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MARKET EFFICIENCY AND SPECULATIVE ACTIVITY IN THE FOREIGN EXCHANGE MARKET

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MARKET EFFICIENCY AND SPECULATIVE ACTIVITY IN THE FOREIGN EXCHANGE MARKET

By

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ABSTRACT

MARKET EFFICIENCY AND SPECULATIVE
ACTIVITY IN THE FOREIGN
EXCHANGE MARKET

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This dissertation examines market efficiency in the context of foreign exchange markets as this concept has been employed to date. The necessary conditions for efficiency to hold in all markets are derived. It is found that it is unlikely that all conditions hold simultaneously. Three alternative models of foreign exchange pricing are developed which invoke the efficiency concept. The necessary conditions in these cases are deemed more viable.

In the first model developed, risk neutral behavior on the part of speculators ensures efficiency in all markets. It is found that opportunities never arise for covered interest arbitrageurs. Also, in order that efficiency holds through time it must be that expectations of tomorrow's price incorporates expectations of prices expected to prevail through all future periods.

A second model of foreign exchange market

determination is derived which assumes risk averse behavior on the part of market participants. When both spot and forward exchange risk are present the following relationships are found to emerge. The interest rate parity condition cannot hold. Spot speculation will contribute more risk to the investors portfolio than forward speculation despite the fact that the latter form of speculation includes two sources of risk and the former only one. It is also found that the inclusion of transactions costs will not alter the relative relationships. Lastly, it is verified that prices in an efficient market will underestimate expectations of future prices if investors are risk averse or if transactions costs are present.

Finally, a model explicitly using expectations of prices expected to prevail for a series of future periods is developed. The coefficients with respect to the different time periods tend to be inversely related to the period for which that expectation is relevant. A policy implication of this formulation is that the official authorities have some influence in regard to "managing the float". However, a contradiction arises. To be effective for an extended period of time without intervening directly during each and every period, it is necessary that policymakers alter expectations of prices expected to prevail at some distant period, say t+j. The policy shock will be magnified as time passes, having its maximum effect during the period t+j-1. At t+j its effect will be reduced to zero. Hence, intervention may tend to make exchange rate fluctuations more volatile ultimately resulting in the opposite of what exchange rate management is purported to accomplish.

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INTRODUCTION

The purpose of this thesis is to deal with the subject of foreign exchange market efficiency. In the first chapter various definitions of market efficiency are presented. These definitions may be categorized in the following manner. On the one hand, we may characterize a market as efficient subject to the type of equilibrium return that is expected to prevail. Alternatively, a market may be said to exhibit a particular degree of efficiency according to the subset of information that is ultimately reflected in prices. The remainder of Chapter One completes the review of the literature. This includes categorizing the many interpretations that have been given to efficiency as this concept relates specifically to the foreign exchange market.

In Chapter Two an examination of the major interpretations of foreign exchange market efficiency is conducted. We attempt to seek answers to the following questions. Are the major interpretations of exchange market efficiency consistent with one another? If they are not, under what conditions can inconsistencies be reconciled with one another? What assumptions remain hidden behind the interpretations of foreign exchange market efficiency? Are these assumptions realistic?

In the third chapter of this thesis we deal with the issue of foreign exchange market efficiency in an alternative manner. As opposed to using a partial equilibrium approach, a general equilibrium approach is used. A simple model of exchange rate determination is presented. In this model spot and forward rates of exchange are simultaneously determined. We find that in this model, the conditions for efficiency in the foreign exchange market are easily found. By making a few modifications of the behavior assumptions regarding the activities of market participants we can easily derive a consistent model of exchange rate determination which insures efficiency in all markets.

Three major results are derived in this chapter. First, covered interest arbitrageurs need never participate in the market. Secondly, expectations of future exchange rates incorporate expectations of all future interest rates as well as future spot prices. The third conclusion is that the forward rate is an unbiased predictor of the future spot price.

The model of exchange rate determination of Chapter Three is deficient in one respect. This model assumes that investors and speculators are risk neutral. It is suggested that such an assumption may not coincide with actual behavior. The purpose of Chapter Four is to build a model that assumes risk aversion on the part of market participants, and is also consistent with respect to the efficiency concept. The Sharp-Linter capital asset pricing model is used to accomplish this.

Three different variants of the "internationalized" capital asset pricing model are presented. In the first instance only one form of risk is incurred. We find that when assets are risky only in regard to the uncertainty of future exchange rates, it must be that the expected return from engaging in a spot transaction is identical to that when engaging in a forward transaction. It is also found that covered interest parity holds exactly. These results are similar, though not identical, to the results obtained in the model assuming risk neutral behavior.

In the second model we allow for the existence of forward exchange risk. In this instance we prove that forward transactions are less risky than spot transactions and that interest rate parity does not hold exactly. Another result is that a forward bias exists. The forward rate is negatively biased with respect to the expected future spot price. Margin requirements are imposed in the third model. It is found that the incorporation of transactions costs does not alter the general results.

In the fifth chapter of this thesis we use results from the previous four chapters to build an alternative model of exchange rate determination. It is suggested that a sequence of expected future prices is most appropriate for describing current exchange rates. Coefficients describing the relative importance of these variables are derived using the results from Chapter Four. It is suggested that a testable model is easily derived. Forward prices, adjusted for biases that may exist can easily be used as estimators of future expectations.

The final contribution of Chapter Five is to point out the similarities, differences, and improvements of our model with respect to the asset approach to exchange rate determination. Our model is similar to that using the asset approach in that expectations play a major role in exchange rate determination. Our model differs in that we need not assume rational expectations. Expectations of this form automatically result. A major improvement is that the coefficients decline in value with time as a result of sound economic theory. This contrasts with the common practice of assuming such a "weighing scheme".

In Chapter Six we investigate the policy implications of foreign exchange market efficiency. We attempt to answer the following questions. Can policymakers alter exchange rates so that they do not correspond to their "true" values? Which methods for intervention are most useful? How effective are these tools? Is it necessary for policymakers to intervene continuously or will a one period alteration be self-sustaining for an extended period of time?

The conclusion to this dissertation summarizes the contributions of this study.

CHAPTER ONE

REVIEW OF THE LITERATURE

Introduction

The intent of this chapter is to convey two major points. The first point is a definition of the efficient market hypothesis (EMH). The second point regards its role in the foreign exchange market literature. We begin the analysis of efficiency by presenting an intuitive explanation of this concept. Next, more formal definitions of the efficient market hypothesis are reviewed. These definitions fall into two major groups. Markets may be regarded as efficient subject to the nature of expected equilibrium returns. Alternatively, markets may exhibit varying degrees of efficiency subject to the subset of information being reflected in final equilibrium values.

In part B of this chapter we review the concept of efficiency as it pertains to the foreign exchange market. Though the major econometric tests concerning the EMH are presented, we do not dwell on the statistical methods employed. Review of the existing theoretical and empirical literature serves to highlight the major interpretations that have been developed in regard to foreign exchange market efficiency. The results of this chapter are used as a basis for a critique of the existing interpretations of foreign exchange market efficiency, the subject of Chapter Two.

A. Definition of an Efficient Market

Before developing a rigorous definition of the EMH, it might be useful to intuit this concept. In an efficient market, prices fully reflect the available information.[1] This results from the premise that market participants use all available information while conducting transactions. This information is used to formulate expectations regarding future prices. Hence, under rational behavior, today's price will be set such that it closely resembles tomorrow's expected price and no "unusual" profit opportunities remain unexploited. If this is not the case, if today's equilibrium price does not reflect tomorrow's expected price, "unusual" profit opportunities remain. All information is not being reflected in prices. By definition the market is not efficient.

The above points to two basic statements that can be made concerning efficiency. In an efficient market, prices are such that no "unusual" profit opportunities remain unexploited. Furthermore, expectations of future prices are reflected in today's price. The first statement implies that certain technical conditions must be satisfied if a market is to be efficient. The second statement characterizes the EMH as being derived from asset market theory.[2] Both approaches to efficiency prove to be useful in our analysis.

Using the technical approach, efficiency implies the elimination of unusual profit opportunities. It follows that on average, returns in excess of those expected are zero. Let $E_t(\tilde{R}_{t+1}|\phi_t)$ be the expected return in time period t+1 given the information available at time t. If R_{t+1} is the actual return realized in period t+1 then we would require in an efficient market that:

$$(1) \qquad E\{\tilde{Z}_t\} = E\{R_{t+1} - E_t(\tilde{R}_{t+1}|\phi_t)\} = 0$$

where E the expectations operator

ϕ_t the information available at time t

$\sim$ indicates a random variable

In addition it is necessary that the Z_t's are serially uncorrelated. This amounts to requiring that the sequence of excess returns $\{Z_t\}$, follows a fair game with respect to the information sequence $\{\phi_t\}$ for efficiency in the market.[3]

Intuitively, the market will set today's price such that no unusual profit opportunities remain unexploited given the information at hand at time t. Hence today's price is set conditional on tomorrow's expected price, allowing for a fair return. This does not preclude the possibility that tomorrow's actual price (P_{t+1}) deviate from the expected price ($E_t[\tilde{P}_{t+1}|\phi_t]$). This may result from new information that becomes available at time t+1. However, new information must be random, otherwise it is not new. It follows then that deviations of actual prices from expected prices are also random and on average sum to zero. It is therefore argued that deviations of actual returns from expected returns will also be characterized by an expectation of zero, hence $E\{R_{t+1} - E(\tilde{R}_{t+1}|\phi_t)\} = 0$.

We have established that in an efficient market prices are set such that market participants expect at the margin to earn a fair though not an "unusual" return. Before characterizing a market as efficient or not, it is necessary to specify the exact nature of this fair return. Once we have done so, we can by examining sequences of prices establish whether in fact the market behaves as posited in equation (1). Richard Levich points out the joint hypothesis problem that arises from this.[4] When one looks for evidence to accept or reject the EMH, one is in fact testing a joint hypothesis. On the one hand, a specific market equilibrium condition (expected fair return) is posited. Secondly, conditions for market efficiency in a technical sense are being tested.

Following are examples of differing market equilibrium conditions that may be posited.[5] If expected returns are positive, then:

$$(2) \qquad E_t(\tilde{R}_{t+1}|\phi_t) = \frac{E_t(\tilde{P}_{t+1}|\phi_t) - P_t}{P_t} > 0 \ .$$

Given that the market determines P_t in the manner just described, it must be true for market efficiency that the sequence of excess returns, $\{Z_t\}$, follows a fair game with respect to the information set, $\{\phi_t\}$. That is:

$$(3) \qquad E(\tilde{Z}_t) = E\{R_{t+1} - E_t(\tilde{R}_{t+1}|\phi_t)\} = 0 \ .$$

Substituting equation (2) into (3) we find that:

$$E(\tilde{Z}_t) = E\{\frac{P_{t+1} - P_t}{P_t} - \frac{E_t(\tilde{P}_{t+1}|\phi_t) - P_t}{P_t}\} = 0$$

or

$$(4) \qquad E(\tilde{Z}_t) = E\{\frac{P_{t+1} - E_t(\tilde{P}_{t+1}|\phi_t)}{P_t}\} = 0$$

Since we do not observe $E_t(\tilde{P}_{t+1}|\phi_t)$ we must hypothesize its nature.

An alternative hypothesis concerning equilibrium expected returns is that they are constant.

$$(5) \qquad E_t(\tilde{R}_{t+1}|\phi_t) = \frac{E_t(\tilde{P}_{t+1}|\phi_t) - P_t}{P_t} = \alpha$$

where α is a nonnegative constant.

The EMH claims that the sequence of excess returns, defined as:

$$(6) \qquad \{Z_t\} = \{\tilde{R}_{t+i} - \alpha\}$$

for $i = 1,2,3,\ldots$

has an expected value of zero and is serially uncorrelated. Once again, by the substitution of (5) into (6) we claim that for efficiency to hold:

$$E\{\tilde{Z}_t\} = E\{\frac{P_{t+1} - P_t}{P_t} - \frac{E_t(\tilde{P}_{t+1}|\phi_t) - P_t}{P_t}\} = 0$$

or

$$E\{\tilde{Z}_t\} = E\{\frac{P_{t+1} - E_t(\tilde{P}_{t+1}|\phi_t)}{P_t}\} = 0 \quad .$$

Hence tests of the EMH should be viewed with skepticism. If tests do not reject the hypothesis it is possible that in fact the market is not efficient since the equilibrium condition has been misspecified. If efficiency is rejected, it can on the other hand be argued that the market is truly efficient but again a misspecified market equilibrium condition is the cause of rejection.

Keeping in mind the issue of jointness, we will review the different manners by which we may expect sequences of prices to behave in a market characterized by efficiency. One common formulation is that of a random walk.

Using Giddy and Duffey's[6] formulation, a formal statement of the random walk may proceed as follows:

$$(7) \qquad E_t(P_{t+1}|G_t) = E(P_{t+1}|\phi_t) = P_{t+1}$$

where G_t is the series of present and past information. This information is specifically, present and past prices for this market, i.e. P_t, P_{t-1}, $P_{t-2}, \ldots$

ϕ_t is all publically available information at time t.

E_t is the expectations operator.

Letting $R_{t+1} = \ln P_{t+1} - \ln P_t$, equation (7) implies that:

$$(8) \quad E_t(\tilde{R}_{t+1} | G_t) = E_t(\tilde{R}_{t+1} | \phi_t) = 0$$

The random walk, further requires that the $\tilde{R}_t$'s are serially independent and identically distributed. Hence $E(\tilde{R}_t) = 0$ and $COV(\tilde{R}_t, \tilde{R}_{t-j}) = 0$ for all $j \neq 0$.

The argument in favor of using a random walk is explained by Roll.[7]

> When a market is competitive in the classic sense, every trader has perfect information and serial dependence in price changes is immediately discovered. Serial dependence in price changes implies that costless mechanical trading rules earn positive profits. But economic profits cannot persist in a competitive market. If such profits should arise, they will soon be erased, along with their cause (the serial dependence), by competition.

The random walk is more restrictive than the submartingale, as defined below. Mandelbrot[8] notes that mechanical trading rules will not be profitable even if prices follow a submartingale. Hence, as Roll[9] points out, we should not expect a stronger condition to hold when a weaker suffices. The submartingale claims the following:

$$(9) \quad E(\tilde{P}_{t+1} | G_t) = E(\tilde{P}_{t+1} | \phi_t) \gtrless P_t$$

and so

$$(10) \quad E(\tilde{R}_{t+1}|G_t) = E(\tilde{R}_{t+1}|\phi_t) \gtreqless 0 \quad .$$

The submartingale differs from the random walk in that it is no longer necessary to assume that the $\tilde{R}_t$'s follow any particular distribution and that they are identically distributed. We need only posit that a finite variance for $\tilde{R}_t$ exists.

A special case of the submartingale is the martingale, which merely states that (9) holds with an equality. That is:

$$(11) \quad E(\tilde{P}_{t+1}|G_t) = E(\tilde{P}_{t+1}|\phi_t) = P_t \quad .$$

Often efficient markets are characterized by the specific subset of information being reflected in prices. In a sense, differing "magnitudes" of efficiency are being defined.[10] In a weakly efficient market, the relevant subset of information is the set of past prices. A semi-strongly efficient market uses all publically available information to determine today's equilibrium price. By contrast, a market characterized by numbers of individuals with priviledged information, and hence marked by monopolistic elements, is a strongly efficient market.

It should be noted that the statement that prices reflect all information has been proven inconsistent by Grossman and Stiglitz.[11] Information is not costless. If prices should contain all available information, the individuals who gathered the information (and thus paid a price) would not be compensated for their activities. Consequently, there is no incentive for traders to gather information. Hence how can the market price be informationally efficient? They conclude that costless information is a necessary condition for efficiency to hold.

B. Interpretations of Market Efficiency in the Foreign Exchange Market

A voluminous set of literature on testing the EMH with respect to the foreign exchange market exists.[12] Though general test results will be presented, the purpose of this chapter and those to follow is not to accept or reject the concept of efficiency on the basis of empirical work. The purpose of this study is to investigate the various interpretations that have been given to the concept of efficiency in the foreign exchange market.

Presentation of interpretations will proceed as follows. First we shall discern the major conclusions derived with respect to behavior of spot prices. Next we shall concern ourselves with expected relationships between spot and forward prices. The last conclusions to be drawn are those that describe the behavior of prices in ways that do not fall into the above two categories.

Spot Market Efficiency

The most common interpretation of spot market efficiency is to claim that spot prices follow a random walk. The reasoning used to arrive at this conclusion is as follows.[13] If speculators are rational they will attempt to set today's price so that it is identical to tomorrow's expected price, presumably so that no unexploited profit opportunities remain. Hence, successive spot prices should change only as a result of new information concerning the expected values of future prices. New information is unpredictable and is independent of past information. It follows then that price changes are random and serially uncorrelated. In essence, it is being claimed that equilibrium returns are zero, and that given that such is the case, in an efficient market we would observe that successive prices follow a random walk.

To test for serial dependence in price changes, filter tests are often conducted. Filter tests[14] discern whether mechanical trading rules can be used to earn profits in the market. One attempts to find a rule which claims that buying when spot prices rise by X percent from a trough and selling when they fall by X percent from a peak will earn positive profits. Poole, by conducting filter in addition to other tests of serial correlation finds evidence to reject the random walk model for spot exchange. He suggests that this might result partly from transactions costs. Also, regarding whether filter rules can be of help, it should be noted that rules need be discerned ex-ante.[15] Using tests we discern them ex-post. It is possible that rules often change and hence speculators cannot easily earn profits if they cannot find the correct filter before the fact. Burt, Kaen and Booth,[16] find that serial dependence exists for the Canadian dollar but accept the random walk hypothesis for the British pound and the German mark.

Perhaps of greater concern for the acceptance or rejection of the EMH is the question concerning whether spot prices follow a submartingale. A variety of tests have been conducted with the submartingale in mind. Recall that each version is presupposing a specific equilibrium expected return. Most tests are close in spirit to those proposed by Giddy and Duffey.[17] In one formulation, they suggest that the following relationship holds:

$$(12) \qquad \frac{E_t(\tilde{S}_{t+1}|\phi_t) - S_t}{S_t} = i_{\$,t} - i_{X,t}$$

where $i_{\$,t}$ and $i_{X,t}$ are the one period interest rates in the two countries under consideration.

Presumably, differential nominal interest rates measure differential expected inflation rates given that nominal rates are composed of the real interest rate and expected inflation rates. The exchange rate is expected to depreciate or appreciate directly in relation to differential price level movements.

Giddy and Duffey also proposed testing for a martingale, under the assumption that equilibrium expected returns could be zero. Assuming a martingale, the following relationship would be observed:

$$(13) \quad \frac{E_t(\tilde{S}_{t+1}|\phi_t) - S_t}{S_t} = 0 \; .$$

It was found that both models fit the data well, and therefore one could not be considered more accurate than the other.

To conclude, some writers feel that for spot market efficiency to exist, it must be that prices follow a submartingale. Though often a random walk is specified, the random walk is really just a special case of the submartingale and the general consensus is that a stronger condition is unnecessary when a weaker one will do as well. It suffices that spot prices follow some version of the submartingale. Hence we might expect that the best predictor of tomorrow's spot price is today's price, or some predetermined function of that price. In other words we expect that:

$$(14) \quad E_t(\tilde{S}_{t+1}|\phi_t) = S_t$$

or

$$(15) \quad E_t(\tilde{S}_{t+1}|\phi_t) = S_t f(X)$$

where $f(X)$ specifies a particular equilibrium return relationship, for example, accounting for differential interest rates for the two countries under consideration, as in Giddy and Duffey's formulation of equation (12) above.

Forward Market Efficiency

In regard to forward market efficiency, many writers have claimed that forward prices are unbiased estimator of future spot rates. Hence the following relationship would be expected to prevail:

$$(16) \quad S_t = a + bF_{t-1,t} + \mu_t$$

where S_t is the spot price at time t,

$F_{t-1,t}$ is the forward price set a t-1 for delivery at t,

μ_t's are serially uncorrelated,

and a and b are not significantly different from zero and unity respectively.[18] It has been argued that if a bias does exist, all profit opportunities have not been exploited and hence the conditions for market efficiency do not exist.

Levich[19] documents fourteen tests of this form. For the most part, it appears that the forward rate is a biased predictor of the future spot price.[20] Note however, that biasedness should not be taken *a priori* as evidence of inefficiency. If risk is systematic, then a risk premium might be consistent with a forward bias and not necessarily indicative of inefficiency.[21] One must take care to not allow an incorrectly specified equilibrium condition disprove efficiency if such a conclusion is unwarranted.

In general, proponents of unbiasedness claim that forward prices correctly reflect expectations of future prices. Moreover, these expectations are on average realized. Hence: $F_{t-1,t} = E_{t-1}(\tilde{S}_t | \phi_{t-1})$ and so on average, $E_{t-1}(\tilde{S}_t | \theta_{t-1}) = S_t$.

Geweke and Feige[22] approach the efficiency of forward markets in a novel way. They propose that as with spot prices, forward prices should follow a martingale. However, they also suggest that one seeks for multimarket efficiency. This is distinguished from single market efficiency in that the information being reflected in prices encompasses more variables. Specifically, the test for multimarket efficiency involves examining the following:

(17) $E(q_t^i | q_{t-1}^j, q_{t-2}^j, \ldots)$ for $j = i, 1, \ldots, N$

where $q_t^i = \dfrac{S_t^i - F_{t-1,t}^i}{S_{t-1}^i}$,

i is the \$/i exchange rate,

j is the \$/j exchange rate.

In other words, Geweke and Feige reason that the dollar/pound exchange rate will depend not only on information concerning the dollar and the pound, but also in information regarding the dollar in relation to the yen, lira, etc.

A test of single market efficiency would on the other hand involve testing the following form:

(18) $E(q_t^i | q_{t-1}^i, q_{t-2}^i, \ldots)$.

In this case, the conditional variables or the information set is a subset of those used in equation (17). It includes $/i but ignores $/j exchange rates.

Geweke and Feige in regard to their econometric results conclude that the efficiency hypothesis must be rejected. They hypothesize that rejection is a result of the existence of transactions costs and risk averse behavior.

Other Forms of Efficiency

Often it is claimed that in an efficient foreign exchange market, the interest rate parity condition ought to hold.[23] Pursuing covered interest arbitrage opportunities is essentially riskless, thus equilibrium expected returns in excess of transactions costs should not exist in an efficient market.[24] In every period the following should approximately hold:

(19) $$\frac{F-S}{S} - \frac{r_a - r_b}{1-r_b} = d = 0$$

where r_a is the n period domestic nominal interest rate prevailing at time t,

r_b is the n period foreign nominal interest rate prevailing at time t,

S is spot price at time t,

F is the forward price set at t for delivery at t+n.

Deviations from interest parity (d), should be zero in every period, or in the presence of transactions costs not exceed these costs.

In general, results from such tests are ambiguous. Frenkel and Levich[25] find with respect to Euro-currencies, interest rate parity is accurate. For other markets, they find the results to be less promising. Presumably, this is because political risk, absent in Euro-currency transactions, is an important factor with respect to less integrated markets.

C. Conclusions

In this chapter we covered two major points. We reviewed the theoretical literature regarding the efficient market hypothesis. Both formal and informal analyses of market efficiency were presented. It was noted that when one seeks for evidence of efficiency, or inefficiency it is necessary that the joint hypothesis problem not be ignored. What may seem as evidence to accept or reject the hypothesis of efficiency must be dealt with cautiously. This is because it may be that equilibrium returns are expressed incorrectly. A true test of the theory has not been conducted.

In addition we reviewed the ways by which the EMH has been interpreted in the foreign exchange market literature. Efficiency has been dealt with on various levels and with respect to differing sets of prices.

Efficiency has been interpreted as implying that sequences of spot prices behave in particular manners. Efficiency has also been taken as establishing particular relationships between current spot and past forward rates. Also, other particular equilibrium relationships are claimed to hold in an efficient foreign exchange market such as the interest rate parity relationship.

The review of the existing literature, as presented in this chapter does not pretend to be exhaustive. It is felt that the major themes of foreign exchange market efficiency have been presented. With this in hand we are ready to pursue a critique of these developments, the subject of Chapter Two.

CHAPTER TWO

CRITIQUE OF THE THEORY

Introduction

The purpose of this chapter is to investigate further foreign exchange market efficiency. Most often a segmented approach is used when studying this issue. It might be claimed, for instance, that spot prices need behave in a particular manner while forward prices follow some other rule. Often these hypotheses are inconsistent with one another. It is not possible that both be true at the same time.

In the sections to follow, we shall be examining various interpretations of market efficiency. In our analysis we shall attempt to uncover the necessary conditions that need hold so that the interpretations be consistent with one another. If these conditions cannot be expected to prevail, then it will be argued that something is lacking in the theory of efficiency of foreign exchange markets as it has evolved to date. If individual market participants can discern inconsistencies there exists ways to "beat the system" to obtain "unusual" profits. Following are four versions of the theory of foreign exchange market efficiency. This is not an exhaustive list, but conclusions regarding the inadequacies of the current theory are nonetheless derived.

A. Four Versions of Foreign Exchange Market Efficiency

Model 1

It was concluded in the previous chapter that it is often stated that spot prices of forward exchange under the EMH will follow a martingale sequence.[1] Expected returns for engaging in further spot transactions yield no additional returns.

$$(1) \qquad \frac{E_t(\tilde{S}_{t+1}|\phi_t) - S_t}{S_t} = 0$$

This implies that today's equilibrium spot price is identical to tomorrow's expected spot price, or

$$(2) \qquad S_t = E_t(\tilde{S}_{t+1}|\phi_t) \quad .$$

The above hypothesis assumes that transactions costs are zero and that individuals do not expect to be compensated for risks they incur when engaging in spot speculative transactions.

Following the same type of reasoning and maintaining the assumptions of no transactions costs and zero compensation for risk we can expect the forward price of foreign exchange to be set to reflect tomorrow's expected spot price.

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The above hypothesis assumes that transactions costs are zero and that individuals do not expect to be compensated for risks they incur when engaging in spot speculative transactions.

Following the same type of reasoning and maintaining the assumptions of no transactions costs and zero compensation for risk we can expect the forward price of foreign exchange to be set to reflect tomorrow's expected spot price.

$$(3) \qquad F_{t,t+1} = E_t(\tilde{S}_{t+1}|\phi_t) \ .$$

To complete the analysis we might add that the interest parity condition must hold.[2] Again, this assumes that there are no transactions costs. In addition individuals are not being compensated for "political risk", the risk that exchange controls may be imposed to render incomplete or partial inconvertibility of holding of foreign currency. Under interest rate parity we could expect (4) to hold.

$$(4) \qquad \frac{F_{t,t+1}}{S_t} = \frac{1+r_a}{1+r_b}$$

Now examine the three propositions together. Under what conditions can all three be expected to prevail? By substituting (2) and (3) into the left-hand side of (4) we find the following:

$$(5) \qquad \frac{E_t(\tilde{S}_{t+1}|\phi_t)}{E_t(\tilde{S}_{t+1}|\phi_t)} = \frac{1+r_a}{1+r_b}$$

For all three propositions to be true at once, it is required that nominal interest rates be identical in the two countries under consideration. Though we might expect that real interest rates are identical across countries, to assume that nominal interest rates are identical requires stronger assumptions. One possible scenario is that expected inflation rates are zero. Then nominal interest rates only reflect real interest rates. This is inadequate however, since we do not observe nonpositive inflation rates in today's world. Alternatively, we might assume that the expected inflation rate in country A is identical to the expected inflation rate in country B. This would make $r_a = r_b$ and hence $F_{t,t+1} = S_t$.

To conclude, propositions (2), (3), and (4) can be expected to prevail simultaneously only under rather restrictive assumptions. These assumptions are that transactions costs are zero, market participants are risk neutral, and expected differential inflation rates are zero. Assuming away transactions costs is a simplifying assumption and not crucial to the analysis. Risk neutrality on the part of speculators may not be entirely adequate but can be ignored for the moment. However, assuming expected differential inflation rates amounting to zero is a crucial assumption. It implies subscribing to the law of one interest rate, and hence accepting the views of global monetarism.[3] The crucial assumption here is that capital is perfectly substitutable across countries and hence in reality there is only one capital market.

Model 2

Now let us examine the hypothesis that spot prices follow a submartingale.[4] Assume the expected returns are constant and reflect compensation for risk taking. Once again we shall assume no transactions costs so as to concentrate on the more important aspects of this scenario.

With constant expected returns

$$(6) \qquad \frac{E_t(\tilde{S}_{t+1}|\phi_t) - S_t}{S_t} = \alpha$$

or

$$(7) \qquad S_t = \frac{E_t(\tilde{S}_{t+1}|\phi_t)}{1+\alpha}$$

Similarly, we might expect that forward prices are settled in the same manner. That is, to compensate individuals for risk taking, today's forward price is set such that the following holds:

$$(8) \qquad F_{t,t+1} = \frac{E_t(\tilde{S}_{t+1}|\phi_t)}{1+\beta}$$

Again, assuming that interest rate parity holds exactly:

$$(9) \qquad \frac{F_{t,t+1}}{S_t} = \frac{1+r_a}{1+r_b}$$

Substituting (7) and (8) into (9) yields the following:

$$(10) \qquad \frac{1+\alpha}{1+\beta} = \frac{1+r_a}{1+r_b}$$

Hence, it is necessary that for the three propositions to hold exactly that the ratio of nominal interest rates exactly reflect the ratio of expected returns. If expected returns are a result of risk premiums, then premiums in some way exactly correspond to differential inflation rates.

Model 3

Another common proposition made by proponents of the EMH is that forward prices are unbiased estimators of future spot rates.[5] The forward price set at time t-1, for delivery at t is an unbiased estimator of S_t, the spot price prevailing at t. Hence, on average the following relationship holds:

$$(11) \quad S_t = a + bF_{t-1,t} + \varepsilon$$

where a is not significantly different from zero,

b is not significantly different from unity, and

the ε's are serially uncorrelated.

This relationship presumably is true because the forward rate set at t-1 for delivery at t was based on the price expected to prevail at t given the information at hand during time period t-1.

$$(12) \quad F_{t-1,t} = E_{t-1}(\tilde{S}_t | \phi_{t-1})$$

where E_{t-1} is the expectations operator relevant for time period t-1,

ϕ_{t-1} is the information at hand at time period t-1.

In addition, expectations on average are unbiased estimators of actual future spot price. Suppose now that we theorize on the formation of S_t. According to the EMH, it is formed based on the premise that it contains all of the information at hand in time period t and should reflect t+1's expected price. Hence,

$$(13) \quad S_t = E_t(\tilde{S}_{t+1} | \phi_t)$$

For equality of $F_{t-1,t}$ and S_t, it must be that equations (12) and (13) are identical or,

$$(14) \quad E_{t-1}(\tilde{S}_t | \phi_{t-1}) = E_t(\tilde{S}_{t+1} | \phi_t) \quad .$$

An EMH proponent would argue that the expectation formed at time t-1 and that one formed at t will differ only as a result of the arrival of new information. Since new information is random, the expectation at time t (and thus t's actual price) will differ from t-1's expectation by only a random variable. Hence unbiasedness of equation (11) ought to be the norm.

Upon examining (14) however, we are left with the impression that if market participants are to act in the manner prescribed above, their expectations incorporate the notion that expectations of future prices will never vary. In other words, it is assumed that prices follow a random walk with zero drift parameter (no trend).

It has been established by Mandelbrot and Roll[6] that a random walk of such specifications is unnecessary[7] and thus not descriptive of foreign exchange markets.

Model 4

An alternative version of the EMH claims that the percentage difference of today's price and tomorrow's expected price will exactly reflect differential nominal interest rates in the two countries under consideration.[8] Hence:

$$(15) \qquad \frac{E_t(\tilde{S}_{t+1}|\phi_t) - S_t}{S_t} = r_a - r_b$$

Thus by rearranging we find:

$$(16) \qquad S_t = \frac{E_t(\tilde{S}_{t+1}|\phi_t)}{1 + r_a - r_b}$$

Now letting forward prices reflect expectations of the future spot price we have:

$$(17) \qquad F_{t,t+1} = E_t(\tilde{S}_{t+1}|\phi_t)$$

Having the interest rate parity condition satisfied as well as (16) and (17) would require that:

$$\frac{F_{t,t+1}}{S_t} = 1 + r_a - r_b = \frac{1+r_a}{1+r_b}$$

With exogenously determined interest rates, this could occur only by accident. Specifically, it is necessary that $r_a = r_b$. Differential inflation rates must be zero.

B. Conclusions

In this chapter, it has been shown that unless rather stringent assumptions are made, efficiency of foreign exchange markets has to date been inadequately described. Studies of this topic have for the most part examined specific variables in the foreign exchange market and reasoned that efficiency would require specific patterns to emerge. However, by studying for example spot prices in isolation of other variables and conditions that might be expected to hold in foreign exchange markets, it is shown that inconsistancies arise.

A segmented approach to the issue of the efficiency of foreign exchange markets is evidently not a proper approach. One must consider the fact that equilibrium prices of spot and forward exchange cannot be isolated from one another. If we disregard this fact, we may reason that efficiency holds regardless of the existence of "unusual" profits to be made via arbitrage. This obviously should not be the case, and ultimately contradicts the EMH.

It was found however, that under special conditions the interpretations could be consistent with one another. If we ignore transactions costs and risk premiums one might expect that forward and spot prices exactly reflect tomorrow's expected price, and that the interest rate parity condition holds. We need require in addition that inflation rates be zero. If we relax the assumption that risk premiums are zero, i.e. that investors are risk neutral, we might claim that the interest rate parity condition can be fulfilled simultaneously with the requirements of spot and forward market efficiency. This requires however that differential nominal interest rates exactly reflect risk premiums.

For forward prices to be unbiased estimators of future spot rates it is necessary that spot rates follow a random walk with zero drift parameter (no trend). In order that interest rate parity holds in addition to the requirement that changes in spot prices reflect differences in nominal interest rates, a special condition must be imposed. This is that differential inflation rates are zero.

It is concluded that the above conditions are rather strong and often unrealistic. A case can be made for the need to seek for other approaches to the issue of efficiency in the foreign exchange market. In the chapter to follow this is accomplished by devising a general equilibrium approach to exchange rate determination which incorporates the efficient market hypothesis.

CHAPTER THREE

EFFICIENCY ASSUMING RISK NEUTRALITY

Introduction

In this chapter we eliminate the assumption that spot and forward exchange rates are set independently of each other. A model of the simultaneous determination of spot and forward foreign exchange prices is presented. Behavioral assumptions are then incorporated into the model, such that market participants behave in accordance to the efficient market hypothesis. It is found that in such a world, covered interest arbitrageurs do not have the opportunity to engage in transactions. Spot speculators arbitrage all profit opportunities away, leaving no room for covered interest arbitrageurs to participate actively in the determination of exchange rates. This is interesting in that it points to the possibility that covered interest arbitrageurs are not as prevalent in the market as is often thought. Also, it raises questions with respect to the idea that these individuals have the "last word" in regard to the determination of forward premiums and thus exchange rates.

In the third section of this chapter, conditions for the efficient market hypothesis to hold through time are derived. It is found that market participants must formulate expectations on all future prices for the model to be consistent. It is suggested that the modeling of expectations conditional on an infinite time horizon is unrealistic and thus poses a severe problem for the proponents of the efficient market hypothesis. The reader is referred to Chapter Five for a solution to this problem.

A. A Model of the Simultaneous Determination of Spot and Forward Prices

In the following section, a freely fluctuating exchange rate regime is assumed. We examine the foreign exchange market as if three classes of transactions exist. These are spot transactions, forward transactions and covered interest arbitrage transactions. In the spot market we encounter traders who buy and sell spot foreign exchange so as to effectuate trade contracts due at that time. We also find spot speculators attempting to make profits from discrepancies between today's price and tomorrow's expected price.

The forward market consists of hedgers and forward speculators. Hedgers are traders who having entered trade contracts due at a future date, wish to insure themselves against uncertain future exchange rates. They agree to purchase or sell foreign exchange at some future date at the price set today. Speculators in the forward market have alternative motives for engaging in such transactions. When entering a forward contract they anticipate being able for example, to buy the foreign currency on the spot market at the time of maturity at a cheaper rate than that stipulated in the forward contract. Thus, the speculator expects to meet the terms of the contract while earning a positive return.

A third type of transaction is conducted by covered interest arbitrageurs (CIAs). These market participants take advantage of riskless profit opportunities that may exist as a result of the relationships between spot prices, forward prices and interest rates between two countries.

The model determining equilibrium exchange rates consists of four equations.[1] The notion to be used is as follows:

A	Country A. Its unit of currency is the dollar ($)
B	Country B. Its unit of currency is the pound (£).
S_t	Spot exchange rate at time t. The exchange rate is defined as the number of dollars that will exchange per pound ($/£).
$F_{t,t+1}$	Forward exchange rate set at time t, for delivery at time t+1.
ES_t^s	Excess supply of spot exchange at time t, $ES_t^s < 0$ implies an excess demand for spot exchange at time t.
ED_t^f	Excess demand for forward exchange at time t. $ED_t^f < 0$ implies an excess supply of forward exchange at time t.
r_a	The nominal interest rate in country A.

r_b The nominal interest rate in country B.

$r_t \equiv \left(\frac{1+r_a}{1+r_b}\right)_t$; a definition.

The analysis begins by positing the existence of an excess demand curve for forward exchange and an excess supply curve for spot exchange.

(1) $F_{t,t+1} = f(ED_t^f)$ where $f(0) = a > 0$, $f' < 0$

(2) $S_t = g(ES_t^s)$ where $g(0) = \beta > 0$, $g' < 0$

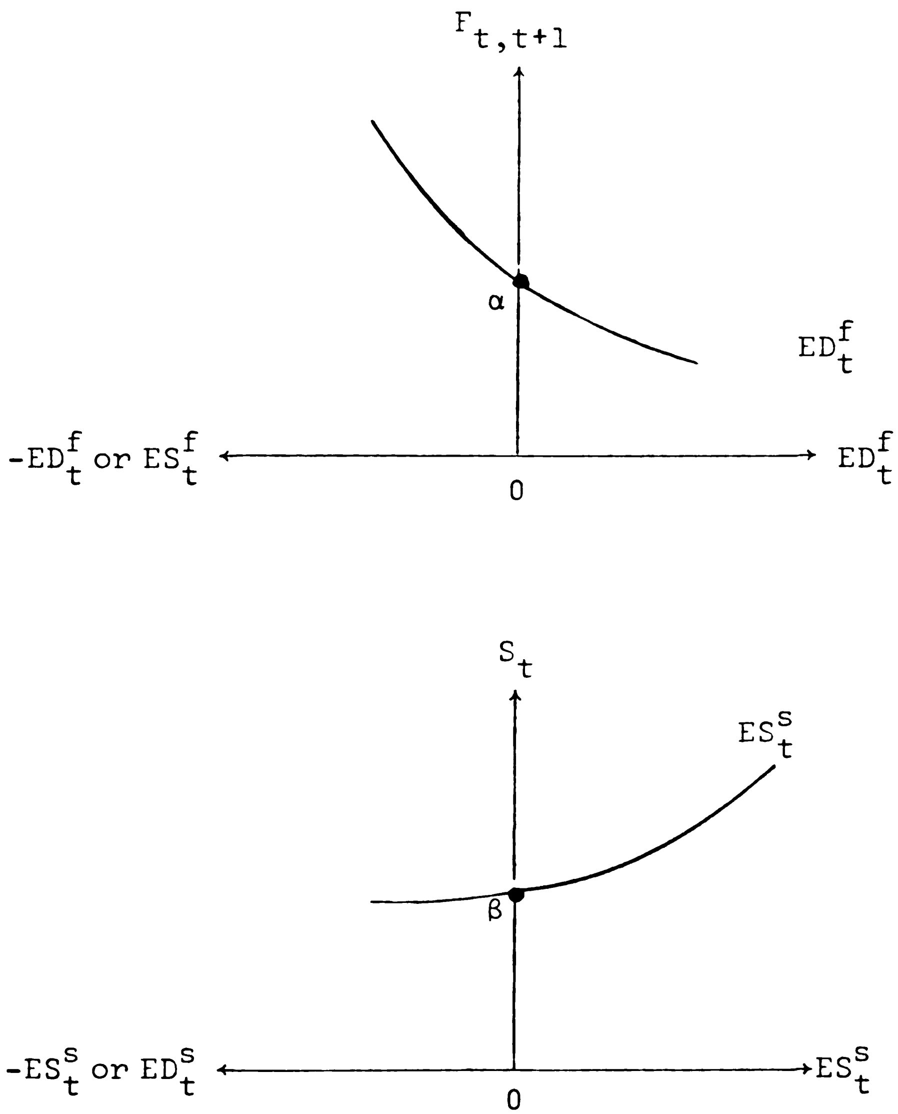


FIGURE ONE

Equations (1) and (2) may be rewritten as follows, so as to explicitly include the intercept term.

$$(3) \quad F_t = \alpha + h(ED_t^f) \qquad \text{where } h' < 0$$

$$(4) \quad S_t = \beta + k(ES_t^s) \qquad \text{where } k' > 0$$

For simplicity, functions (3) and (4) may be approximated by the following linear equations:

$$(5) \quad F_t = \alpha - aED_t^f \qquad \alpha,\ a > 0$$

$$(6) \quad S_t = \beta + cES_t^s \qquad \beta,\ c > 0$$

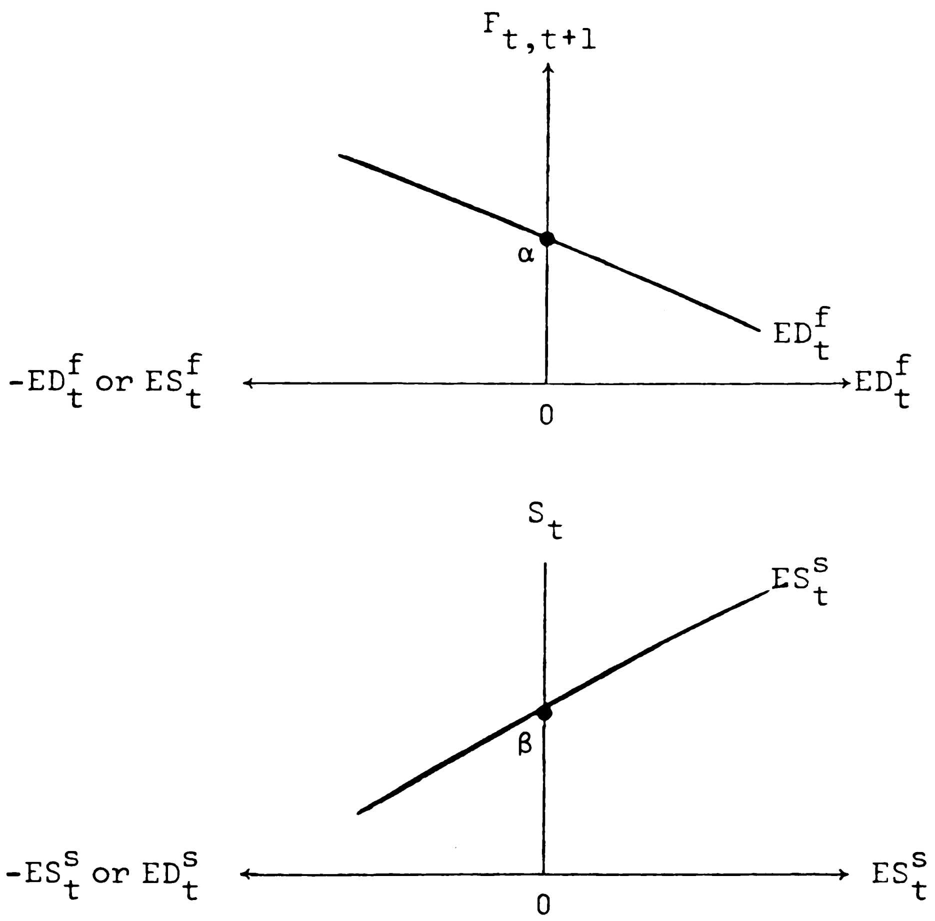


FIGURE TWO

Equations (5) and (6) depict the behavior of spot and forward prices when covered interest arbitrageurs do not participate in the market. Equilibrium will be attained where excess demand and excess supply are equal to zero. Thus forward and spot prices will be set at α and β when only traders, hedgers and speculators deal in foreign exchange. However, α and β need not necessarily be such that CIAs are without profit opportunities. Once we include CIAs as market participants the additional condition, interest rate parity must be met. The following is a derivation of the interest rate parity condition.[2]

Assume transactions costs are zero, there is no currency inconvertability risk, interest rates are fixed, there are no liquidity time preferences, and unlimited arbitrage funds exist. Then an American (resident of country A) with one dollar has two nearly risk free options to undertake if he or she chooses to place that dollar in a financial asset. The first option is to place that dollar in a U.S. interest bearing asset. At maturity the investor will have $1+r_a$, principle plus return. Alternatively, the investor may exchange the dollar for pounds, place it in a British interest earning asset of equivalent maturity, and simultaneously exchange it for dollars in the forward market. These alternatives are depicted in Figure Three on the next page.

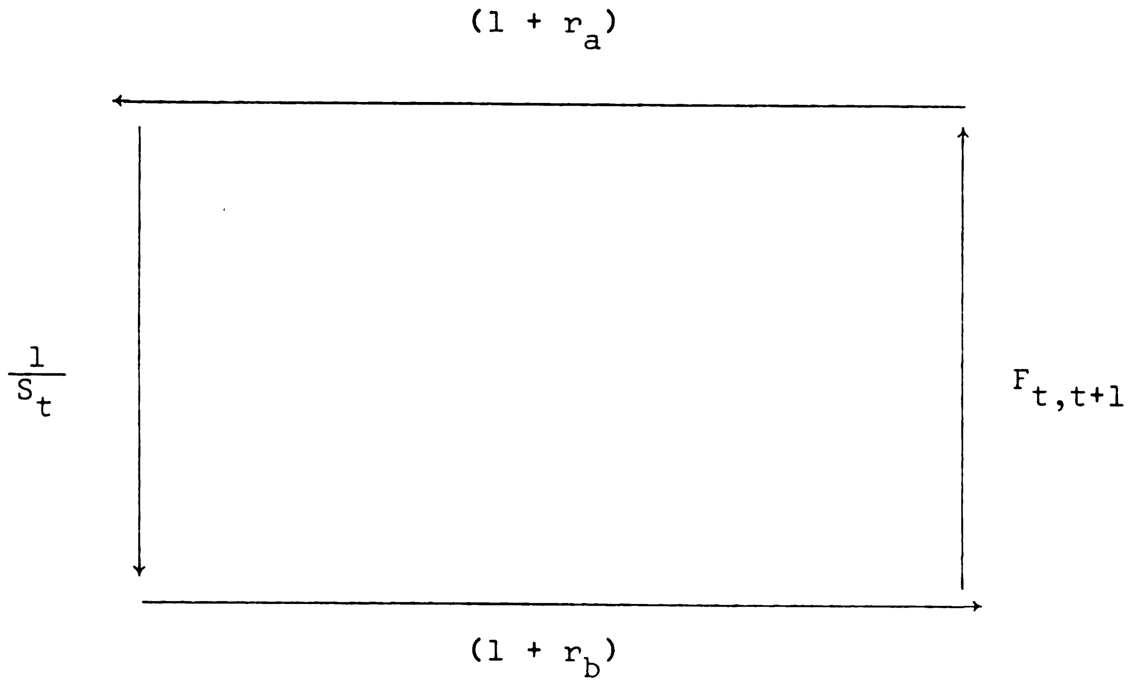


FIGURE THREE

The two options yield identical returns when

$$1 + r_a = \frac{1}{S_t}(1+r_b)\, F_{t,t+1} \quad .$$

If interest parity does not hold, if for example the return from keeping funds in the U.S. is less than the return that can be earned from placing covered funds abroad, then funds will flow out of the United States assets into British denominated assets. The resulting activity in the exchange market, exchanging dollars for spot pounds, will cause S_t to rise. In the forward market we would expect F_t to fall as the volume of contracts to exchange pounds for dollars rises. Thus, prices will adjust such that the excess returns from transferring funds abroad is eliminated.[3]

The interest rate parity relationship may be rewritten as follows:

$$\frac{F_{t,t+1}}{S_t} = \left(\frac{1+r_a}{1+r_b}\right)_t$$

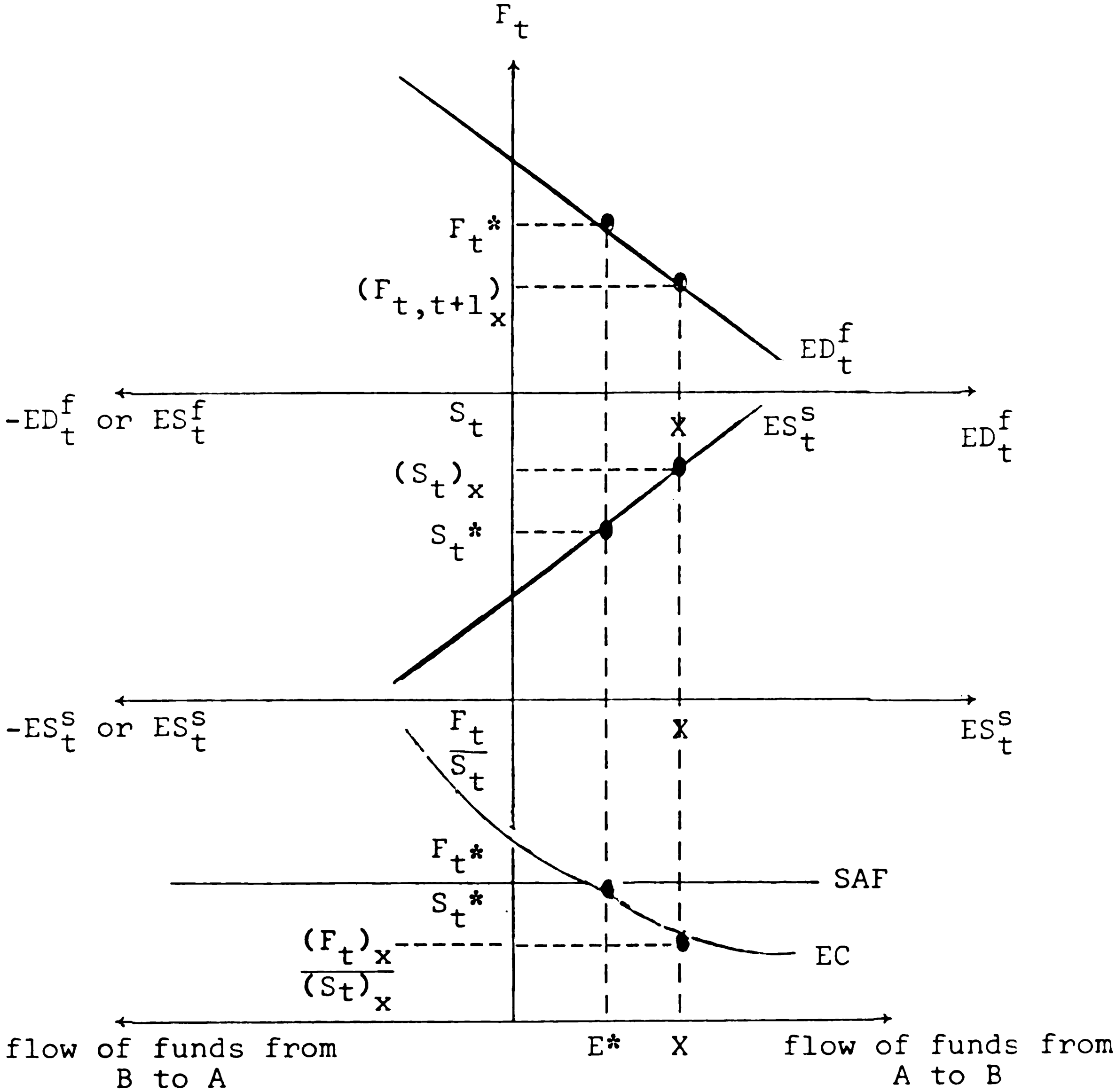
Letting $\frac{1+r_a}{1+r_b} \equiv r_t$ we have,

$$(7) \qquad \frac{F_{t,t+1}}{S_t} = r_t \quad .$$

So far the model consists of equations (5), (6), and (7). Equation (5) depicts the behavior of forward market participants. The resulting forward price is set independently of S_t (except for the IRP condition) and is obtained via the activities of spot speculators and traders as described by equation (6). The ratio of forward to spot prices necessary to eliminate all profit opportunities is indicated by (7). A fourth equation links the setting of prices in the spot and forward markets to the activities of CIAs and thus to each other. CIAs will demand as much forward exchange as they demand spot while pursuing arbitrage transactions.[4]

(8) $ED_t^f = ES_t^s$

The complete system of four equations is depicted in Figure Four.[5] In the upper quadrants excess demand and excess supply for forward and spot exchange are shown. In the lower quadrants the equilibrium curve (EC) indicates at each quantity of flow of funds from country A to B, what the ratio of forward to spot price must be. For a flow of funds of quantity X, for example, so that there be an excess supply of spot funds of this amount and an excess demand for forward funds of the equivalent amount, prices $(S_t)_x$ and $(F_{t,t+1})_x$ must prevail. The ratio $(F_t)x/(S_t)x$ is then plotted against flow of funds of quantity x in the lower



F_t
F_t*
$(F_{t,t+1})_x$
ED_t^f
$-ED_t^f$ or ES_t^f
S_t
X
ES_t^s
ED_t^f
$(S_t)_x$
S_t*
$-ES_t^s$ or ES_t^s
$\frac{F_t}{S_t}$
X
ES_t^s
F_t*
S_t*
SAF
$\frac{(F_t)_x}{(S_t)_x}$
EC
flow of funds from B to A
E*
X
flow of funds from A to B

FIGURE FOUR

quadrant. The supply of arbitrage funds (SAF) curve maps the interest rate parity relationship, equation (7). The SAF curve is horizontal throughout as a result of assumptions made while deriving the interest rate parity condition. These are, no currency inconvertability risk, fixed interest rates, unlimited funds and no liquidity preferences.

Where EC and SAF intersect, interest rate parity holds and prices in the spot and forward market are such that enough funds are available to effectuate the transfer of covered funds from country A to B or vice versa. In Figure Two there is a positive flow of funds from A to B at E*. In order for CIAs to purchase quantity E* of pounds in the spot market, the spot price must be S_t*. To obtain that same quantity of forward dollars (or to be able to sell quantity E* of forward pounds), the price of forward exchange needs be F_t*.

B. The Model Assuming Efficient Markets

The efficient markets hypothesis states that prices are set such that no unusual profit opportunities exist. If this were not the case market participants would take advantage of the discrepancy. Thus, the activities of speculators and other investors in the foreign exchange market will ensure that prices will conform to those necessary in an efficient market.

In order to introduce the efficient markets hypothesis in our model, it is useful to elaborate on the behavior of the various participants in the spot and forward markets. Assume for the moment that traders are the only participants. Traders, who enter contracts at time t due that same period, buy or sell spot exchange, while those that have contracts due at time t+1 hedge and thus trade in the forward market. In this case, demand and supply of foreign exchange and thus equilibrium prices, simply reflect import demand functions for the residents of the two countries.

Now allow spot and forward speculators to enter the market. These participants will make inferences concerning tomorrow's spot price based on all the relevant economic information available today. If today's prices, set by spot traders and hedgers, differs from the expectation of tomorrow's price, profits will be expected from buying or selling foreign exchange. Thus trading on the part of speculators will not cease until today's price is equal to tomorrow's expected price if speculators are risk neutral.[6]

To reiterate, an initial equilibrium is set by market participants with non-speculative motives. Speculators observe this price and compare it to the expected future price formulated from all the publically available information. This expectation may be formally expressed as follows:

(9) $E_t(S_{t+1} | \phi_t)$

where E_t is the expectations operator

ϕ_t is the information set at time t. ϕ_t includes all publically available information which may have an effect on foreign exchange rates such as interest rates, projected trade volumes, etc. (For notational simplicitity, the tilda ($\sim$), has been dropped from S_t. Hereafter it should be understood that $E_t(S_{t+1}|\phi_t)$ is actually a random variable.)

If $S_t°$ or $F_t°$, the initial equilibrium prices, differ from the above expectation expected profits from engaging in foreign exchange transactions remain and speculators effectively do so until the expectation is attained. This implies that where excess demand for forward exchange is zero and excess supply of spot exchange is zero (the intercept terms), prices will be equal to the above expectation. The new system of equations is then:

$$(10) \qquad F_{t,t+1} = E_t(S_{t+1}|\phi_t) - aED_t^f$$

$$(11) \qquad S_t = E_t(S_{t+1}|\phi_t) + cED_t^f$$

$$(8) \qquad ED_t^f = ES_t^s$$

$$(7) \qquad \frac{F_{t,t+1}}{S_t} = r_t$$

where (9) has been substituted in for α and β, the intercept terms, to establish prices where excess demand = excess supply = 0. This results because speculators will then be satisfied that all profit opportunities have been removed. For example, with regard to equation (5) $F_{t,t+1} = \alpha - aED_t^f$, excess demand for forward funds is zero at α. Hence α must correspond to the expectation of the spot price at time t+1.

Solving for the system of four equations we find:

$$(12)\quad S_t{}^* = E_t(S_{t+1}|\phi_t)\,\frac{c+1}{a+cr_t}$$

$$(13)\quad F_t{}^* = r_t E_t(S_{t+1}|\phi_t)\,\frac{c+1}{a+cr_t}$$

where * denotes final equilibrium values.

Equilibrium is attained at a price that is biased with respect to expected future values. Without knowing the specific values of c, a and r_t we cannot define the bias. We do observe, however that $S_t{}^*$ and $F_t{}^*$ will tend to overestimate the future expected spot price, given values for the slopes of the excess demand and excess supply curves, as r_b rises relative to r_a. Alternatively, equilibrium S_t and F_t tend to underestimate the expected future spot price as r_b falls relative to r_a. One might attempt to explain this bias in a mean-variance framework. However, we have been employing the assumption of risk neutrality. It follows then that the above equilibrium values cannot be explained as ones which compensate investors for incurring greater risk.

An alternative explanation might be that prices are biased because CIAs are selling and buying additional amounts of forward and spot exchange to traders which are now in the position as a result of arbitrage activities to export and import more goods and services. However, when prices no longer equal their expected values, profitable opportunities remain for speculators to act upon and then prices will once again be bid up to their expected values. But this leaves us with opportunities for CIAs once again, and so prices will once again change.

Thus, equations (12) and (13) leave us with a disequilibrium situation. An equilibrium might be attained if one group exhausts its supply of funds. Since we have assumed that the supply of funds is unlimited, such a situation is not possible. No unique equilibrium exists and hence there are inherent inconsistencies in this model.

The model is inconsistent in an alternative sense as well. We cannot expect forward and spot speculators to continue acting as posited in the previous system of equations. Suppose we allow (12) and (13) to remain at their initial equilibrium value. Then we can show that behavior will change over time by examing equilibrium values in time period t+1.

Equations (14) through (17) depict for the period t+1 the relevant system of equations. They are identical to t's system of equations with the exception of the substitution of an expectations term relevant to time period t+2.

$$(14) \quad F_{t+1,t+2} = E_{t+1}(S_{t+2}|\phi_{t+1}) - aED^{f}_{t+1}$$

$$(15) \quad S_{t+1} = E_{t+1}(S_{t+2}|\phi_{t+1}) + cED^{s}_{t+1}$$

$$(16) \quad ED^{f}_{t+1} = ES^{s}_{t+1}$$

$$(17) \quad \frac{F_{t+1,t+2}}{S_{t+1}} = r_{t+1}$$

Solving for the spot price we find, $S^*_{t+1} = E_{t+1}(S_{t+2}|\phi_{t+1}) \frac{c+1}{a+cr_t}$.

In order for speculators to continue behaving as posited two conditions must hold. First, it must be true that expectations are met on average. If there is a consistent bias, market participants will eventually discern such and will change their behavioral patterns. The second condition which must be fulfilled is that the forward price be a "reasonable" predictor of the future spot price. Being a "reasonable" predictor implies that on average unbiasedness between the forward price and next period's spot price exists. If there is a consistent bias we encounter a discrepancy. In this model transactions costs have been ignored and thus cannot be used to explain a bias. Also since risk neutrality has been assumed, one cannot explain a bias as a result of risk compensation.

The first condition implies that:

$$E_t(S_{t+1}|\phi_t) = S^*_{t+1}$$

or

$$(18) \quad E_t(S_{t+1}|\phi_t) = E_{t+1}(S_{t+2}|\phi_{t+1}) \frac{c+1}{a+cr_t}$$

The second condition implies that:

$$(19) \quad r_t E_t(S_{t+1}|\phi_t) \frac{c+1}{a+cr_t} = E_{t+1}(S_{t+2}|\phi_{t+1}) \frac{c+1}{a+cr_t}$$

For both (18) and (19) to hold it must be that:

$$(20) \quad E_t(S_{t+1}|\phi_t) = r_t E_t(S_{t+1}|\phi_t) \frac{c+1}{a+cr_t}$$

Equation (20) will be true only under very special condition. For example, if $r_t = 1$ and $a = 1$, (20) will be true. Requiring $r_t = 1$ implies that $r_a = r_b$, that nominal interest rates are identical across countries. Even though it may be argued that the law of one real interest rate holds, to assume that the law of one nominal interest rate holds implies subscribing to the notion that capital is perfectly substitutable across national boundaries. This is a rather strong assumption and implies assuming global monetarism.[7] If we do not agree with this view of the world and feel that expected inflation rates across countries are not identical, then markets behaving in the above manner cannot be efficient.

We ought not be unduly discouraged however. The above model used behavioral assumptions as presented by most writers of efficient markets. In our system of equations the substitution of such behavior results in a serious theoretical flaw. Recall equation (11):

$$(11) \quad S_t = E_t(S_{t+1}|\phi_t) + cES_t^s$$

The intercept is based on the premise that spot speculators engage in pure spot speculation. These market participants buy or sell spot currency until today's price is equal to tomorrow's expected price. This is inconsistent with rational behavior. To see this, consider the following.

An individual in the U.S. with a dollar to speculate has an alternative option. He or she may exchange that dollar for pounds, place it in a British interest bearing asset and then convert the principle plus return into dollars in the spot market on the maturity date. This yields an expected return on a one dollar investment equivalent to:

$$(21) \qquad 1 - \frac{E_t(S_{t+1}|\phi_t)}{S_t}\ (1+r_b)$$

The expected return from one dollar of "pure" spot speculation is:

$$(22) \qquad 1 - \frac{E_t(S_{t+1}|\phi_t)}{S_t}$$

Equations (21) and (22) will yield identical expected returns only if $r_b = 0$.

Alternatively, if we begin with pounds, the two options are:

$$(23) \qquad 1 - \frac{S_t}{E_t(S_{t+1}|\phi_t)}\ (1+r_a)$$

for an investment in the U.S. securities market, and

$$(24) \qquad 1 - \frac{S_t}{E_t(S_{t+1}|\phi_t)}$$

for a pure speculative transaction. Again, (23) and (24) are equivalent only if the nominal interest rate r_a is zero. The expected return from pure spot speculation can be greater only if the nominal interest rate is negative.

Thus, as long as nominal interest rates are positive, speculators will never choose to pursue pure spot speculation. Instead, speculators will choose between holding domestic interest earning assets and foreign interest earning assets in a manner analogous to that of covered interest arbitrageurs. Thus they ensure that "uncovered interest rate parity" is attained.

The uncovered interest parity condition may be derived in a manner analagous to that of covered interest parity. We shall again assume that transactions costs are zero, there is no currency inconvertability risk, interest rates are fixed, and funds are unlimited. Observe Figure Five. This is identical to figure One with the exception that in place of the forward price we have substituted expectations corresponding to the expected spot price on the day of maturity. Individuals choose between placing funds in domestic denominated assets and foreign denominated assets thereby setting prices such that the return from the two activities coincide.

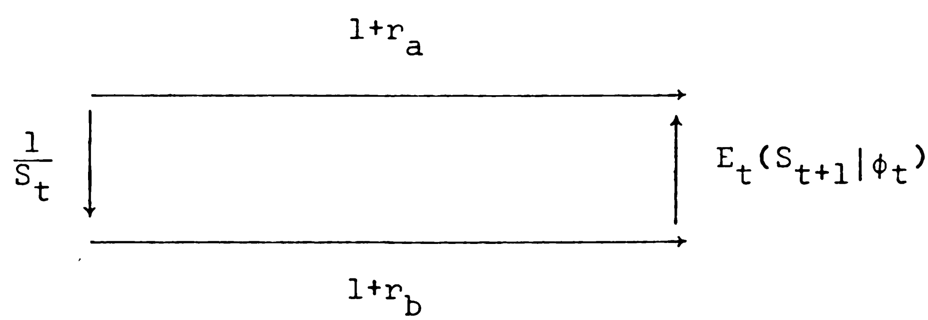


FIGURE FIVE

This implies:

$$(25) \qquad (1+r_a) = \frac{1}{S_t}(1+r_b)\, E_t(S_{t+1}|\phi_t)$$

or

$$(26) \qquad \frac{E_t(S_{t+1}|\phi_t)}{S_t} = \frac{1+r_a}{1+r_b} = r_t$$

Spot speculators will indulge in uncovered interest arbitrage so that:

$$(27) \qquad S_t = \frac{E_t(S_{t+1}|\phi_t)}{r_t}$$

or uncovered interest parity is attained. Thus if spot speculators behave as posited above, the uncovered interest parity condition is substituted in for the intercept term of equation (11). At this point there is no excess supply or demand for spot exchange. The excess supply curve for spot exchange is now:

$$(28) \qquad S_t = \frac{E_t(S_{t+1}|\phi_t)}{r_t} + cES_t^s$$

Does the same argument apply to forward speculators? Do they have the option to commit their funds where they can earn a higher return? It may be that this is the case; however, assume that forward commitments are opportunity cost-free until the contract is due. By this we mean that contracts to buy or sell forward exchange require only a promise. No funds need be committed until the contract becomes due.[8]

The system of equations under the efficient market hypothesis and under the assumption that spot speculators pursue uncovered interest arbitrage is as follows:

$$(10) \quad F_t = E_t(S_{t+1}|\phi_t) - aED_t^f$$

$$(28) \quad S_t = \frac{E_t(S_{t+1}|\phi_t)}{r_t} + cES_t^s$$

$$(8) \quad ED_t^f = ES_t^s$$

$$(7) \quad \frac{F_t}{S_t} = r_t$$

The solution is:

$$S_t{}^* = \frac{E_t(S_{t+1}|\phi_t)}{r_t}$$

$$F_t{}^* = E_t(S_{t+1}|\phi_t)$$

$$ED_t^{f^*} = ES_t^{s*} = 0$$

Examine Figure Six:

Spot speculators set the spot price such that uncovered interest parity is attained. Since forward speculators insure that the forward price is equal to next period's expectation, no covered interest arbitrage opportunities remain.[9] EC intersects SAF at a zero flow of arbitrage funds. Spot and forward speculators are also satisfied since no more profit opportunities exist in these markets.

A word ought to be said here concerning the actual sequence of events. If CIAs enter the market before

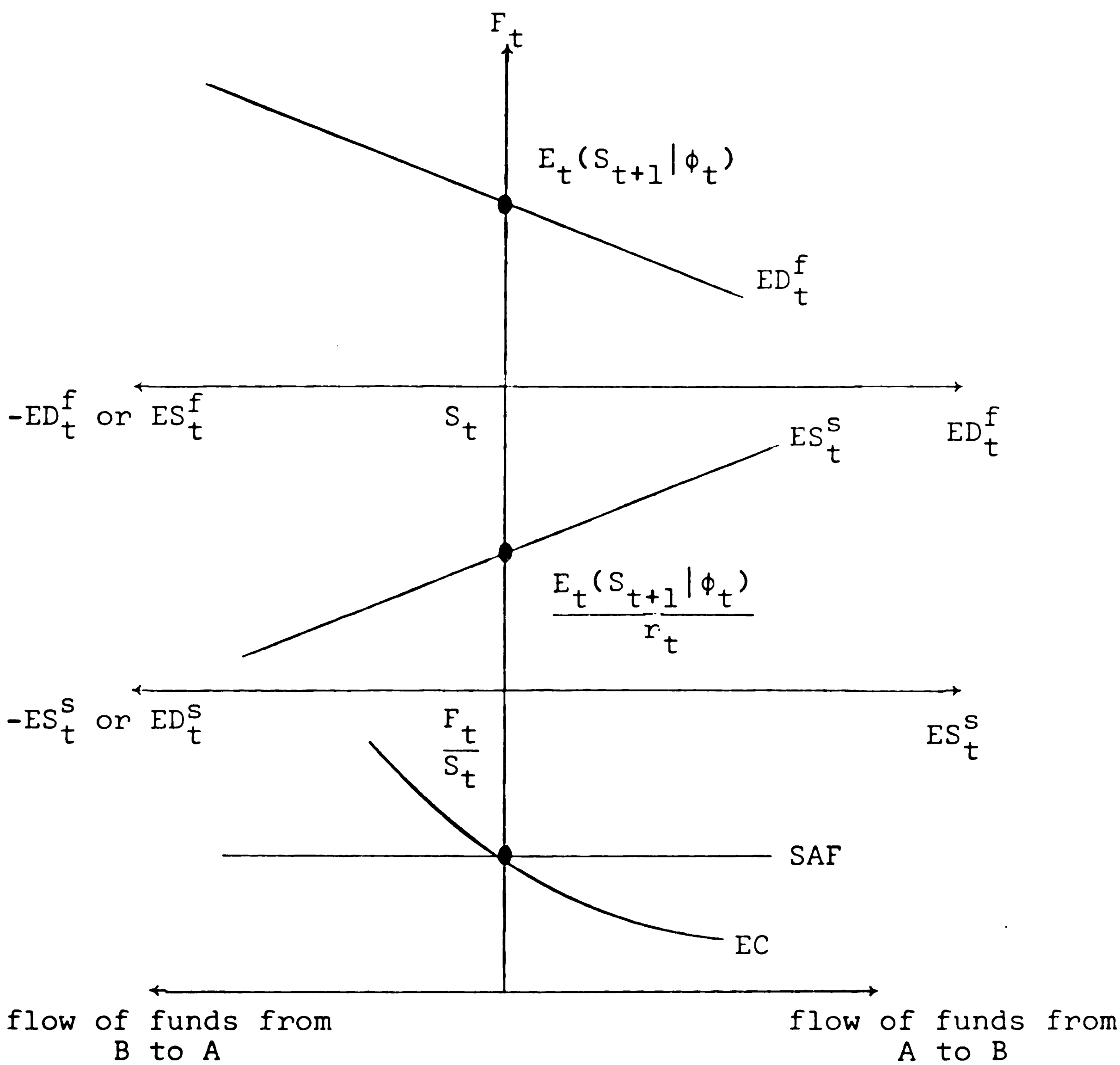

F_t
$E_t(S_{t+1}|\phi_t)$
ED_t^f
$-ED_t^f$ or ES_t^f
S_t
ES_t^s
ED_t^f
$\frac{E_t(S_{t+1}|\phi_t)}{r_t}$
$-ES_t^s$ or ED_t^s
$\frac{F_t}{S_t}$
ES_t^s
SAF
EC
flow of funds from B to A
flow of funds from A to B

FIGURE SIX

speculators do, the above arguments will run in reverse. IRP will be attained and hence forward and spot speculators will not have a motive to participate.

The answer to this indeterminancy lies in which set of participants has the lower threshold to begin pursuing their respective activities. This might be explained by transactions costs. Since we have assumed away these costs this cannot be used to verify that speculators begin transacting first. However, speculators pursue only one transaction, while CIAs simultaneously engage in two. Hence, it follows that speculators' transactions costs are lower than those for CIAs. It follows then, that the incorporation of transactions costs would ensure that speculators initiate trading.

C. Efficient Markets Through Time

Now we investigate the conditions under which the market is efficient through time. We will retain the assumption that spot speculators behave as uncovered interest arbitrageurs, and we will allow exogenously determined interest rates to differ according to the time period. The system of equations applying to period t+1 is obtained by substituting in place of period's t+1 expectation, that expectation concerning period t+2 formulated in period t+1; $E_{t+1}(S_{t+2}|\phi_{t+1})$.

$$(29) \quad F_{t+1,t+2} = E_{t+1}(S_{t+2}|\phi_{t+1}) - aED^{f}_{t+1}$$

$$(30) \quad S_{t+1} = \frac{E_{t+1}(S_{t+2} | \phi_{t+1})}{r} + cES^s_{t+1}$$

$$(31) \quad ED^f_{t+1} = ES^s_{t+1}$$

$$(32) \quad \frac{F_{t+1}}{S_{t+1}} = r_{t+1}$$

where $r_{t+1} \equiv (\frac{1+r_a}{1+r_b})$ in period t+1.

The solutions to this system of equations are:

$$F_{t+1,t+2}{}^* = E_{t+1}(S_{t+2} | \phi_{t+1})$$

$$S_{t+1}{}^* = \frac{E(S_{t+2} | \phi_{t+1})}{r_{t+1}}$$

$$ED^f_{t+1}{}^* = ES^s_{t+1}{}^* = 0$$

Two conditions must be found to ensure market efficiency. First, we must investigate whether the forward rate is an unbiased predictor of the future spot rate. Also, expectations must be met so that market participants continue to act as posited, that spot speculators ensure that uncovered interest arbitrage is attained, that forward speculators trade until the forward rate is equal to tomorrow's expected spot rate, and that CIAs ensure that covered interest arbitrage is attained.

The first condition is met if:

$$F_{t,t+1}{}^* = S_{t+1}{}^*$$

or

$$(33) \quad E_t(S_{t+1} | \phi_t) = \frac{E_{t+1}(S_{t+2} | \phi_{t+1})}{r_{t+1}}$$

The second condition is met if:

$$E_t(S_{t+1}|\phi_t) = S_{t+1}{}^*$$

or

$$(34) \quad E_t(S_{t+1}|\phi_t) = \frac{E_{t+1}(S_{t+2}|\phi_{t+1})}{r_{t+1}}$$

Fulfillment of (33) and (34) amount to the same condition. Expectations of tomorrow's price must incorporate expectations of the following period's price and must reflect <u>exactly</u> tomorrow's interest rates.

An important implication of the above discussion is the following. It must be that expectations concerning tomorrow's price incorporate expectations on <u>all</u> future prices and on all future interest rates. If

$$E_t(S_{t+1}|\phi_t) = f[E_t(S_{t+2}|\phi_t), E_t(r_{t+1}|\phi_t)]$$

it follows that

$$E_t(S_{t+2}|\phi_t) = g[E_t(S_{t+3}|\phi_t), E_t(r_{t+2}|\phi_t)].$$

In general then, we have that:

$$(35) \quad E_t(S_{t+1}|\phi_t) = h[E_t(S_{t+1+i}|\phi_t), E_t(r_{t+i}|\phi_t)] \qquad i = 1, 2, \ldots, \infty \; .$$

If a finite time horizon is assumed, then (35) will hold for $i = 1, 2, \ldots, n$. The modeling of such behavior is the subject of Chapter Five.

D. Conclusions

In this chapter, a model which allowed forward and spot prices to be simultaneously determined was presented. The efficient markets hypothesis was then introduced. This was done by incorporating the basic behavioral assumptions of the hypothesis. It was found that the model could not represent true behavior as a result of inherent inconsistencies. The two conditions needed to ensure that market participants continue to act as posited through time could not be met simultaneously under normal conditions.

Under further scrutiny, it was found that the behavior of spot speculators as is often presented in studies of the EMH, is too naive. It assumes that speculators do not take into consideration the opportunity costs of placing funds in alternative currencies in particular with respect to interest earnings. It was then suggested that we approximate speculative behavior by assuming that speculators operate in a manner analagous to covered interest arbitrageurs. In place of the forward price, the expected future spot rate is compared to current spot and interest rates. The uncovered interest rate parity condition was then derived.

The uncovered interest parity condition was incorporated into the model. It was found that spot speculators would end up arbitraging all profit opportunities away and thus eliminate the participation of covered interest arbitrageurs in the market. In was also found that it was no longer true that conditions necessary for efficiency through time were inconsistent with one another. An implication of the necessary conditions was that speculators formulate expectations on <u>all</u> future prices and that these expectations incorporate <u>all</u> future expected interest rate. The reader was referred to Chapter Five for further exploration of this point.

CHAPTER FOUR

EFFICIENCY ASSUMING RISK AVERSE BEHAVIOR

Introduction

In this chapter, the determination of exchange rates is assumed to proceed within the framework of the Capital Asset Pricing Model (CAPM). The approach allows for the explicit incorporation of risk averse behavior on the part of investors. Investors still attempt to maximize expected returns, but view as equally important the minimization of risk. For our purposes, risk is encountered with respect to the uncertainty of future spot prices. Risk averse behavior allows for an equilibrium situation with non-equality of expected returns among the securities which make up the investor's portfolio. In essence, individual securities are expected to earn a return proportional to the risk inherent with the holding of that security.

Following is an exposition of the Capital Asset Pricing Model. Next, the various investment opportunities available to market participants in foreign markets are outlined. Expected returns to these investments are assumed to conform to CAPM results. The difference in expected returns between two investment opportunities should reflect differences in risk inherent in the holding of the securities. We then impose the condition that interest rate parity (IRP), holds. It is concluded that if IRP holds, all investment opportunities have identical expected returns and thus carry identical risk.

In Part C of this chapter, a more generalized version of CAPM is developed. In this case, it is assumed that two forms of risk exist. As before, risk exists with respect to the uncertainty of future spot exchange rates. In addition, one incurs additional risk when entering a forward contract. This results because it is possible that the forward contract will not be honored. Imposing this form of risk will prevent the attainment of perfect interest rate parity. Individuals pursuing interest arbitrage opportunities will only do so if expected returns compensate them for entering a risky contract. Hence, expected returns will be greater than returns earned on the domestic riskless asset.

It is found that forward prices are set at values lower than next period's expected spot price i.e., a forward bias with respect to expectations exists. It is also concluded that though forward speculation includes two forms of risk while spot speculation incurs only one, the equilibrium expected return from spot speculation is greater than the return expected from a forward transaction. Finally, it is verified that there is greater risk with respect to pursuing spot speculative transactions as compared to pursuing interest arbitrage opportunities. In the final section of this chapter, it is found that the basic conclusions do not change when transactions costs are assumed to exist.

A. The Capital Asset Pricing Model

The Sharpe-Lintner Capital Asset Pricing Model hinges on the following assumptions.[1]

1. Investors are expected-utility of end-of-period wealth maximizers, and they are risk averse.
2. There exists an exogenous risk-free rate of interest.
3. Expectations of future returns and variances of returns are homogenous for all investors.
4. The capital asset market is perfectly competitive. All assets are perfectly divisible, there are no transactions costs and individual investment decisions will not affect asset prices.

A word ought to be said here regarding risk preferences. We state that investors are risk averse, i.e. they have diminishing marginal utility of expected wealth.[2] Hence, in order to incur more risk, the risk averter expects to earn a greater return. This is in contrast to a risk lover, who's utility function is such that she or he has increasing marginal utility of expected wealth, i.e. is willing to accept less return for incuring greater risk.

It should be noted that we can distinguish between varying degrees of risk aversion. In the case of increasing risk aversion, the investor expects relatively more expected return per increment in risk, i.e. the second derivative of the utility function is positive. In the case of decreasing risk aversion, the investor will demand relatively smaller increments in expected return as risk increases. The second derivative of the utility function is negative. With constant risk aversion, additional increments of risk require equally increasing increments of expected return.

In regard to the CAPM the degree of risk aversion is not crucial to the analysis. Indeed, we can assume that all degrees of risk aversion are represented by the various individual market participants. We need not assume that the utility functions of all investors are identical. As long as all utility functions exhibit some degree of diminishing marginal utility of wealth, the same general results are obtained.

The set of attainable portfolios, or the investment opportunity set is depicted in expected return, standard deviation space. An example is provided by Figure Seven. Each attainable portfolio can be characterized by its expected return [$E(R_p)$] and its standard deviation [$\sigma(R_p)$] of risk.

However, as a result of assumption (1), that investors are risk averse, only a portion of the attainable

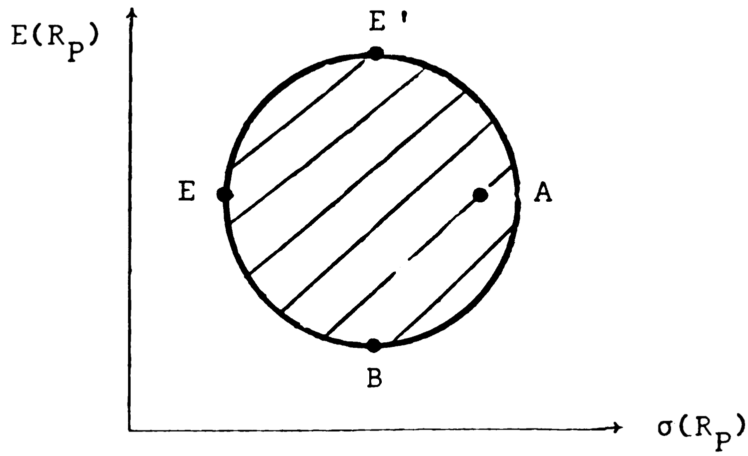


FIGURE SEVEN

set is of concern to us. Since investors view returns as desirable and risk or standard deviation as undesirable, the efficient frontier $\overline{EE'}$ dominates all other points in the attainable set. E will dominate a portfolio such as A since expected returns are identical, but the risk associated with A is larger. Portfolios with characteristics described by point B will be dominated by E' since though risk is identical, expected returns from E' are greater.

The efficient frontier is derived mathematically as follows:

$$(1) \quad \min_{x_i, x_j} \theta = \left[\sum_i^n \sum_j^n x_i x_j \sigma_{ij} \right]^{1/2} + \lambda_1 [E(R_P) - \sum_i^n x_i E(R_i)] + \lambda_2 [1 - \sum_i^n x_i]$$

where x_i, x_j represent the asset weights in the portfolio.

σ_{ij}	is the covariance between assets i and j.
$E(R_i)$	is the expected return on portfolio i.
λ_1 and λ_2	are lagrangian multipliers.

One finds the portfolio that minimizes risk or standard deviation, given an expected return $E(R_p)$, and subject also the the constraint that the portfolio is indeed an attainable one. This last condition is imposed by constraining the weights or total proportions of assets i in the portfolio ($\sum_{i=1}^{n} x_i$), to sum to one.

Recall from assumption (2) that the investor is faced with an exogenously determined risk-free rate of interest, R_F. The investor may place all or a portion of his or her wealth into the riskless asset, in effect be a lender. In Figure Eight, R_F denotes the riskless return. Suppose the investor were to place a portion of his or her funds in portfolio A and the remainder in the riskless asset. Then the investor will be at some point on the line segment $\overline{R_F A}$.

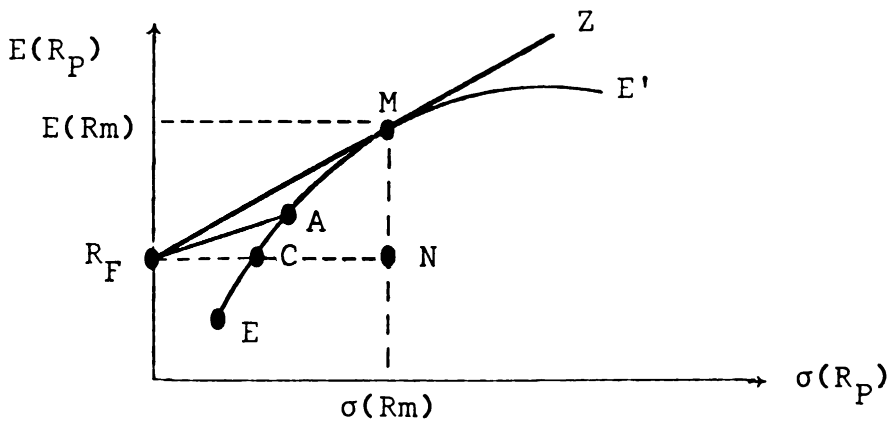


FIGURE EIGHT

By changing the proportion of funds to be placed into the two options, one generates the attainable locus $\overline{R_F A}$, of investment opportunities. Note however that $\overline{R_F A}$ dominates $\overline{EA}$. For every point on $\overline{EA}$, a point can be found on $\overline{R_F A}$ with identical variance, but higher expected return.

By choosing different portfolios on EE' with which to combine the riskless asset the investor will eventually find an "optimum portfolio of risky assets". In Figure Eight this is described by point M. By combining investments in the risk-free assets with investments in the risky portfolio M, the investor can attain any point on the investment locus $\overline{R_F M}$ and expect returns as great as those that can be expected from corresponding points on $\overline{CM}$. However, the risk associated with the segment $R_F M$ will with the exception of point M be smaller. At M both expected returns and risk are identical. $\overline{R_F M}$ also dominates $\overline{R_F A}$ and $\overline{EC}$ in that by combining investments in M with the riskless asset, an investor can attain equivalent levels of risk but expect greater returns. The investor can also be a net borrower thereby attaining positions on $\overline{MZ}$ which in expected returns terms dominates $\overline{ME}$ since risk is comparable. The entire segment $\overline{R_F MZ}$ is often referred to as the capital market line.

In sum, by varying the relative proportions of all risky assets an investment opportunity set of portfolios is constructed. Since it is assumed that investors are risk averse, portions of this set are eliminated such that

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at each attainable expected return the portfolio with minimum risk is found. These portfolios make up the efficient frontier of risky portfolios. Next the investor constructs portfolios on the efficient frontier with the riskless asset until he or she finds that risky portfolio on the efficient frontier that when combined with the risk-free asset earns the greatest return. In this manner the capital market line $\overline{R_F MZ}$ is constructed.

Depending on individual preferences for risk and return the investor will choose to be at some point on the capital market line. At R_F, the investor has placed his or her entire wealth in the riskless asset. At M, the investor has placed his or her entire wealth in the optimum risky portfolio. If the investor is between R_F and M, he or she has placed a portion of his or her wealth in the risky portfolio and has lent the remainder at the riskless rate. The individual can incur more risk by placing a sum greater than his or her wealth into the risky portfolio by borrowing at the risk-free rate and thus be somewhere to the right of M on the capital market line.

Until now, we have explored the manner by which individuals choose portfolios. By combining lending or borrowing at the riskless rate with the optimum risky portfolio, the investor can attain that specific portfolio that corresponds to their preferences for risk and return. Now we need discern how market equilibrium prices for individual securities are found.

It has been shown that individuals demand and supply specific amounts of individual securities. If demand is less than supply for an individual security then a disequilibrium situation exists. The price adjustment mechanism will ensure that the price falls, raising that security's expected return. This will result in the shifting of the entire attainable portfolio set. Following the same analysis as before, individuals will discern the new efficient border, the optimum risky portfolio and the capital market line. According to individual preferences for risk and return, specific demands and supplies for the individual securities will once again result. The market determines whether the new vector of prices corresponds to a market equilibrium situation. If not, adjustment will continue as before. In this manner, the market eventually sets prices for all the individual securities in the final optimum risky portfolio.

Now we can mathematically derive the conditions for asset equilibrium. First we substitute $E(R_m)$ and $\sigma(R_m)$, the expected value and standard deviation of the optimum risky portfolio, into equation (1) to obtain (2).

$$(2) \qquad \min_{x_j} \theta = \left[\sum_i^n \sum_j^n x_i x_j \sigma_{ij}\right]^{1/2} + \lambda_1 \left[E(R_m) - \sum_i^n x_i E(R_i)\right] + \lambda_2 \left[1 - \sum_i^n x_i\right]$$

The first partials are as follows:

$$(3) \qquad \frac{\partial\theta}{\partial x_i} = \frac{\partial\sigma(R_m)}{\partial x_i} - \lambda_1 E(R_i) - \lambda_2 = 0, \quad \text{for all } i,$$

and

$$(4) \qquad \frac{\partial\theta}{\partial x_j} = \frac{\partial\sigma(R_m)}{\partial x_j} - \lambda_1 E(R_j) - \lambda_2 = 0, \quad \text{for all } j.$$

From (3) and (4) we obtain equation (5):

$$(5) \qquad E(R_j) - E(R_i) = \frac{1}{\lambda_1}\left[\frac{\partial\sigma(R_m)}{\partial x_j} - \frac{\partial\sigma(R_m)}{\partial x_i}\right], \quad \text{for all } i,j.$$

Note from (2) that:

$$\frac{\partial\sigma(R_m)}{\partial E(R_m)} = \lambda_1$$

or equivalently:

$$\frac{1}{\lambda_1} = \frac{\partial E(R_m)}{\partial\sigma(R_m)} \quad .$$

Thus $1/\lambda_1$ is the slope of the capital market line. From Figure Eight note that the slope can be described as $\frac{MN}{R_F N}$ or

$$(6) \qquad \frac{E(R_m) - R_F}{\sigma(R_m)} = \frac{1}{\lambda_1}$$

Thus in (5) substitute (6) to obtain:

$$(7) \qquad E(R_j) - E(R_i) = \frac{E(R_m) - R_F}{\sigma(R_m)}\left[\frac{\partial\sigma(R_m)}{\partial x_j} - \frac{\partial\sigma(R_m)}{\partial x_i}\right] \quad .$$

Multiply this result by Σx_i to obtain:

$$(8) \qquad \Sigma x_i\, E(R_j) - \Sigma x_i E(R_i) = \frac{E(R_m) - R_F}{\sigma(R_m)}\left[\Sigma x_i \frac{\partial\sigma(R_m)}{\partial x_j} - \Sigma x_i \frac{\partial\sigma(R_m)}{\partial x_i}\right] \quad .$$

But $\Sigma x_i = 1$ so we have the following:

$$(9) \qquad E(R_j) - E(R_i) = \frac{E(R_m) - R_F}{\sigma(R_m)} [\Sigma x_i \frac{\partial\sigma(R_m)}{\partial x_j} - \Sigma x_i \frac{\partial\sigma(R_m)}{\partial x_i}].$$

Note that:

$$\sigma(R_m) = [\sum_i \sum_j x_i x_j \sigma_{ij}]^{1/2}$$

$$= \frac{\sigma^2(R_m)}{\sigma(R_m)} = \frac{\sum_i \sum_j x_i x_j \sigma_{ij}}{\sigma(R_m)}$$

$$= \Sigma x_i \frac{\Sigma x_j \sigma_{ij}}{\sigma(R_m)} .$$

Thus:

$$(10) \qquad \frac{\partial\sigma(R_m)}{\partial x_i} = \frac{\Sigma x_j \sigma_{ij}}{\partial(R_m)} .$$

Note also that:

$$(11) \qquad COV\ (R_i, R_m) = COV\ (R_i, \Sigma x_j R_j) = \Sigma x_j COV(R_i, R_j)$$

If (11) is substituted into (10) we have:

$$(12) \qquad \frac{\partial\sigma(R_m)}{\partial x_i} = \frac{COV(R_i, R_m)}{\sigma(R_m)} .$$

Now, substitute relation (12) into equation (9) and recall that $\Sigma x_i = 1$.

$$(13) \qquad E(R_j) - E(R_m) = \frac{E(R_m) - R_F}{\sigma(R_m)} [\frac{COV(R_j, R_m)}{\sigma(R_m)}$$

$$- \frac{\Sigma x_i \Sigma x_j \sigma_{ij}}{\sigma(R_m)} .$$

But $\frac{\Sigma x_i \Sigma x_j \sigma_{ij}}{\sigma(R_m)} = \frac{\sigma^2(R_m)}{\sigma(R_m)} = \sigma(R_m)$

Thus, (13) becomes:

$$(14) \quad E(R_j) - E(R_m) = R_F - E(R_m) + \left[\frac{E(R_m) - R_F}{\sigma(R_m)}\right] \cdot \frac{COV(R_j R_m)}{\sigma(R_m)} .$$

Equation (14) can be rewritten as follows:

$$(15) \quad E(R_j) = R_F + [E(R_m) - R_F] \frac{COV(R_j R_m)}{\sigma^2(R_m)} .$$

Let

$$\frac{COV(R_j, R_m)}{\sigma^2(R_m)} = \beta_{jm} .$$

Thus we obtain the asset equilibrium condition (16):

$$(16) \quad E(R_j) = R_F + \beta_{jm} [E(R_m) - R_F], \text{ for all } j.$$

Intuitively, relation (16) claims that the expected return from security j is composed of two factors. The first is the riskless rate of return. The second factor is a term which adjusts the expected return from each individual security to be proportional to the amount of risk that the particular asset j, contributes to the market portfolio. This risk is measured by β_{jm}, commonly referred to as the beta coefficient.

The expected return on j differs from that of the riskless asset by:

$$\beta_{jm}[E(R_m) - R_F]$$

or

$$(17) \qquad \frac{COV,(R_j,R_m}{\sigma^2(R_m)} \; [E(R_m) - R_F] \quad .$$

Hence if the expected return on j moves by very much with the expected return on the market portfolio (of which j is a part) then we would observe that $COV(R_j,R_m)$ is high. In a relative sense j contributes much risk to the entire portfolio. Hence, (17) will be large, making the difference between $E(R_j)$ and R_F large. If on the other hand, $COV(R_j,R_m)$ is low, j contributes less risk to the portfolio. Proportionately the difference between $E(R_j)$ and R_F will be smaller than in the first instance.

We noted earlier that the final results of the CAPM are independent of the degree of risk aversion that individual investors exhibit. This results from the fact that the decision to distribute one's wealth between the risky market portfolio and the riskless rate of return is separable from the final composition of the optimum risky portfolio.[3] The aggregate degree of risk aversion will only change final equilibrium prices in a relative sense.

To intuit this, it might be helpful to assume that the market is initially in equilibrium and that a specific aggregate degree of risk aversion is present. Now suppose that individual preferences change so that a relatively greater aggregate amount of risk aversion ensues.

Individual investors will now prefer to place relatively larger amounts of their wealth in the riskless asset. An excess supply of risky assets results, driving prices of individual securities down and hence increasing the expected return of the market portfolio. Individuals will once again shift their funds into risky assets until equilibrium is attained.

Suppose on the other hand that investors exhibit an aggregate smaller degree of risk aversion. This would cause the final portfolio to be composed of a proportionately greater share of the risky market portfolio. An excess demand for individual risky securities results and hence prices rise, causing expected returns to fall. In general, a comparatively lower aggregate degree of risk aversion will cause prices of securities to be higher than with respect to a comparatively higher aggregate degree of risk aversion. This causes expected returns to fall and hence compensation for risk to be less.

We now proceed to explore the pricing of foreign exchange with the aid of the CAPM. This allows for the explicit introduction of risk aversion as a behavioral characteristic of foreign exchange market participants. The CAPM has been used before to investigate questions regarding exchange risk and equilibrium asset prices in an international setting. Solnik[4] develops a model similar to the one presented in this chapter. Market participants are rational risk averse maximizers of expected utility.

Capital markets are frictionless in that transactions costs and other barriers to trade do not exist. Solnik also assumes that interest rate parity holds exactly. This assumption is used in the first model developed in the forthcoming section but relaxed in the following ones.

Solnik and Roll[5] estimate Solnik's form of the CAPM using data covering July 1971 through January 1975 for six Western European countries, the United States and Canada. They are able to empirically verify that exchange risk is a relevant factor in regard to exchange rate equilibrium.

Solnik's model differs from the CAPMs developed in part B of this chapter in the following respect. The risky market portfolio in Solnik's case is assumed to consist of a world portfolio of bonds. In our analysis we have generalized and essentially assumed that the world consists of two countries. Hence the market portfolio consists of assets from two countries only. This does not appear to alter the general results however.

Westerfield[6] uses the CAPM to investigate the relationship between maturity and risk in regard to forward exchange. Her results indicate that the exchange risk associated with holding securities of varying maturities for comparable periods of time does not differ. Buying a ninety-day forward contract and holding it for only thirty days does not carry more or less risk than buying a thirty-day forward contract and holding it for that same period. Her model is essentially constructed as is ours, with the exception again that the market portfolio consists of a world portfolio of bonds.

Grauer, Litzenberger and Stehle[7] and Fama and Farber[8] use alternative formulations of the capital asset pricing model. Grauer, et. al. assume multiplicative multicommodity utility functions. In their formulation, relative asset prices do not change if a single currency is assumed to exist; i.e. they do not see a case for the existence of exchange risk. Fama and Farber, on the other hand, show that the purchasing power risk of a country's money supply is borne by residents of other countries.

B. Application of the Capital Asset Pricing Model to the Pricing of Forward and Spot Exchange

Consider the investor from Country A. This individual is faced with various alternatives insofar as the acquisition of foreign risky and domestic riskless assets is concerned.[9] One option is to place funds in the domestic risk-free asset, while contracting to purchase foreign exchange forward. On the maturity date the foreign currency will be bought at the contracted price and simultaneously exchange in the spot market for domestic currency at the price that prevails that day. A one dollar investment will secure the following expected return:

$$(17) \quad E(R_1) = (1 + r_a) \frac{E_t(S_{t+1} | \phi_t)}{F_{t,t+1}} - 1 ,$$

where: r_a is the riskless nominal interest rate in country A.

r_b is the riskless nominal interest rate in country B.

$E_t(S_{t+1}|\phi_t)$ is the expected price of spot exchange in period t+1, formulated at time t conditioned on the information set available at time t.

$F_{t,t+1}$ is the price of forward exchange, set at time t, for delivery at time t+1.

S_t is the price of spot exchange formulated at t for time period t.

$E(R_i)$ is the expected return from transaction i.

It is assumed that there are no margin requirements with respect to the acquisition of a forward contract. Also, there is no foreign exchange risk with respect to the acquisition of a forward contract. The domestic risk-free interest rate r_a, is exogenously determined.

Alternatively, the investor may buy pounds at today's price and place the funds in a British interest-bearing asset earning r_b. On the maturity date, the investor exchanges principle plus return into dollars at the going spot price. The expected return from this transaction is as follows:

$$(18) \quad E(R_2) = (1 + r_b) \frac{E_t(S_{t+1}|\phi_t)}{S_t} - 1 \ .$$

As a result of assuming that no risk is involved with respect to the acquisition of forward contracts, and no default risk exists insofar as r_a and r_b are concerned, options (17) and (18) bear risk only with respect to uncertainty of actual values of spot exchange in period t+1.

There are two alternative options which the investor must consider. He or she may simply place his or her funds in the domestic risk-free asset to earn return r_a.

$$(19) \quad E(R_3) = (1 + r_a) - 1 = r_a \quad .$$

The alternative option is to place funds in the foreign riskless asset while covering for exchange risk. The return for the American investor is described by (20).

$$(20) \quad E(R_4) = (1 + r_b) \frac{F_{t,t+1}}{S_t} - 1 \quad .$$

Since it is assumed that there exists no risk with respect to the completion of the forward contract, it must be the case that in equilibrium the return from option three is identical to the return from option four; i.e. in equilibrium the interest rate parity theorem will hold.

$$(21) \quad (1 + r_a) = (1 + r_b) \frac{F_{t,t+1}}{S_t} \quad .$$

For the moment then, we can ignore option (4). The investor is faced with three investment alternatives. He or she may place funds in the first two risky options or in the risk-free domestic asset.

The CAPM implies that the expected return on risky assets j will be set as in equation (16),

$$(16) \quad E(R_j) = R_f + \beta_{jm}[E(R_m) - r_a]$$

Substituting r_a for the riskless return it follows that for the American investor,

$$(22) \quad E(R_1) = r_a + \beta_{1m} [E(R_m) - r_a]$$

and

$$(23) \quad E(R_2) = r_a + \beta_{2m} [E(R_m) - r_a] .$$

The differences in expected returns can be described as below:

$$(24) \quad E(R_1) - (E(R_2) = [E(R_m) - r_a] \beta_{1m} - [E(R_m) - r_a]\beta_{2m}$$

$$= [\beta_{1m} - \beta_{2m}] A$$

where $A \equiv E(R_m) - r_a$.

Note however, that from (17) and (18) differences in returns may be described as follows:

$$(25) \quad E(R_1) - E(R_2) = (1 + r_a) \frac{E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} - \frac{(1 + r_b) E_t(S_{t+1}|\phi_t)}{S_t}$$

Substituting (25) into (24) yields the following expression;

$$(26) \quad (1 + r_a) \frac{[E_t(S_{t+1}|\phi_t]}{F_{t,t+1}} - \frac{(1 + r_b) E_t (S_{t+1}|\phi_t)}{S_t}$$

$$= [\beta_{1m} - \beta_{2m}] A .$$

The difference in expected returns from engaging in investment alternatives 1 and 2 should in equilibrium be described by the differences in $COV(R_1,R_m)$ and $COV(R_2,R_m)$. Recall however that the return from an investment in the domestic riskless asset must be identical to the return from investment in the foreign default-free security covered for exchange risk. Thus we substitute the interest rate parity condition (21) into (26) to obtain,

$$(27) \quad \frac{E_t(S_{t+1})(1 + r_a)(1 + r_b)}{(1 + r_a)S_t} - \frac{E_t(S_{t+1})(1 + r_a)(1 + r_b)}{(1 + r_a)S_t}$$

$$= [\beta_{1m} - \beta_{2m}] A \quad .$$

The two terms on the left-hand side of equation (27) cancel. Consequently,

$$(28) \quad [\beta_{1m} - \beta_{2m}] \; A = 0 \quad .$$

For (28) to hold, it must be that either:

$$A = E(R_m) - r_a = 0, \text{ so that}$$

$$(29) \quad E(R_m) = r_a$$

or that

$$[\beta_{1m} - \beta_{1m}] = 0, \text{ so that}$$

$$(30) \quad \beta_{1m} = \beta_{2m} \quad .$$

If (29) holds; i.e. if the expected return from the optimum risky portfolio is identical to the riskless rate of return, there would be no investments in risky assets because CAPM is built on the proposition of risk-averse behavior. Thus we are left with interpreting the significance of (30). If the beta coefficients are equal for the two options it must be that $COV(R_1,R_m) = COV(R_2,R_m)$. This in turn implies that expected returns on R_1 and R_2 will move with the return on the optimum risky market portfolio in exactly the same manner. Since in this special case the optimum market portfolio is composed only of the securities 1 and 2 we are left with a very special case of the CAPM. Depending on the prevailing set of prices, the investment opportunity set will consist of one point on $E(R_p)$, $\sigma(R_p)$ space. As prices change, expected returns change but the level of risk does not. Hence, regardless of price we know for certain that the optimum risky portfolio carries a specific level of risk. Investors cannot change the prevailing level of risk independently of combining the risky portfolio with the riskless one.

As prices change, the attainable portfolio changes. Since the attainable portfolio consists of only one point by definition it is the optimum portfolio. The set of all optimum portfolios, allowing for prices to vary, can be described by a vertical line as in Figure Nine. This line should not be interpreted as the attainable set of portfolios as described by Figure Eight. In Figure Eight, the attainable set is defined given an unique vector of prices. Here, we are describing all possible portfolios given the <u>entire</u> range of prices.

We can bound the set described in Figure Nine at the

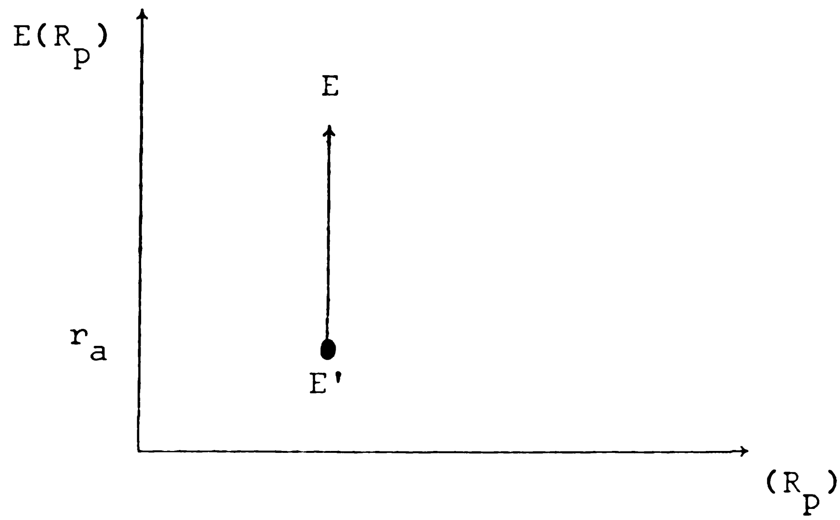

FIGURE NINE

lower end by the riskless return, r_a. The vectors of prices which make expected returns from investments in risky assets less than or equal to the riskless rate, cannot be a stable equilibrium. If prices are such that they are within this range, it will have to be that as a result of risk averse behavior, market participants place all their funds in the riskless asset. This will result in a disequilibrium situation, with an excess supply of risky assets, which will ultimately lower the price, raise its expected return and hence shift the optimum portfolio up.

It is not possible, however, to bound this set from above. It may be that demand and supply conditions are such that expected returns from investing in the risky portfolio becomes indefinitely high. The exact level of prices will be determined by demand and supply, and hence the sum of individual risk preferences.

In sum, final equilibrium prices will be determined at the point where demand for securities is equal to supply. Demand and supply will be determined by the interest rate parity condition and by individual preferences for risk. It will be true in equilibrium that the expected return from engaging in transaction one is identical to that for engaging in two.

C. Capital Asset Pricing with Forward Exchange Risk

In this section, we shall attempt to elaborate on the results of the previous analysis. This is done by introducing another source of risk in the investment alternatives. We shall assume that one incurs risk upon entering a forward contract. There exists the possibility that a forward commitment will not be honored.[10] We shall refer to this as forward exchange risk. The alternative form of risk, exchange risk, refers to the uncertainty pertaining to pursuing transactions that require use of the spot market at some future period.

By introducing forward exchange risk, we in effect prevent the interest rate parity theorem from holding exactly. A "covered" position in a foreign asset may in effect not be covered because the forward contract may not be honored. It follows that the expected return from engaging in such a position needs to be greater than the riskless alternative r_a.

We are now faced with three risky investment opportunities. The first option is to place funds in the domestic riskless asset and purchase forward exchange which requires no margin. On the maturity date, buy the foreign currency at the contracted price and exchange it back into dollars at the going spot price. The expected return is described by equation (31).

$$(31) \quad E(R_1) = (1 + r_a) \frac{E_t(S_{t+1} | \phi_t)}{F_{t,t+1}} - 1 \ .$$

Secondly, the investor may buy spot exchange at time t, place these funds in a British asset and at maturity exchange principle plus return into dollars.

$$(32) \quad E(R_2) = (1 + r_b) \frac{E_t(S_{t+1} | \phi_t)}{S_t} - 1 \ .$$

The last risky alternative is to exchange dollars for pounds, place the funds in the riskless British asset and simultaneously cover for exchange risk by purchasing dollars forward. The expected return from this option is described by (33).

$$(33) \quad E(R_4) = (1 + r_b) \frac{F_{t,t+1}}{S_t} - 1 \ .$$

The first alternative carries both forward exchange and exchange risk. The second operation carries only exchange risk. The last transaction is risky in that the forward contract may not be honored.

Capital asset market equilibrium requires that the following relationships hold:

$$(34) \quad E(R_1) = r_a + \beta_{1m}[E(R_m) - r_a],$$

$$(35) \quad E(R_2) = r_a + \beta_{2m}[E(R_m) - r_a],$$

$$(36) \quad E(R_4) = r_a + \beta_{4m}[E(R_m) - r_a],$$

Subtracting (35) from (34) we observe the following,

$$(37) \quad E(R_1) - (E(R_2) = [\beta_{1m} - \beta_{2m}]\, A$$

where $A = E(R_m) - r_a$.

Clearly, the expected return of the optimum risky portfolio $E(R_m)$, is greater than the risk free rate of return. Thus, $E(R_1) \gtreqless E(R_2) - 0$ depending on whether $\beta_{1m} \gtreqless \beta_{2m} - 0$. Suppose $\beta_{1m} \geq \beta_{2m}$. Then $E(R_1) \geq E(R_2)$ or

$$(1 + r_a)\, \frac{E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} \geq (1 + r_b)\, \frac{E_t(S_{t+1}|\phi_t)}{S_t}$$

Rearranging, we see that this implies that:

$$(1 + r_a) \geq (1 + r_b)\, \frac{F_{t,t+1}}{S_t} \quad .$$

This is a contradiction since it would imply that pursing a risky investment alternative leads one to expect to earn at most as much as the riskless return. Thus, we must conclude that $\beta_{2m} > \beta_{1m}$ and that $E(R_2) > E(R_1)$. This is interesting in that it implies that though investment alternative 1 incurs two forms of risk, while alternative 2 incurs only one, alternative 2 is in fact riskier. Presumably, by introducing forward exchange risk, part of the risk associated with exchange rate uncertainty is cancelled. asset 2 moves with the market asset more than does asset 1, i.e. $\beta_{2m} > \beta_{1m}$. Intuitively, actual R_2 is subject to greater variations than is R_1. In regard to a forward transaction, default of the contract would at most imply that the investor earns only the risk-free rate of return. His or her funds have not been converted into foreign exchange and hence actual losses will only consist of the difference between expected returns and the riskless return. In regard to the spot speculator, the variability of his or her return is much greater and more closely follows the market portfolio. If actual S_{t+1} differs by much from the expected spot price, his or her returns will vary by much. If on the other hand actually S_t varies by little from the expected spot price, his or her returns will vary by little. These differences will be closely associated with the variability of the market portfolio.

A second relationship may be derived from the above model. The return from any of the three risky alternatives must be greater than the riskless return. For example:

$$E(R_1) = (1 + r_a) \frac{E_t(S_{t+1} | \phi_t)}{F_{t,t+1}} - 1 > r_a$$

so

$$(1 + r_a) \frac{E_t(S_{t+1} | \phi_t)}{F_{t,t+1}} > 1 + r_a$$

or

$$\frac{E_t(S_{t+1} | \phi_t)}{F_{t,t+1}} > 1 .$$

This, of course implies that $F_{t,t+1} < E_t(S_{t+1}|\phi_t)$.

Observe the difference in risky alternatives 2 and 4.

$$E(R_2) - E(R_4) = (1 + r_b)\frac{E_t(S_{t+1}|\phi_t)}{S_t} - (1 + r_b)\frac{F_{t,t+1}}{S_t}$$

$$= [\beta_{2m} - \beta_{4m}]\ A.$$

Since we have concluded that $F_t < E_t(S_{t+1}|\phi_t)$, it must be the case that the difference is positive; i.e. $\beta_{2m} > \beta_{4m}$ and therefore risky investment alternative 2 is in fact riskier than 4.

It might be argued that one can make the analysis more appropriate by introducing margin requirements for forward exchange contracts. This is done below by subtracting the margin requirement q, from expected returns 1 and 4. The new equations describing returns are as follows:

$$(38)\quad E(R_1) = (1 + r_a)\frac{E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} - (1 + q)$$

$$(39)\quad E(R_2) = (1 + r_b)\frac{E_t(S_{t+1}|\phi_t)}{S_t} - 1$$

$$(40)\quad E(R_4) = (1 + r_b)\frac{F_{t,t+1}}{S_t}$$

We know that the expected return from a risky investment alternative is in equilibrium greater than the expected return from a riskless alternative. It follows then that $E(R_1) > E(R_3) = r_a$, or:

$$(1 + r_a)\frac{E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} - (1 + q) > r_a.$$

Hence:

$$(1 + r_a) \frac{E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} > 1 + r_a + q$$

or

$$(41) \qquad \frac{E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} > \frac{1 + r_a + q}{(1 + r_a)}$$

The right hand side of (41) is greater than one, provided that transactions costs are positive. It follows then that the left hand side is greater than one. As before, $E_t(S_{t+1}|\phi_t) > F_{t,t+1}$.

A second relationship is easily derived. This is that the expected return from pursuing investment alternative 2 is greater than that from pursuing 1. This can be proven by contradiction.

Suppose this were not the case; i.e. $E(R_1) \geq E(R_2)$. From (38) and (39) we have:

$$\frac{(1 + r_a)E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} - (1 + q) \geq \frac{(1 + r_b)E_t(S_{t+1}|\phi_t)}{S_t} - 1$$

or

$$(1 + r_a) \frac{E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} + q \geq \frac{(1 + r_b)E_t(S_{t+1})}{S_t}$$

or

$$(1 + r_a)E_t(S_{t+1}|\phi_t) + qF_t \geq (1 + r_b)E_t(S_{t+1}|\phi_t) \frac{F_{t,t+1}}{S_t}$$

or

$$(42) \qquad (1 + r_a) + q \frac{F_{t,t+1}}{E_t(S_{t+1}|\phi_t)} \geq (1 + r_b) \frac{F_{t,t+1}}{S_t}$$

Examine the left hand side. From p. 87 we know that

$F_{t,t+1} < E_t(S_{t+1}|\phi_t)$. Therefore $\frac{F_{t,t+1}}{E_t(S_{t+1}|\phi_t)}$ is a number smaller than one. It follows then that $1 + r_a + q \frac{F_{t,t+1}}{E_t(S_{t+1}|\phi_t)}$ is smaller than $1 + r_a + q$ since q multiplied by a number less than itself must result in a number less than q.

But we know that the expected return from a risky investment alternative must be greater than the return from a riskless alternative. Hence $E(R_4) > r_a$ or

$$(1 + r_b) \frac{F_{t,t+1}}{F_{t,t+1}} (1 + q) > r_a$$

equivalently

$$(43) \quad = \quad (1 + r_b) \frac{F_{t,t+1}}{S_t} > 1 + r_a + q$$

It therefore follows that

$$(44) \quad (1 + r_b) \frac{F_{t,t+1}}{S_t} \quad 1 + r_a + q \frac{F_{t,t+1}}{E_t(S_{t+1}|\phi_t)} \quad ,$$

Since the right hand side of (44) is even smaller than the right hand side of (43) Equation (42) is a contradiction. It follows then that $E(R_2) > E(R_1)$.

D. Conclusions

In this chapter the Sharpe-Linter capital asset pricing model is used as an alternative to the model of Chapter Three. The CAPM allows us to account for risk aversion on the part of investors. In addition, we are able to derive final equilibrium values such that no unusual profit opportunities remain unexploited. Hence the market complies with the conditions necessary for efficiency.

Three versions of the CAPM are derived. In the first instance we assume that there exists only one form of risk. Spot and forward speculative transactions are risky only with respect to uncertainty regarding tomorrow's exchange rate. We derive the following results. The forward price is a biased estimator of the expected future spot price, i.e. speculators earn a risk premium. Secondly, the expected return from engaging in spot speculation is identical to the expected return of forward speculation. Thirdly, interest rate parity holds exactly. This results from the assumption that there is no forward exchange risk; investments in the covered foreign asset are riskless.

The second model assumes that forward exchange risk exists, i.e., forward contracts may not be honored as a result of political risk, for example. Hence, in this instance pursuing covered arbitrage opportunities will earn a positive expected return. Now we have three risky investment alternatives. As in the previous model, the forward rate is negatively biased with respect to the expected future spot price. Another result is that returns expected from spot transactions exceed those expected from forward transactions. Hence despite the fact that spot transactions incur one form of risk, while forward transactions incur two, the spot asset is in fact riskier.

In the third model, we incorporate margin requirements on forward contracts. The results concerning relative returns remain unaffected. It was also noted in this chapter that varying degrees of risk aversion will not change the basic results. If high degrees of risk aversion are present in an aggregate sense, risk premiums will be relatively larger than if lower degrees of risk aversion are present.[11] Basic relationships between differing assets remain unaffected, however.

We use the results of this analysis in the following chapter where an alternative equilibrium model of exchange rate determination is developed.

CHAPTER FIVE

AN ALTERNATIVE MODEL OF EFFICIENT FOREIGN EXCHANGE RATES

Introduction

Past empirical work on the efficient market hypothesis in the context of the foreign exchange market has dealt mainly with the relationship between forward prices set at past dates due at time t, and the spot price set at time t.[1] The following equation is frequently estimated.

$$S_t = \gamma + \beta F_{t-1,t} + \varepsilon,$$

where S_t is the spot price prevailing at time period t.

$F_{t-1,t}$ is the forward price set at time t-1 for delivery at t.

ε is an error term.

If γ is not significantly different from zero and β is not significantly different from unity, then the forward rate is an unbiased estimator of the future spot price. This implies that the foreign exchange market is efficient since no unusual profit opportunities remain to be exploited. If test results show that a bias does exist, then it is claimed that this is a result of a risk premium and the market is still efficient since investors are being compensated for risk and thus unusual profit opportunities do not exist.

Tests of biasedness and unbiasedness are plentiful in the literature covering efficient foreign exchange markets. We shall not prove that the above approach to testing is invalid. It is in keeping with testing for weak efficiency. In a weakly efficient market, past prices cannot be used to earn unusual profits. The above approach is testing just for that. Tests which keep more in line with the more elaborate specifications of an efficient market however, can be devised and can better explain the formulation of spot prices and consequently be better tests of the theory. This is the approach that will be used in this chapter.

Three major improvements can be made in devising test of the EMH. First, one should use an observable variable which measures expectations conditional on the information set at time t. Specifically, as opposed to regressing $F_{t-1,t}$ on S_t, one ought to use as the regressor $F_{t,t+1}$. When one measures expectations via the use of forward prices set at a time period prior to t the expectation is based on a past information set. It should not be optimal in explaining S_t which in theory is explainable by t's information set. The expectation formulated at t-1 given the information available at that time, concerning price at t, $\{E_{t-1}(S_t|\phi_{t-1})\}$, on two accounts differs from $E_t(S_{t+1}|\phi_t)$. The information sets differ, as does the period during which the expectation is formed.[2]

The second improvement which can be made in devising tests of the EMH is to discern the specific manner by which expectations are involved in the formulation of forward prices. These prices may measure expectations in a biased manner. If one can theoretically discern these biases they can be accounted for in the estimation process.

The third improvement involves testing for the significance of the time series of expectations. If today's spot price is based on expectations of (t+1)'s price, why should it not be that S_t is based on expectations of (t+2)'s price? In the study of efficient markets one ought to use expectations of prices expected to prevail at different points of time in the future. One should examine the problem as indicated below.

The efficient market hypothesis claims that today's price incorporates all available information and thus should reflect expectations of prices to prevail in future periods. Hence, we can expect some form of the following relationship to hold:

$$(1) \qquad S_t = \sum_{i=1}^{\infty} \beta_i E_t(S_{t+i}|\phi_t)$$

where $\sum_{i=1}^{\infty} \beta_i = 1$ The betas give differential weights to each expectation, and may at some future point in time converge to zero.

S_t is the spot price at time t.

$E_t(S_{t+i}|\phi_t)$ is the expected spot price at t+i given the information set at time t.

If forward prices exactly reflect expectations of future prices then the observable variable, $F_{t,t+i}$ can be used in place of the expectations term to test the hypothesis. Equation (1) would then become:

$$(2) \qquad S_t = \sum_{i=1}^{\infty} \beta_i F_{t,t+i}$$

where $F_{t,t+i}$ is the forward price set at time t for delivery at t+i.

It may be however, that though forward prices indicate expectations they do not exactly reflect expected future prices. This may be the result of risk premiums earned by holders of forward contracts, or transactions costs. Thus, the correct form for the determination of spot prices would be derived in the following general manner. Suppose it is assumed that forward prices are determined as in (3).

$$(3) \qquad F_{t,t+i} = \frac{E_t(S_{t+i}|\phi_t)}{x_i}$$

The term x_i, adjust the setting of forward prices such that holders of forward contracts earn a risk premium, and/or are compensated for transactions costs. By rearranging, the following is true:

$$(4) \qquad E_t(S_{t+i}|\phi_t) = x_i F_{t,t+i} \, .$$

We have hypothesized that spot prices are determined as in equation (2).

$$(2) \qquad S_t = \sum_{i=1}^{\infty} \beta_i E_t(S_{t+i} | \phi_t)$$

where $\sum_{i=1}^{\infty} \beta_i = 1$.

By substituting (4) into (2) we find that:

$$(5) \qquad S_t = \sum_{i=1}^{\infty} \beta_i [x_i F_{t,t+i}].$$

Letting $\beta_i x_i = \gamma_i$, equation (5) can be written as follows:

$$(6) \qquad S_t = \sum_{i=1}^{\infty} \gamma_i F_{t,t+i} \ .$$

Under different theories of the formulation of forward prices (the specific forward bias to be encountered with respect to expectations), and of the weighting scheme in the formulation of today's price, specific patterns for the coefficients x_i and β_i can be expected to prevail.

In this chapter we examine the biases which may exist in using current forward prices as indicators of future prices. In part B the use of many forward prices as regressors is explored. Theories concerning the weights that would be expected to prevail are developed. Part B is followed by a digression on rational expectations which proves interesting. On the one hand, it is shown that the specification of the model in Chapter Three complies with expectations which are formed under the Rational Expectations Hypothesis. On the other hand, it is shown that it is desirable that one uses a time series of expectations to explain current spot prices. In Part D, the model is further improved by accounting for the fact that just as forward prices may be biased measures of expectations, expectations of future prices may be a biased measure of spot prices.

A. Are Forward Prices Biased or Unbiased Estimators of Expectations?

In this section we investigate under varying conditions the question of biasedness of forward prices with respect to expected future prices. Different conclusions are derived using different sets of assumptions. We begin using the results from Chapter Four regarding the setting of prices in a world conforming to the capital asset pricing model.

Version I

The following is assumed.

1. There are margin requirements on purchases of forward exchange.
2. Final equilibrium values are attained using the CAPM. This implies the following assumptions:
    a. Risk averse behavior.
    b. Homogeneous expectations on the part of all investors.
    c. Perfect capital markets.
    d. An exogenously determined interest rate

pertaining to the riskless asset.

Using the results from Chapter Four we can specify the expected return on purchases of forward contracts to be as follows:

$$(7) \qquad E(R_1) = (1 + r_a) \frac{E_t(S_{t+1}|\phi_t)}{F_{t,t+1}} - (1 + q)$$

where q is the margin requirement per unit of forward exchange contracted.

To simplify notation let $E(R_1) = \alpha_1$. We know from Chapter Four that the particular value for α_1 will be determined according to the specific conditions that exist in the market simultaneously with the expected returns from alternative investments. We can unequivocally state that with the existance of some risk, α_1 is greater than r_a, the riskless return. Solving for the forward rate, we find that:

$$F_{t,t+1} = \frac{(1 + r_a)}{(1 + \alpha_1 + q)} E_t(S_{t+1}|\phi_t)$$

or

$$(8) \qquad F_{t,t+1} = x_1 E_t (S_{t+1}|\phi_t)$$

where $$x_1 = \frac{(1 + r_a)}{(1 + \alpha_1 + q)}$$

Since we know that α_1 must be greater than r_a, and that margin requirements are positive, it must be that x_1 is less than one, and so $F_{t,t+1}$ underestimates tomorrow's expected spot price.

Version II

In this specification of the forward rate, we shall eliminate the assumption that margin requirements are necessary when contracting for a forward position. Thus with respect to equation (7) we drop the transactions cost q_1.

$$(9) \qquad \alpha_2 = (1 + r_a) \frac{E_t(S_{t+1} | \phi_t)}{F_{t,t+1}} - 1 \quad .$$

Once again α_2, or the expected return from engaging in a forward transaction is determined within the framework of the entire model. We still are certain however that in equilibrium α_2 will be greater than the riskless rate of return r_a since risk is still a relevant factor. By rearranging we find that:

$$(10) \qquad F_{t,t+1} = x_2 \, E_t(S_{t+1} | \phi_t)$$

where $\quad x_2 = \dfrac{(1 + r_a)}{(1 + \alpha_2)} \quad .$

It must be that the forward rate is again a biased estimator of tomorrow's expected price. This bias is negative since x_2 must be a number less than one.

Version III

Now we shall drop the assumption that investors are risk averse. In a risk neutral world, market equilibrium will insure that all investment alternatives earn the same expected rates of return regardless of risk inherent in pursuing the various investment alternatives. If margin requirements are

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are necessary, asset equilibrium expected returns will be determined as follows:

$$(11) \quad \alpha_3 = (1 + r_a) \frac{E_t(S_{t+1} | \phi_t)}{F_{t,t+1}} - (1 + q)$$

Equation (11) is identical to (7). In this instance however, we know that α_3 or the expected return from engaging in a forward speculative position will in equilibrium be equal to the riskless rate of return. Thus, by substitution r_a for α_3 and rearranging the terms we find that:

$$(12) \quad F_{t,t+1} = x_3 \, E_t(S_{t+1} | \phi_t)$$

where $x_3 = \dfrac{1 + r_a}{1 + r_a + q}$.

Since margin requirements must be positive, it follows that once again the forward price is biased. It is biased in the same direction as determined in the previous two specifications of the model. In contrast to the first two specifications however, the bias results solely from transactions costs and is not a result of risk compensation.

<u>Version IV</u>

In this instance, we shall eliminate the assumption that margin requirements exist for investors wishing to pursue forward transactions. Asset equilibrium expected returns will then be as follows:

$$(13) \quad r_a = (1 + r_a) \frac{E_t(S_{t+1} | \phi_t)}{F_{t,t+1}} - 1$$

Solving for the forward rate yields the following:

$$(14) \quad F_{t,t+1} = x_4 \; E_t \; (S_{t+1} | \phi_t)$$

where $$x_4 = \frac{1 + r_a}{1 + r_a} = 1$$

In this last case, the forward rate will be an unbiased estimator of the expected future spot price.

We can conclude that in most instances it would be incorrect to assume that the forward price of foreign exchange is an exact estimator of the expected future spot price. If one is working with a risk averse world, it must be that the forward price underestimates the future expected spot rate. Even in a world which assumes risk neutrality, as long as some transactions cost exist, the forward rate will be biased. Only in the case where investors are risk neutral and where no transactions exist can we unequivically state that the forward price is an unbiased estimator of the expected future price.

B. Using a Time Series of Expected Prices to Explain Current Prices

It is often stated that in an efficient market, today's price is the best estimator of tomorrow's price.[3] This result from the contention that the current price is based on tomorrow's expected price. If this were not so profits could be earned. Hence, trading on the part of profit seekers will ensure that the expected price is attained.

The question one is tempted to ask is, what is meant by tomorrow's expected price? Is the relevant expectation the price expected at t+1, t+2, or t+100? Suppose for instance at time t there exists the following expectations:

$$E_t(S_{t+1}|\phi_t) = \$10.00$$

and

$$E_t(S_{t+2}|\phi_t) = \$11.00$$

Also suppose that there only exist for speculative purposes dollars and pounds, neither of which can earn interest in alternative ways. If some individuals trade with the shorter time horizon in view, and others with the longer time horizon in mind, then at the conclusion of trading in time period t we would expect the price to settle somewhere between \$10.00 and \$11.00. If one group has more power (i.e., more funds at its disposal) than the other group, then we would expect the price to settle closer to the expectation held by the stronger group. Hence, the final price will be set according to the following relationship:

$$S_t = b[\$10.00] + (1 - b)[\$11.00]$$

where $0 \leq b \leq 1$

Note that it is not implied that expectations are heterogeneous. All individuals may have the same time series of expected prices, but for economic reasons may trade with different time horizons in mind. One might perhaps assume a preferred habitat theory for behavior of this nature.

In general, we can specify the determination of today's price in the following manner:

$$(15) \quad S_t = \sum_{i=1}^{\infty} \beta_i E_t(S_{t+i}|\phi_t)$$

where $\sum_{i=1}^{\infty} \beta_i = 1$

It might be hypothesized that the betas decline in value as i increases. That is, $\beta_1 > \beta_2 > \beta_3$ and so forth. The reasoning for such a weighing scheme may be as follows. In a risk-averse world the variance of an expectation for some period further away from today is likely to be higher. Since the time lapse is longer, say between t and t+2 then between t and t+1, it is more likely that actual S_{t+2} be more different from $E_t(S_{t+2}|\phi_t)$ than actual S_{t+1} be different from $E_t(S_{t+1}|\phi_t)$. Since there is a greater time difference, more new information is likely to emerge, thus changing the actual price from its expected by a greater amount. Hence individuals are likely to give less weight to expectations concerning prices further from today than those closer to today. There may be other reasons for this type of behavior to be exhibited. We shall return to this again.

C. Rational Expectations

In this section we shall investigate whether in the model of Chapter Three, expectations are being formulated according to the rational expectations hypothesis (REH). If expectations are in fact rational, then individuals form them according to the underlying model. Individuals use the relevant theory to make predictions concerning future variables.[4]

In Chapter Three it was concluded that equilibrium could be described by the following system of equations.

$$(16) \quad F_{t,t+1} = E_t(S_{t+1}|\phi_t) - aED_t^f$$

$$(17) \quad S_t = \frac{E_t(S_{t+1}|\phi_t)}{r_t} + cES_t^s$$

$$(18) \quad ED_t^f = ES^s{}_t$$

$$(19) \quad \frac{F_{t,t+1}}{S_t} = r_t$$

where ED_t^f is excess demand for forward exchange at time t.

a is the slope of the excess demand curve for forward exchange.

ES_t^s is excess supply for spot exchange at t.

c is the slope of the excess supply curve of spot exchange.

$r_t \equiv \left(\frac{1 + r_a}{1 + r_b}\right)_t$, a definition where t pertains to the period for which these parameters exist.

r_a the interest rate in country A.

r_b the interest rate in country B.

If investors behave according to the rational expectations hypothesis, it must be the case that in forming expectations concerning next period's spot price,

$E_t(S_{t+1}|\phi_t)$, they use the underlying model. Thus individuals will attempt to solve the following system of equations.

$$(20) \quad E_t(F_{t+1}|\phi_t) = E_t(S_{t+2}|\phi_t) - a\ ED^f_{t+1}$$

$$(21) \quad E_t(S_{t+1}|\phi_t) = \frac{E_t(S_{t+2}|\phi_t)}{E_t(r_{t+1}|\phi_t)} - c\ ES^s_{t+1}$$

$$(22) \quad ED^f_{t+1} = ES^s_{t+1}$$

$$(23) \quad \frac{E_t(F_{t+1}|\phi_t)}{E_t(S_{t+1}|\phi_t)} = E_t(r_{t+1}|\phi_t)$$

where $E_t(r_{t+1}|\phi_t) \equiv E_t\left[\left(\frac{1 + r_a}{1 + r_b}\right)_{t+1} \middle| \phi_t\right]$

or the expected ratio of one plus the interest rates expected to prevail at time period t+1 for the two countries under consideration, given the available information at time t.

The solution to this system of equations is:

$$(24) \quad E_t(S_{t+1}|\phi_t) = \frac{E_t(S_{t+2}|\phi_t)}{E_t(r_{t+1}|\phi_t)} .$$

If (24) is substituted into equations (16) and (17), the resulting solution to that system of equation is:

$$(25) \quad S_t^* = \frac{E_t(S_{t+1}|\phi_t)}{r_t} = \frac{\frac{E_t(S_{t+2}|\phi_t)}{E_t(r_{t+1}|\phi_t)}}{r_t}$$

One should note the implications of (25). If in fact individuals are behaving according to the rational expectations hypothesis, then the solution is still not evident. Individuals must in this case attempt to solve for (t+3)'s expected price, which will also involve making an inference concerning (t+2)'s expected interest rates and (t+3)'s expected price. The true solution to the actual price at time t is some function of the following form,

$$(26) \quad S_t^* = g[E_t(S_{t+\infty}|\phi_t);\ r_t;\ E_t(r_{t+i}|\phi_t)]$$

where $i = 1, \ldots, \infty$.

The one and only expected future spot price which is relevant, is that one which pertains to the price expected to prevail at time infinity. This indeed is an absurd situation. It might be recalled that (26) is identical to that solution which was determined ought to persist if the market were to remain efficient through time from Chapter Three.

In the real world it does not seem plausible that individuals formulate expectations concerning the price at time infinity. Hence, what would the determining expectation be? Is it likely to correspond to the same time period for all individuals? We might venture to say that there must exist individual economic reasons for expecting individuals to differ insofar as the appropriate future determining expectation is concerned. We might for instance propose a preferred habitat theory. Individuals may based on, for instance, their liquidity preferences, the nature and timing of future obligations and their individual degree of risk aversion, choose to invest sums for particular periods of time. If individuals differ insofar as liquidity preferences, obligations and degree of risk aversion are concerned, we can hypothesize that they will be most concerned with the nature of returns for different periods of time. Hence, individual investors will concern themselves with the expected future spot price for different future periods. For the market as a whole we could expect that S_t^* be some function of the following form:

$$(27) \quad S_t^* = g[E_t(S_{t+i}|\phi_t);\ r_t;\ E_t(r_{t+i}|\phi_t)]$$

where $i = 1, 2, \ldots, n$.

We have reasoned that within the framework of a rational expectations model, today's spot price will involve expectations concerning some time series of future expected prices. In the prior section the same conclusion resulted. However, we still need a theoretical basis for explaining exactly how to specify this type of behavior. The succeeding section which attempts to explain the specific relationship between future expectations and current prices deals with this question.

D. Relationships Between Current Spot Prices and Expected Spot Prices

Suppose we use the reasoning of Chapter Four and claim that the current spot price and the expected future spot price are related in the following manner:

$$(28) \quad E(R') = (1 + r_{b,1}) \frac{E_t(S_{t+1}|\phi_t)}{S_t} - 1$$

where $r_{b,1}$ is the return from an investment in the asset of country B if that investment is made for one period of time

Individuals engage in spot transactions until the expected return from a one period transaction, E(R') is as indicated. If we are dealing with a risk neutral world E(R') will be equivalent to the one period domestic riskless interest rate or $r_{a,1}$. Rearranging, (28) becomes

$$(29) \quad S_t = \frac{E_t(S_{t+1}|\phi_t)}{\frac{1 + r_{a,1}}{1 + r_{b,1}}}$$

because $E(R') = r_{a,1}$. Note that (29) is identical to the resulting spot price expected to prevail in the model of Chapter Three. In a risk neutral world, we would expect uncovered interest parity to be the result of spot speculation.

Suppose now that we assume a risk-averse world. We know then that E(R') will have to be greater than $r_{a,1}$ because a spot transaction as described above is a risky venture. In a risk-averse world investors are compensated for incurring risk. Let γ_1 stand for the compensation in excess of the domestic interest rate for individuals engaging in such transactions for one period. That is,

$$E(R') = r_{a,1} + \gamma_1 \quad .$$

Hence:

$$r_{a,1} + \gamma_1 = (1 + r_{b,1}) \frac{E_t(S_{t+1}|\phi_t)}{S_t} - 1$$

for asset equilibrium. Then the spot price at time t can be described in the following manner:

$$(30) \quad S_t = \frac{(1 + r_{b,1})}{(1 + r_{a,1} + \gamma_1)} E_t(S_{t+1}|\phi_t)$$

Letting $\frac{(1 + r_{b,1})}{(1 + r_{a,1} + \gamma_1)} = Z_1$, equation (30) becomes:

$$(31) \quad S_t = Z_1 E_t(S_{t+1}|\phi_t) .$$

Using the same reasoning, in a risk averse world individuals wishing to pursue spot transaction in regard to a two period time horizon will wish to set the spot price as follows,

$$(32) \quad S_t = Z_2 E_t(S_{t+2}|\phi_t)$$

where $Z_2 \quad \frac{(1 + r_{b,2})}{(1 + r_{a,2} + \gamma_2)}$

$r_{a,2}$ is the two period risk-free interest rate for Country A

$r_{b,2}$ is the two period risk-free interest rate for Country B

γ_2 is the two period compensation term for engaging in a risky venture

We would expect the following relative values to be true:

$r_{a,2} > r_{a,1}$ and

$r_{b,2} > r_{b,1}$

due to the time preference for money. Also

$\gamma_2 > \gamma_1$

because as the time horizon lengthens, the variance of returns or risk rises.

If we assume that the term structure of interest rates in Country A follows that of Country B, then with $\gamma_2 > \gamma_1$, it might be plausible to say that $Z_2 < Z_1$. For instance suppose that we assume the following values:

$r_{a,1} = .10$, $r_{b,1} = .09$ and $\gamma_1 = .05$. Then $Z_1 = .947$.

Now assume that in regard to the two period time horizon, interest rates are 100% greater as is compensation for risk. then $r_{a,2} = .20$, $r_{b,2} = .18$ and $\gamma_2 = .10$. Z_2 then becomes .907. Hence, Z_2 is less than Z_1.

Now we are left with the task of formulating one current spot price as a function of two operations being conducted with regard to two time horizons. Suppose we weigh the determination of today's price by the two operations equally. That is, multiply Z_1 and Z_2 each by one half. Then we may posit that:

$$(33) \quad S_t = \beta_1 E_t(S_{t+1} | \phi_t) + \beta_2 E_t(S_{t+2} | \phi_t)$$

where $\beta_1 = Z_1 \cdot 1/2$

$\beta_2 = Z_2 \cdot 1/2$

As a result of equal weighing, and given that $Z_1 > Z_2$ it follows that $\beta_1 > \beta_2$.

In generalized form then, we might expect the following relationship to hold:

$$(34) \qquad S_t = \sum_{i=1}^{n} \beta_i E_t(S_{t+i} | \phi_t)$$

$$\text{where} \quad \beta_i = \left(\frac{1 + r_{b,i}}{1 + r_{a,i} + \gamma_i}\right) \left(\frac{1}{n}\right)$$

It should be noted that we are not requiring that the betas sum to one. Actual spot prices need not be an unbiased measure of expectations. Note also that we might further generalize, and conceivably let the normalization coefficient $\left(\frac{1}{n}\right)$, take some other form. Most probably as the time horizon lengthens, individuals may speculate with smaller sums and hence we might multiply the Z coefficient by a number $\left(\frac{1}{g}\right)i$ where $\left(\frac{1}{g}\right)i$ decreases as i increases and $\sum_{i=1}^{n} \left(\frac{1}{g}\right) = 1$. This would strengthen the hypothesis that the betas decline as the time horizon lengthens.

In order to test the above model, it is necessary to find an appropriate measure of expectations. This can be done by using forward prices adjusted for inherent biases. Suppose we use as our model, that one presented as Version I in this chapter. It was determined that

$$F_{t,t+1} = x_1 E_t(S_{t+1} | \phi_t) \text{ where } x_1 = \frac{(1 + r_{a,1})}{(1 + \alpha_1 + q)}$$

$$\text{Thus, } E_t(S_{t+1} | \phi_t) = \frac{F_{t,t+1}}{x_1}.$$

We need also develop a theory for the determination of $F_{t,t+2}$. Once its bias (x_2), is discerned we can adjust the forward rate to account for tomorrow's expected rate.

Thus, in general we can test the following relationship,

$$(35) \qquad S_t = \sum_{i=1}^{n} \frac{\beta_i}{x_i} F_{t,t+i} \quad .$$

A word ought to be said here concerning the final equilibrium relationship implied by the above equation. By substituting for $F_{t,t+1}$ in (35) we actually are implying that the current spot price is formulated in the following manner:

$$S_t = \sum_{i=1}^{n} \beta_i E_t(S_{t+i} | \phi_t)$$

The exchange rate is determined in an asset market manner. Frankel and Mussa[5] elaborate on this basic approach to market efficiency. They define the asset market theory as one where prices are strongly influenced by expectations of future prices. In general, the asset market approach can be characterized as follows:

$$(36) \qquad S_t = Z_t + b\{E_t(S_{t+1} | \phi_t) - S_t\}$$

where S_t is the logarithm of the spot price at time t.

Z_t is the ordinary factors of supply and demand that affect the exchange rate at time t.

$$E_t(S_{t+j} | \phi_t) = \frac{1}{1+b} \sum_{k=0}^{\infty} [\frac{b}{1+b}]^k \; E_t(Z_{t+j+k} | \phi_t)$$

if rational expectations are assumed.

In many respects the determination of exchange rates as proposed by this thesis is similar in spirit. As in the asset approach today's exchange rate is dependent on a time series of expected future prices. However, in the Frankel and Mussa formulation the time series resulted from the rational expectations assumption. In Chapter Three of this thesis it was found that such an assumption was unnecessary. Rational expectation was a natural outgrowth for consistancy of the model. Expectations will be rational if the model is be consistent, the assumption need not be added independently.

Secondly, it appears that expectations closer in time carry more weight than these further away in the Frankel and Mussa formulation. This is accomplished by assuming the coefficient follows the form $[\frac{1}{1+b}]^k$. The coefficient declines as k increases. This is not developed theoretically in the Frankel and Mussa formulation. In this thesis the coefficients have a theoretical basis for declining in value. The basis is a result of risks and the time preference for money.

A third point is that as in the Frankel and Mussa formulation, a Z_{t+j} factor exists in the model of this chapter. It is explicit in the formulation of the coefficient, β_i.

E. Conclusions

In this chapter, we explored ways to reinterprete the efficient market hypothesis. It was suggested that current empirical work which uses past period's expectations via the use of forward prices set yesterday to explain current prices could not adequately explain today's price.

A better way for explaining today's price should be found in current forward prices. In deriving this result it was also uncovered that in order to claim that last period's forward price is an estimator of the current spot price, one needs assume that expectations are formed in a rational manner. Hence, rational expectations is a necessary condition for efficiency of markets according to the specification of such in much of the literature on foreign exchange market efficiency.

Prices of forward exchange, set today for delivery tomorrow might not accurately reflect expectations of tomorrow's price. This may be a result of margin requirements, and risk aversion on the part of market participants. By using the capital asset pricing model developed in Chapter Four we were able to take into account these varying biases.

It was suggested then that today's spot price might best be explained by using a time series of expected spot prices. Such might be the case if differing groups of investors prefer to speculate with differing time horizons. A model was then developed where today's spot price is a function of varying expected future prices with biases taken into account. This model was then compared to the asset market model of exchange rate determination. It was concluded that the model developed in this chapter is superior since its economic foundations were deemed superior.

CHAPTER SIX

POLICY IMPLICATIONS OF THE EFFICIENT MARKET HYPOTHESIS

Introduction

This chapter is devoted to an examination of the policy implications of efficiency in foreign exchange markets. We examine the models of Chapters Three and Five in the context of the efficient market hypothesis. We discern the alternatives available to policymakers in regard to managing exchange rates. We find that successful intervention is possible in an efficient foreign exchange market. However, questions arise as to the desirability of intervention. Also, it is argued that though intervention is theoretically possible, practically speaking the implementation of these policies is questioned.

In the section to follow we seek for answers to the following questions. How can policymakers alter the exchange rate so that it corresponds to something other than its "true" value? Secondly, we shall attempt to discern whether successful intervention in one period will affect exchange rates in following periods. Do policymakers need to intervene on a continuous basis, or will an exogeneous shock to the system affect the exchange rate for a series of periods.

First we shall study the effects of intervention in regard to the model of Chapter Three. Next, we investigate these same issues assuming that exchange rates are determined by a time-series of expected future prices. The models of Chapter Four will not be examined since they are defined for a single time period, and hence we cannot discern long range effects of intervention.

A. The Management of Exchange Rates Assuming Risk Neutrality

In the model of Chapter Three the equilibrium spot exchange rate at t is:

$$S_t^* = \frac{E_t(S_{t+1}|\phi_t)}{r_t}$$

where $E_t(S_{t+1}|\phi_t) = f[E_t(S_{t+n}|\phi_t), E_t(r_{t+i}|\phi_t)]$ for $i = 1, \ldots, n$ if a finite time horizon is assumed.

Hence it follows that today's exchange rate is some function of the following form:

$$S_t^* = g[E_t(S_{t+n}|\phi_t), E_t(r_{t+i}|\phi_t), r_t]$$

$$i = 1, \ldots, n$$

Policymakers then can affect the exchange rate in four ways. They can alter expectations regarding the expected price at t+n. Secondly, they can motive individuals to reevaluate or alter expectations regarding all or some future expected interest rate. The third option open to policymakers is to alter today's "true" equilibrium interest rate factor, r_t. The last option open to policy makers is to intervene directly in the foreign exchange market, i.e. demand or supply foreign exchange.

In order to discern in what manner a policy move instituted at time t will effect exchange rates in following periods, it is useful to examine the variables which affect the exchange rate at time period t+1. These variables are as follows:

$$S_{t+1}^{*} = h[E_{t+1}(S_{t+n}|\phi_{t+1}), r_{t+1}, E_{t+1}(r_{t+1+i}|\phi_{t+1})]$$

$$i = 1, \ldots ,n$$

If policy makers alter r_t we find that S_t^* will deviate from what it would be under nonintervention. However, this is a one period deviation. The interest factor r_t plays no role in the determination of exchange rates in period t+1. Hence intervention via the manipulation of current interest rates has a small role to play. If policymakers feel that the future course of exchange rates needs be altered permanently they will have to intervene continuously if the current interest rate is to constitute the policy tool.

The result just derived assumes that by manipulating the current interest factor, future expected interest rates are not affected. Also, it assumes that no transmission mechanism exists whereby the expected exchange rate at period t+n is altered as a result of changes in r_t, i.e. r_t is not a function of $E_t(S_{t+n}|\phi_t)$.

In regard to the first assumption; it may be argued that whether or not $E_t(r_{t+i}|\phi_t)$ is independent of movements in r_t is dependent on the theory of interest rate determination that is assumed. It is suggested that this might constitute a further area of research. However, we may posit that interest rates are determined within a rational expectations framework and hence claim that unless market participants believe that policymakers will continually alter future interest rates, it is unlikely that a one period deviation of r_t will result in a reformulation of all expected interest rates.

With respect to the second assumption which claims that $E_t(S_{t+n}|\phi_t)$ is independent of r_t a similar statement may be invoked. It is unlikely that a one period manipulation of interest rates will be felt on a future expectation, especially if n, the time horizon, is very long.

Policymakers have two other manners by which to change exchange rates. On the one hand they may alter $E_t(S_{t+n}|\phi_t)$. If they raise expectations of the future spot price then exchange rates for all future periods (through t+n-1), will be altered. In this case intervention may have long run results. Secondly, policymakers may make attempts to change expectations of all future interest rates, once again inducing long range consequences.

These two results are of course dependent on the assumption that policymakers can alter expectations. In regard to the rational expectations hypothesis, only if the policymaker continually intervenes in the interest rate market or the determinants of it, will the consequences of intervention be long standing. Practically speaking, it is probably more suiting that the relevant future expected spot price $E_t(S_{t+n}|\phi_t)$, be manipulated. Further work in the area of the formation of expectations regarding period t+n would better enable us to answer the question regarding the practicality of such a policy.

The final manner by which exchange rates can be altered is via direct intervention on the part of the government authorities. This can be successful in the long run only if the official authorities make known their intentions, and it is believed that they can successfully intervene on a continuous basis. The authorities will of course be constrained by the availability of reserves and hence this option may not be viable in the long run.

To conclude, the practicality of managing the exchange rate via the manipulation of actual interest rates and by direct intervention is questionable. For long range deviations to be successful, intervention will have to be pursued at every time period. Only in the case of altering the expectations of future variables can policymakers expect to have exchange rates deviate from their "normal" course for an extended period of time.

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B. The Management of Exchange Rates Assuming Risk Averse Behavior

Now we shall examine the options available in regard to managed floating with respect to the model of exchange rate determination of Chapter Five. It was hypothesized that the equilibrium spot rate is determined as follows.

$$S_t^* = \sum_{i=1}^{n} \beta_i E_t(S_{t+i} | \phi_t)$$

where $$_i = \frac{1 + r_{b,i}}{1 + r_{a,i} + \gamma_i} \left(\frac{1}{n}\right)$$

The betas decline in value as i increases since $\gamma_i < \gamma_{i+1}$. This is because as the time horizon lengthens a larger risk premium (γ_i) is earned. Greater risks, are incured as the time horizon lengthens as a result of the possibility of larger variations between actual and expected future exchange rates.

The determination of t's equilibrium price is a function of the following form:

$$S_t^* = f[r_{b,i}, r_{a,i}, \gamma_i, E_t(S_{t+i} | \phi_t)]$$

$$i = 1, \ldots, n$$

By analogy, the equilibrium price of spot exchange in period t+1 is,

$$S_{t+1}^* = g[r_{b,i+1}, r_{a,i+1}, \gamma_{i+1}, E_{t+1}(S_{t+1+i} | \phi_{t+1})].$$

$$i = 1, \ldots, n$$

Again we need specify whether the interest rate variables will affect expectations of future prices. Recall that these relationships were derived from the capital asset pricing model. In this model expectations are assumed exogenous. This may be an oversimplifying assumption, and hence constitute an area for further research.

The policy maker may manipulate S_t by varying the interest rates. If only $r_{a,1}$ or $r_{b,1}$ are used as policy tools, then S_t will be altered, but all forthcoming spot exchange rates will remain unaffected. If on the other hand, the policy maker chooses to use $r_{a,i+1}$ or $r_{b,i+1}$, i.e., change interest rates for maturities of length greater than one, we see that corresponding exchange rates will be altered from their natural course as well.

A second option is available. By affecting the risk premium γ_i, exchange rates can be made to alter from their natural course. Once again, however, we find that this will have effects on future exchange rates only as long as those premiums which correspond to longer than one period time horizons are chosen.

A third area available to economic policy officials is the manipulation of expectations of future exchange rates. If officials can alter say, $E_t(S_{t+j}|\phi_t)$ and these revised expectations are sustained through period t+j-1, then exchange rates pertaining to period t through t+j-1 will follow a course different from what would ensue otherwise. A curious result arises from this, however. If this policy is instituted in time period t it must hold true that as we move further away from t, the effect of this policy becomes magnified. This is because the betas decline in value as t+i increases. Hence in time period t the altered expectation is weighted by a relatively small beta. But as we move closer to the time period for which the expectation is relevant, the corresponding beta increases in value. Hence in effect we may observe a lag between a policy move and its subsequent effects. If the economic policymakers are unaware of this lag they may incorrectly assume that the policy is ineffective.

Finally, the foreign exchange officials may intervene directly in the markets. As was concluded in the prior section, intervention during one period can only yield promised results for that period, if at all. Ideally, policy makers will need to intervene during each and every period to maintain a long range goal. Hence, policy-makers are again constrained by the availability of reserves.

C. Conclusions

To conclude, using an asset approach to the exchange rate and invoking the EMH it was found that policy makers have a variety of tools available to alter exchange rates from their natural course. Some courses of action may have long term effects while others will only serve to alter the current exchange rate. If the policymaker wishes to affect rates for an extended period of time, he or she will have to consider such policies as changing interest rates that pertain to longer time horizons. This results from the fact that an interest rate for a short maturity plays little or no role in the determination of exchange rates in the future. This is based on the premise that expectations of future exchange rates are exogenous.

Secondly, policymakers can alter exchange rates in the long run if they are able to manipulate expectations of spot prices for periods in the far future. The effect of such a policy move will be magnified as that time period is approached if risk averse behavior is assumed on the part of investors. Consequently spot prices will deviate by the greatest amount at the time period just preceeding that expectation. After that, the effect will be nil. This is a very important results as it implies that intervention will, as opposed to smoothing exchange rate fluctuation, make them more volatile.

CHAPTER SEVEN

CONCLUSIONS

In Chapter One we presented and categorized the differing theories of foreign exchange market efficiency. Writers of this subject have had much to say regarding equilibrium spot and forward prices, and other equilibrium relationships expected to prevail in an efficient foreign exchange market.

In Chapter Two we attempted to answer questions regarding the consistency of these interpretations. For instance, is it possible for both spot and forward foreign exchange markets to be efficient in that both rates reflect the future expected spot price? If forward and spot markets are independent of one another there appear to be no obstacles for this condition to hold. However, if efficiency also requires that the interest rate parity theorem holds, i.e. that a specific relationship exists between spot, forward and interest rates, it becomes questionable that efficiency can be satisfied in all respects under general conditions. To insure efficiency in all markets it is necessary that special conditions be imposed. Transactions costs and risk premiums are zero, and interest rates must be identical in the two countries. In order that there be identical nominal interest rates, one of two conditions must hold. Expected inflation rates in the two countries must be zero, or more generally, the law of one interest rate must hold, i.e. assets denominated in different currencies must be perfect substitutes for one another.

If one does not subscribe to the last assumption, the interpretations given forth by proponents of market efficiency cannot be expected to hold. The propositions are inconsistent since efficiency in all markets cannot be expected to prevail simultaneously under normal conditions.

Chapter Two concludes with the observation that in the efficient markets literature, foreign exchange markets are treated as separate entities, i.e. a partial equilibrium approach is employed. It is assumed that spot and forward rates of exchange are determined independently of one another, and of the desires of covered interest arbitrageurs. This is not true. Covered interest arbitrageurs also participate in spot and forward markets. Their activities must be accounted for in the determination of foreign exchange prices. It was concluded that a model ought to be employed showing these simularities before answers can be found regarding efficiency in foreign exchange markets.

In the third chapter, a model employing the fact that spot and forward prices are simultaneously determined as a result of the activities of covered interest arbitrageurs was presented. The basic model was then modified so that the requirements for efficient behavior in all markets could be satisfied. Nonetheless, inconsistancies still emerged. Biases were found to exist which could not be explained by transactions costs or risk premiums since neither were assumed to exist in the model. Furthermore, it was shown that by using a period by period analysis, these biases consistantly emerged. It was concluded that under these conditions, whether assuming efficient markets or not, behavior could not continue as posited. The biases would be discerned by individual market participants and hence the behavior assumptions would eventually be violated.

We then found that behavior assumed to be exhibited by spot speculators was not viable. The EMH proposes that spot speculators attempt to set today's price equal to tomorrow's expected price. This can only be true if interest rates are zero. If expected returns on virtually riskless investments are positive, it must be that spot speculators take this into consideration. In effect they become uncovered interest arbitrageurs.

Once this was taken into account, an interesting result emerged. Covered interest arbitrageurs never participate in the market. The opportunities to do so are never available since spot together with forward speculators insure that the interest parity condition is satisfied. It was also found that the forward rate is an unbiased estimator of the expected future spot price, and that this rate is identical to the actual future spot price. It was also shown that expectations of tomorrow's spot price are actually a function of expectations of prices expected to prevail through time infinity, or if a finite time horizon is assumed, of prices expected to prevail through that time. This expectation also incorporates expected future interest rate levels.

In Chapter Four it was suggested that the model of the previous chapter lacked validity in one respect, that investor's risk preferences are such that they exhibit risk neutral behavior. It was hypothesized that risk averse behavior might be more appropriate. The Sharpe-Linter capital asset pricing model was then presented so that efficiency could be examined in that light.

We derived results using three different sets of assumptions. In the first instance it was assumed that the only form of risk present was spot exchange risk. This implies that it is as risky to indulge in forward speculation as to indulge in spot speculation. As in the model of Chapter Three, expected returns from either form of speculation were identical. However, it no longer held true that the forward price was an unbiased estimator of the expected price. Risk averse behavior implies that the forward rate will underestimate the expected future price.

The second version of the CAPM assumes that two forms of risk prevail. In addition to spot exchange risk there exists forward exchange risk. Spot speculation incorporates the former form of risk while forward speculation is risky in the two dimensions. Despite this, expected returns from spot transactions are greater than those for forward transactions. In essence, the incorporation of forward exchange risk as a factor partially concels the risk incurred in regard to spot exchange. It was also found that the forward rate is a biased estimator of future expectations. This bias is negative.

In the last section of Chapter Four we introduced margin requirements. It was shown that the equilibrium relationships derived in the second model hold true when transactions costs of this form are incorporated.

In the fifth chapter of this thesis we claimed that the notion that the forward rate will be an unbiased predictor of the future actual spot price is incorrect. The forward price set at time t-1 for delivery at t is a function of $E_{t-1}(S_t|\phi_{t-1})$. By analogy S_t is a function of $E_t(S_{t+1}|\phi_t)$. Hence, not only do information sets differ, but the period for which the expectation is being formed also differs. We therefore claimed that there is no theoretical basis for assuming that $F_{t-1,t}$ and S_t are closely related.

We claimed that it would be more appropriate to expect today's spot price to be composed of expectations of various future spot exchange rates. It was reasoned that individuals may have different time horizons resulting from a habitat theory of preferences and hence today's exchange rate will incorporate a variety of expectations, each corresponding to a particular time horizon.

We used the model of Chapter Four to discern the exact nature of the coefficients which in effect weigh the importance of each future expectation with regard to today's exchange rate. It was found that the following relationship may be expected to prevail:

$$S_t = \sum_{i=1}^{n} \beta_i E_t(S_{t+i} | \phi_t)$$

where

$$\beta_i = \frac{1+r_{b,i}}{1+r_{a,i}+\gamma_i} \left(\frac{1}{n}\right) .$$

There are sound theoretical reasons for expecting the betas to decline in value as the time horizon lengthens.

The above model is estimable. In place of expectations, one may use forward prices adjusted for biases as detailed in Chapter Four. In sum, this model is similar to the asset market theory of exchange rate determination. In both models, expectations play major roles in the determination of exchange rates. The model of Chapter Five is superior to these alternative models, because the weights are not only assumed to decline in value, but result from the model.

The last contribution of this thesis dealt with the policy implications of efficiency. In general, the role of intervention is somewhat limited in scope. In order to alter the natural course of exchange rates policymakers need be capable of altering expectations of future price. However, according to our models, an alteration of tomorrow's [(t+1)'s] expected price will result in only a one period deviation from the natural course. In order to change exchange rate levels for periods to come, policymakers need alter expectation for each period. Alternatively, by altering expectations of prices say in period t+n, the official authorities may change the natural course of exchange rates for period t through t+n-1.

It was also found that we might encounter a magnification effect. If policymakers alter the expected price pertaining to period t+n, the effect on period t+i will be greater than the effect on t+j for all i greater than j. However, the effect on the price that prevails at period t+n will be nil. Hence, one might encounter a situation where exchange rates will vary by greater amounts from period to period as a result of "managing the float", in effect doing the opposite of what is purported to be the objectives of intervention.

FOOTNOTES

CHAPTER ONE

[1]Fama (1970, 1976a).

[2]The asset market theory claims that the prices of assets in organized markets are formulated in accordance to the market's expectation of future price. In regard to foreign exchange, see Frenkel and Mussa, (1980).

[3]Levich (1979). To reiterate, by a fair game we mean the following, let $Z_t = P_{t+1} - E_t(P_{t+1}|\phi_t)$. Z_t is the difference between the actual price at t+1 and the price expected to prevail given the information at hand at time t. For prices to follow a fair game it is necessary that:

(i) $E\{Z_t\} = 0$, i.e. it is expected that the expected price be the actual price on average, and

(ii) Z_t's are serially uncorrelated, i.e. errors are truly random.

With respect to a fair game, consistently large gains or losses are not possible.

[4]Levich (1979).

[5]Fama (1970).

[6]Giddy and Duffey (1975).

[7]Roll (1970), pg. 3.

[8]Mandelbrot (1966).

[9]Roll (1970).

[10]Fama (1976a), Levich (1979).

[11]Grossman and Stiglitz (1980).

[12]See for example, Levich (1979), (1978), Poole (1967), Dooley and Shafer (1976), Logue, Sweeney and Willett (1977), Frenkel (1978), Giddy and Duffey (1975), Giddy (1976).

[13]Poole (1967).

[14]See Poole (1967). Also see Dooley and Shafer (1976), and Logue, Sweeney and Willett (1977).

[15]Giddy and Duffey (1975).

[16]Burt, Kaen and Booth (1977).

[17]Giddy and Duffey (1975) and Giddy (1976).

[18]Frenkel (1978).

[19]Levich (1979).

[20]The reader is asked to refer to the individual studies cited by Levich (1979). Some are Porter (1971), Kaserman (1973), Giddy and Duffey (1975), Cornell (1977), Frenkel (1978), and Stockman (1978).

[21]See Cornell (1977), Solnik (1973), and Graver, Litzenberger and Stehle (1976).

[22]Geweke and Feige (1979).

[23]The interest rate parity condition is fully developed in Chapter Three. Basically if interest rate parity holds, there exists a specific relationship between spot, forward and interest rates so that riskless arbitrage opportunities have been eliminated.

[24]Levich (1979).

[25]Frenkel and Levich (1975 and 1977), and Levich (1977).

CHAPTER TWO

[1]Giddy and Duffey (1975).

[2]Levich (1979).

[3]For a brief description of global monetarism, see Kreinin and Officer (1978).

[4]Submartingale models have been suggested by Giddy and Duffey (1975).

[5]Levich (1979). Also see footnote 20 of Chapter One for references of additional tests of this nature.

[6]Mandelbrot (1966), Roll (1970).

[7]See the discussion in Chapter One, page 12.

[8]Giddy and Duffey (1975). See Chapter One page 16 for an explanation of this formulation.

CHAPTER THREE

[1]The general model is developed from a diagrammatic exposition proposed by Chacholiades (1978).

[2]For a similar derivation see Vanek (1962).

[3]If we allow interest rates to adjust as funds flow from Country A to B, r_a will rise while r_b falls resulting in the attainment of interest parity at a faster rate. However, we will assume that interest rates are fixed and exogenously determined for simplicity.

[4]Actually, CIA's may also wish to cover expected interest earnings. This is a relatively minor point and will be ignored.

[5]Chacholiades (1978), Chapter 6.

[6]Actually, hedgers traders and speculators simultaneously determine prices. The same result would follow if we allowed all participants to trade during the same time period. This is because in particular the speculative motive will not terminate until all profit opportunities have been removed.

[7]See discussion of this point, page (27), Chapter Two.

[8]This is not an unduly restrictive assumption since margins required for forward commitments are small. Alternatively when one participates in a spot transaction one must commit the entire amount stipulated in the contract. The assumption then allows us to capture the basic premise that the opportunity cost of entering a forward contract is considerably less than when conducting a spot transaction.

[9]It should be noted that Deardorff (1979) has concluded that if transactions costs are present, market participants by engaging in transactions in one exchange market and two securities markets will ensure that there is no need for covered interest arbitrageurs to enter the market. Though the same result holds in this chapter, the reasons for such differ.

CHAPTER FOUR

[1]This presentation of the Sharpe-Lintner Capital Asset Pricing Model closely follows that of Douglas Vickers, (1978). See also Fama, (1976), and Sharpe, (1970).

[2]See Ott, Ott, and Yoo (1975) and Branson (1972).

[3]See Vickers (1978), p. 93.

[4]Solnik (1973).

[5]Solnik and Roll (1977).

[6]Westerfield (1977).

[7]Graver, Litzenberger and Stehle (1976).

[8]Fama and Farber (1979).

[9]The following investment strategies have been suggested by Westerfield (1977).

[10]For instance, one of the parties may default and hence be unable to cover their commitments. Alternatively, currency controls might be imposed.

[11]It should be noted however, that the degree of risk aversion has been shown to be important regarding the stability and variance of exchange rates when one assumes rational expectation and the existence of J-curve effects. See Driskill and McCafferty (1980).

CHAPTER FIVE

[1]Levich (1979) and see footnote (20) from Chapter One for a list of studies.

[2]A clarification regarding this is in order. In Chapter Three we determined that if markets are to be efficient through time it must be true that expectations are formulated in a particular manner. By assuming a finite time horizon it was determined that expectations would be of the following form:

$$E_t(\tilde{S}_{t+1}|\phi_t) = h[E_t(\tilde{S}_{t+n}|\phi_t),\ E_t(\tilde{r}_{t+i}|\phi_t)] \quad i = 1,\ldots,n$$

It follows that

$$S_t = g[r_t, E_t(\tilde{S}_{t+n}|\phi_t),\ E_t(\tilde{r}_{t+i}|\phi_t)] \quad i = 1,\ldots,n$$

$$F_{t-1,t} = k[E_{t-1}(\tilde{S}_{t+n}|\phi_{t-1}), E_{t-1}(\tilde{r}_{t+i}|\phi_{t-1})] \quad i = 0,\ldots,n$$

and

$$F_{t,t+1} = \ell[E_t(\tilde{S}_{t+n}|\phi_t),\ E_t(\tilde{r}_{t+i}|\phi_t)] \quad i = 1,\ldots,n\ .$$

Hence expectations of future spot prices, whether with respect to forward prices set at t or t-1, are expectations of prices in one particular period, S_{t+n}. In this respect using $F_{t-1,t}$ or $F_{t,t+1}$ as an estimator of this expectation is equally valid. However, information sets differ, and so on this account, $F_{t,t+1}$ is a better estimator. Also, $F_{t-1,t}$ incorporates the expectation of interest rates expected to prevail at time t, a variable not present in $E_t(S_{t+1}|\phi_t)$. Hence, it still holds true that $F_{t,t+1}$ is a better measure of expectations.

Incidently, this uncovers another assumption necessary for claiming that forward prices are unbiased estimators of future spot prices. This assumption is that expectations are formulated as described above. In essence this is a rational expectations assumption. We return to the issue of rational expectations in part C of this chapter.

[3]Fama (1970, 1976a)

[4]Muth (1961).

[5]Frenkel and Mussa (1980).

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