. Canada, Japan, Australia and New Zealand), see Figures 2.2-2.5 and 3.2-3.5. It should be remembered, however, that in the case of Japan, the forward discount was on US $ and the net covered yield was in favour of Tokyo, whereas for all the other countries, the reverse was the case. Note also that, unlike all other currencies, the Japanese yen tended to appreciate quite substantially against the US $ (Figure 1.6). It can be seen from Figure 2.6 that, for most of the years in the 1982-1996 period, the rate of interest was lower in New York than elsewhere, except for Tokyo.

Thus, Figures 1.1-1.6, 2.1-2.6 and 3.1-3.5 clearly demonstrate the fact that countries with higher interest rates (Great Britain, Canada, Australia and New Zealand) appeared to be less attractive in terms of the net covered yield than countries with lower interest rates (USA and Japan) and that the higher was the interest differential in favour of a country, the less attractive it would appear to become as a centre for risk-adverse investors to invest. One of the main objectives of this study is to present some plausible explanations for these observed phenomena and econometric support for them.

IV. The Forward Market Model

The above cursory examination of the data on the interest rates and the spot and forward exchange rates of six developed countries throws a definite doubt on the view (i) that the forward discount is
a good predictor of the future spot rate (ie. UIP holds) or (ii) that the forward discount tends to be
equal to the interest differential (ie. CIP holds). As discussed above, UIP or CIP is a condition for
speculative or arbitraging efficiency only if’ (a) there is no risk premium, no transaction costs and
(b) that expectations are unbiased and efficient, firmly held and identical across agents. Therefore,
underlying the UIP or CIP test is simply the joint hypothesis concerning propositions (a) and (b)
and the rejection of UIP or CIP simply means the rejection of this joint hypothesis and has no
implication for market efficiency. The UIP or CIP tests of market efficiency are red herrings.

In this section, the demand for and the supply of forward exchange in Stein (1965) model will
be derived, using the assumption that the dealers in the forward market do not hold identical
expectations concerning. One result of this model is that market efficiency requires neither that
the forward discount is a good predictor of currency depreciation nor that the forward discount tends
to be equal to the interest differential.

The participants in the forward market can conveniently be divided into two groups: (i) the
hedgers and (ii) the speculators. For convenience, let the discussion be in terms of the above-
mentioned case in which net uncovered yield is in favour of New York (foreign market) and the
hedgers (ie. hedged arbitrageurs) and speculators are buyers and sellers forward £ respectively.
[Note that their roles as buyers and sellers of forward £ would have been reversed had the net
covered yield been in favour of London.]

**Definition**

\[
\begin{align*}
\text{n} & = \text{number of months ahead [1 month or 3 months]} \\
& [\text{n is the same for interest rates and forward exchange rates}]
\end{align*}
\]

\[
\begin{align*}
\text{i} & = \text{domestic interest rate [for n months], in London.} \\
\text{i}^* & = \text{foreign interest rate [for n months], in New York.} \\
\text{S} & = \text{current spot rate: the value of } \$ (\text{foreign currency}) \text{ in terms of } £ (\text{domestic currency}). \\
\text{S}^e & = \text{expected future spot rate [n months ahead]: the value of } \$ \text{ in terms of } £. \\
\text{F} & = \text{forward rate [n-month future delivery]: the value of } \$ \text{ in terms of } £. \\
\text{d} & = \log(S^e) - \log(S) = \text{expected depreciation} (+) \text{ in the value of } £.
\end{align*}
\]

The covered interest parity (CIP) can be specified as follows:\(^{14}\)

\[
\frac{1 + i}{1 + i^*} = \frac{F_n}{S} \quad \text{(1.1)}
\]

The more usual form of CIP is: \(i - i^* = f + \varepsilon\), where \(f = \frac{F_n - S}{S}\) and \(\varepsilon = i^* f\), or

\[
i - i^* = f \quad \text{(1.2)}^{15}\]

if \(\varepsilon\), being small, is omitted for simplicity. Taking the logarithms of (1) gives the CIP in logarithm
form:

\[
x = y \quad \text{(1.3)}
\]

---

\(^{14}\) See equation (2.3) of Appendix A, with the omission of \(K\).

\(^{15}\) \(\frac{1 + i}{1 + i^*} = \frac{F_n}{S}\) is the same as \(\frac{1 + i}{1 + i^*} - 1 = \frac{F_n}{S} - 1\) or \(\frac{i - i^*}{1 + i^*} = \frac{F_n - S}{S}\) or \(i - i^* = f + \varepsilon\),

where \(f = \frac{F_n - S}{S}\) and \(\varepsilon = i^* f\).
where \[ x = \log(1+i)-\log(1+i^*) = \text{interest differential}, \] (+) favours London, and \[ y = \log(F_n)-\log(S) = \text{forward discount} \] (+) on £ (or premium on $).

It can be shown that using the conventional form of CIP (1.2) rather than its logarithm form (1.3) can cause the results to be sensitive to whether the exchange rate is defined as the value of $ in terms of £ or as the value of £ in terms of $ (the so-called Siegel paradox).\(^{16}\) The omission of \( \varepsilon \) in (1.2) may be a useful simplifying assumption for teaching purpose but is not justifiable for applied works, because often it could make quite a significant difference to the results whether \( \varepsilon \) is omitted or not. As far as I am aware of, previous studies, e.g. Tease (1988) and Levich (1979), use (1.2) with \( f \) replaced by \( y \) (logarithm form) to avoid the Siegel paradox problem, but they still omit \( \varepsilon \) in their definition of the interest differential.\(^{17}\)

### The Speculators

A speculator is an agent which sells forward £ if the future spot rate he or she expects is lower than the forward rate (minus average transaction costs) or equivalently that the spot rate is expected to depreciate by a smaller percentage (d) than the forward discount \( y \), i.e. if \( d < y \).

Let us assume that each speculator \( j \) will sell an amount \( Q \) of forward £ if \( d_j < y \) (where \( d_j \) is the rate speculator \( j \) expects the spot rate to depreciate) and buy the amount \( Q \) of forward £ if \( Q > y \).\(^{18}\) Let us further assume that \( Q \) (the expected rate of depreciation of each individual \( i \)) is drawn from a distribution (which can be normal, logistic or rectangular), with mean \( \mu_d \) and standard deviation \( \sigma_d \). It is clear that the proportion of speculators with \( Q < y \) is the larger, the larger is \( y \), and is exactly equal to half if \( y \) is equal to its mean, \( \mu_d \).

Let us assume initially \( y = \mu_d \). This would imply that the proportion of speculators who want to sell forward £ is exactly equal to the proportion of speculators who want to buy forward £, so that the net supply of forward £ is zero. Assuming further that net covered yield is in favour of New York (the foreign market), i.e. \( x > y \), so that the hedgers want to buy forward £ (and sell spot £), but there are no suppliers of forward £, i.e. \( y \) is not at its equilibrium value. Excess demand for forward £ will increase \( y \), its discount vis-a-vis $, causing \( y \) to exceed \( \mu_d \) and hence causing the proportion of speculators wishing to sell forward £ to exceed the proportion of speculators wishing to buy forward £. This would mean that there is now a positive net speculators’ supply of forward £ to meet the demand for forward £ by the hedgers (which decreases in response to an increase in \( y \)). Thus, equilibrium in forward exchange market will result in \( y \) being in the range: \( x < y < \mu_d \).

The supply of forward £ by the speculators as a group can be expressed as follows:

---

\(^{16}\) Siegel Paradox is an application of the statistical theorem known as Jenson’s Inequality, which indicates that different results would be obtained depending on whether our definition of the exchange rate was the value of foreign currency in terms of domestic currency or the value of domestic currency in terms of foreign currency. This follows because \( E(X) \neq 1/E(1/X) \).

\(^{17}\) Using \( -i + \varepsilon = \frac{(1+i)-(1+i^*)}{(1+i^*)} \) would again encounter the Siegel paradox problem.

\(^{18}\) Note that the speculator expects to be able to sell $ spot in \( n \) months' time at price \( S_n^e \), so that by selling forward $ at the forward rate \( F_n \), he expects to receive a gross profit of \( F_nS_n^e \) per $. The larger is the funds accessible to each individual speculator and the more firmly held his expectation, the larger would \( Q \) be. Factors implying larger \( Q \) would also imply a larger elasticity for the speculators’ supply of forward £.
\[ G = (2F_G(z) - 1)Q_G \quad (2.1), \]

where \( Q_G \) is the maximum total supply of forward £ by the speculators and \( F_G(z) \) is the proportion of speculators with \( z_i = (d_i - \mu_d)/\sigma_d \) less than

\[ z = (y + k_G - \mu_d)/\sigma_d \quad (2.2) \]

where \( z \) is random variable with zero mean and unit variance. Let us assume that \( F_G(z) \) has the following rectangular distribution:

\[ F_G(z) = 0.5(1 + z/ z_G) \quad (0 \leq z \leq z_G) \quad (2.3) \]

where \( z_G \) is the maximum value for \( z \). It can be seen from (2.2) and (2.3), that for \( y = \mu_d, z = 0 \) and \( F_G(0) = 0.5 \) and for \( z = z_G, F_G(z_G) = 1 \). Substituting (2.3) and (2.2) into (2.1) gives:

\[ G = (z / z_G)Q_G = g(\mu_d - (y + k_G)) \quad (2.4) \]

where

\[ g = Q_G / (\sigma_d z_G) \quad (2.5) \]

It can be seen from (2.4) that \( G = 0 \) for \( y = \mu_d \) and \( G = Q_G \) for \( z = z_G \), its maximum value. For the model to have a meaningful equilibrium solution, let us assume that \( Q_G \) is sufficiently large so that there is always a sufficient supply of forward £ by the speculators to meet the demand for forward £ by the hedgers. It can be seen from (2.5) that \( g \) varies inversely with \( \sigma_G \), the standard deviation of the distribution of \( Q_j \). Since differences of opinions concerning the future spot rate are bound to increase as the uncertainty concerning the spot rate increases, \( \sigma_G \) should be related positively to the standard deviation of the forecast. Intuitively, (2.4) makes good sense. The larger is \( y \), the smaller would be the proportion of speculators who expect the rate of depreciation to exceed it, and hence the smaller is the amount of forward £ supplied by the speculators.

**The Hedgers**

Let \( \Pr(d_i < y) \) be the probability of \( d_i < y \). It can be shown that \( \Pr(d_i < y) = \Pr(z_i < z) \), where \( z_i = (d_i - \mu_i)/\sigma_i \) and \( z = (y - \mu_d)/\sigma_d \), since, by definition of \( z_i \) and \( z \), \( d_i < y \) if \( z_i < z \). Note that \( \Pr(z_i < z) = F(z) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^z e^{-t^2/2} \, dt \), the Cumulative Normal Distribution. By definition, the proportion of speculators in the group of all speculators with \( z_i < z \) is the same as the probability of picking a speculator with a value \( z_i < z \). Since the proportion of speculators with \( z_i < z \) is equal to \( 1 - F(z) \), the difference between the proportion of speculators with \( z_i < z \) and that of speculators with \( z_i > z \) is equal to \( F(z) - [1 - F(z)] = 2F(z) - 1 \). Note that a speculator with \( z_i < z \) will buy forward $ whereas a speculator with \( z_i > z \) will sell forward $, so that \( 2F(z) - 1 \) gives us the net proportion of speculators buying forward $.

\( F_G(z) \) denotes the probability of picking a speculator with \( z_i \) less than or equal to \( z \). An alternative plausible distribution is the logistic distribution:

\[ F(z) = \frac{\exp(z)}{\exp(z) + 1} \]

Substituting the above equation into (2.1) gives:

\[ F(z) = \frac{\exp(z)}{\exp(z) + 1} \]

where \( z = \frac{y - \mu_d}{\sigma_d} \). Thus \( G \) becomes a non-linear function of \( y \) and \( \sigma_d \).
It is useful to distinguish three group of hedgers: the interest arbitrageurs, the borrowers and the traders. Suppose that the forward discount on £ exceeds the interest differential (in favour of London) so that the net covered yield is in favour of New York. The interest arbitrageurs would borrow £ from London, sell £ for $ to purchase bills denominated in $ in New York. To hedge against the risk of exchange rate depreciates between now and the maturity date, they simultaneously buy forward £ (or sell $). The borrowers are firms and institutions in the UK, US and elsewhere who search for the cheapest place internationally to borrow. They sell spot £ (the borrowed currency) for $ and, to hedge against exchange rate depreciation, they buy forward £. The traders include exporters who expect to receive $ at some future dates and importers who expect to pay in $ to foreigners at some future date and, to hedge against exchange rate changes, the risk-averse exporters sell forward £ (buy forward $) and the risk-averse importers buy forward £ (sell forward $). The traders as a group may buy or sell forward £, depending on whether the demand for forward £ by the importers is less than, equal to or greater than the supply of forward £ by the exporters.

Of course, there are interest arbitrageurs, borrowers and traders who do not hedge and are not therefore hedgers. These people can be said to buy and sell forward £ in identical quantities and hence play no role in the determination of forward rate. For simplicity, let us assume that all arbitrageurs, borrowers and traders hedge. If the amount of £ the importers expect to receive is less than the amount the exporters expect to receive, than the traders (i.e. the third group) may sell forward £ (buy forward $) even if the covered-yield is in favour of New York. Hence, it could be argued that these three groups of hedgers differ in the degree of sensitivity to the variation in the covered-yield. For example, the first group is more sensitive than the second and the second more than the third. However, this is not quite correct, since what really matters is the degree of risk aversion, and there is no presumption that traders are necessarily more risk-averse than borrowers or interest-arbitrageurs. Note that net covered yield can be considered to be the cost of hedging to traders and the less risk-averse traders may choose not to hedge when net covered yield rises. The degree of risk-aversion depends on the ability to carry exchange risk and large traders, borrowers and interest-arbitrageurs with easier access to the capital market are more able to carry exchange risk than small ones.

It is reasonable to assume that each individual hedger j requires a different (political) risk premium \( r_j \) because he has his own assessment of the political risk involved in holding foreign assets and his own degree of risk aversion, where the risk premium \( r_j \) is drawn from a distribution with mean \( \mu_r \) and standard deviation \( \sigma_r \). Let us assume that the hedger j will buy an amount \( Q_j \) of forward £ if \( y-r_j>x \) (or \( r_j<y-x \)), and will sell the amount \( Q_j \) of forward £ if \( y-r_j<x \) (or \( r_j>y-x \); see Appendix A). Let us assume again for simplicity that \( Q_j \) is the same for all arbitrageurs.

The demand for forward £ by the arbitrageurs as a group can be expressed as follows:

\[
H = (2F_H(z)-1)Q_H \quad (3.1)
\]

where \( Q_H \) is the maximum amount of arbitraging fund and \( F(z) \) is the proportion of arbitrageurs with \( z_i = (r_i - \mu_r) / \sigma_r \) less than

\[
z = (y-x - \mu_r) / \sigma_r \quad (3.2)
\]

Let us assume that \( F(z) \) has the following rectangular distribution:

---

Demand for forward £ by Australian importers tend to exceed supply of forward £ not necessarily because of an Australian trade deficit but because of the existing trade convention that importers have to pay in the local currency of their suppliers.
FH(z) = 0.5(1+z/z_H) \quad (3.3)

where \( z_H \) is the maximum value for \( z_j \). Substituting (3.2) and (3.3) into (3.1) gives:

\[
H = \frac{z}{z_H} Q_H = h(y - \mu_r - x) \quad (3.4),
\]

where

\[
h = Q_H / (\sigma_r z_H) \quad (3.5)
\]

Thus, by similar reasoning as in the case of the speculators, \( h \) is shown to be inversely related to the standard deviation of the political risk premium.\(^{22}\) It can be seen from (3.4) that an increase in \( y \) would increase the demand for forward £ by the arbitrageurs, because the higher is \( y \), the larger is the proportion of arbitrageurs who believe that \( y-r \) is greater than \( x \).

**The Revised Stein Model**

It is convenient at this point to choose a country (e.g. UK) with \( x>0 \) as the home country. Let us specify the model for the case of \( y>x>0 \). (The model has to be specified differently for the case \( y<x<0 \).) Consider the following revised Stein model (Stein, 1967) for this case:\(^{23}\)

\[
G = -gy + g\mu_d + u_G \quad (4.1),
\]

\[
H = hy - hx - h\mu_r + u_H \quad (4.2)
\]

and

\[
G = H \quad (4.3)
\]

where

- \( G \) = the amount of forward £ supplied by speculators,
- \( H \) = the amount of forward £ demanded by hedged interest-arbitrageurs (hedgers),
- \( a \) = an autonomous component of the hedgers purchase of forward £; \( a \) is expected to be positive for current account surplus and negative for a current account deficit.
- \( g, h \) = the slopes of the hedgers’ demand for and speculators’ supply of forward £ respectively, and
- \( u_G, u_H \) = random variables with zero means, representing the joint effects of all omitted variables on \( G \) and \( H \) respectively.

Equations (4.1) and (4.2) are the same as (2.4) and (3.4) with the addition of \( u_G \) and \( u_H \) respectively. Note that \( g \) and \( h \) are inversely related to a measure of exchange risk (\( \sigma_d \)) and political risk (\( \sigma_r \)) respectively. To simplify the analysis, it is assumed that transaction costs are zero.

This model differs from Stein model in a number of ways: (1) the hedgers are assumed to adjust to their desired positions without a lag and (2) \( x \) and \( y \) are here defined in terms of

---

\(^{22}\) In practice, \( a \) can be added to \(-gk_H \) to give the intercept. Note that \( a<0 \) for is a debtor country such as Australia, with a current account deficit.

\(^{23}\) For the case of \( y<x<0 \), equations (2.1) and (2.2) become: \( G = g(y - \mu_d) + u_G \) and \( H = h(x - y) + u_H \), where \( G \) and \( H \) are the amounts of forward $ demanded by the speculators and supplied by the hedgers respectively.
logarithms (using the logarithm form of the CIP). Although Stein (1965) includes this lag, it is assumed away when his equations are estimated. Since G and H are here defined in terms of the supply of and demand for forward £ (domestic currency), whereas Stein define them in terms of the supply of and demand for foreign currency, the signs of x, y and d in this study are the reverse of those in Stein model.

The reason for defining G and H in this way is to take account of the fact that y in practice tends to be larger than x when x>0. Substituting (4.1) and (4.2) into (4.3) and rearranging give:

\[-h\mu_x + (g + h)y - g\mu_d - hx + (u_H - u_G) = 0\]  

(4.4)

Assuming that \(\mu_x\) is given, equation (4.4) gives an equilibrium relationship among three variables (y, x and \(\mu_d\)), each of which can be solved to be an explicit function of the other two.

If we assume that x and \(\mu_d\) are exogenously determined, then we can follow Stein (1983) to solve (4.4) for y to give:

\[y = \alpha_y + (1 - \beta_y)x + \beta_y\mu_d + u_y\]  

(4.5)

where \(\alpha_y = \frac{h\mu_x}{g + h}, \beta_y = \frac{g}{g + h} > 0\, \text{and} \, u_y = \frac{u_G - u_H}{g + h}.

According to (4.5), with \(\alpha_y = u_y = 0\, \text{and} \, y>x\) implies and is implied by \(y>\mu_d\, (\mu_d = \text{the mean of the inflationary expectations})\) and, since y is a linear combination of x and \(\mu_d\) (so that y always lies between x and \(\mu_d\) in magnitude) \(y>x\) also implies and is implied by \(y>\mu_d\). For example, suppose \(y>x\); the hedgers buy forward £ (and sell spot £ and invest in New York, H>0) and, since \(y>x\) implies \(y<\mu_d\), the speculators sell forward £ (G>0).

Tests for speculative and arbitraging efficiency

To test for speculative efficiency, several authors test the hypothesis that y is a good predictor of \(d_a\), where \(d_a\) is the actual rate of depreciation, ie. they adopt the following null hypothesis- \(H_0: y-d_a=0\). Let RE be rational expectations and \(E_d\) be the expected mean of \(d_a\). Since \(y-d_a=(y-x)+(x-d_a)\)

24 Stein (1965, p.114) indicates that factors affecting the intercepts in (1.1) and (1.2) include extra transaction costs of foreign relative to domestic investment. See Appendix A for an equation showing how the intercept (\(h_0\)) in (1.1) can be related to transaction costs. Of course, \(h_0\) may also be related to other factors such as the interest on foreign debt, but this is assumed away here for simplicity.

25 Let \(\alpha_y u_y = 0\). Subtracting x from both sides of (4.5) gives:

\[y - x = \beta_y (\mu_d - x)\]  

(I)

It can be seen that \(y>x\) if \(\mu_d>x\), since \(\beta_y>0\). Similarly, subtracting \(\mu_d\) from both sides of (4.5) gives:

\[y - \mu_d = -(1 - \beta_y)(\mu_d - x)\]  

or

\[(\mu_d - x) = \frac{y - \mu_d}{1 - \beta_y}\]  

(II)

Substituting (II) into (I) gives:

\[y - x = \frac{\beta_y}{1 - \beta_y}(y - \mu_d)\]  

(III)

It can be seen that if \(y>x\), then \(y<\mu_d\, \text{since} \, 1>\beta_y>0\). Since y is a linear combination of x and \(\mu_d\), its value must lie between x and \(\mu_d\).
The above null hypothesis is not rejected if all the following three hypotheses are not rejected: CIP: \( y = x = 0 \); UIP: \( x = \mu_d = 0 \) and RE: \( \mu_d - E_d = 0 \). Hence, the null hypothesis underlying the conventional test for speculative efficiency is in fact the joint hypothesis that CIP, UIP and RE all hold simultaneously. Since the non-rejection of the above null hypothesis of the test for speculative efficiency implies that CIP holds, this means that the hypothesis of arbitraging efficiency is also not rejected and there is no need for a separate test for CIP or arbitraging efficiency. As it turns out, \( d_a \) has fluctuated much more than \( y \) (see Figures 1.1-1.5) and very unpredictably, so that \( y \) is a very poor predictor of \( d_a \), but this does mean that speculators are inefficient.

Let us assume \( \alpha_y = 0 \). According to equation (4.5) above, UIP holds if \( h/g > 0 \) (since \( \beta_y = 1 \)) and CIP holds if \( g/h > 0 \) (since \( \beta_y = 0 \)). Note that \( h \) and \( g \) are the slopes of the hedgers’ demand for and the speculators supply of forward £. Since \( G_f = G_h \), \( g/h > 0 \) if \( \sigma_d \) is very large relative to \( \sigma_r \). A test for CIP is equivalent to a test of the hypothesis that exchange rate uncertainty (\( \sigma_d \)) is considerably greater than political uncertainty (\( \sigma_r \)). In practice, for the countries considered here, it is most unlikely that \( \sigma_d \) is small relative to \( \sigma_r \), hence we can be quite confident that UIP would not hold.

The finding that the coefficient of \( x \) in (4.5) has consistently been found to be greater than unity, ie. CIP does not hold. However, this is perfectly consistent with the foreign exchange market efficiency in the sense that market participants act rationally to maximize their earnings, given the distributions of their expectations concerning the future spot rate and political risk involved.

An increase in the exchange risk (\( \sigma_G \)) would reduce \( g \) [according to (2.5)] and \( \beta_y \) and hence would increase \( (1-\beta_x) \), the coefficient of \( x \) in (4.5). This means that, given the interest differential \( x \), an increase in the exchange risk would increase the forward discount \( y \). An increase in political risk (\( \sigma_r \)) would reduce \( h \), increase \( \beta_y \) and reduce \( (1-\beta_x) \) and would hence increase the forward discount, given the interest differential.

In practice, at least in the case of Australia, it is widely acknowledged that forward rate is continually set by the Reserve Bank, rather than being freely determined in the forward market. With \( y \) (instead of \( x \)) being exogenous, it is appropriate to solve (2.4) for \( x \) to give:

\[
x = \alpha_x + (1 + \beta_x) y - \beta_x \mu_d + u_x
\]

where \( \alpha_x = -\mu_x, \beta_x = \frac{g}{h} > 0 \) and \( u_x = \frac{u_H - u_G}{h} \).

**Bias problem due to the omission of \( \mu_d \)**

Unless \( g/h = 0 \) (or negligible), the coefficient of \( x \) in (4.5) is expected to be greater than unity and that of \( y \) in (4.6) is expected to be less than unity. One problem is that \( \mu_d \) is not directly observable. Consequently, empirical studies tend to omit \( \mu_d \) in their regressions of \( y \) on \( x \) or \( x \) on \( y \) to test for foreign exchange market efficiency. The omission of \( \mu_d \) can be shown to bias the estimates of \( (1-\beta_x) \) and \( (1+\beta_y) \) in equations (4.5) and (4.6) respectively to the extent that \( \mu_d \) is correlated with \( x \) or \( y \). If \( \mu_d \) is correlated with \( x \) or \( y \), then the regression coefficient is no longer an estimate of \( (1-\beta_x) \) or \( (1+\beta_y) \).

---

or \((1+\beta_y)\) but some other quantity. It is clear from (4.5) and (4.6) that the regression coefficient of \(y\) on \(x\) is expected to be \textit{less than unity} and that of \(x\) on \(y\), to be \textit{greater than unity}, if either (i) a valid proxy for \(\mu_d\) is included or (ii) \(\mu_d\) is omitted but happens to be \textit{uncorrelated} with \(x\) in (4.5) or \(y\) in (4.6).

Since it is found that all the estimates of the coefficient of \(x\) in a regression of \(y\) on \(x\) are \textit{greater than unity} (and all the estimates of the coefficient of \(y\) in a regression of \(x\) on \(y\) are \textit{smaller than unity}), it follows that the omitted \(\mu_d\) has to be \textit{correlated} with \(x\) and it is important to investigate the possible theoretical relationship these two variables to arrive at some explanations of these unexpected results. These results can be explained in terms of any one of the following behaviour by the government or speculators:

(i) The speculators react excessively to news concerning the interest rate differential, ie. \(\eta>1\) (Case A).

(ii) The government reacts \textit{conservatively} to news concerning inflationary expectations, when they fix the domestic rate of interest, ie. \(\phi<1\) (Case B).

(iii) The government reacts \textit{excessively} to news concerning inflationary expectations when they intervene in the forward market to fix the forward discount \(y\), ie. \(\theta>1\) (Case C).

Case A: \(\mu_d\) \textit{adjusts to exogenous x}

Suppose that the speculators adjust \(\mu_d\) to \(x\) as follows:

\[
\mu_d = \eta x + e \quad (\eta>0)
\]  

(5.1)

Substituting (5.1) into (4.5) gives:

\[
y = \alpha_y + \delta_c x + [(1-\beta_y)e]
\]  

(5.2)

where \(\delta_c = 1-\beta_y(1-\eta)\). It is clear that \(\delta_c\) is positive, given that \(\beta_y = -\frac{g_1}{g_1 + h_1} < 1\), that \(\delta_c\) exceeds unity if \(\eta<1\) and that \(\delta_c\) falls short of unity if \(\eta>1\). At the means, ie. with \(Ee=0\), \(\eta=1\) implies \(\mu_d = \eta x\), according to (5.1) and \(y=x\) according to (5.2). UIP implies and is implied by CIP if \(\alpha_y=0\) and \(\eta=1\). However, in general \(\eta \neq 1\), UIP does not imply CIP or vice versa. The coefficient of \(x\) (\(\delta_c\)) \textit{greater} than unity can be explained in terms of case A, with \(\eta>1\), ie. with the speculators reacting \textit{excessively} to the interest rate differential (x).

Case B: \(\mu_d\) is \textit{related to x} (fixed by the government)

Suppose \(x\) is fixed by the \textit{domestic} government on the basis of the gap between the rates of inflation at home and abroad (or \textit{inflation differential}, \(p\)) as follows:

\[
x = \phi p + v
\]  

(6.1)

where \(p = \log\) of one plus expected \textit{domestic} inflation minus the \log of one plus expected \textit{foreign} inflation, \(\phi\) is a positive coefficient and \(v\) is a random disturbance, with zero mean. The rationale for (6.1) can be given as follows. An increase in \(p\) would be expected to increase the
expected rate of depreciation \( \mu_d \) and hence the forward discount \( y \) and capital outflow. The latter exerts a downward pressure on the spot rate (for £). To support the £, reduce capital outflow and moderate inflationary pressure, the government raises domestic interest rate vis-à-vis foreign rate, thus raising \( x \). From the definition of expected real depreciation of the exchange rate: \( \omega = p + \mu_d \), we obtain:

\[
p = \mu_d - \omega
\]  

(6.2),

where \( \omega \) = expected depreciation (+) or appreciation (-) of the real exchange rate. Substituting (6.2) into (6.1) and solving for \( \mu_d \) give:

\[
\mu_d = \lambda x + \omega - v / \phi
\]  

(6.3)

where \( \lambda = 1 / \phi \). Substituting (6.3) into (4.5) gives:

\[
y = \alpha_y + \delta_y x + [u_y + \beta_y (\omega - v / \phi)]
\]  

(6.4)

where

\[
\delta_y = 1 - \beta_y (1 - \lambda)
\]  

(6.5)

It can be seen from (6.5) that \( \delta_y > 1 \), if \( \phi < 1 \), since \( \beta_y > 0 \). Thus, \( \delta_y \) (the coefficient of \( x \)) being greater than unity can be explained in terms of case B, with \( \phi < 1 \). It is also clear that \( \delta_y = 1 \) if \( \phi = 1 \) and this implies that real interest differential remains constant.

**Case C: \( \mu_d \) is related to \( y \) (fixed by the government)**

Suppose \( y \) is fixed by the government on the basis of the gap between the rates of inflation at home and abroad as follows:

\[
y = \theta p + w
\]  

(7.1)

where \( \theta \) is a positive coefficient and \( p \) is as defined above. Substituting (6.2) into (7.1) and solving for \( \mu_d \) give:

\[
\mu_d = \phi y + (\omega - \phi w)
\]  

(7.3)

where \( \phi = 1 / \theta \). Substituting (7.3) into (4.6) gives:

\[
x = \alpha_x + \delta_x y + [u_x - \beta_x (\omega - \phi w)]
\]  

(7.4)

---

27 In the short-run it is reasonable to assume \( d = p \), i.e. purchasing power parity holds, this means that the currencies of countries with relatively high inflation are expected to depreciate against currencies of low inflation countries. Gruen and Menzies (1995, p.163) observe: “Countries with relatively high inflation have relatively high long-term nominal interest rates and their currencies secularly depreciate against currencies of low inflation countries.”

28 In the short-run it is reasonable to assume \( d = p \), i.e. purchasing power parity holds, this means that the currencies of countries with relatively high inflation are expected to depreciate against currencies of low inflation countries. Gruen and Menzies (1995, p.163) observe: “Countries with relatively high inflation have relatively high long-term nominal interest rates and their currencies secularly depreciate against currencies of low inflation countries.”
where  
\[ \delta_x = 1 + \beta_x (1 - \varphi) \]  \hspace{1cm} (7.5) 

It can be seen from (7.5) \( \delta_x > 1 \) implies \( \theta < 1 \) (ie. conservative reaction by the government to inflation) and \( \delta_x < 1 \) implies \( \theta > 1 \) (ie. over-reaction by the government to inflation).

International capital flows: The role of un-hedged arbitrageurs

Let us now introduce \( k \), the rate of transaction costs per forward £ (supplied/demanded by the market participants). Frankel and Levich (1975, p.327) identify the following four component of transaction costs: (i) those associated with the sale of domestic securities, (ii) those associated with the purchase of foreign currency, (iii) those associated with the purchase of foreign securities and (iv) those associated with the sale of foreign currency (forward). The un-hedged arbitrageurs can be conceived as arbitrageurs who provide their own hedge.

For simplicity, let us assume that each agent has one £ to invest or sell in the forward market. An agent \( j \) with \( k_j > y-x > 0 \) \[ \text{or } x-d > y-(d+k_j) > 0 \] would invest in the UK his £ as an un-hedged arbitrageur rather than to sell it forward as a speculator, because his profit \( [y-(d+k_j)] \) as a speculator is less than his profit \( [x-d] \) as an un-hedged arbitrageur. In practice, the rate of transactions costs per forward £ is expected to vary quite considerably across individuals, as brokers and foreign exchange dealers tend to demand different fees/commissions from different clients, depending on volumes of the contracts, the frequencies of deals, financial backgrounds, etc. In other words, \( k_j \) varies across individual economic agents. For simplicity, let us assume that \( k_j \) has a normal distribution with mean \( \mu_k \) and variance \( \sigma_k^2 \) and let \( c = y-x \). The proportion of speculators investing as un-hedged arbitrageurs (ie. with \( k_j > c \)) is \( \Pr(k_j > c) = 1 - F_k(c) \), where \( F_k(c) \) is the proportion of agents with \( k_j < c \).

Let \( z_j = \frac{k_j - \mu_k}{\sigma_k} \) and \( z = \frac{c - \mu_k}{\sigma_k} \). Then \( z_j \) is a standard normal variable, ie. with zero mean and unit variance, and \( F_k(z) = F_k(c) \), i.e. \( \Pr(z_j < z) = \Pr(k_j < c) \). The amount \( Q \) of £ invested in the UK is equal to the proportion of speculators choosing to act as un-hedged arbitrageurs time the total number of speculators and is given by \( Q = (1 - F_k(z))N_s \), where \( N_s \) is the number of speculators. A decrease in \( c \) (ie. \( y-x \)) and an increase in \( \mu_k \) or \( \sigma_k^2 \) would decrease \( z \) and \( F_k(z) \) and would increase the capital inflow \( Q \) to the UK. [Note that the proportion of speculators acting as un-hedged arbitrageurs is 50%, if \( y-x = \mu_k \).]

In other words, while it pays hedged arbitrageurs to invest in the US because \( y-x > 0 \), it pays un-hedged arbitrageurs to invest in the UK because for them \( k_j > y-x \). In practice, each country with a current account deficit must obtain foreign loans and it is the un-hedged arbitrageurs who provide these loans. Without them, excess demand for foreign loans would have pushed \( x \) to a level above \( y \). The fact that this has not happened suggests that transaction costs are sufficiently high to allow a sufficiently large supply of un-hedged arbitraging funds.

V. Regression Results

Let us follow Stein (1965) and many previous studies to estimate equation (4.5) with the omission of a proxy for expected depreciation, \( \mu_d \). With the omission of \( \mu_d \), equation (4.5) can be written as follows:

\[ \delta_x = 1 + \beta_x (1 - \varphi) \leq 1 \] or \( \beta_x (1 - \varphi) \leq 0 \) or \( \varphi \geq 1 \), given \( \beta_x > 0 \).
\[ y = a + b x + u \]  
\[ (y-x) = a + B x + u \]

where \( B = b - 1 \) and \((y-x)\) is the negative of net covered yield (or covered interest differential). [Note that a positive \( B \) would indicate an inverse relationship between net covered yield and interest differential.] In fact, equation (9.2) is mathematically the same as equations (5.2) or (6.4) or the inverse form of equation (7.4). To test for CIP, previous studies would test the following hypotheses: (i) \( B = 0 \) and (ii) \( a = B = 0 \) simultaneously.\(^{30}\) For 1-month assets, the estimated values of \( B \) for Australia vs US, Australia vs Great Britain, Australia vs Canada, Australia vs New Zealand and Australia vs Japan are .143, .098, .101, .103 and .059 respectively, all are significant at .1%, with \( t \)-values in the range of 7.1 to 30.1 (see Table 1 for the results for other countries vs one another). For 3-month assets, the corresponding estimates are .106, .083, .047, .068 and .046 (ie. all are smaller than their counterparts for 1-month assets) but with higher \( t \)-values in the range of 10.1 to 37.4 (see Table 2 for further results for other countries). Since the DW statistics are low for some equations, suggesting autocorrelation, all the equations are re-estimated using Cochrane-Orcutt (GLS) procedure. The above conclusions basically remain the same, ie. that all the estimates are significantly greater than zero, suggesting that the coefficient of \( x \) in the regression of \( y \) on \( x \) is greater than unity (see Tables 3 and 4 for details of results). Thus, all the test results suggest the acceptance of the hypothesis that net covered yield varies inversely with interest differential and the rejection of CIP hypothesis. However, as shown in Section IV, the rejection of CIP is consistent with foreign market efficiency in the sense that every agent makes full use of information and profit opportunity available to him/her, given his/her particular expectations concerning exchange and political risks.\(^{31}\)

VI. Concluding Remarks

There is an extensive literature on the testing of the efficient market hypothesis (for the foreign exchange market) that prices fully reflect information available to market participants and that there are no opportunity for them to make super-normal profits, i.e. both speculative efficiency and arbitraging efficiency exist. The speculative efficiency hypothesis is the proposition that the expected rate of return to speculation in the forward foreign exchange market conditioned on available information is zero. The arbitraging efficiency hypothesis is the proposition that the expected rate of return to covered or uncovered interest arbitrage in the international capital market is zero. However, with transaction costs and exchange/political risk premia, it has been

---

\(^{30}\) Since \( E_u = 0 \); the hypothesis \( a = B = 0 \) is the same as the same as the hypothesis \( E(y-x) = 0 \), i.e. that net covered yield has a zero mean, a hypothesis which clearly does not hold for any country at all.

\(^{31}\) Although mathematically identical, a regression of \( y \) on \( x \) and a regression of \( x \) on \( y \) would necessarily produce two different estimates for the same coefficient (eg. \( \delta \)). The regression coefficient (\( b_{xy} \)) of \( x \) (with \( y \) as the dependent variable) is always smaller than the inverse of the regression coefficient (\( b_{yx} \)) of \( y \) (with \( x \) as the dependent variable), i.e. \( b_{xy} \leq 1/b_{yx} \) (unless \( y \) and \( x \) are perfectly correlated with each other) and the smaller is the correlation coefficient \( r^2 \) between \( y \) and \( x \), the larger is the difference between these two slopes, since \( b_{xy} = r^2/b_{yx} \) and \( r^2 \leq 1 \). Where \( r^2 \) falls significantly short of unity, it would matter greatly for the outcome of the test which of the two variables is treated as the dependent variable in the regression. However, since the \( r^2 \) in this study are very high (in the range of .93-.99) for all pairs of countries in our sample of data, it makes little difference to the results and no difference to the conclusions which regression is used. Therefore, the results for only one set of regressions (say of \( y \) on \( x \)) would be presented. The results for the regressions with \( y \) as the dependent variable are chosen because the majority of previous studies have done so.
shown that foreign exchange market efficiency does not imply covered or uncovered interest parity. In testing for speculative efficiency, many authors have adopted the null hypothesis that the forward discount is a good predictor of the (actual) change in the spot rate. It has been shown in Section IV that this hypothesis is equivalent to the joint hypothesis that CIP, UIP and RE all hold, so that if this hypothesis is not rejected, then there is no need to test for CIP, UIP or RE separately.

Adopting the assumption that market participants do not hold identical expectations concerning depreciation and political risk, this study derives the demand for and supply of forward exchange specified in the forward exchange market model specified by Stein (1967). Starting from a real life scenario with the interest rate being higher in the home than country (UK) than in the foreign country (US), but uncovered yield is negative so that arbitrageurs invest in the US, buying forward £, whereas the speculators sell the forward £. The underlying idea is that the greater is the forward discount, the greater is the proportion of speculators finding it profitable to sell forward £ and the smaller is the proportion of arbitrageurs finding it profitable to invest in the US and buy forward £, since the forward discount is paid by the arbitrageurs and received by the speculators in the forward deals. One interesting result of this model is that market efficiency does no longer require the fulfillment of UIP and/or CIP, even if there are no transaction costs. The model in this study is the same as that in Stein (1965), and the contribution of this paper lies in the provision of the rationale for its equations.

The scatter diagrams on two key variables (interest differential and forward discount) and the regressions results given in this study for 6 currencies for the periods January 82-June 96 (US, UK, Canada and Japan) and May 90-June 96 (Australia and New Zealand), indicate the following results: (a) while there is a very high correlation between the forward discount and the interest differential, CIP does not hold, because the forward discount tends to exceed the interest differential when both are positive and to fall short of the interest differential when both are negative (b) net covered yield has an opposite sign to the interest rate differential and (c) an increase the interest rate differential reduces rather than increases net covered yield. Since borrowing countries tend to have higher interest rates than lending countries, the above results can be cause for concern in the sense that borrowing countries are less attractive than lending countries for hedged-arbitrageurs to invest, and the raising of domestic interest rates by borrowing countries wishing to induce greater (net) capital inflows could have the opposite effect.

Result (c) above is rather surprising and does require some explanation. Section IV demonstrates three scenarios (i.e. Cases A, B and C) for this proposition. In Case A, it is postulated that the speculators react excessively to the interest rate differential when forming expectations concerning the currency depreciation, so that as the former is raised, the forward discount is raised even more, causing net covered yield to decrease instead of increasing.

In Case B, it is postulated that the government reacts conservatively to inflationary expectations, when fixing the domestic rate of interest. As expected inflation differential increases, the government raises the interest differential but by less than the expected increase in the inflation differential. By definition, the expected (nominal) depreciation is equal to the expected real depreciation plus the expected change in the inflation differential. Hence, given the expected real depreciation, an increase in the inflation differential would increase expected (nominal) depreciation by the same amount and this would mean that the expected (nominal) depreciation (and hence the forward discount) would increase by more than the interest differential, causing the net covered yield to fall in response to the increase in the interest differential.

In Case C, it is postulated that the government reacts excessively to inflationary expectations when it intervenes in the foreign exchange market to increase the forward discount in response to an increase in domestic inflation relative to foreign inflation. Again, with the real exchange rate assumed constant, the expected depreciation is equal to the expected increase in the inflation differential. This means that the forward discount increases by more than the expected
depreciation, causing an increase in the supply of forward £ by the speculators. Higher supply of forward £ would be absorbed by the arbitrageurs (to invest in the US) only if the net covered yield decreases, ie. only if the interest differential increases by less than the forward discount. Therefore, once again, it is possible to observe that as the interest differential rises, the forward discount rises by a larger quantity, causing net covered yield to decrease. In this case, what drives the system is the changes in the inflation differential, not the forward discount or the interest rate differential.

It is plausible for some governments and/or the speculators to over-react to news concerning inflationary expectations over some short periods of time but not for them to persistently do so over a long period of time. Since the finding that the covered interest differential varies inversely with uncovered interest differential holds for every pair of countries over a long time, ie. the whole sample period, the hypothesis of over-reactions either by the governments or by the agents does not appear plausible. The most plausible explanation appears to be that the governments generally fail to raise the interest rate differential enough to allow for inflation higher at home than abroad, causing the real interest differential and hence the covered interest differential to deteriorate.

Consider the home country (UK) with a current account deficit and a positive interest differential (x>0) but a negative net covered yield (x-y<0), so that hedged arbitrageurs have the incentives to move funds away from the UK. It has been shown in Section IV that there are speculators (with sufficiently large transaction costs, ie. k_i>y-x>0) who would find it more profitable to invest in the UK without hedge than to supply forward £. This is because the profit from the former, x-d, exceeds that from the latter, y-(d+k). The fact that y is greater than x could suggest that transaction costs are large enough for the inflow of funds by the un-hedged speculators to exceed the outflow of funds by the hedged arbitrageurs, resulting in a net inflow of funds.

In short, the existence of the transaction costs and the pool of un-hedged speculators is the prime reason for capital flows to respond to the interest differential in the manner postulated in the Mundell-Flemming model. The fact that net covered yield has the opposite sign to interest differential and varies inversely with the latter could be reconciled with the prediction of the Mundell-Flemming model concerning international capital movements, once the role of un-hedged arbitrageurs and the existence of transaction costs are recognized.
APPENDIX A

The Forward Market Model With Transaction Costs

Consider first an outflow of covered arbitrage funds from New York (the foreign market) to London (the domestic market). The cost ($C_O$) associated with a capital outflow of the amount $Q$ is the foregone earnings on the holdings of £-securities (domestic securities):

$$ C_O = Q (1+i) \quad (A1) $$

The revenue ($R_O$) derived from a covered investment of these funds in comparable £-securities (foreign securities) is:

$$ R_O = K_{H} Q(1+i*) \frac{F}{S} \quad (A2) $$

where $K_{H} = 1 - tc$; $tc = $ total transaction costs. Consider next an inflow of covered arbitrage funds from London to New York. The cost ($C_I$) associated with a capital inflow of the amount $Q$ is the foregone earnings on the holdings of £-securities:

$$ C_I = Q (1+i*) \frac{S}{F} \quad (A3) $$

The revenue derived from a covered investment of these funds in comparable £-securities is:

$$ R_I = K_{H} Q(1+i) \quad (A4) $$

The covered interest parity (CIP) condition for an absence of profit incentive for hedgers to move funds, in the case of an outflow, is obtained by equating $C_O$ and $R_O$ to give:

$$ \frac{1+i}{1+i*} = K_{H} \frac{F}{S} \quad (A5) $$

whose logarithm form is:

$$ x = y + k \quad (A6) $$

where $x = \log(1+i) - \log(1+i*)$ and $y = \log(F) - \log(S)$ are the interest differential and the forward discount respectively and $k_H = \log(K_H) < 0$, since $K_H < 1$. Thus, the marginal outflow of arbitrage funds is profitable only if $y > y_1$, where

$$ y_1 = x - k_H \quad (A7) $$

is the lower limit on $y$. For an inflow, by equating $C_I$ and $R_I$ and using similar reasoning, it can be shown that the marginal inflow of arbitrage funds is profitable only if $y < y_2$, where

$$ y_2 = x + k_H \quad (A8) $$

is the upper limit on $y$. For $y$ in the range $y_2 < y < y_1$, both marginal outflow and inflow of funds are unprofitable ($y_2 < y_1$, since $k < 0$). Thus, with the presence of transaction costs, the amount of forward exchange demanded or supplied by hedgers becomes:

$$ H = h_i(x - y - k_H), \quad \text{for } y > y_1 \quad \text{and} \quad H = h_i(y - x - k_H), \quad \text{for } y < y_2. $$

Again, by similar reasoning, we can obtain $G = g_i(d - y - k_G)$ for $d > y$ and $G = g_i(y - d - k_G)$ for $d < y$. It is possible that $k_G$ and $k_H$ vary across the speculators and hedgers respectively. If so, we can equate them to $\bar{k}_G + e_G$ and $\bar{k}_H + e_H$, where $\bar{k}_G$ and $\bar{k}_H$ are their means and $e_G$ and $e_H$ are random variables with zero means. Substituting these into the hedgers’ demand and the speculators’ supply equations gives

$$ H = (h_i \bar{k}_H) + h_i(x - y) + h_i e_H \quad \text{and} \quad G = (g_i \bar{k}_G) + h_i(d - y) + g_i e_G $$

respectively. The fact that $k_G$ and $k_H$ are stochastic essentially makes little difference to these relationships or the results.
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FIGURE 1.1
Monthly Rate of Change of Spot Rate & Forward Margin:
US Dollar vs British Pound
(One Month Moving Averages)

FIGURE 1.2
Monthly Rate of Change of Spot Rate & Forward Discount
US Dollar vs Canadian Dollar
(One-Month Moving Averages)
FIGURE 1.3
Monthly Rate of Change of Spot Rate & Forward Discount
US Dollar vs Japanese Yen
(One-Month Moving Averages)

FIGURE 1.4
Monthly Rate of Change of Spot Rate & Forward Discount
US Dollar vs Australian Dollar
(One-Month Moving Averages)
FIGURE 1.5
Monthly Rate of Change of Spot Rate & Forward Discount
US Dollar vs New Zealand Dollar
(One-Month Moving Averages)

Figure 1.6
Spot Exchange Rates of Various Currencies vs US$
GBP=British Pounds; CAD=Canadian $; AUD=Australian $;
NZD=New Zealand $; JPYI=Japanese Yen (Index)
FIGURE 2.1
Forward Discount & Interest Differential:
US Dollars vs British Pound Sterling
(One-Month Moving Averages)
FIGURE 2.2
Forward Discount & Interest Differential: US Dollars vs Canadian Dollars (One-Month Moving Averages)
FIGURE 2.3
Forward Discount & Interest Differential:
US Dollars vs Japanese Yen
(One-Month Moving Averages)
FIGURE 2.4
Forward Discount & Interest Differential:
US Dollars vs Australian Dollars
(One-Month Moving Averages)
FIGURE 2.5
Forward Discount & Interest Differential: US Dollars vs New Zealand Dollars (One-Month Moving Averages)
FIGURE 3.1
Scatter Plot of Forward Discount vs Interest Differential:
US Dollar vs British Pound
(One-Month Moving Averages)

FIGURE 3.2
Scatter Plot of Forward Discount vs Interest Differential:
US Dollars vs Canadian Dollars
(One-Month Moving Averages)
FIGURE 3.3
Scatter Plot of Forward Discount vs Interest Differential:
US Dollar vs Japanese Yen
(One-Month Moving Averages)

FIGURE 3.4
Scatter Plot of Forward Discount vs Interest Differential:
US Dollar vs Australian Dollar
(One-Month Moving Averages)
FIGURE 3.5
Scatter Plot of Forward Discount vs Interest Differential:
US Dollars vs New Zealand Dollars
(One-Month Moving Averages)
### TABLE 1

**Relationship between Forward Discount (FD) & Interest Differential**

*(For 1-month assets)*

<table>
<thead>
<tr>
<th></th>
<th>AU</th>
<th>US</th>
<th>GB</th>
<th>CA</th>
<th>NZ</th>
<th>JP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OLS Results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log FD = a + b log ID; A = exp(a); B=b-1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AU B</strong></td>
<td>0.14256</td>
<td>0.09841</td>
<td>0.10099</td>
<td>0.10306</td>
<td>0.05877</td>
<td></td>
</tr>
<tr>
<td>t-val</td>
<td>(30.85)</td>
<td>(22.05)</td>
<td>(16.20)</td>
<td>(14.09)</td>
<td>(14.95)</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.99991</td>
<td>0.99982</td>
<td>0.99991</td>
<td>1.00005</td>
<td>0.99961</td>
<td></td>
</tr>
<tr>
<td>t-val</td>
<td>(9.31)</td>
<td>(29.08)</td>
<td>(15.13)</td>
<td>(7.14)</td>
<td>(30.06)</td>
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1. The number in brackets under each intercept (A) is the (absolute value of the) t-value of
   the log of the intercept. It provides a t-test for the hypothesis that A is equal to zero.
2. All the elasticities are significantly greater than unity, i.e. a 1% increase in the interest
differential(ID) will lead to more than 1% increase in the forward discount(FD).
3. All DW’s, except for AU vs NZ, indicate that there is evidence of autocorrelation at 1%.
### TABLE 2

**Relationship between Forward Discount (FD) & Interest Differential**

(For 3-month assets)

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1. The number in brackets under each intercept (A) is the (absolute value of the) t-value of the log of the intercept. It provides a t-test for the hypothesis that A is equal to zero.

2. All the elasticities are significantly greater than unity, i.e. a 1% increase in the interest differential(ID) will lead to more than 1% increase in the forward discount(FD).

3. All DW's, except for GB vs US&CA, indicate that there is evidence of autocorrelation at 1%. 

---

**Notes:**

- **AU**: Australia
- **US**: United States
- **GB**: United Kingdom
- **CA**: Canada
- **NZ**: New Zealand
- **JP**: Japan
### TABLE 3

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1. Both R² and DW are for original data.
2. All the elasticities are significantly greater than unity, i.e. a 1% increase in the interest differential(ID) will lead to more than 1% increase in the forward discount(FD).
3. All DW’s indicate that there is no evidence of autocorrelation at 1%.
### TABLE 4
Relationship between Forward Discount (FD) & Interest Differential (For 3-month assets)

Results, using Cochrane-Orcutt method to deal with autocorrelation

\[ \log FD = a + b \log ID; \quad B = b - 1. \]

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1. Both R2 and DW are for original data.
2. All the elasticities are significantly greater than unity, i.e. a 1% increase in the interest differential(ID) will lead to more than 1% increase in the forward discount(FD).
3. All DW's, except for JP vs AU&CA, indicate no evidence of autocorrelation at 1%.
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