CHAPTER 2

CONCEPTUAL FRAMEWORK AND REVIEW'S LITERATURE

This chapter discusses the economic implications for foreign exchange market efficiency and reviews the relate works in this issue. The precise definition, and intuition, of foreign exchange market efficiency is discussed first and focuses on the joint hypothesis of the rational expectations hypothesis (REH) and the risk premium hypothesis. Then, the foreign exchange market efficiency tests are provided in several methods - regress the future spot rate on the forward rate , regress the rate of depreciation on the forward premium and the alternative test.[5] Finally, the relationship between cointegration and market efficiency is examined.

2.1 Efficiency of Foreign Exchange Markets [6]

The classic definition of an efficient market by Eugene Fama [7] is a market where prices "fully reflect" available information. In the specific application to the foreign exchange market this implies that market participants use all relevant available information to produce a set of exchange rates -spot and forward- that does not provide an opportunity for unusual profit. In other words, unusual profits cannot be made by speculators who make exchange rate forecasts on a similar information set.[8]

---

[5] For more detail in theoretical framework suggest to read *International Finance* by Keith Pilbeam. First published, The Macmillan Press Ltd, 1992.

[6] Suggest to read "Forward rates as the optimal future spot rate forecast" by Richard M. Levich in *Exchange Rate Forecasting* edited by Christian Dunis and Michael Feeny, First Published; (England : Woodhead-Faulkner Limited) 1989.

[7] Fama Eugene. "Efficient Capital Markets: a Review of Theory and Empirical Work". *Journal of Finance*, p.383.

[8] Keith Pilbeam. Ibid.

The efficient market hypothesis is linked closely with the forward rate as a forecaster of the future spot rate. Because investors' expectations of the future spot rate are part of the available information set, and because these expectations should be reflected in market prices, it is correct to argue that today's forward exchange rate is an unbiased forecast of the future spot rate.

If we define the forecast error of the forward rate against the future spot rate as [9]

$$\varepsilon_{t,n} = S_{t+n} - F_n \qquad \text{.....(1)}$$

The forward exchange rate is an unbiased predictor of the future spot exchange rate when, based on a sample of many independent observations, the average forecast error is not significantly different form zero. The $\varepsilon_{t,n}$ from Equation (1) also represents the speculative profit for investors who buy forward contracts outright at $F_{t,n}$ and then sell their matured contracts in the spot market at S_{t+n}.

Equation (1) represents a joint hypothesis. The first hypothesis is that the market participants use all available information rationally, so that the expected returns to speculators are zero -unbiased expectations of the future spot rate ($E_tS_{t+n} = S_{t+n}$). The second hypothesis is that the market participants are risk neutral, so that the risk premium is zero - the market elects to set its forward rate equal to that expectation ($F_{t,n} = E_t S_{t+n}$). The second hypothesis involves a pricing model.

Frequently these joint assumptions are summarized by saying that markets in which they hold are ' efficient' and if both parts of the hypothesis hold, then the current forward rate is an unbiased predictor of the future spot

---

[9] Richard M. Levich. Ibid., p.2.

rate. [10] Therefore, whether or not the forward rate is an unbiased forecaster depends on the two parts of a joint hypothesis being satisfied that will be discussed in detail in the following sections.

2.2 The Rational Expectations Hypothesis (REH)

The rational expectations hypothesis is that on the average, over the number of time period, market participants do not systematically over or under predict the exchange rate. They may make forecast error but these mistakes consist of sometimes over or under predicting the future exchange rate.[11]

That is, the expected exchange rate in the next period ($E_t S_{t+n}$) will on the average be equal to the actual exchange rate (S_{t+n}), although it may deviate by a random error (u_{t+n}) but the average of the errors are zero.

$$S_{t+n} = E_t S_{t+n} + u_{t+n} \qquad \text{.....(2)}$$

The rational expectations hypothesis is particularly useful when examining the concept of ***market efficiency hypothesis(MEH).*** This is because like the MEH it presumes that market participants do not make systematic errors when making their predictions.

If capital is perfectly mobile, currencies will shift until domestic interest rates are equal to foreign interest rates plus the expected rated of change in the currency. Dornbusch[12] assumed that expectations are " rational " - that investors take account of all available information about current and future

---

[10] Craig S. Hakkio and Mark Rush. " Market Efficiency and Cointegration : an Application to the Sterling and Deutschemark Exchange Markets ". *Journal of International Money and Finance*. 8 (1989) : 75

[11] Keith Pilbeam. Ibid. p.6.

[12] Rudiger Dornbusch. " Expectations and Exchange Rate Dynamics ". *Journal of Political Economy*, Vol. 84, 1976.

events, including a view on the fundamental forces that drive exchange rates. His paper also highlighted the role that expectations play in determining current exchange rates.

Liu and Maddala[13] used the cointegration technique by Phillips and Ouliaris to test the rational expectations hypothesis (REH) . They followed a more direct approach to test the REH. First, they tested whether S_t and $E_t S_{t+n}$ are random walks or I(1) series (integrated of order 1). The cointegrating regression is

$$S_{t+1} = \alpha + \beta E_t S_{t+n} + U_{t+1} \quad \text{.....(3)}$$

But under the hypothesis $\alpha = 0$ and $\beta = 1$, they considered the residual $S_{t+1} - E_t S_{t+n}$ and tested the hypothesis that this residual is stationary. That is a direct test since the null hypothesis specifies the parameters α and β in the cointegration regression. Thus, they considered the restricted residual $U_t = S_{t+1} - E_t S_{t+n}$ and tested for its stationarity. They did not estimate any cointegrating regression. If u_t is stationary then S_{t+1} and $E_t S_{t+n}$ are cointegrated with a factor of one because the cointegratng factor is unique when it exists. They used the Box - Pierce Q - statistic to test for serial correlation in the u_t series. The tests for cointegration used are the Phillips and Ouliaris (1990). Their results showed that only the weekly expectations data satisfy the REH, but the monthly expectations data did not.

Phichet Prompouri[14] employed the cointegration and error correction technique to expect the future spot exchange rates of Thai Baht per US. Dollar

---

[13] Peter C. Liu and G.S. Maddala. "Rationality of Survey Data and Tests for Market Efficiency in the Foreign Exchange Markets". *Journal of International Money and Finance* 11 (1992) : 366-381.

[14] Phichet Prompouri, "An Analysis of Factors Influencing Forward and Risk Premiums in Forward Foreign Exchange Trading ". Faculty of Economics, Graduate School, Chiangmai University, 1997.

during January 1993- December 1995 by using the monthly data from January 1985- December 1992. He found that the expected future spot exchange rate followed in line with the rational expectation hypothesis.

2.3 The Risk Premium Hypothesis

If one discover that the forward rate systematically over or under predicts the future spot rate, it may be indicative of the existence of a risk premium. For example, if the speculators regard foreign currency as being relatively risky as compared to domestic currency, they will require a higher expected return on foreign currency than domestic currency. This additional expected return on the relatively risky, as compared to the less risky currency, is known as the "risk premium".[15]

The presence of foreign exchange risk arises from uncertainty regarding the future. If future exchange rates were known with certainty there would be no foreign exchange risk. If we consider the effects of foreign exchange risk on the determination of forward exchange rates, the forward rate should be equal to the expected future spot rate. Or, if we consider whether there is a risk premium incorporated in the forward rate that serves as an insurance premium inducing others to take risk, in which case the forward rate would differ from the expected future spot rate by this risk premium.

That is, speculators will only buy forward if they expect to be able to sell them in the future and make profit. Hence, any expected excess profits to be earned on buying the foreign currency forward might represent the compensation required by speculators for the risks associated with holding the foreign currency forward which is regarded to have more risk involved than with domestic currency. It is important to stress that while profit opportunities in foreign exchange speculation have been reported, they are always risky profit

---

[15] Keith Pilbeam. Ibid. p.6.

opportunities. In that sense, these results are the evidence of market inefficiency.

Fluctuations in exchange rates are the source of exchange rate risk. There are different factors that may cause emergence of a risk premium. Currency traders watch these factors very carefully. For example, the growth rate of gross national product, the size of trade surpluses and deficits, capital flows between countries, central bank interventions, monetary policy decisions, fiscal policy decision, unemployment rates, interest rates, inflation rates and political situations.

Keenwan Park [16] tested for a risk premium in the foreign exchange market. The null hypothesis of the test is the random walk hypothesis in the foreign exchange market. The alternative hypothesis is that biases of current spot rates(or forward rates) from future spot rates are systematically related to a set of economic variables on which a risk premium may depend. Using the dollar/mark rate and other economic data during the floating rate period, he found firm statistical evidence for a risk premium in the foreign exchange market.

The random walk hypothesis in the foreign exchange market claims that any deviation of the current spot rate (and/or the forward rate) from the future spot rate is entirely of a random nature due to unpredictable innovations in the determinants of the future spot rate. Hence, tests of the random walk hypothesis can be viewed as tests of the assumption of a zero risk premium in the foreign exchange market.

The random walk hypothesis may be specified in term of three equations.

The first equation specifies that the spot rate series exhibits a random walk process with zero drift:

---

[16] Keenwan Park. "Tests of the Hypothesis of the Existence of Risk Premium in the Foreign Exchange Market". *Journal of International Money and Finance* 3 (1984) , p. 169-178.

$$E_t S_{t+1} = S_t \quad \text{.....(4)}$$

S_t is spot exchange rate at time t, and E is the expectations operator.

Second, the spot rate series adjusted for interest rate differentials between assets denominated in two different national currencies displays a random walk process:

$$E_t S_{t+1} = S_t ((1+I) / (1+I^*)) \quad \text{.....(5)}$$

where I is one period interest rate on domestic currency asset.
I* is one period interest rate on foreign currency asset.

Last, when covered interest parity holds, equation (5) can be rewritten as:

$$E_t S_{t+1} = F_{t+1} \quad \text{.....(6)}$$

where F_{t+1} is the forward dollar price of the foreign currency at time t for delivery at time t+1.

Liu and Maddala [17] applied the restrict cointegration tests to test the hypothesis of "no risk premium" to investigate the reasons behind the rejection of the MEH. This hypothesis was uniformly rejected for the weekly data, and in case of the monthly data it was not rejected for the Japanese Yen but was rejected in the other currencies.

Pope and Peel[18] used the closing spot and 3 month forward exchange rate for nine currencies (Belgium, Canada, France, Italy, Japan, Sweden, Switzerland, UK, West German) over the 54 month period of March 1984 to

---

[17] Ibid., p. 9.

[18] Peter F. Pope and David A. Peel, "Forward foreign exchange rates and risk premia - a reappraisal", *Journal of International Money and Finance* 6 (1991) : 443-456.

August 1988. The exchange rate data were obtained from Datastream. Data were also collected from the monthly survey of the 54 market analysis conducted by Euromoney Treasury Report and introduced as a new proxy for the market's future spot exchange rate expectation. Their empirical tests did not reject the hypothesis of time-varying risk premium.

2.4.Foreign Exchange Markets Efficiency Tests

There are a number of tests that have been proposed to determine whether or not the foreign exchange market is efficient. There are two general methods commonly used to test for efficiency.

2.4.1 Regress the Future Spot Rate (S_{t+1}) on the Forward Rate (F_t)

The *rational expectations hypothesis (REH)* states that economic agents should take all available information in forming expectations and should have a good knowledge of the economic model relevant to predicting a variable so that they do not persistently over or under predict the future value of that exchange rate.

Applying rational expectations to the prediction of the future exchange rate we bring the equation (2) :

$$S_{t+1} = E_t S_{t+1} + u_{t+1}$$

Where S_{t+1} is the log of the actual spot exchange rate in time t + 1, $E_t S_{t+1}$ is the log of the expected exchange rate make in time t for the spot exchange rate at time t + 1, and u_{t+1} is a random error term with a normal distribution and mean of zero.

Equation (2) says that the actual future exchange rate corresponds to that which was anticipated by market participants plus or minus some random error.

The next step is to assume that investors is a risk neutral - there is a ' ***no risk premium*** '. The hypothesis of no risk premium in the forward rate states that the expected spot exchange rate at time t for time t + 1 equals the forward rate at time t with maturity at t + 1, which bring the following equation, (6) :

$$F_{t,t+1} = E_t S_{t+1} \quad \text{.....(6)}$$

where $F_{t,t+1}$ is the log of the forward exchange rate at time t with maturity at t + 1 (defined as domestic currency units per units of foreign currency).

Substituting equation (6) into equation (2) , equation (7) is obtained :

$$S_{t+1} = F_{t,t+1} + U_{t+1} \quad \text{.....(7)}$$

Equation (7) says that providing economic agents have rational expectations and there is a no risk premium in foreign exchange market, then the future spot rate should be equal to today's quoted forward rate plus a random error. In other words, in the average the forward rate should neither over nor under predict the actual exchange rate one period ahead.

Equation (7) contains a joint test of both exchange market efficiency and no risk premium. The exchange market efficiency test that has been most commonly employed is based on equation (1). In the beginning study in this area has used the classic technique of the ordinary least squares method.

Frenkel (1981)[19] examine the Monthly Data for the period of June 1973 - July 1979 for three exchange rates : the pound, franc and Deutsche Mark all denominated in US. dollars. He originally appeared to offer strong confirmation

---

[19] Jacop a. Frenkel ," Flexible Exchange Rates, Prices, and the Role of "News" : Lessons from the 1970s". *Journal of Political Economy* 89 (1981) : 665-703.

of the hypothesis that conducted by using ordinary least square in estimation an equation (7) :

$$S_{t+1} = \alpha + \beta F_{t,t+1} + U_{t+1}$$

According to this test, if the foreign exchange market is efficient in the sense that the exchange rate (spot and forward) incorporates all currently available information and there is no risk premium in the foreign exchange market, then the forward rate will be an unbiased predictor of the future spot exchange rate.

Hence, the expected sign of α is zero (0); if it were non zero then the forward exchange rate would systematically over or under predict the future spot exchange rate and rational economic agents could use this information to make systematic profits. The coefficient β will be equal to unity (1) showing that the forward exchange rate, on average, correctly predicts the future spot exchange rate.

Finally, the error term u_{t+1} will possess the classical ordinary least squares (OLS) properties. In particular, errors will not be serially correlated. By having no serial correlation we mean that there is no statistically significant relationship between the error of one period and errors made in other periods. One cannot forecast future errors on the basis of past errors. If agents could predict future errors on the basis of past errors this would be a sign of foreign exchange market inefficiency. That is, there would not be exploited profit opportunities.

Frenkel's results are highly supportive of the joint hypothesis of foreign exchange market efficiency and no risk premium. The implication of his results is that the foreign exchange market is efficient and there is no risk premium.

For the foreign exchange market efficiency test in Thailand, Sanong (1989)[20] applied the ordinary least squares method to test the accuracy of using the forward rate as a forecaster of the future spot rate. By estimate the equation (7) , he found that the forward rate is not a good forecaster for the future spot rate (59.9% forecast).

However, the classical regression used by Frenkel and Sanong is inappropriate if exchange rates follow a non-stationary process . Non-stationarity generally implies that estimators of β in equation (7) are biased and inconsistent. In fact, it is now well documented that both spot and forward exchange rates follow unit-root processes and therefore classical inference on regression parameters is invalid.[21] If the spot exchange rate and the forward rate are non stationary, the appropriate test of the market efficiency hypothesis MEH will be based on cointegration tests. [22]

Besides, some economists try to avoid problems associated with non stationary variables which introduces spurious estimation results , the second method employ the regression on the forward premium.

2.4.2 Regress the Rate of Depreciation on the Forward Premium

Researchers transform variables by subtracting the current spot exchange rate from both sides of the level regression and regress the realized change in the future spot rate on the current forward premium (the difference between the spot and forward rates). That is:

---

[20] Sanong Shamrum. *Foreign Exchange Market Efficiency in Thailand*. Thesis for Master of Economics, Thamasart University,1989.

[21] Yangru Wu and Hua Zhang. "Forward Premiums as Unbiased Predictors of Future Currency Depreciation: a Non-parametric Analysis". *Journal of International Money and Finance* 16(4) (1997) : 609-623.

[22] Peter C. Liu and G.S. Maddala, Ibid. p 9.

$$(S_{t+1} - S_t) = \alpha + \beta (F_t - S_t) + u_{t+1} \quad \text{.....(8)}$$

where S_t is the log of the spot exchange rate at time t .

In (8) the null hypothesis requires the same condition as before, and implies that the forward premium is said to be an unbiased predictor of future currency depreciation if α is zero ($\alpha = 0$) and the coefficient β does not differ significantly from unity ($\beta = 1$), indicating that on average the realized change in the exchange rate is correctly forecasted by the forward premium/ discount.

The hypothesis that the forward exchange rate premium is an unbiased predictor of future currency depreciation has been extensively tested by regression analysis. In a survey of this tests, Fama found that the coefficient β is usually closer to minus one than the hypothesis value of unity . He concluded that the negative slope coefficient is due to the existence of a time varying risk premium.

Wu and Zhang [23] also investigated whether the forward premium can predict the direction of change in the future spot exchange. Their test strongly rejected the unbiasedness hypothesis and concluded that the forward premium contains either no information or the wrong information about future currency depreciation.

However, Liu and Maddala [24] give some interesting aspects of this procedure. If S_t and F_t are unit root processes. Assume that both variables are I (1). Then the left hand side of the equation (8) becomes stationary. But there is no guarantee that the variable on the right hand side ($F_t - S_t$) , is stationary. In fact, it will only be stationary if the MEH is true.

---

[23] Ibid., p. 16.

[24] Ibid., p. 9.

They discuss the results from the estimation of equation (8) under two conditions :

1. If $F_t - S_t$ is non stationary, since $S_{t+1} - S_t$ is stationary, it means, regress of a stationary variable on a non stationary variable. The MEH will must be surely be rejected.
2. If $F_t - S_t$ is stationary, the MEH is true, there is no point in testing the MEH using equation (8).

In Crowder's paper [26], the efficiency of foreign exchange markets was tested by examining the existence of stochastic trends in the forward premium. The results of standard Augmented Dickey-Fuller (ADF) unit root tests supported the hypothesis of a unit root in the forward premium, which implied that the forward premium is non-stationary.

2.4.3 Alternative Tests of the Efficient Market Hypothesis

According to the MEH, the forward rate is supposed to embody all the relevant information concerning the future expected spot exchange rate. This implies that it should not be possible to add a further variable available at time t to regression equation (1) which proves to be statistically significant. This can be taken as evidence that the forward exchange rate does not contain all relevant information concerning the future spot exchange rate.

An example of a regression that tests to see if another variable can improve the fit of regression is :

$$S_{t+1} = \alpha + \beta F_{t,t+1} + \gamma S_{t,t-n} + U_{t+1} \qquad \text{.....(9)}$$

Where $S_{t,t-n}$ is the log of the spot rate in the previous period.

---

[25] William J. Crowder. "Foreign exchange market efficiency and common stochastic trends". *Journal of International Money and Finance* 13(5) (1994) : 551-564.

According to the MEH a variable such as the previous period's spot rate should not contain any additional information relevant to the future exchange rate (not only $\alpha = 0$, $\beta = 1$ but γ should also not be statistically different from zero).

By using the monthly nominal exchange rate of Thai baht against US.dollar obtained from Bank of Thailand during the period of November 1983-March 1988. Sanong [26] found the lag 2 months spot rate could predict 35.5 % of the future spot rate. He concluded that the weakly efficient of Thai foreign exchange market are not available.

2.5 The Theory of Cointegration test on the Market Efficiency

Non stationarity generally implies that estimators of β in equation (1) are biased and inconsistent. Recent developments in the theory of cointegration by Engle and Granger (1987) provide new methods of testing market efficiency. More recent empirical evidence, however, suggests that the spot and forward rates are cointegrated. Cointegration has two important implications for tests of MEH. First, the estimates of β obtained from regressing the spot rate on the lagged forward rate as in equation (5) are super-consistent. Second the changes in the spot rate can be modeled by an ECM.

2.5.1 Cointegration Regression

From the Hakkio and Rush [27] paper, cointegration is a relatively new statistical concept, pioneered by Granger (1983), Granger and Weiss (1983) , and Engle and Granger (1987). Cointegration is a property possessed by some non stationary time series data. In general terms, two variables are said to be

---

[26] Ibid., p. 8.

[27] Ibid., p. 7.

cointegrated when a linear combination of the two is stationary, even though each variable is non stationary.

More precisely, consider two time series, say X_t and Y_t. Assume that both X_t and Y_t are non stationary and need to be differenced once to induce stationarity. In general, most linear combinations of X_t and Y_t, such as $X_t - \beta Y_t = U_t$, are also non stationary. If first differencing causes X_t and Y_t to be stationary, then U_t also will be stationary after first differencing. However, there may exist a linear combination of X_t and Y_t that is stationary.

For example, there may be a number d such that $X_t - d\ Y_t = U_t$ is stationary. In this special case, X_t and Y_t are said to be cointegrated of order (1,1) with a cointegrating vector of d, and the regression $X_t = d\ Y_t + U_t$ is called the cointegrating, or equilibrium, regression.

The test results for the German and United Kingdom foreign exchange markets by using logged, monthly data from July 1975 to October 1986 on the spot and forward rates for the British pound and German mark, Hakkio and Rush suggested that the German and UK spot rates and forward rates are not cointegrated. As long as the German and UK currencies are considered different assets, this indicates that both the German and UK spot and forward markets are efficient.

Liu and Maddala [28] also used the cointegration technique by Phillips and Ouliaris to test the market efficiency hypothesis (MEH) in the foreign exchange markets. They used both the weekly (1 week) and monthly (1 month = 30 days) survey data from October 24, 1984 to May 19, 1986 on expectations. The data obtained from the money market services (MMS), the Wall Street Journal and the Financial Time. They considered four different currencies: the British Pound, Deutsche Mark, Swiss Franc, and Japanese Yen, all denominated in US dollars per unit.

---

[28] Ibid., p. 9.

They first tested the series for unit roots to investigate whether the series on the spot exchange rate, the expected spot rate and the forward rate are all non-stationary. They did this for both the weekly and monthly data. When the unit-root hypothesis is not rejected, they test whether the series under consideration are cointegrated with cointegrating factor of unity and that the errors do not exhibit serial correlation.

They use the restricted cointegration tests along with the Q -statistics to test for serial correlation in the residuals to test the MEH. Their result was rejected the MEH for both the weekly and monthly data. They finally concluded that the failure of the MEH for the weekly data is due to risk premium rather than the failure of the REH. With monthly data, in the case of the Japanese Yen, it is the failure of the REH that accounts for the failure of the MEH. In the case of the other three currencies, it is the rejection of REH as well as the rejection of the "no risk premium" hypothesis that lead to the rejection of the MEH.

Besides, the result of Johansen cointegration tests which were conducted on the monthly spot and 30 day forward rates over the period 1974 to 1991 for the British pound, German Deutsche mark, and Canadian dollar, all relative to the US. dollar by Crowder showed that the cointegration between them was critically dependent. This evidence leads to the conclusion that the foreign exchange markets efficiency are violated.

Moreover, Mcfarland, McMahon and Ngama [29] used the Phillips-Hansen cointegration test to reconsidered whether or not the forward rate is an unbiased predictor of the future spot rate for the 1920s. The data set consisted of daily observations of the spot and one-month forward rates for five bilateral exchange rates: German mark-UK pound, Belgium franc-UK pound, French franc-UK pound, Italian lira-UK pound, and US dollar-UK pound. for six days per week,

---

[29] James W. Mcfarland, Patrick C. McMahon and Yerima Ngama ," Forward exchange rates and expectations during the 1920s: A re-examination of the evidence ". *Journal of International Money and Finance* 13(6) (1994) : 627-636.

The data were collected from back issues of *The Manchester Guardian* for the period May 1, 1922 to May 10, 1925.

The results of a single unit root test and the Phillips and Ouluaris cointegrating regression indicated that, with the exception of the German mark, all the forward and corresponding future spot exchange rates are cointegrated. The results of applying the Phillips and Hansen estimation and inference procedures to test the forward unbiasedness hypothesis were that the forward unbiasedness hypothesis can be rejected in three (Belgian franc, French franc, and German mark) out of five currencies at the 5 percent level of significance. This result might be due to the presence of a risk premium for the Belgian and French francs and to market failure in the case of the German mark.

Naka and Whitney [30] employed the methods of Dickey and Fuller(1991) and Phillips and Perron (1990) to test for unit roots and Engle and Granger (1987) and Phillips and Perror (1988) to test for cointegration. They employ monthly data of one month forward and spot exchange rates quoted in terms of the US dollar, which spanned from January, 1974 to April,1991 with 208 observations. The seven major exchange markets examined are: the British pound, Canadian dollar, Deutsche mark, French franc, Italian lira, Japanese yen, and Swiss franc.

The results indicate that all seven currencies are non-stationary at the levels but stationary after taking the first differences. They also found that the spot and forward rates are cointegrated for all exchange rates. These results confirm findings of other studies including Hakkio and Rush (1989) and support applying ECM.

---

[30] Atsuyuki Naka and Gerald Whitney."The unbiased forward rate hypothesis re-examined" *Journal of International Money and Finance* 14(6) (1995) : 857-867.

In Norrbin and Reffett's work [31], evidence is presented to support the hypothesis of unbiased long-run forward rates. They used the spot and 3 month forward rates (Japan, Germany, the United Kingdom, Switzerland, and Canada) during 1973:1 to 1992:4 from the IFS database and OECD Main Economic Indicators. All data show evidence of being first order integrated processes. They also test the unit cointegrating vector implied by the FRUC hypothesis - that the future spot rate and the forward rate for a given country must be cointegrated and the coefficient on the cointegrating relationship for the forward rate must be unity- in a VECM framework. They find strong support for a unit cointegrating vector between spot rates and forward rates.

Another work conducted by Chowdhury [32] employed the cointegration technique developed in Johansen(1991) and Johansen and Juselius(1990) to test the long run equilibrium relationship among the spot exchange rates.

The bilateral nominal spot exchange rates of the Thai baht against the currencies of Thailand's seven major trading partners: the US dollar, the German deutschmark, the Hong Kong dollar, the Japanese yen, the Malaysian ringgit, the Singapore dollar, and the UK pound sterling were considered. He used the daily data (spot and 30-day future exchange rate) which were provided by the Department of Economics Research, and the Bank of Thailand for the period November 1, 1984 through May 31. 1995. The initial results implied causality of at least one of the exchange rates in the system.

Further investigation revealed the presence of a unidirectional causality from the stationary linear combination of exchange rates to the US$/Baht exchange rate. In case of a temporary disequilibrium in the system, the US$/Baht exchange rate will adjust in order to return the system to equilibrium.

---

[31] Stefan c. Norrbin and Kevin L. Reffett. "Exogeneity and Forward Rate Unbisedness" *Journal of International Money and Finance* 15(2) (1996) :267-274.

[32] Abdur R. Chowdhury "Foreign Exchange Market Efficiency in Thailand" *Journal of Thamasart Economics* 1 (1996) : 5-22.

This evidence of asymmetric convergence implied that information about past disequilibrium could be used to predict changes in the US$/Baht exchange rate, and this causality is evidence of inefficiency in the Thailand foreign exchange market.

2.5.2 Error Correction Model

There is an equivalent characterization of cointegration due to Granger. If two variables are cointegrated with a cointegrating vector d, then they can be written in an error correction form.

$$X_t - X_{t-1} = a (X_{t-1} - d Y_{t-1}) + b (Y_t - Y_{t-1}) + \text{lagged} (\Delta Y\text{s and } \Delta X\text{s}) + U_t \ldots\ldots (10)$$

where $a \neq 0$, $b \neq 0$, U_t is a stationary, possible autocorrelated, error term, and the lagged ΔYs and ΔXs may be necessary.

This is the standard error correction model and has the usual interpretation: the change in X_t is due to the immediate, " short run " effect from the change in Y_t and to last period's error, which represents the " long run " adjustment to past disequilibrium. This error correction equation is fundamental to the tests they develop.

Hakkio and Rush[33] use the results from Granger (1986) which demonstrated that two prices from a pair of efficient markets cannot be cointegrated. To test for efficiency in the German and United Kingdom foreign exchange markets. They used logged, monthly data from July 1975 to October 1986 on the spot and forward rates. They can intuitively show this using equation (10). Basically, if an asset incorporates all available information, its price change will be unpredictable. They assume X_t in equation (10) is the spot price of German marks and Y_t is the spot price of British pounds. Then , if these two spot prices are cointegrated, they can be expressed in an error correction

---

[33] Ibid., p. 8.

equation similar to equation (10) and in turn test the forward exchange rate of the two countries.

They next focused on the relationship between future spot exchange rates and current forward rates in a single currency. If S_{t+1} and F_t are cointegrated, with a cointegrating vector of 1, then they cannot drift too far apart because their difference, $S_{t+1} - F_t = U_t$, is stationary. If the variables that are random walks are cointegrated, they can be written in the error correction form. They, therefore, write the model in the ECM and test the hypothesis that the cointegrating factor is one, and the error is white noise, by applying the corresponding tests on the coefficients of the ECM.

For simplicity, Specialize equation (10) to the spot and forward rates for one country, and assume that no lagged terms enter the equation. Thus, if S_{t+1} and F_t are cointegrated, they can be written as an error correcting regression :

$$(S_{t+1} - S_t) = a(S_t - d F_{t-1}) + b(F_t - F_{t-1}) + U_t \quad \text{.....(11)}$$

They found that both the German future spot and current forward rates as well as the UK future spot and current forward rates appear to be cointegrated. This again was consistent with the market being efficient. However, they conclude that based on the results of the estimation of a single equation error correction model, they were able to reject the joint hypothesis of no risk premium combined with efficient use of information for both Germany and the United Kingdom. Unfortunately, they were unable to determine which factor (or factors) cause these rejections.

Besides, Norrbin and Reffett [34] show in their paper how testing a single equation error correction model with the incorrect causality assumption will lead to an incorrect inference of no cointegration between the forward and spot rates. Therefore, it is always important to test the causality assumption in the VECM system prior to estimating single equation versions of the FRUC.

---

[34] Ibid., p. 23

By applying the cointegration technique to test the marked efficiency in Thailand, Chowdhury also investigated the possibility that the error correction term in the VECM was serving as a proxy for the risk premium. In order to investigate this possibility, stationary tests were performed on the forward premium of the seven exchange rates. Test results showed that each of the seven forward premiums were non-stationary implying significant predictability for the future spot rate changes. As the error correction term and the forward premium were integrated of different orders, the former did not serve as a proxy for the latter. Thus, the results were consistent with a violation of the conditions of market efficiency in the foreign exchange market in Thailand.

Recently, Parichart [35] conducted the cointegration and error correction model to test Thailand's forward foreign exchange market efficiency. She used the daily data of spot and one month forward exchange rate of US. dollar, Japanese yen, and Deutsche mark against baht. All of these currencies are sight export bill of Bangkok bank. She concluded that Thailand's forward foreign exchange market is not efficient. That is, the joint hypothesis of rational expectation and risk neutral is rejected. Inefficiency of Thailand's forward foreign exchange market can be explained by some factors such as a small market size, irrational expectation of investors and risk premium.

Over the past decade a considerable number of studies have been conducted on the efficiency of the forward foreign exchange market. Much of this research has focused on examining whether the forward exchange rate can predict the future spot exchange rate. Consequently, there has been an ongoing effort to re-examine the simple MEH in view of recent developments in econometric methodology and the availability of new data sets.

There has been a great deal of testing of the joint hypothesis of foreign exchange market efficiency and the non existence of a risk premium. Overall,

---

[35] Parichart Thongkhundam. "Efficiency in Thailand Forward Foreign Exchange Market". (Master Thesis, Department of Economics, Gruduate School, Chulalongkorn University, 1995)

the results of the various exchange market efficiency tests are fairly mixed depending upon the exchange rate used and the particular test considered. Many researchers tried to investigate the MEH using procedures proposed by Engel and Granger, Johansen, Phillips and Ouliaris and Phillips and Hansen that take account of non-stationarities in spot and forward exchange rate series. The evidence based on these procedures has also been mixed and showed in the Table 2.1.

None the less, there is an accumulation of evidence suggesting that for certain periods and rates, the joint hypothesis does not hold. Then the big issue left to solve is whether or not the rejection is due to the existence of a risk premium or the existence of inefficiency/non rational expectations in the foreign exchange market.

For this study, there are some study points similar to Liu and Maddala in the idea of REH and no risk premium, but use different cointegration analysis. Where as Liu and Maddala applied the Phillips and Ouliaris cointegration, this study will use the Engle and Granger cointegration and extend the study to investigate the short run relationship by applying the EC-model which is similar to the study of Hakkio and Rush.

Compared with other studies of the efficiency in Thailand foreign exchange market, similar to Pichet, this study will use the EC-model to expect the future spot exchange rate and similar to Parichart in that both apply cointegration tests but using different technique. While she used the Johensen cointegration method, this thesis will use the Engle and Granger (1987) cointegration technique. Because the joint hypothesis which strongly rejected in a number of different tests is not new, this study will extend the joint hypothesis testing of rational expectation and no risk premium to find the conclusion of Thailand foreign exchange market efficiency in the early managed float system.

TABLE 2.1 REVIEW'S LITERATURE

No	Year	Name	Hyp. Tests	Currencies	Data	Methodology	Results, Causes and Conclusion
1	1989	Hakkio and Rush	MEH	Mark,Pound	Monthly spot and forward rate July 1975-Oct1986	Engle and Granger Cointegration test -ECM	Their results are mixed 1. Accept MEH in Spot and Forward Markets in German and UK because the two spot and forward rates among 2 countries are not cointegrated and the spot and forward rates from within the same country are cointegrated. 2.Reject joint Hypothesis and can not determine causes of the rejection.
2	1992	Liu and Maddala	REH. MEH and no risk premium	Mark, Yen, Pound SW. Franc: US dollar	Weekly, Monthly spot and forward rate , exchange rate expectation Oct 24,1984-May19,1989	-Phillips and Ouliaris Cointegration test	1.For weekly data the failure of MEH is due to risk premium rather than the REH. 2.For monthly data, the failure of MEH of Yen is due to the failure of REH. The failure of MEH of Pound, Mark, SW. Franc is due to the rejection of REH and risk premium.

TABLE 2.1 REVIEW'S LITERATURE (CONTINUE)

3	1994	Crowder	MEH	Mark , Pound, Ca. Dollar : US dollar	Monthly spot and forward rate Jan1978-Dec1991	-Johansen Cointegration test	-Reject MEH because no coin. between spot and forward rate.
4	1994	Mcfarland, Mcmahon and Ngama	MEH	Mark, Bel.Franc, Fr.Franc, Ita.Lira US.dollar : Pound	Daily spot and 1 month forward rate May1,1992-May30,1925	-Phillips and Ouliaris Cointegration test -Philips and Hansen	1.Exception of the German mark, all forward and spot rate are cointegrated. 2.Rejection the MEH in Mark, Bel. Franc, Fr. Franc.
5	1995	Naka and Whitney	MEH	Pound, Ca. Dollar, Mark, Fr. Franc, Lira, Yen, SW. Franc : US. dollar	Monthly spot and one month forward rate Jan, 1974 - April, 1991	Engle and Granger Cointegration Test	-Spot and forward rates are cointegrated for all exchange rates. Their results are mixed 1. Accept the MEH. 2. Accept the no risk premium.

TABLE 2.1 REVIEW'S LITERATURE (CONTINUE)

6	1996	Chowdury	MEH	US. dollar, Mark, Yen,HK. dollar, Riggit Sing. Dollar, Pound: Baht	Daily spot rate Nov1,1984-May31,1995	-Johansen Cointegration - VECM	-Reject MEH in Thailand because the past spot exchange rate could be used in prediction.
7	1996	Norrbin and Reffett	MEH	Pound, Ca. Dollar, Mark, Yen, SW. Franc	Spot and 3 month forward rates 1973:1 to 1992:4	- VECM	1.Found unit cointegrated vector between spot and forward rates. 2.Found a completed adjustment of forward rates to any short run disequilibriam between forward and spot rates.
8	1996	Parichart	MEH	US. Dollar Yen, Mark : Baht	Daily Jan1988-May1995	-Johansen Cointegration , ECM	-Reject MEH in Thailand
9	1997	Phichet	REH	US. dollar : Baht	Monthly Jan1993-Dec1995	-Engle and Granger Cointegration Test	-The expected future spot rate follow the REH