ABSTRACT

A THEORETICAL AND EMPIRICAL ANALYSIS ON EFFICIENCY OF THE FOREIGN EXCHANGE MARKETS WITH APPLICATION TO THE BRITISH POUND, FRENCH FRANC AND CANADIAN DOLLAR BY TESTING FOR COINTEGRATION AND UNBIASEDNESS

by
Panagiotis Paleologos

This paper discusses the important aspects of efficiency, expectations, and risk in the foreign exchange market. First, a brief presentation of the existing single-equation structural models of exchange-rate determination is given. A mathematical efficiency specification model is defined which employs of a system of interrelated equations testing the random walk and unbiasedness hypothesis. The model is validated by analyzing fluctuations in the spot and forward foreign exchange rates. Utilizing a regression estimation and many different specification and diagnostic tests for the series and the error terms (residuals), this study addresses the efficiency of the English, Canadian and French foreign exchange markets. The unbiased hypothesis is so prevalent in the finance literature that many tests for it have been developed. The study examines common tests and uses the regression results to demonstrate why each of these results does or does not reject the null hypothesis of unbiasedness. Furthermore, I compared two sample spans to test the intertemporal behavior of the spot and forward rates. In addition, the Johancen procedure (1991), which tests for cointegration in a system of equations, is applied to test for Efficient Market Hypothesis (EMH). The existence of such long run or cointegration

relationships directly violates the EMH in a speculative efficient market (Granger 1986).

In my sample testing cointegration was found to be present for the British Pound,

Canadian Dollar, and French Franc. The random walk hypothesis as well has failed to be

rejected for all three major currencies, however the unbiased forward rate hypothesis has

been failed to be accepted for the British Pound and French Franc. However, more

researches are needed in this area to be able to achieve better statistical inferences.

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This thesis is dedicated to
my mother Viola, the memory of my father George and grandmother Ermioni

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CHAPTER 1

INTRODUCTION

The importance of efficiency of organized markets for future delivery of foreign currencies became a critical issue since the abandonment of the Bretton Woods arrangement in early 1970's. Most tests of market efficiency involve a joint hypothesis: first, the ability to determine equilibrium prices or expected returns; second, the hypothesis whether available information can enable agents to achieve turns that conform or surpass their expected values.

The results of Meese and Rogoff [(1983), 3-24] indicate that current economic models of spot exchange rate determination are generally unable to explain the movement in major exchange currency exchange rates. The majority of previous studies offer a very strong evidence against the hypothesis that the forward exchange rates, of any maturity are unbiased predictors of future spot rates.

There are two major interpretations which reject the unbiased hypothesis; first, is the so called asymptotic distribution theory where the sample moments of the data are poor reflections of their asymptotic counterparts. Government policies and other exogenous processes may have significant impact on determining exchange. A second interpretation relies on Fama's [(1984), 319-38] decomposition argument where the forward premium is viewed as the sum of two unobservable components: the expected rate of deprecation and the normalized risk premium. By considering the algebra of least squares, Fama demonstrated that risk premiums are more variable that the expected rate of depreciation and that the two co-vary negatively. I review these models to give some

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econometric interpretations for the underlying currencies of this study. In addition, I examine the profitability of various trading strategies which show that there are inefficiencies in the forward exchange markets. The work of Hodrick and Srivastava [(1984), 1-29] questions whether Bilson's trading strategy produces expected profits that are too realistic to be consistent with risk aversion [Bilson, J.F.O., (1981),435-452]. Similarly the profitability of the interesting filter rule studies of Dooley and Shalfer show that many currencies either were not efficient in their use of price information or real interest differentials were large and variable during the sample period.

The notion of market efficiency is usually associated with the rationality of market expectations. One way to examine this issue is to determine whether market participants could systematically earn an excess profit. In the foreign exchange markets, the current prices reflect all available information. The efficient market approach in conjunction with rational expectations imply that economic agents' expectations about future values of exchange rate determinants are fully reflected in the forward rates. Under these circumstances, the investor cannot earn an unusual profit by exploiting the available information. Empirical tests conducted by Hansen and Hodrick (1980, 1983), Fama (1984), Domowitz and Hakkio (1985), show that the evidence supporting the unbiased forward rate hypothesis is quite weak.

Market efficiency implies a testable restriction that the coefficients $a=0$ and $b=1$ in equation of "simple efficiency" based upon the unbiased hypothesis. Hadsen and Hodrick (1988) called it "simple efficiency" whereas Bilson (1981) call it "speculative efficiency" meaning that traders have rational expectations, and that the supply of speculative funds is infinitely elastic at the forward price that equals the expected future

price. In a similar fashion, Edam and Diction (1988) observed that final price series were generally found to be non-stationary. As a result, the standard F-test of the hypothesis $a=0$ and $b=1$, is no longer appropriate, rejecting market efficiency [Elam E., and Dixon B.L., (1988), 365-372]. Regression estimation by Cornell and Edward find that the coefficient of the forward rate (for predicting the subsequent spot) does not differ significantly from one and the error term displays no serial correlation. Their evidence supports the unbiasedness hypothesis.

On the other hand, Kon S. Lai's and Michael Lai's analysis of five major forward currency markets did not result in a favorable response to the joint hypothesis of market efficiency and no-risk premium [Lai, Kon S. and Michael Lai, (October 1991),567-575]. The problems they encounter in testing forward or futures were that the series are not stationary and statistical procedures are no longer valid in providing a test for market efficiency. Shen and Wang (1990) suggest a cointegration approach developed by Engle and Granger (1987) that can test efficiency accounting for non-stationarity in price series. The least square residuals of the equilibrium regression equation were tested for being stationary. If the residuals are found to be stationary, then the null hypothesis of no equilibrium relationship between S_t and f_t^{t-1} is rejected. However, no strong statistical evidence could be drawn with respect to the parameters a and b which are of main interest.

In this paper, I start from an In this paper I start from an equilibrium state in the dynamics of the stochastic coefficients for the model used to test the unbiased efficiency hypothesis, general efficiency and random walk. In addition I performed statistical and

time series tests for the variables of the model. To test the validity of the model, diagnostic tests were employed based upon the underlying assumptions. I then use the Johansen's (1988) method to test the different pairs of spot and forward exchange rates for the absence of cointegration. Furthermore, it is my interest to explain why shocks to the basis and forward premium are persistent and why strong serial correlation might exist for some currencies. Furthermore, I will discuss the implications of our results and rationalize the inefficiency findings.

Since the focus is on testing the market efficiency represented by various specifications, it is not the intention of this thesis to introduce a new technique to examine the related empirical issue. Rather it follows a conventional approach.

This paper is organized as follows: The first section gives a brief statement of exchange rate determination and defines market efficiency: The second section discusses the empirical models pertinent to testing the efficient market hypothesis, and one model was selected for this research. The third section provides some basic statistics of the variables of the models that are used. The fourth section gives the empirical results and discusses the assumptions or problems encountered. The fifth section deals with the different specification and diagnostic testing of the four models analyzing efficiency and presents a comparative analysis between two periods. The sixth section gives a review of the cointegration concept and applies the using Augmented Dickey-Fuller (test) regression consulting the MacKinnon critical values. The seventh section rationalizes the findings, introducing the concept of profitability rules and the final section gives a summary of test results. The final part stands on its own. It concludes giving attention on individual behavior. It analyses the determination of the equilibrium risk premium

using the macroeconomics at choice under uncertainty and is looking at some of the

issues, theoretical and empirical, not touched upon in this thesis.

CHAPTER 2

EXCHANGE RATE DETERMINATION -
SINGLE AND WIDE MACROECONOMIC MODELS

2.1 Shorting Out Theory and Evidence

2.1.1 Introduction

Participants in international markets are vitally concerned with determining and understanding the behavior of exchange rates since they are interested in making speculative profits or in protecting their investments from changes in the value of their currencies.

Traditional structural models of exchange-rate determination are of a single equation, semi reduced form type, which is inadequate to capture all the complex phenomena underlying the determination of exchange rate[Jane Marrinan, 1993]. One has to move away from the single-equation, semi-reduced form models forward suitable economy-wide macro-econometric models capable of capturing all the complex associations between the exchange rate and other variables (both real and financial, both stocks and flows) of a modern economy. Such models should capture all the associations between exchange rates, interest rate differentials, and other variables. Since the exchange rate is just one of the endogenous variables of an economy-wide mode. The determination of the foreign exchange rate should be weighted along with other endogenous variables in a general (dis)equilibrium setting where stocks and flows, real and financial variables, etc., all interact.

2.1.2 The Role of Monetary Policy with Relationship to Exchange Rates

The value of- the dollar relative to other currencies has not been consistent with the predictions of several economic models. The conflict between what has occurred and the theory has caused problems in formulating the monetary policy and the roll of the exchange rate in that policy. Researchers attempted to find a common ground between the "non-fundamental" explanations of the exchange rate movement and the three current models of exchange rate determination (i.e. Monetary model, Dis-equilibrium Macro-economics model, and General Equilibrium model).

There are two opposing views regarding the role of *monetary policy* in influencing the nominal exchange rate in order to adjust the real exchange rates[Franker J. A. (1983)]. The supporters of using a monetary policy to achieve stability in the nominal exchange rate hope to slow the large and persistent swings in the real exchange rate. It is believed that the fluctuations in the real exchange rates are caused by departures from some equilibrium position. On the contrary, doubtful opponents believe that the important changes in the real exchange rate, are resulted from disturbances in the economy. The following factors are affecting the relative prices in the economy and the real exchange rate: (a) current and expected changes in investment opportunities, (b) government purchases, and (c) tax rates.

Devaluation is seen as the major switching device in reversing the original current account to bring alteration in the exchange rate. Devaluation is seen in this approach as an exogenous or parametric policy device. There is a market for foreign exchange and the Central Bank pegs the price in this market by buying or selling foreign

exchange. If there is excess demand for foreign exchange (which is excess supply for the home country) the price does not rise because the Central Bank is selling some of its foreign exchange reserves. The Central Bank makes a policy to raise the price of foreign exchange, and this requires selling less in a given time period. The currency is thus devaluated, and we study the effects of this devaluation on domestic production on domestic production and absorption. In the presence of capital mobility, this matter is actually a little more complicated. Essentially, monetary policy will be the instrument that determines the exchange rate. For the moment, it is sufficient to assume that, one way or another, policy can bring about a desired change in the exchange rate.

The monetary approach focuses only in the determination of foreign exchange reserves, (FR). It's main point is that changes in (FR) reflect changes in the demand for money and in the supply of domestic credit. The basic idea of the monetary approach is the following: The money base of a country, (M), consists of the Central Bank's foreign assets, (FR), and of its domestic assets, (D) where $M = FR + D$. Given a fixed exchange rate and capital mobility, the monetary approach shows how, various policies or exogenous shocks bring about monetary equilibrium through variations in (FR). In the absence of capital mobility (D= constant), equilibrium would be restored by a rise in the interest rate, which would reduce the demand for money again. In that case, the supply of the money base does not need to change. Now, if we allow for international capital mobility, a rise in the interest rate will then lead to capital inflow ,and, given intervention to keep the exchange rate fixed, this will raise (FR). Consequently, it would raise the monetary base and, thus, bring the required increase in the supply of (M) which in

response to the increased demand of M. If the interest rates cannot finally rise above the world rate, the whole adjustment must take place through the rise of (FR).

To sum- up, the change in FR is part of adjustment mechanism to an imbalance between demand and supply of money. If capital mobility is imperfect, adjustment takes place both through the interest rate- which changes the demand for money and through (FR) which changes the supply.

If internal balance is to be maintained, a change in a current account must be associated with an appropriate change in the real exchange rate, the latter brought about (given certain assumptions) by an appropriate change in the nominal exchange rate. For example, if the US budget deficit is expected to be reduced, and this is likely to reduce the current account deficit, there will also have to be real depreciation which may have to be brought about by nominal depreciation. The opposite is, also, true. If a real depreciation is desired or predicted, there will have to be a decline in absorption which, when there is international capital mobility, this can be achieved by fiscal policy. In that case, maintenance of internal balance would call for an increase in absorption |W. Max Corden (1994), 21].

In order to understand exchange rate behavior, we need to focus upon the behavior of the nominal and real exchange rates during the floating rate regime after 1973. Empirical studies of the exchange rates indicated the following:

I.   Month to month variability in the bilateral spot exchange rates are frequently large and unpredictable.

II. There is a strong correlation between spot and contemporaneous forward exchange rates. The maturity forward contracts that extend for one year tend to have the spot and forward rates move in the same direction by the same percentage.

III. Short term variability of nominal exchange rates have been significantly greater than the variability of national prices [Wasserfallen, W. and H. Kyburz. (1985)].

IV. The fluctuation of nominal and real exchange rates differ across alternative nominal exchange rates.

Evidence has shown that: *exchange-rates behave similarly to assets traded in organized markets. An* asset price is closely linked to the expectation of the future worth of the asset [Stuz, Renee M. (1987), 1024-1040]. Therefore, similar to evaluating an asset, the value of a foreign currency is linked to the expectation of the future worth of the currency.

The next topic to be addressed is the three leading models for exchange rate determination and how they account for the behavior of exchange rates, as well as their implications in the formation of the monetary policy.

2.2 Exchange-rate Specification in Economy Wide Macro-economic Models

Participants in international markets are vitally concerned with determining rates of exchange, since such rates largely affect the costs and benefits of engaging in the

international trade of goods and services as well as financial securities. It is generally agreed that the factors likely to determine the value of a nation's currency are the relative money supplies, real incomes, inflation rates, and interest rates of the home and foreign countries.

In order to put exchange determination into proper perspective, a distinction should be made between two types of models. First, there are models where there is a specific equation for the exchange rate; secondly there are models the exchange rate, implicitly is determined by the balance-of-payments equation. Firstly, economists make a distinction between, models of a single country, where we have a small open economy, and the rest of the world is considered exogenous; secondly, we envision a multi-country model where there the same common structure exists but now with no national barriers.

From the mathematical point of view the two approaches are equivalent once the balance of payments equation is accounted for. It should be emphasized that if one uses the equation to determine the exchange rate, one is not necessarily adhering to the traditional or 'flow' approach to the exchange rate, as was once incorrectly believed. Decisively, no theory of exchange rate determination is regarded as complete if it does not explain how the variables that it considers crucial (such as stocks of assets or the flows of goods or expectations or whatever) actually translate into supply and demand in the foreign exchange market.

When all these sources are present in the balance-of payment equation , this equation then becomes a market clearing condition and it is perfectly legitimate to use the balance-of payments to calculate the exchange rate once all the behavioral equations for

all the items included in the balance have been specified, [Benstock, M., P. Warburton, P. Levington and A.Dalziel, (1986), 249-254].

A second distinction, is between models of a single country or small open economy, in which the rest of the world is taken to be exogenous and multicountry models. The latter model type can be derived from a national model(regularly used as such for forecasting and policy analysis within each country) linked by some superimposed structure for traded flows. Another approach to evaluate exchange rates, is to consider a multicountry model with a common structure for the national blocks.

2.3 The Single Equation Structural Models of the Exchange Rate

2.3.1 Monetary Approach: Flexible Price Version

The so called *asset-market* (monetary) approach takes the exchange rate as the relative price of two moneys whereas the portfolio approach takes it as the relative price of bonds. The two views differ in the assumption made on the substitutability between domestic and foreign assets given the hypothesis of perfect capital mobility. The monetary approach assumes perfect substitutability, whereas the portfolio approach presents a *risk premium*. In the simplest version of monetary *approach purchasing power parity* (PPP) is taken to hold instantaneously as a result of perfect price flexibility.

According to Monetary Models, it is assumed that each country's money demand and money supply determines its own prices; the prices of these two countries is determined by the exchange rate. Presenting, two market equilibrium conditions of two countries hold true [Mundell, R. (May1960), 227-57]:

$$m_t = p_t + Fy_t - lr_t \qquad\qquad (2.3.1.a)$$

$$m_t{}^* = p_t{}^* + Fy_t{}^* - lr_t{}^* \qquad\qquad (2.3.1.b)$$

Where m_t and $m_t{}^*$ are the logarithms of the domestic and foreign money supplies, respectively, the right side variables are the elements of the money demand functions. The money demand functions are assumed to be positively related to cover price levels: (p_t or $p_t{}^*$), real output, Y_t, $Y_t{}^*$, and negatively related to the rate of interests rates r_t, $r_t{}^*$ [Chiang, T. (Autumn 1984), 49-57]. The coefficients F and l, are constant for both countries. Assuming flexible prices and efficiency in the international arbitrage, PPP holds in the short run. That means:

$$S_t = p_t - p_t{}^* \qquad\qquad (2.3.1.c)$$

By expressing(1.2.a) and (1.2.b) terms of p_t and $p_t{}^*$ and then substituting them in (1.2c), we get a new version of the monetary equation (1.2.d), [Frankel J, (1984),239-59], which explains that the equilibrium exchange rate is expressed by the differences between the two countries money supplies, interest rates and real income.

$$S_t = (m_t - m_t{}^*) - F(y_t - y_t{}^*) + l(r_t - r_t{}^*) \qquad\qquad (2.3.1.d)$$

This model predicts that an increase in the domestic money supply (m_t) causes an increase in the domestic prices proportionally and, hence, through the PPP leads to the depreciation of the domestic currency. In addition, a higher interest rate differential causes a decrease in the demand for domestic money, leading to a domestic currency depreciation. A negative relationship between exchange rate and relative real income, [-

F $(y_t - y_t {}^*)]$, indicates that an increase in the domestic real income causes excess

demand for money balances. In addition, the model presumes that an increase in interest

rates differential between two countries(when the host country has a higher interest i ,

would lead to a devaluation of the domestic currency resulting from a poor demand of

that currency.

Assuming that money supply remains the same then equilibrium can only be

maintained by reduction in the prices which results in the appreciation of the domestic

currency. More sophisticated versions acknowledge that in the short run the there may be

deviations due to the price stickiness. In that regard the portfolio approach risk premium

is expressed in terms of easily observed variables. Amongst those variables are

cumulative imbalances in the trade accounts of the home country, the rest of the world,

and the cumulative imbalance in the capital movements account [Franker J. A. (1983),

84-115].

A quasi-reduced forms of the models considered by Meese & Rogoff, (flexible

prices) Frenkel-Biston (monetary approach), Dornbusch-Frankel, (sticky prices monetary

model) Hooper-Morton (asset model) can be submitted under the following general

specification model[Giancarlo Gandolfo, (1990), 965-992]:

$$e_t = a_0 + a_1 (m\text{-}m_f)_t + a_2 (y\text{-}y_f)_t\ e_t + a_3 (i_s\text{-}i_{sf})_t +$$

$$a_4 (i_L\text{-}i_{Lf})_t + a_5 (CA\text{-}CA_f)_t + a_6 K_t + u_t \qquad (2.3.1.e)$$

where f denotes the foreign country, t is the time, and

e = logarithm of the spot exchange rate (price of foreign country),

m = logarithm of the money supply,

y = logarithm of the real income,

i_s = short term interest rate

i_L = long term interest rate

CA = cumulate trade balance

K = cumulated capital movements balance,

u_t = disturbance term

The four models are derived as follows:

Frenkel-Bilson: $a_1 > 0$, $a_2 > 0$, $a_3 > 0$, $a_4 = a_5 = a_6 = 0$;   (2.3.1.f)

Dernbusch-Frankel $a_1 > 0$, $a_2 < 0$, $a_3 < 0$, $a_4 > 0$, $a_5 = a_6 = 0$;   (2.3.1.g)

both models are monetary models where model (2.3.1.f), assumes purchase power

parity(PPP) in both and the short and long run whereas model (2.3.1.g) assumes PPP

only in the long run and assumes sticky prices in the short run.

Houper-Morton: $a_1 > 0$, $a_2 < 0$, $a_3 < 0$, $a_4 > 0$ $a_5 < 0 a_6 = 0$;   (2.3.1.h)

Houper-Morton with risk: $a_1 > 0$, $a_2 < 0$, $a_3 < 0$, $a_4 > 0$,

$$a_5 < 0, \ a_6 > 0; \hspace{3cm} (2.3.1.j)$$

Model (2.3.1.h) follows model (2.3.1j) but introduces the effects of trade-

balance surplus: a persistent domestic (foreign) trade-balance surplus(deficit) indicates

an appreciation of the long run exchange rate. Model (2.3.1.j) introduces imperfect asset

substitutability, hence, it introduces a risk premium that is approximated by K

Subsequent studies by Somanath indicated a non-instantaneous adjustment of the actual

exchange rate to its equilibrium value, given as a lagged version of the four above

models:

$$e_t = a_0 + a_1 (m\text{-}m_f)_t + a_2 (y\text{-}y_f)_t\, e_t + a_3 (i_s\text{-}i_{sf})_t +$$

$$a_4 (i_L\text{-}i_{Lf})_t + a_5 (CA\text{-} \ CA_f)_t + a_6 K_t + u_t + a_7 e_{t\text{-}1} \qquad (2.3.1.k)$$

Finally, Boothe and Glassman (1987) suggested the use of error correction models

(ECM), which in their opinion are best suited for theories that postulate long ran

proportionality between the exchange rate and relative money stocks in the monetary

models. The basic idea of the ECM formulation is that a certain fraction of the dis-

equilibrium is corrected in the following period. Thus, it is equivalent to the

cointegration between the exchange rate and the relative money stock.

2.4 General Equilibrium Models

2.4.1 Balance of Payment Approach

The balance-of-payments (BOP) approach is a general equilibrium model. The demand

and the supply for foreign exchange determines the exchange rate. Under this freely

fluctuating exchange rate system, the exchange rate of two national currencies, like any

commodity price, is determined by the interplay of demand and supply. The demand for

foreign exchange derives from individuals or traders who make payments to foreigners in

foreign currencies [Friedman, Milton (1959), 327-351]. The transactions may involve the

importation of goods and services or the purchase of foreign securities. These are the

items listed on the debit side of the U.S. balance of payments. The supply of foreign

exchange comes from the receipts of foreign currencies obtained from exporting goods

and services or selling financial securities to foreigners. 'These items are entered in the

credit column of the U.S. balance of payments.

Shifts of the demand and supply functions occur because of exogenous factors

such as inflation, real income etc. which are responsible for shifts in the exchange rate to

adjust continuously to a new equilibrium. Equilibrium is restored either by international

capital mobility of adjustments or changes in interest domestically or Internationally. If

capital mobility is imperfect, adjustment takes place either rough the interest rates which

changes the demand for money or through reserves- which changes the supply. In the

extreme case of prefect and instantaneous capital mobility, the offset is complete.

Devaluation of the domestic currency can increase foreign direct investment

which brings an increase in the money supply. An increase in the demand for money

leads to an increase in the supply of money and, hence, reserves of foreign assets. Thus,

the money base, which consists of the domestic and foreign assets, will increase. The

supply of the monetary approach shows how, given a fixed exchange rate and capital

mobility, various policies or exogenous shocks bring about monetary equilibrium

through variations of the foreign assets. Though two mechanisms: [W. Max

Corden(1994), 55-59], higher capital inflow and a current account improvement only can

be temporary, unless the rise in prices is continuous and is not adjusted by a continuous

rise in the domestic assets. The *balance-of payments* (BOP) equals to [Alan L. Tucker,

Jeff Madura, Thomas C. Chiang, (1991), 64]:

$$BOP = C(Pt / S_t P_t^*, \quad Y_t/Y_t^*, \quad Zt) + K (r_t - r_t^*) \qquad (2.4.1.a)$$

Equation (2.4.1a) states that the balance of payments is the sum of the current account, C, and the capital account, K. The current account balance is dictated by relative prices, $Pt/St\ Pt^*$, relative real incomes, Y_t /Y_t^*, and a shift variable, Z_t, which captures the factors such as tariffs, export subsidies, and other interventions. The capital account balance is governed by the interest rate differential, $r_t - r_t^*$. All asterisks denote a foreign variable.

Under a truly floating exchange rate system, balance of payments equilibrium is maintained by a continual adjustment of the exchange rate. The equilibrium exchange rate is determine by intersection of the demand and supply curves. Changes in domestic prices, real income, tastes, and other factors cause shifts of the entire demand schedule. For instance, a rapid growth of domestic real income causes an increase in the demand for imports. Similarly, changes in prices, real income. and foreign country cause shifts of the supply curve. For example, if higher inflation occurs in Franc, this inflation encourages the residents of France to purchase more of U.S. exports and brings about an increase in the supply of the French Franc. Clearly, the continuing shifts on demand and supply conditions force the exchange rate to adjust continuously to a new equilibrium. The following equation summarizes the determinants of the exchange rates namely into three groups, namely relative prices, relative real incomes, and nominal interest rate differentials:

$$S_t = hI(p_t -p_t^*) + j (y_t -y_t^*) - l(r_t - r_t^*) \qquad (2.4.1.b)$$

In equation (2.4.1.b), η, φ and λ are constant coefficients. The BOP approach makes some prophecies: Firstly it advocates that η is positive denoting that an increase in domestic prices relative to foreign prices will lead to deterioration of the domestic country's competitive position and has a negative effect on the current account. This, in turn, will cause a depreciation in the domestic currency. Secondly, this approach predicts that the sign of φ is positive. It recommends that a rapid growth in real output will have the tendency to increase imports, leading to a domestic currency depreciation. Thirdly, an increase in the domestic interest rate, with no comparable change in foreign interest, will attract capital inflows that bring about an appreciation of the domestic currency. Therefore, the coefficient of $(r_t - r_t{}^*)$ is negative.

Monetary models, equilibrium and dis-equilibrium models have deficiencies associated with the determination of the exchange rate: First, they have been over-simplified for the benefit of theoretical analysis which makes them to be not be as accurate as other models. Second, it is difficult to determine the degree of risk taken by individuals according to their expectations (rational or not) as well as measuring or quantifying the risk premium.

2.4.2. Empirical Results for the Single-Equation Models

The forecasting performance of the structural models remains very poor and deteriorates as the forecasting horizon increases. One would expect a better performance of these models when there is more time for the fundamentals to make their influence felt. The

results give more doubt on the validity of the structural models. The estimates of the four models of eq.(2.3.1.d) have shown the presence of multicollinearity in all models. Based on their experiences, Booth and Gassman ,(1987) suggest the use of the first differences since exchange rates seem to be non-stationary integrated in order of 1, so that the first differences ought to be white noise[Boothe, P. and D. Glassman, (1987), 443-457]. The usual tests of residual tests of serial correlation (DW, Godferey's LM) rejected the presence of Heteroscedasticity, with mixed evidence as regards the lagged and ECM versions.

Meese and Rogoff examined the out-of-sample predictive performance of the structural models using a benchmark the simple random walk model, $e_t = e_{t-1} + u_t$, where $\hat{e}_{t-1} = e_t$ denotes the predictive valued and e is the (log) of the exchange rate and u a zero-mean white noise process. Meese and Rogoff concluded that the structural exchange rate models have explanatory power, but predict badly because their explanatory variables are themselves difficult to predict which shows that explanation and prediction are not necessarily related [Messe, R.A and Rogoff, 1983b].

The basic problem in the debate on exchange rate determination is the question of the adjustment speeds in the various markets. Assuming that asset markets adjusts instantaneously or have adjustment speeds higher than the goods markets, then it is the asset flows in a country which have immediate effects on the exchange rate. If this is not true, then the asset market approach is not a correct way of describing the process of exchange rate determination. With the continuous time approach, we can determine the adjustment speed accurately by using the balance-of payment equation in which all the

relevant variables are present and come from adjustment equations with their specific estimated adjustments speeds. Researchers have concluded that the monetary model is deficient because: the *purchasing power parity* does not hold in the short run.; the model does not explicitly incorporate expectations and, therefore, the model fails to capture the dynamic characteristics of- exchange rate behavior. In addition, to some extent the money supplies and the interest rates are endogenous, depending on the operating regimes and banking behavior.

2.5 Dis-equilibrium Macro-economic Models

A Dis-equilibrium Macro-economic Model can be the *sticky, price version,* (Keynesian) of the monetary approach. First, each nation's money supply is endogenous in the sense that is positively related to the market rate of interest. This alters the money market equilibrium conditions. Secondly, the assumption of flexible prices is replaced by the one with sticky prices. Therefore, *purchasing power parity* can only hold in the long run. In the short run, it is assumed that uncovered interest rate parity theorem holds, [Frendel J. A. (1978), 145-652].

If the spot rate is below (above) the long run equilibrium level, the exchange rate is expected to depreciate (appreciate). In addition, the expected inflation differential leads to expected currency depreciation. Therefore, the sticky version attempts to account for market expectations by incorporating the information from market equilibrium as well as effect from the inflation expectations. Under this model, monetary policy can directly influence the exchange rate movements. For instance, a tight monetary policy

increases the real interest rate differential, attracts an incipient capital flow, and appreciates the domestic currency above its equilibrium level, [Bilson, J., (1984), 239-59].

However, dis-equilibrium macro-economic models are also problematic because the model can only determine the direction (upward or downward) of the actual exchange rate but not the exact figure of the actual dollar exchange rate. This occurs because market participants' expectations maybe biased and/ or irrational.

2.6 Irregularities in the Behavior of Real Exchange Rates

Exchange rates have been observed to follow certain empirical regularities, which have being formalized in economic relations known as parity conditions. These relationships are incorporated into formal models and attempt to predict the behavior of exchange rates. Exchange rates can be regarded as asset prices, specifically relative prices of two national currencies. From this perspective their behavior is determined by the same framework applicable to other asset prices, particularly by the efficient market hypothesis. Based on this hypothesis prices depend primary on future behavior of relative variable that affect exchange rates [Levich, R, (1985)]. An examination of empirical regularities of exchange behavior lead us to understand the characteristics of exchange rate behavior [Mussa. M., (1979), 9-57].

Firstly, levels of exchange rates may display some degree of persistence such as tendency for continuous appreciation or depreciation over a period of time. Such movements appear to be random and the process is described to be random walk.

Secondly, the spot and the forward rate tend to co-vary over time. The evidence concerning whether the forward rate f_t^{t+1} is an unbiased predictor of the future spot rate $E_t(S_{t+1})$ is mixed.

Thirdly, exchange rate movements display an asset behavior. Spot rates are seriously affected by economic news and political events, whereas in the long ran are functionally related to economic fundamentals such as the known international parity conditions.

Lastly, in the short time horizon, no model can outperform the random walk hypothesis. These empirical regularities suggest that part of the exchange rate movement can be explained. However, the volatility of exchange rates implies that they are largely an unpredictable by any observable economic reasoning ; thus, they exhibit random behavior. My purpose next is to investigate exchange rate behavior in relation to a set of economic fundamentals organized around international parity conditions.

CHAPTER 3

INTERNATIONAL PARITY CONDITIONS

Foreign exchange rate movements are partially explained by economic variables. The guiding principles that dictate international trade flows and capital movements, thus determine the balance of payments between countries. It can be summarized by the following international parity conditions.

3.1 Purchase Parity Theory

Purchase parity theory(PPP) is a prominent theory of international finance explaining how exchange rates react to changes in inflation rates of countries. One country's inflation rises relative to another, the demand for its currency declines as its exports decline (due to its higher prices). There are various forms of PPP. The *absolute* form also called "the law of one price" suggests that prices of similar products of two different countries should be equal when measured in a common currency [Adler, M. and B. Lehmann, (1983), 1471-1487].

Realistically, the existence of transportation cost, tariffs, quotas may prevent the absolute form of PPP, where the *relative form* accounts for the possibility of such market imperfections [Krugman, P. R., (1978), 397-407]. For PPP to hold the exchange rate should adjust to offset the differential in the inflation rates of the two countries.

Assuming $P_h(1+I_h)$ is the price index of the home country after experiencing an inflation rate I_h and $P_f(1+I_f)$ is the price index of the foreign country that changes

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due to inflation I_f. If inflation occurs and the exchange rate of the foreign country changes, the foreign price index from the home consumer's perspective becomes [Galliot, Henry J. (May 1978), 247-276]:

$$P_f(1+I_f)(1+e_f) \tag{3.1.a}$$

Where e_f represents the percentage change in the value of the foreign currency, in order to maintain parity in the new price index of the foreign county equal to the formula for the new price indexes of the two countries, setting the two country indexes equal each other as follows [Jeff Madura (1992), p.205-207]:

$$P_f(1+I_f)(1+e_f) = P_h(1+I_h) \tag{3.1b}$$

Then solving for e_f we obtain:

$$(1+e_f) = P_h(1+I_h)/ P_f(1+I_f) \tag{3.1c}$$

$$e_f = P_h(1+I_h)/ P_f(1+I_f)-1 \tag{3.1d}$$

In using purchase parity to assess future currency movements, the new value of the spot exchange rate of a given country is:

$$S_{j,t-1} = S_j \left[1+(1+I_h)/ P_f(1+I_f)-1\right] = S_j \left[(1+I_h)/P_f(1+I_f)\right] \tag{3.1e}$$

and the approximate version is:

$$S_{j,t-1} = S_j \left[1+(I_h-I_f)\right] \tag{3.1f}$$

Empirical evidence showed that PPP does not consistently holds true. The percentage change in exchange rates typically was much more than the inflation differential. The reason is that exchange rates are affected by other factors in addition to the inflation

differential and also there are no substitutes for certain traded goods and services and that will impel consumers to continue buying high priced goods and services.

3.2 Fisher Parity ($r_t - r^*_t = \Delta p^e_t - \Delta p^{e*}_t$)

States that the nominal rate of interest approximately equals the real rate of interest plus the expected rate of inflation. If the Fisher equation [Cummby, R., and M. Obstfeld. (June 1981), 697-704] holds true for two countries and real interest rates are equal in the two countries, the nominal interest rate differential will reflect the expected inflation differential between two countries . The condition is particularly applicable in the case of high inflationary periods,

$$. S^{ex*}_{t-1} - S_t = i_t - i^*_t \qquad (3.2.a)$$

where S_t i_t are the spot and nominal interest rate respectively. Taking the mathematical expectation of the (e) where

$$i_t = r_t + \Delta p^{ex}_t \text{ assuming also } \Delta p^{ex}_t - \Delta p^{ex*}_t = 0 \qquad (3.2.b)$$

and given that the real interest rates in two given countries are equal $r_t = r^*_t$ we get the following:

$$E(S_{t-1}|I_t) = i_t - i^*_t + s_t = r_t + \Delta p^{ex}_t - (r^*_t + \Delta p^{ex*}_t) + s_t \qquad (3.2.c)$$

$$E(S_{t-1}|I_t) = s_t \qquad (3.2.d)$$

Substituting (3.2.c) in (3.1f) we *get* $E[S_{t-1} - S_t |I] = 0$

3.3 International Fisher Effect (IFE)

If the ex-ante purchase power parity incorporated into the fisher parity condition, we can see that the expected change in exchange rates correspond to the interest rate differential Roll, R. and B. Solnik: (1979), 267-283.

$$S^{ex}_{t+1} - S_j = (i_h - i_f)$$
(3.3.a)

The rate of exchange is determined by the difference in the exchange rates. Assuming the interest rate differential between the U.S. and the U.K. is -3% $(r_t - r_t')$ this condition can be used to predict that the US currency will appreciate by 3%. The interest rate differential will exists only if the exchange rate is expected to change is such a way that the advantage of the higher interest rate is offset by the loss of the foreign exchange transactions [Rogalski, R. J. and J. D. Vinso, (1978), 69-79]. International Fisher Effect implies that while an investor in a low-interest country can convert his funds into the currency of the high interest country and get paid a higher rate, his gains will be offset by his expected loss of foreign exchange rate returns.

The value at $t+1$ of an original investment earning interest at rate of i (interest of the home country) is equal to the value of and equal amount converted to a foreign currency at t, invested at the foreign interest rate i_f and converted back into domestic currency at $1 + i_h$ [Roll, R. and B. Solnik, (1979), 267-283]:

$$1 + i_h = [1/ S_t (1 + i_f) E(S_{t+1})]$$
(3.3.b)

subtracting 1 from both sides we get:

$$[E(S_{t+1}) /S_t]-1 = [(1 + i_f)/ 1 + i_h]-1$$
(3.3.c)

$$[E(S_{t+1}) - S_t]/ S_t = [(1+i_f)/1+ i_h]-1 \qquad (3.3.d)$$

$$E(\Delta\%S_t)= 1+ i_h \qquad (3.3.e)$$

We can derive IFE as follows; the actual return to investors who invest in foreign money market security depends not only on the interest rate i_f but also the percent change in the value of the foreign currency e_f denominated security. The effective(exchange rate adjusted) return of the foreign bank deposit is:

$$r = (1+i_f)(1+e_f)-1 \qquad (3.3.f)$$

According to the IFE, the effective return on a home investment should be on average equal to the effective return on a foreign investment:

$$r = i_h \qquad (3.3.g)$$

We can determine the degree by which the foreign currency must change in order to make investments in both countries generate similar returns. Taking the previous formula of what determines r, and set it equal to i_h.

$$r= i_h \qquad (3.3.h)$$

$$(1+i_f)(1+e_f)-1 = i_h \qquad (3.3.i)$$

solving for e_f we get

$$e_f =[(1+i_h)/(1+e_f)] -1 \qquad (3.3.j)$$

Whether IFE holds in reality depends on the particular time period examined

3.4 Interest Parity Theorem (IPT)

Interest Parity Theorem is the most basic relationship in international finance. The rationale behind the application of this theory to both international investments as well as to international lending , is that for investment projects , investors compare the return from the domestic market with the return of the foreign; the latter is the return from the foreign asset plus the forward premium. Equilibrium will be achieved only when the parity condition is established. In the Fisher effect we had the unknown expected future rate. The forward rate is a contractual rate. According to this theorem the observed differences in the interest rates will be equal to the premium or the discount of the forward rate over the spot rate [Aliber, Robert Z. (December 1973), 1451 - 1459].

If interest rates rise in country A, domestic as well international agents will tend to hold fewer M_1 assets [Kouri, P., (1977)]. Thus, when interests go up, the demand for money will drop. Because money is defined to be non-interest bearing, and we don't want to for sake the higher interest that securities can provide, we will demand more bonds, either domestic of foreign. Hence, the less demand for dollars will devaluate the dollar and greater demand for foreign bonds that can be purchased by selling dollars for foreign currencies. If interest rates decline we have the opposite effect. The monetary model also builds a high degree of exchange rate volatility. A current change in the money supply can have a more than proportionate effect on the existing exchange rate if the market expects more money growth and currency depreciation in the future. IPT can be illustrated through an arbitrage scenario, buying and selling of the same amount of currency into two different foreign exchange markets in order to profit [Lucas, R. E. J. (1982), 335-360].

Arbitrage dictates that you take your principal in dollars and go to the spot market to convert the dollars to foreign currency and invest at the interest rate of the host country. At the same time, you sell forward the foreign currency for the domestic currency.

Assuming the amount of the home country initially invested is (A_h), the spot rate (S_j) when the foreign currency was purchased, the interest rate on the foreign deposit (i_j), and (A_n) is the amount of the home currency received at the end of the deposit period due to such a strategy is: [Jeff Madura (1992), 205-207]:

$$A_n = \left(A_h / S_j \right)\left(1 + i_j \right) F_j \qquad (3.4.a)$$

Since F_j is simply S_j times one plus the forward premium (called p), this equation can be written as:

$$A_n = \left(\frac{A_h}{S_j} \right)\left(1 + i_j \right)\left[S_j(1 + p) \right] \quad (2.1.4b) \quad = A_h\left(1 + i_j \right)\left(1 + p \right) \ (3.4.b)$$

the rate of return is: $\qquad r_j = \dfrac{A_n - A_h}{A_h} \qquad\qquad (3.4.c)$

$$r_j = \frac{\left[A_n\left(1 + i_j \right)\left(1 + p \right) \right] - A_h}{A_h} = \left(1 + i_j \right)\left(1 + p \right) - 1 \qquad (3.4.d)$$

If interest parity exists, then the rate of return achieved from covered interest arbitrage (r_j) should be equal to the rate available in the home country. Setting the rate that can

be achieved from using covered interest arbitrage[1] to the rate that can be achieved from an investment in the home country the return on the home investment is simply the come interest rate called (i_h):

$$r_j = i_h \qquad (3.4.e)$$

By substituting into the formula how r_j is determined we obtain

$$\left(1 + i_j\right)\left(1 + p\right) - 1 = i_h \qquad (3.4.f)$$

Rearranging the terms, we find out that the forward premium of the foreign currency should be under conditions of interest rate parity:

$$\left(1 + i_j\right)\left(1 + p\right) = \left(1 + i_h\right), \ \left(1 + i_j\right)\Big/\left(1 + i_h\right) = 1 + p(1 + p) \qquad (3.4.g)$$

$$\left(1 + i_j\right)\Big/\left(1 + i_h\right) - 1 = p \qquad (3.4.h)$$

The relationship between the forward premium (or discount) and the interest rate differential according to interest parity is simplified in approximate form as follows [Loopesko, B. E, (1984), 257-278]:

$$p = \frac{F_j + S_j}{S_j} \cong i_h - i_j \qquad (3.4.j)$$

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[1] Covered interest arbitrage tends to force a relationship between interest rates of two countries and their forward exchange rate premium or discount. I t involves investing in a foreign country and converting against the exchange rate risk.

and shows that the larger the degree by which the foreign interest rate exceeds the home interest, the larger would be the forward discount of the foreign currency specified by the IRP formula.

3.5 Real Interest Rate Parity

RIRP emphasizes the real relationship between the exchange rate and the interest rate differential [Loopesko, B. E (1984), 257-278]. It is an expression of the international Fisher parity condition in real terms and states that the expected change in real exchange rates equals the real interest rate differential. This can be achieved by deflating the relative expected inflation rate (or subtracting the natural log-difference of price levels) from the international Fisher parity condition.

$$\left[\Delta s_t^e - \left(\Delta p_t^e - \Delta p_t^{e*} \right) = \left(r_t - \Delta p_t^{e*} \right) - \left(r_t^* - \Delta p_t^{e*} \right) \right] \qquad (3.5.a)$$

We should keep in mind that the validity of these conditions is based on the assumptions that there is no transaction cost or other forms of market imperfections such tax differentials and government intervention [Roll, R. and B. Solnik (1979), 267-283]. More precisely, the purchase power parity theory assumes that the commodity markets are efficient, while the interest rate parities assume that the asset markets are efficient. The unbiased forward rate hypothesis, Fisher parity, and the international Fisher equation requires rational expectations and intertemporal efficiency.

CHAPTER 4

EFFICIENT MARKET HYPOTHESIS

This chapter discusses the different forms of efficiency that have been maintained by Fama. Pricing efficiency concerns whether an asset's price is equal to it's intristic economic value. Since efficiency depends on how fast information is being processed and how accurately is being delivered pricing efficiency is examined as informational efficiency. Different degrees of informational efficiency have been suggested by researchers and it is my intention to present them in detail.

4.1 Theoretical Approach of the Efficient Market hypothesis

Fama [Loopesko, B. E., (1984), 257-278] argued that efficient market is the market where prices "fully reflect" available information. In such a case, no investor or speculator can earn extraordinary profits by exploring publicly available information. This does not imply that that equilibrium expected returns are all the same but it is assumed that it is constant through time. The tests of market efficiency in the foreign exchange market are necessarily tests of the equilibrium model of expected returns and rational processing of available information by investors. The structure of this test is that first a specification model has to be developed [Levich, R., 1985].

The selection of equilibrium process describing foreign exchange is certainly critical for a proper testing of market efficiency. If we assume that market equilibrium is expressed in terms of equilibrium the excess of expected returns on asset j is given by

$$Z_{j,t+1} = [R_{j,t+1} - E(R_{j,t+1}|I)] = 0 \qquad\qquad (4.1a)$$

where $Z_{j,t+1}$ is one-period percentage return and I presents the information set, which is assumed to be fully reflected in the price at time t. When the return sequence $Z_{j,t}$ is a "fair game" with respect to the information sequence I_j, the market is efficient.

A condition for the existence of market efficiency is that the expected returns of a series of investments are equal to zero. This does not mean that returns from every single investment should be equal to zero but the average is expected to be zero. We envision the case where actual asset returns fluctuate randomly around the equilibrium return. Thus, the question is whether investors can efficiently set their actual returns equal to their equilibrium value. What we actually need to examine is the scope of information in which we can set up a model to determine the impact of information on prices.

4.2 Weak Efficient Market Hypothesis

The weakly efficient market hypothesis states that historical price and volume data for assets contain no information that can be used to earn trading profits above the one could attained with a naive buy-hold investment strategy. Technical Analysis is well recorded but worthless legend. That means that past prices and volumes is worthless for improving the predictions of future prices changes. The weak form implies that the best predictor of the future actual spot rate is the current. That is:

$$E(S_{t+1}|I_t) = S_t \qquad\qquad (4.2.b)$$

which denotes that the expected change on the spot rate between two period is zero. The realized difference between them is probably due to the disturbance term associated with news or innovation that occurs between t and $t+1$.

$$S_{t+1} - S_t = \varepsilon_{t+1} \qquad\qquad (4.2.c)$$

Thus, we expect that ε_{t+1} behaves randomly and is uncorrelated with the information set, I_t, which means that investors can not find a systematic pattern that will help them improve their predictions of exchange rate behavior. The weak form efficiency is a short -run phenomenon since its behavior is largely unpredictable especially when the time horizon involves daily or weakly rates.

Evidence on trading using the x percentage filter rule show that the filter rules might enable an investor to earn significant profit, if some of the patterns used by technical analysis are reliable indicators. The 1 percent filter is the most profitable. However, after commissions are deducted, it cannot win the naive strategy.

Sweeney, developed a rule that was able to earn modest profits through long positions. He found that the filter rule trading to be fairly consistently profitable in some stocks while being unprofitable year after year in other stocks. After delineating these problems, Fama, and Sweeney's filter rule could mechanically trade some stocks and earn a statistically significant rate of profit [See Richard J. Sweeney, 1988, 285-300]. However, the high commissions made this rule not profitable. In conclusion, some patterns do exist that can be used for profitable trading strategy but are so weak and complex that the filter rule is unable to generate from every stock. Studies of spot rate behavior focused on the short term patterns (1-90days) that can allow larger profits after commissions from aggressive trading [Wasserfallen. W. and H. Zimmerman (1985), 55-

72]. The serial correlation strategy failed to detect any significant patterns. The test of serial correlation furnish some support for the weakly efficient market hypothesis.

4.3 Semi-Strong Market Hypothesis

The semi-strong market efficiency supports the idea that markets are efficient only when exchange rates reflect all publicly available information. In this case no further information can be gained from public sources that will help explain the movement of the currency. If today's exchange rate fully reflect any historical trends exchange rate movements, but not other public information on expected interest rate movements, the foreign exchange market would be weak form efficient. Only insiders who have access to valuable information could earn a profit greater than that could earned by using a buy-hold strategy in a semi-efficient market [Rose, A. K. and J. G. Selody, (1984), 669-672]. Much research has tested the efficient market hypothesis for foreign exchange and stock market. It is suggested that in order to test semi-strong efficiency a formal model has to be determined that reflects market equilibrium state and also the variables which condition the exchange rate and bring it into equilibrium. Such determinants may be the price level of a country, real income, interest rates, money supply etc.

The anticipated and unanticipated components of the exchange rate determinants must be distinguished in order to examine the nature of semi-strong market efficiency. Since the foreseen components have been observed by the market participants and therefore incorporated into the spot rate of the currency, then any deviations from the rational expected spot rate must be assigned to the unexpected factors which govern the exchange rate.

Professors Fama, Fisher , Jensesen and Roll conducted a study to test the semi-strong efficient hypothesis. Their study was based on a sample of 960 stock splits and stock dividends that occurred on the NYSE between 1927 and 1959. Stock prices have been checked in reaction to important public information announcements. The study was asked if stock dividends, or splits had any influence on one period rate of return. Splits and dividends are public announced events that furnish a good vehicle with which to test the hypothesis.. Effects of federal discount rate showed that there was a small but significant change of 1/2% [R. N. Waud, 1971]. The study employed a regression model using 60 monthly rates of return (r_i) (30/30 around the split). Attention paid to the error term of returns (e_{it}) around the time of split. The regression model used was the following:

$$r_i = a_i + b_i (r_m) + e_{it} \qquad\qquad (4.3.a)$$

where r_m is the average rate of return of the market. If the error term is equal to zero at the time of split then the security's rate of return is equal to what the characteristic line predicted. If e_i is greater than the one predicted by the characteristic line,

$$r_i > a_i + b_i(r_m) + e_{it} \qquad\qquad (4.3.b)$$

that means that the split, is boosting rate of returns (r_i) greater that normal, $e_i=0$, for the months after the change resulting the difference affecting the value of the of the firms. In such case, the market is inefficient.

Cumulative average error terms e month by month can show the influence that dividends or splits have on price (r_i). Dividends or splits are accompanied by an increase

in cash dividends and this information discloses information about the internal workings of a company. CEOs are confident that the earning power of the firm has increased to provide higher future dividends. Such firms showed a positive e_i. If a firm fails to rise its cash dividend earnings, then the error term e_i would be negative.

Price changes occurring near the time of the dividends and splits can be implicit to their information content but in the long run the firm nor the investor's rate of return (r_j) are changed by splits or dividends [W. Hausman, R.R. West, and J. A. Largay, 1971, 69-77]. The investor can earn returns above the ones determined by the characteristic line where the error term is positive ($e_i>0$)by speculating on the announcement of dividends proceeding the public announcement. The studies show that security prices not only react immediately and rationally to news; they often are anticipated. Security prices seem to reflect publicly information. Empirical evidence in the literature does not find a strong confirmation of the semi-strong efficiency form. The difficulty may come either from a luck of a well specified model of the determination of exchange rates or from an insufficient precise procedure to decompose the anticipated parts in testing the model.

4.4 Strong Efficient Hypothesis

In a strong efficient market, all information, and not just publicly available information is reflected in asset prices. Prices are always equal to its values. Prices adjust instantly to the arrival of new information. Researchers have examined the profitability of inside traders to see if access to inside information allows statistically significant trading profits.

Jaffe, (1974), analyzed the sum over six years to measure insides profit [J.F.Jaffe, 1968, 35-51]. He used the CAPM to determine if the error term, e_i, of the inside traders in their own companies' stock is positive or negative. He added selling and buying plurality and yield average residual for all insiders (after commissions). Statistically speaking, this rate of insiders trading profit is statistically greater than normal returns but practically the average investor is not getting richer by making investments based on their information because of the commissions paid [Sweeney, R. J., (1986), 163-82]. Given the complexity of the currency markets, it is not easy for financial analysts to find inside information that leads to forecasting returns accurately enough to outweigh the research and transaction cost. From this perspective, it is difficult to test the strong form of the efficient markets hypothesis.

Dr. H. N. Seyhum analyzed insiders' trading between 1975 and 1981 using larger sample and a different research methodology than Jeffe [Dr. H. N. Seyhum, 1986, vol. 16, no. 1, 189-212], suggesting that Jeff's estimates of the insiders' modest profits were upward biased. He examined *outsiders* who traded on inside information purchased from one of the financial services that data about insiders' trading activities. Seyhum found that, on average, outsiders who traded on the latest available reported by insiders to the SEC where unable to earn positive profits from their trades. The fact that insiders on average, can earn profits from their information disprove the strong efficient market hypothesis. Discovery of such flaws in the perfect markets hypothesis direct one to wonder how many people have monopolistic access to valuable information. Seyhum addressed this question when he reported that *outsiders* who followed the insiders' trades

a few weeks later could not earn returns that beat the naïve buy-and-hold-strategy[1].

The efficient market hypothesis has been extensively developed in the domestic finance

literature (Fama 1970). The notion of market efficiency is usually associated with

rational expectations of market expectations. One way to examine this issue is to

determine whether market participants could systematically earn an excess profit. In the

foreign exchange markets the efficient markets hypothesis has been applied to both spot

and forward markets. Following Fama (1970), Levich(1985) and Mishkin (1983), we

write [Mishkin, F. S., 1981, 151-200]:

$$E\left[X_{t+1} X^{ex}_{t+1} | \Omega_t\right] = 0 \qquad\qquad (4.4.a)$$

where X^{ex}_{t+1} is the expectation derived from the one-period-ahead forecast of the

actual value X_{t+1}, and E is the expectations operator conditions of the information set

Ω_t available at the end of the period t. If we designate x as market returns, eq. (4.4.a),

implies that there are no systematic unexploited profits over time. If there are systematic

forecast errors that may be detected of observed by investors, the information

undoubtedly would be incorporated into the forecast process.

4.5 Against Efficient Market Hypothesis

A respectable evidence that weighed against the efficient market theory was published in

1981, the research findings of Professor Robert J. Shiller dealt a blow to the efficient

markets theory.

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[1] During 1988 many newspapers published stories about millions of dollars of Ivan Boesky made by trading inside information and manipulating security process.

Shiller compared the market prices of two stock market indexes (each for different period) with their present value for every year $v_t = PV$ at time t for t=71-79. He used per share cash dividends and stock price data, denoted d and p, respectively that have been adjusted to remove inflationary effects and other factors that might confound his tests. Using eq. (4.5.a) he compared the mark prices of these two stock market indexes with their present values, where, p_T is the price of the stock at terminal date T, and f is the period when dividends occur.

$$PV_t = \sum_{f=t+1}^{T} \frac{df}{(1+k)^{f-1}} + \frac{p_T}{(1+k)^{T-1}} \qquad (4.5.a)$$

The theory of finance suggest that the true economic value of a security is equal to the present value (PV) of the dividends. However, findings showed significant differences between present value of stock indexes and market prices [LeRoy and M. Porter, 1981, 555-574].

Levich. R., (1985) notes that part of the confusion surrounding tests of efficiency of foreign exchange markets is generated by an application to foreign exchange markets of ideas from the early finance literature on efficiency of stock markets.

Fama E.F. , (1970, 383-417) argued that an efficient market is a market where prices "fully reflect" all available information. In such a circumstance, no investor or speculator can earn extraordinary profits by exploiting publicly available information. This does not imply that equilibrium expected returns on single assets may not differ when all bear the same risk. Also, one cannot assume that the equilibrium expected return on an asset is constant through time. These qualifications that expand the

definition of an efficient market, make testing the concept quite hard. The ideas also generally imply that tests of efficiency in the forward foreign exchange market are necessarily joint tests of an equilibrium model of expected returns and rational processing of available information by investors [Hsieh, D., 1984, 173-184]. Again testing of market efficiency requires one to specify a model of equilibrium expected returns and the information set of investors, also specify the assumptions about the economic agents who set asset prices to make expected returns on assets conform to the expected values predicted by the model. Technical analysis has helped in some extend to gain insight to negate the market efficiency hypothesis.

However, it is costly to implement trading strategies that are designed to benefit from the anomalies in the efficient market theory. In the final analysis, the efficient markets theory simply documents the well-known slogan that "you cannot expect to get something for nothing." Would you disagree with that?

CHAPTER 5

EFFICIENT MARKET HYPOTHESIS
AND RATIONAL EXPECTATIONS

5.1. Introduction

This section develops and discusses various empirical tests that seek to assess the

efficiency of the foreign exchange market. At the outset it is important to note that

as with other financial markets any test of market efficiency is a joint test of

several composite hypotheses. Hence, it is impossible to develop a direct test of

the hypothesis that the foreign exchange market is efficient. All that can be done

is to present various statistical hypotheses regarding what one means by market

efficiency and test these specifications by placing additional assumptions on the

statistical properties of the data. Rejection of the null hypothesis is consequently

not necessarily identified with market inefficiency[1].

Following Fama's (1970) definition of an efficient market, no particular market

operation can earn an excess profit. Defining the excess market return for currency

asset, (j), at time $t+1$, as:

$$R_{j,t+1} = R_{j,t+1} - E(R_{j,t+1}|I_t) \qquad (5.1.a)$$

where I_t is the information available reflected in the price of the price at time t then we

can say that; if the excess market return $[R_{j,t+1}]$ is a "fair game" with respect to the

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information set I_t then the market is efficient and the expected value of the excess return

equals zero.

$$E(P_{j,t+1})=0 \qquad\qquad (5.1.b)$$

With respect to currency exchange rates we will say that the expectation derived from the

one-period-ahead forecast of the S^{ex}_{t+1} actual value of the spot exchange rate S_{t+1} is

not different. E is the expectations operator and I is the available information.

$$E[S_{t+1} - S^{ex}_{t+1}|I]=0 \qquad\qquad (5.1.1c)$$

The study of the efficient market and the random walk hypothesis involves joint tests of

equilibrium price determination and of efficiency. The equilibrium pricing determination

is mainly based on the international parity conditions mention in chapter two.

5.2 Rational Expectations

Economists profess that the forward rate will be an unbiased predictor of the future actual

spot rate given that markets are efficient and expectations are rational [Dr. J. Malindretos

& Dr. N. Kallianotis, 1995].   In the foreign exchange market the efficiency concept

suggests that the forward rate includes all available information valuable to forecast the

actual future spot rate. Consequently the expected value of the future spot should be the

current forward rate.

The rational expectations (RE) hypothesis states that the market's rational

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of models of equilibrium expected returns. Fama writes [(1976) p. 168], "Formal tests require formal
models, with their more or less unrealistic structuring of the world."

expectations[2] are in fact the same as the expected value, conditional to all available information. Literally, for an expectation to be rational, it does not need to be derived through particular set of calculations.[3] Consequently, experienced traders which are presume to have the ability keeping ahead of the market they should behave as if they are computing expected values. Subjective expectations derived by forecasting models which best exploit the pattern of systematic errors,[4] should demonstrate identical results with those of truly rational expectations.

Under RE the subjective market expectation will equal to the mathematical expectation of the next period's spot rate conditional on particular information set at time t. Expressing the RE hypothesis formally we get a conditional expectation $E(S_{t+1}|I_t)$ which expresses the expected value of the period $t+1$ spot rate, conditional to information available to the market at t. Following, we can manifest the expected spot rate S^{ex} with the following parallelism [Laurence S. Copeland, 1990]:

$$S_t^{ex} = E(S_{t+1}|I_t) \equiv E_t S_{t+1} \tag{5.2.a}$$

Since the dollar price of the British Pound price (assume $S^{ex} = \$/\pounds$) is equal to the reciprocal of the British Pound $[1/(1/S^{S/\pounds})^{ex}]$ then the expected spot S^{ex} should be equal to the reciprocal of expected $1/S^{ex}$.

In other words

$$S^{ex} = 1/(1/S)^{ex} \text{ equal to } 1/S^{ex} = (1/S)^{ex} \tag{5.2.b}$$

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[2] The expectations in which are not necessarily the same as the conditional expected value of the variable in question.

[3] Firms are assumed to maximize profit without necessarily setting marginal revenue equal to marginal cost.

[4] Errors that display a non-random pattern.

However, the reciprocal of expected value of the Spot is not equal to the expected value of reciprocal of the spot.

$$1/E(S) \neq E(1/S) \qquad\qquad (5.2.c)$$

It is natural to specify the RE hypothesis in term of logarithms to avoid the problem of translating from British Pound per dollar to dollar per British Pound. The lower case s represents the natural logarithm of the exchange rate.

$$-E(\log s) = E(-\log s) \qquad\qquad (5.2.d)$$

However, we might question what would have determined the exchange rate at time t-1

If we had to determine the expected value of t-1 for the current period t the equation (5.2.a) becomes

$$S_{t-1}{}^{ex} = E(S_t | I_{t-1}) \equiv E_{t-1}S_t \qquad\qquad (5.2.e)$$

Agents might form forecasts of the future exchange rate by deriving the best possible predictor, based solely on a set of series of past exchange rates. For example, an agent faced at time t can predict the future exchange rate, S_{t+1}, by limiting the required information assigned to the series of past exchange rates.

$$S_t, \; S_{t-1}, \; S_{t-2}, \; S_{t-3}, \ldots, S_{t-n}$$

If the rational expectation of the $S_t{}^{ex}$ is equal to the mathematical expected value of the historical expected values contingent on the information set, containing only the past history of those expected spot rates forecast, then we are talking about a weakly rational expectations theory. Note that this forecast will usually be a poorer one than a fully rational expectation. That means that subjective expectations are given by the following

$$S_t^{ex} = E(S_t| S_{t-1}, S_{t-2}, S_{t-3}, \dots S_{t-n}) \tag{5.2.f}$$

Following, we introduce the forward rate and rationalize market efficiency using an arbitrage scenario.

5.3 Market Efficiency - Explanation through Arbitrage

We can show the relationship of the S^{ex} and forward f_t at time of present spot S_t by considering an arbitrage scenario. Assuming that there are no exchange controls, there are available funds for arbitrage operations, and no transaction cost.

Imagine an investor expecting a 6.6% appreciation of the British Pound. Lets say the British pound spot appreciates from $S_{t1} = 150^{\$/£}$ to $S_{t2} = 160^{\$/£}$ and the forward rate is quoted at $f_{t1} = 150^{\$/£}$. Arbitrage profits can be experienced by selling forward 12 months F_{12} liras for dollars. At expiration time he sells at the spot rate liras making a profit of 6.6% minus the premium paid for the forward dollars[Frenkel J.A. and Levich R. M., 1975, 325-38].

If the same view is share with the rest of the market then the forward rate will be bit up until the premium is high enough to discourage any further speculation. The required forward risk premium (p_t) should be equal to the difference between the forward and the expected spot rate.

$$f_t^{t+1} - E_t(S_{t+1}) = p_t \tag{5..3a}$$

The following equation represents an efficient market equilibrium between the forward and the expected spot. Where f_t^{t+1} is the forward price of the dollars at time t for delivery one period later ($t+1$) and $E_t(S_{t+1})$ is the market's expectation of the future spot

$$f_t^{t+1} = E_t(S_{t+1}) + p_t \qquad\qquad (5.3.b)$$

If we bring in to the setting the actual spot rate, S^a_{t+1}, then we get an expression which summarizes the efficient market hypothesis, showing that the gap between the forward and the actual spot is equal to the sum of the two components, the random expected error and a risk premium.

$$f_t^{t+1} - S^a_{t+1} \quad = \quad [E_t(S^a_{t+1}) - S^a_{t+1}] + p_t \qquad\qquad (5.3.c)$$

$$= \quad u_{t+1} + p_t$$

The error term u_{t+1} has been substituted for the expression in the square brackets on the right-hand side, which is simply the percentage gap between what the market expected the exchange rate to be at $t+1$ and the actual outcome. The critical term u_{t+1} represents the unexplained variation between the actual future spot rate S_{t+1} and the expected future spot rate $E_t S^a_{t+1}$. The critical term u_{t+1} should show no systematic pattern of variation over time, should have a mean value of zero, a zero autocorrelation function, and exhibit no cross correlation with other spot or forward rates [Huang, R. D., 1984, 153-168].

The reason we want this unexplained error to remain unpredictable is because we want to exclude the possibility of the profitability of further exploited information. Equation (5.3.b) implies that the following:

$$S_{t+1} \quad = \quad f_t^{t+1} - u_{t+1} - p_t \qquad\qquad (5.3.d)$$

if we shift this scenario back one period the expression for the current actual spot rate can be viewed as the sum of three components; the previous period forward rate, minus the risk premium, minus an unpredictable, expectation error. Hence, we get the following:

$$S_t = f_{t-1}^t - u_{t+1} - p_{t-1} \qquad\qquad (5.3.e)$$

Note that if we were able to set or determine a certain structure of the risk premium then we would be able to test whether the spot rate and the forward rate are related in s similar fashion the are predicted by the efficient market hypothesis. Specifically we set assumptions that the unpredictable component u_{t+1} and p_t are constant over time and fluctuate randomly about its mean value [Franker J. A., 1980, 1083-1 101].

CHAPTER 6

UNBIASED FORWARD RATE HYPOTHESIS

6.1 Unconditional Unbiasedness in the Foreign Exchange Markets

Unbiasedness is said to be obtain when the forward market is efficient and investors are

risk neutral so that the forward rate is equal to the mathematical expectation of the future

spot rate at the day the forward contract expires. The forward rate has been widely

viewed as an unbiased predictor of the future spot rate. This proposition is derived from

an efficient arbitrage activity investors.

Under risk neutrality agents are willing to undertake risky transactions in return

for a zero risk premium – no risk premium is required to induce market agents to

undertake risky transactions [Franker J. A. and Froot K. A., 1987, 133-53]. This means

that they are willing to speculate on the future spot rate up to the point where the reward

is insignificant, and by doing so they are pushing the forward rate to the point where it is

equal to the rational expected future spot rate S^{ex} and reducing the risk premium p_{t-1} into

zero. In symbols we express this ideas as [Chiang, T.C., 1986, 153-162]

$$S^{ex}_{t+1} = f_t \qquad\qquad (6.1.a)$$

The following equation will hold true substituting eq (6.1. a) into (5.1.b) yields :

$$E\left[S_{t+1} - f_t \,|I_t\right] = 0 \qquad\qquad (6.1b)$$

Equation (6.1b) states that the forecast errors resulting from using forward rates will

equal zero on average. An nonzero value would reject the unbiased forward hypothesis.

The sources of rejection may be attributable to the following: no-negligible transaction

cost associated with arbitrage, a risk premium when investors are not risk-neutral or specification error if the model is not well specified.

Thus, the validity of the unbiased forward rate hypothesis implies that investors are risk-neutral and by definition, market agents require no risk premium to persuade them to undertake risky transactions. Speculation on the forward will be driven up to a point where reward is negligible. At this point we have:

$$S_t = f_{t-1}^{t} - u_t \qquad (6.1c)$$

Similarly, we can express the actual rate of change of two periods by the one anticipated in advance, reflected by the previous period's premium or discount on the forward rate, plus or minus the random error'.

$$S_t - S_{t-1} = (f_{t-1}^{t} - S_{t-1}) - u_t \qquad (6.1.d)$$

Each period's forward rate is an optimal forecast of the next period's actual spot rate, where any deviation form the actual spot is only explained by the unpredictable predictor u_t. Unbiasedness implies that the forward rate can not be improved as a forecast since there is little way of inside information in currency markets. As a result the actual future spot rate cannot be predicted any further by using any other forecast unless there is an inside information in currency markets.

The relationship between the spot and forward rates are shared by all the major currencies. Unbiasedness requires that the spot rate is on average equal to the one month forward rate that ruled at a lagged month. Looking at the background of efficiency studies, we can see that when market sentiment changed, the direction on both

spot and forward rate changed simultaneously as well. The predominant influences on the forward rate are exactly the same set of factors that determine the spot rate. That means that the spot rates may be more closely linked to contemporaneous rather than lagged forward rates.

The volatility of spot exchange rates has for the most part be unanticipated. Statistically, the forward premium has less volatility than the spot rate by one fifth. Moreover, the correlation between them is statistically insignificant since the correlation coefficient is negative. It is not definitive that spot rates follow a pure random walk, but the approximation is close enough for a forecast to be quite hard to beat.

All that is required for unbiasedness is that the forward rate be an unbiased predictor of the actual spot rate, which means that the forward rate is not systematically wrong predicting the actual future spot rate. However, we have to determine whether u_t is random or not. Latest studies seemed to support unbiasedness but most recent work shows that markets have become more inefficient in the last decade [Hansen, L.P. and R.J. Hodrick, 1980, 829-853]. This also contradicts to what one might reasonably have expected in view of the continued removal of controls on international capital movements (technology in money transfer, and consequent fall in the cost of transactions).

Efficiency implies that equation like (6.1.e) holds true. Assuming that the risk premium is constant we get:

$$S_t = a + b f_t^{t-1} - u_t \qquad\qquad (6.1e)$$

Nonetheless, at this point a consensus view seems to have emerged against unbiasedness

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[1] A number of writers identify Equation 10.5 with efficiency, which seems over-restrictive, while Bilson (1981) calls this condition speculative efficiency.

(efficiency) and, by and large, against the constant risk premium version of efficiency. If the foreign exchange market is efficient, then it should be impossible to find a trading rule to 'beat the market'. The best strategy in that case would be buy-and-hold, since it involves the minimum of transaction cost [Levich, R., 1979].

We have two possible explanations of the failure of the efficiency hypothesis [Levich, R., 1979]. Either the market is efficient but with a non-constant risk premium, or expectations are irrational, or both. The deviations from efficiency that have been uncovered seem difficult to square with any pattern of risk premium variation. Recent research using survey data appears to indicate that explanation may lie in irrational expectations.

6.2 Examination of Unbiasedness in Real Terms

Engle (1984) defines the real profit on a sale of foreign currency as the following relationship[Engle, C. H.(1984), 309-324]

$$e_{t-1} = [(f_t^J - S_{t-1}) - \pi^{m}{}_{t-1}] \tag{6.2.a}$$

Engle obtains an estimate of specification of the risk neutrality hypothesis, on the absence of the real profits. He proposes that

$$E_t (e_{t-1}) = 0 \tag{6.2.b}$$

and implies that e_{t+1} is uncorrelated with all information in time t information set. Engle specifies two sets of tests: One is a weak form test, in which e_{t-1} is regressed on four lagged values of itself and on the other set of tests. Engle regresses $e^J{}_{t-1}$ for a particular currency on $e^J{}_t$ for four other currencies as well as one own lag $e^J{}_t$.

In addition, he defines the crucial term u_{t+1} in the following relationship as

$$u_{t+1} = f_t^{t+1} - S_{t+1} \qquad (6.2.c)$$

and performs the same tests described above with the only difference that he replaces e^j_{t+1} with u_{t+1}. The results from Engle's[Engle, C. H., (1984), 309-324] study are seemingly overlay with Fama's analysis.

Fama utilizes a specification model that positions the forward premium as the only stochastic regressor, which has smaller variance than the lagged depended variable, u'_t. [Fama, E.F., (November 1984)., 319-338]. Hence, the a priori likelihood of being able to explain much of the volatility in u_{t-1} is limited in Fama's study [(1984)., 319-338], but if market efficiency in the forward exchange markets is characterized by a time varying risk premium, the part of u_{t-1} that can be accounted for, with time t information ought to be relatively small if movement in risk premiums are small. If there is serial correlation in the in u_t series, it is likely to be weak because of the large anticipated change in exchange rates.

Since the forward premium is categorically forward appearing, according to Fama's decomposition argument in (6.2.d) expressed bellow, its variance is not hidden with irrelevant noise, and the true signal is more likely to appear. This is important in environment with constant serial correlation coefficients. According to Fama, the percentage difference between the forward contracted at time t for delivery at time k and the spot rate is expressed to be equal to the expected percentage difference of the spot between two time periods t and $t+k$ plus a ratio of the risk premium to the spot.

$$[(f_{t,1} - S_t)/S_t)] = E_t[(S_{t+1} - S_t)/S_t] + \rho_{t,k}/S_t \qquad (6.2.d)$$

Hodrick believes that the difference in the two studies, Fama and Engle, arise from the use of different regressors than from the alternative statistical techniques employed by them. (1984).

Bilson's investigation goes a step further than has typically begin the case in studies of unbiasedness. He questions whether the trade-off between risk and return on a trading strategy implied by the parameter estimates and the rejection of unbiasedness is consistent with the types of trade-off found in other asset markets. After investigating the relationship between the expected return of a portfolio of positions in the forward market and the variability of the payoffs of these positions, Bilson [(1981), 449] concludes that, "the profit risk ratio appears to be too large to be accounted for in terms of risk aversion." Bilson used the following specification test of unbiasedness;

$$s_{t+1}^i - f\frac{i}{t} = \delta_1\left(s_{t+1}^i - s_t^i\right)^S + \delta_2\left(s_{t-1}^i - s_t^i\right)^L + \varepsilon_{t+1}^i \qquad (6.2.e)$$

where the subscripts (S and L) indicate values of the forward premium expressed at the annual rate are smaller or larger than 10% in absolute value respectively. Bilson's estimates of δ_1, δ_2 are constrained to be the same across currencies and reveal that their values show that in Fama's analysis of the depreciation of the forward premium in testing the unbiased hypothesis, the data he used were associated with large values of the forward premium in absolute value. Bilson ascribe this difference due to small sample problems that may bring trouble in these studies. Considering Bilson's argument we realize that the speculator cares only about the first two moments of the profit on his forward market portfolio and not about the covariation of the profit with the returns on other assets or with his consumption stream. Hence, it is necessary to find a trade-off

between risk and return that is too good to be consistent with risk aversion in order to conclude that the forward market is inefficient. This is in contrast to the rational investigator assumptions of the theoretical asset-pricing relationship between forward and expected future spot rates. Bilson mentions, that the 'efficient frontier' of a portfolio composed of dollar value positions in the forward market, is defined as the focus of points of maximum expected profit for a give standard deviation of profit, and is linear in this case. The weights of forward contracts on different currencies is determined by:

$$\min q'_t \Omega_t q_t \quad \text{subject to the desired target profit } \pi^* = q'_t r_t \quad (6.2.f)$$

then the optimum weights on this efficient portfolio are given by

$$q^*_t = \Omega_t^{-1} r_t (r_t' \Omega_t^{-1} r_t)^{-1} \pi^* \qquad (6.2.g)$$

where the maximum expected profit for a given risk is determined as

$$\pi^* = k_t \sigma(\pi^*), \qquad (6.2.h)$$

where the factor of ratio is $k_t = (r_t' \Omega_t r_t)$, and Ω_t denotes the estimated covariance of the concurrent errors in (6.2.d). Ω_t is dependent on the sample data at time t. Ω_t is then used in combination with a vector of expected profits, r_t, to form a portfolio with dollar value positions in the forward market with different currencies. The efficient frontier is a linear ray through the origin because the speculator can avoid both profit and risk by taking zero investment in the currency foreign exchange.

Bilson's argument of market inefficiency relies on the comparison of standardized expected profits (SRE) and standardized actual profits (SRP). SRE is defined to be expected profits divided by the standard deviation of the portfolio and SRA

is the analogously defined using actual profits[2]. Bilson, notes that an average SRE of

0.929 implies that if expected profits are one, this becomes a favorable trade-off and

prima facie evidence against market efficiency. To test whether trade-off is stable

overtime Bilson investigates the error structure between the difference of SRA-SRE and

he regresses this error term on a constant and a time trend. His results indicate some

relatively strong evidence against the hypothesis that SRE is an unbiased predictor of

SRA.

Bilson concludes from the signs of the coefficients that significant predictable

speculative profits had been available but they may have been arbitraged away by the end

of the time period. Nonetheless, he concludes that the average SRE indicated that the

market is inefficient.

6.3 Deriving the Regression Model of Unbiasedness

This section examines whether regression tests confirm evidence of predictable changes

in exchange rates. Frenkel [(1977), 653-70] was the first to introduce a regression model

investigating of the unbiasedness hypothesis. His empirical research relies on a

specification of the model in natural logarithms [Frenkel (1977), 653-70]

$$ln\, f_{t,k} = E_t(ln\, S_{t+k}) \qquad\qquad (6.3a)$$

Hodrick and Hansen (1983) introduced an alternative interpretation of Frenkel's model.

Equating the market's subjective expectation in (6.3a), based on a common information

set alongside to the hypothesis of rational expectations they obtained the following:

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[2] Geweke and Feige(1979) take risk to be measured by the unconditional standard deviation of the error
term in a specification like (5.2.2c). Return is assumed to be measured by the unconditional standard

$$S_{t+k} = f_{t,k} + \varepsilon_{t+k,k} \tag{6.3.b}$$

The hypothesis of rational expectations implies that any variable such spot rates $S_{t,k}$ may be written as

$$S_{t+k} = E_t(S_{t+k}) + \varepsilon^s_{t,k} \tag{6.3.c}$$

where $\varepsilon_s{}^s_{t+k,k}$ is the innovation or unanticipated part of S_{t-k} that could not be predicted with time t information and has a mean of zero. Substituting from (6.3c) into (6.3a) and letting lower case letters represent the natural logarithms of their -upper case counterparts Hodrick and Hansen derived the following:

$$S_{t+k} = f_{t-1}{}^t + \varepsilon_{t+k,k} \tag{6.3.d}.$$

Frenkel (1977) as well as other researchers performed ordinary least squares regression such as:

$$lnS_{t+k} = a + ln\, f_{t-1}{}^t + \varepsilon_{t+k,k} \tag{6.3.e}$$

to test $\alpha = 0$ and $\beta = 1$ as the null hypothesis.[3]

The following assumptions were considered. First, since $\varepsilon_{t+i,i}$ is caused by new information that arrives between time t and time $t+i$, the residuals of (6.3.d) will be serially correlated even under the null hypothesis, unless $k = 1$. Second, consistency of the parameter estimates is assured if $\varepsilon_{t+i,i}$ has a finite variance and $\sum_{t=1}^{T} f_{t,k}^2 \to \infty$ as $T \to \infty$, since $\varepsilon_{t+i,i}$ is orthogonal to all time t information. This condition is satisfied, almost definitely, when f,k has a finite autoregressive representation with roots inside, on, or outside the unit circle. Testing the null

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deviation of the explained part of the regression . However, the variance of returns may be an inappropriate measure of the riskiness of an asset and may not be related to the expected returns.

hypothesis, though, requires that the asymptotic distribution theory for the estimators is followed. Since f_ik is not an exogenous variable, in the sense that knowledge of f_{t+h}, for $1 \leq h < k$ would provide useful information about $\varepsilon_{t+i,i}$ it must be considered as stochastic regressor that is a predetermined variable at time t.

Since the mid-1980s several researchers took the first differences of their data before concluding unbiasedness hypothesis testing.

$$LnS_t - LnS_{t-1} = -E\left(LnD_{t|t-1}\right) + E\left(LnD_{t-1|t-2}\right) +$$
$$+ Lnf_{t|t-1} - Lnf_{t-1|t-2} + \left(n_{t|t-1} + \gamma[W_t - W_t]\right) - \quad (6.3.f)$$
$$- \left(n_{t-1|t-2} + \gamma[W_{t-1} - W_{t-2}]\right)$$

The term $Lnf_{t|t-1} - Lnf_{t-1|t-2}$ is called the "error correction term". Equation (6.3.f). reveals that an appropriate test for unbiasedness can be obtained from the regression,

$$\Delta LnS_t = \alpha + \beta \Delta Lnf_{t-1|t-1} + \delta\left(Lnf_{t-1|t-2} - LnS_{t-1}\right) + \varepsilon_t \quad (6.3.g).$$

In this regression, the unbiasedness hypothesis is satisfied if $(\alpha, \beta, \delta) = (0,1,1)$ and the residuals are serially uncorrelated. Equation (6.3.f) does not expect $\alpha=0$ or ε_t, to be serially uncorrelated. Perhaps the only application of (6.3.g) in the literature is, Hakkio and Rush (1989), who add terms to (6.3.g) to capture the serial correlation in the residuals, and reject the unbiasedness, in part because these extra terms belong. There results show that this is to be expected unless the differential is white noise [Hakkio, C.

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[3] "Using a specification like (8.1.1), Longworth (1981) fails to reject the null hypothesis a = 0 and b = 1 while Franker (1980) finds statistically significant $a = 0$ and b significantly less than one. Edwards (1982),

S., (1981), 663-678]. Both equations (6.3.f) and (6.3.g) were developed assuming that differential is stationary.

If the differential has a stochastic trend, then the undiasedness hypothesis is failed not to be rejected. However, this has not been scientifically proven in the literature. The intuition is that the difference between the realized spot and forward rate includes an error term which follows a stochastic trend. Hence, it means that it must be serial correlation in the forecaster error which violates the unbiasedness hypothesis.

Concluding this part we recognize that efficiency tests are based on comparison of forecast errors. All that is required is that liquidity premium does not vary overtime. A more direct way to test that the forward incorporates the information contained in the history of spot rates has been proposed by Fama(1976b). The new test requires the assumption that the liquidity premium is uncorrelated with the past spot rates.

6.4 Possible Reasons for Rejecting Unbiased Hypothesis

It is apprehensible that rational expectations on its own is not be sufficient for someone to test efficient market hypothesis. Even if we had data on subjective expectations, we would still need to specify a model determining exchange rates. The problem then would be to explain the difference between the market expectations and the predictions of the model. This difference can be attributable either to irrationality or to a misspecified model. In order to test efficiency one must make additional assumptions about the behavior of he risk premium to be consistent with the random error term.

Following Hodrick,(1991), Fama specifies two alternative reasons sufficient to

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Frenkel (1981) also report results with specificantions like (8.1.1).

justify a strong rejection of the proposition that the forward exchange rate is an unbiased predictor of the future spot rate. First, is the variance decomposition statement. Second, is the profitability of various trading strategies. We should note that these interpretations are not mutually exclusive because some combination of both could also be an explanation.

6. 5 Fama's Decomposition Argument

The first position is consistent with the unbiasedness hypothesis by arguing that either there is a statistical problem with the data that makes the application of asymptotic distribution theory inappropriate and the analysis to subject to severe small sample bias or it is argued that the unbiasedness hypothesis cannot be rejected until we have an alternative model of a time varying risk premium that is not rejected by the data.

Conditional to market efficiency and rational expectations, Fama argues that the forward exchange rate-as mentioned above- is equal to the expected future spot rate plus a risk premium, as demonstrated in derivation of

$$f_t^{t+1} = E_t(S_{t+1}) + p_t \qquad (6.5.a)$$

where p_t is a logarithmic risk premium. Subtracting S_t from both sides we derive

$$f_t^{t+1} - S_t = E_t(S_{t+1} - S_t) + p_t \qquad (6.5.b)$$

The left-hand side denotes the forward premium and the right-hand side indicates the expected rate of depreciation of the home country relative to the foreign plus a risk premium. For example, considering the exchange rate between the US dollar and the British Pound, the forward premium on the British Pound (assuming shorting the British Pound) will be: $155^{\$/£} - 145^{\$/£} = (150^{\$/£} - 145^{\$/£}) + 5^{\$/£}$. By regressing the actual rate

of depreciation on the forward premium $f_t^{t+1} - S_t$, Fama conceived two complimentary regressions of the forward premium. He used two complimentary regressions with non-overlapping data to determine the degree of variability of the components of the forward premium.

$$f_t^{t+1} - S_{t-1} = \alpha_1 + \beta_1(f_t^{t+1} - S_t) + \varepsilon_{t+1}^1 \tag{6.5.c}$$

$$S_{t+1} - S_t = a_2 + \beta_2 \cdot (f_t^{t+1} - S_t) + \varepsilon_{t+1}^2 \tag{6.5.d}$$

The stochastic regressor is the same in both equations and the sum of the depended variables is the stochastic regressor. The complimentarity of the regressions implies that $\hat{a}_1 = -\hat{a}_2$, that $\beta_1^` = 1 - \beta_2^`$, and that $\hat{e}_{t+1}^1 = -\hat{e}_{t+1}^2$. The equations (6.5.c) and (6.5.d) are viewed as linear predictors of the risk premium and the expected rate of depreciation of the currency. The OLS can isolate ε_{t+1}^1 & ε_{t+1}^2 as the components of $f_t^{t+1} - S_{t+1}$ and $S_{t+1} - S_t$ that are related to the forward premium. The probability limits of $\beta_1^`$ and $\beta_2^`$ are given by

$$\beta_1 = Cov(f_t^{t+1} - S_{t+1} ; f_t^{t+1} - S_t) / Var(f_t^{t+1} - S_t) \tag{6.5.e}$$

$$\beta_2 = Cov(S_{t+1} - S_t ; f_t^{t+1} - S_t) / Var(f_t^{t+1} - S_t) \tag{6.5.f}$$

where Cov and Var denote unconditional covariance and variance respectively. Referring to the assumption of rational expectations $S_{t+1} = E_t(S_{t+1}) + v_{t+1}^1$, and subtracting S_t form both sides we derive the following:

$$S_{t+1} - S_t = E_t (S_{t+1} - S_t) + \varepsilon_{t+1}^1 \tag{6.5.g}$$

where ε_{t+1}^1 is serially uncorrelated white noise to all time t information. Combining the rational expectations assumption, (6.5.g), with the decomposition of the forward premium (6.5.b) we get [Robert Hodrick (1991) p.58]:

$$Cov(f_t^{t+1} - S_{t+1} ; f_t^{t+1} - S_t) = Cov [p_t ; E(S_{t+1} - S_t) + p_t]$$

$$= Cov [p_t ; E(S_{t+1} - S_t)] + Cov(p_t) \qquad (6.5h)$$

$$Cov(S_{t+1} - S_t ; f_t^{t+1} - S_t) = Cov [E_t (S_{t+1} - S_t) ; E(S_{t+1} - S_t) + p_t]$$

$$= Cov [p_t ; E(S_{t+1} - S_t)] + Var [E(S_{t+1} - S_t)] \qquad (6.5.i)$$

and

$$Var (f_t^{t+1} - S_t) = Var [E_t (S_{t+1} - S_t)] + Var (p_t)$$

$$+ 2 Cov [E(S_{t+1} - S_t) ; p_t] \qquad (6.5.j)$$

Substituting (5.25.d), (5.25.e), (5.25fc) into (5.25c) and solve for β_1 and β_2 we get:

$$\beta_1 = \frac{Cov\left[p_t ; E_t\left(s_{t+1} - s_t\right)\right] + Var\left(p_t\right)}{Var\left[E_t\left(s_{t+1} - s_t\right)\right] + Var\left(p_t\right) + 2Cov\left[p_t ; E_t\left(s_{t+1} - s_t\right)\right]} \qquad (6.5.k)$$

$$\beta_2 = \frac{Cov\left[p_t ; E_t\left(s_{t+1} - s_t\right)\right] + Var\left[E_t\left(s_{t+1} - s_t\right)\right]}{Var\left[E_t\left(s_{t+1} - s_t\right)\right] + Var\left(p_t\right) + 2Cov\left[p_t ; E_t\left(s_{t+1} - s\right)\right]} \qquad (6.5.l)$$

The coefficients β_1 and β_2 can only give an approximate estimate of the volatility of the components of the forward premium. Fama states that β_1 would be equal to the proportion of the variance of the forward premium due to the variance of the risk premium only and only if the risk premium and the expected rate of depreciation are uncorrelated. Likewise, β_2, would be equal to the proportion of the variance of the forward premium due to the expected rate of depreciation. However, it is unlikely that the two components of the forward premium to be uncorrelated, therefore the covariance terms in (6.5.k) (6.5.l) must be examined. Since the denominator, should be always

positive in order the fraction to have meaning, a finding of negative coefficient ($b_2 < 0$)

suggests that the covariance between the expected rate of depreciation and the risk

premium must be negative and greater in absolute value than the variance of the expected

rate of depreciation. Since the variance of the forward premium must be positive, *Var*

$[E(S_{t+1} - S_t) + p_t] > 0$, then the following is true

$$V(p_t) > /Cov [E(S_{t+1} - S_t) ; p_t]) > Var [E_t (S_{t+1} - S_t)] \qquad (6.5.m)$$

Therefore we can presume that in that case the variance of the risk premium is greater

than the variance of the expected rate of depreciation.

6.6 The Consistency of Negative Covariation Theory.

Hodrick and Srivastava [(1986), S5-S22] suggest that a negative covariation between

$E_t(S_{t+1} - S_t)$ and p_t might be expected. Their intuitive explanation as it is explained by

Hodrick, why this might occur is that p_t is observed being the expected return dollar

denominated return from buying foreign currency forward while ($-p_t$) is regard being the

expected return to selling foreign forward currency in the spot market. Hence, ($-p_t$) is a

dollar denominated return subjected to macro-economic expectations. For example an

expected inflation in the U.S., will depreciate the dollar relative to foreign currencies.

Thus, this creates negative covariation between p_t and $E(S_{t+1} - S_t) + p_t$. This rationale

has also being supported by Lucas model [(1982), 335-360].

The derivation of the expected rate of depreciation in the Lucas Model is based

on the inter-temporal marginal rates of substitution

$$E_t[(S_{t+1} - S_t)/S_t] = E_t(Q''_{t+1,1} - S_t)/Q'''_{t+1,1}) - 1 \qquad (6.6.a)$$

where $Q''_{t+1,t}$ is the inter-temporal marginal rate of substitution of currency n, which is an index that weights the change in the purchasing power of a money between two time periods by the inter-temporal marginal rate of substitution of goods between two time periods t and t+1. Similarly, $Q'''_{t+1,t}$ denotes that the inter-temporal rate of substitution of currency m between time t and $t+1$.

$$Q''_{t+1,t} \equiv \beta^l \, U^y_{t+1,t} \pi^n_{t+1} / U^y_t \, \pi^n_t$$

$$Q'''_{t+1,t} \equiv \beta^l \, U^x_{t+1,t} \pi^m_{t+1} / U^x_t \, \pi^m_t \qquad (6.6.b)$$

where π^n_{t+1}, $\pi^m_{t+1}=$ are the purchasing power of currencies n and m that depend on the ratio of X_t to N_t and X_t to M_t respectively where N_t and M_t are the per capita quantity of money of countries n and m at period t.

$\beta^l =$ is the common discount factor, $0<\beta<1$

$$U^y_t \equiv \partial U \, (X_{it}/Y_{it})/\partial Y_{it}$$

$$U^x_t \equiv \partial U \, (X_{it}/Y_{it})/\partial X_{it} \qquad (6.6.c)$$

where X_{it}, Y_{it} are representative agent's consumption of two commodities endowment in country at time t. A similar derivation of the risk premium gives us

$$E_t[(f_{t-1} - S_{t+1})/S_t] = E_t (Q''_{t+1,t})/ E_t (Q'''_{t+1,t}) - E_t (Q''_{t-1,t}/Q'''_{t+1,t}) \qquad (6.6.d)$$

Using both equations (6.6.a) and (6.6.b) the covariance between the risk premium and the expected rate of depreciation is:

$$Cov\left[\frac{f^t_{t-1} - E(S_{t+1})}{S_t}; \frac{E(S_{t+1}) - S_t}{S_t}\right] =$$

$$= Cov\left[\frac{E(Q''_{t+1,t})}{E(Q'''_{t+1,t})}; E_t\left(\frac{Q''_{t+1,t}}{Q'''_{t+1,t}}\right)\right] - Var\left[E_t\left(\frac{Q''_{t-1,t}}{Q'''_{t-1,t}}\right)\right] \qquad (6.6.e)$$

Following Domowiz and Hakkio [(1985), 47-66] in assuming that X_{t+1}, Y_{t+1} M_{t+1}, and N_{t+1} are conditionally log normally distributed an their variables are not correlated contemporaneously . Using the lower case to denote logarithms the following distributions are assumed.

$$x_t \sim N(E_{t-1}(x_t), \sigma^2_{xt}), \qquad\qquad (6.6.\text{f}),$$

$$y_t \sim N(E_{t-1}(x_t), \sigma^2_{xt}), \qquad\qquad (6.6.\text{g}),$$

$$m_t \sim N(E_{t-1}(x_t), \sigma^2_{xt}), \qquad\qquad (6.6.\text{h}),$$

$$n_t \sim N(E_{t-1}(x_t), \sigma^2_{xt}) \qquad\qquad (6.6.\text{j}),$$

Based on these assumptions and the assumed utility function, the expected related rate of depreciation in (6.6.a)is:

$$E_t(Q^n_{t+1,1} / Q^m_{t+1,1})-1 = exp\ \{E_t(m_{t-1,1} - E_t\ n_{t-1} + (n_t - m_t)$$

$$+ (1/2)(\sigma^2_{mt-1} + \sigma^2_{nt-1})\}-1 \qquad (6.6.\text{k})$$

and the risk premium from (6.6.d) gives

$$-exp\ \{E_t m_{t-1,1} - E_t\ n_{t-1} + n_t - m_t + (1/2)(\sigma^2_{mt-1} + \sigma^2_{nt-1})\} \bullet$$

$$[1 - exp\ (-\sigma^2_{mt-1})] \qquad\qquad (6.6.\text{l})$$

Both (6.6.k), (6.6.l) are determined by the same variables. The partial effect of any of these variables is opposite in sign. If we compare the two expressions, it is obvious that the partial effect of any of these variables is opposite in sign. Hence, the covariance between the risk premium and the expected relative rate of depreciation must be negative. The intricacy is why the negative covariation is so large. Assuming that the statistical

time series properties of the data satisfy the assumptions of stationarity and ergoticity and that a sample of twenty years of monthly data is large, the statistical analysis can reveal that the variability of the risk premium is sufficient to make the forward premium predict the wrong direction for the expected rate of change of the exchange rate.

Hodrick and Srivastava [(1986), S5-S22] advocate that there is a potential bias in Fama's analysis due to the nature of the error term in (6.6.a), $\varepsilon_{t+1}^2 = v_{t+1} + \mu_t$ where v_{t+1} is the rational expectations error, not autocorrelated in a nonoverlaping sample, and μ_t is the error affected by the fact that the forward premium in the presence of the risk premium is not the conditional expectation of the rate of change of currency exchange rate of time t.

Hodrick and Srivastava contend that μ_t is probably serially correlated, which is supported by their analysis of unbiasedness set of forward premiums for other currencies.

Fama performed seemingly unrelated regression(SUR) of the system of nine equations given by (6.5.c) for nine countries in his study. He checked the residuals with standard time series tests for autocorrelation and failed to detect evidence against the hypothesis of no serial correlation. He assumed that conditional homoscedasticity is much less tenable. The standard test performed on the first equation (6.6.a) for serial correlation on the series $S_{t+1} - S_t$ revealed that these variables S_{t+1}, S_t are serially uncorrelated. However, testing the second equation of (6.6.b) the series $f_{t+1} - S_t$ showed serial correlation. In all likelihood the variance of the forecast error v_{t+1} is much larger than μ_t.

In each case study, the estimated b_2 was statistically significant negative, at the one percent marginal level of significance, except for the cases of Italy, Japan, and

France. It seems surprising though that in sub-period analysis there is evidence against the hypothesis that all slope coefficients are equal among each sub-period, yet there is little evidence against this hypothesis when parameters are estimated from the full sample.

It should be noted, that statistically speaking standard errors will be larger in shorter samples, thus it is more difficult to reject hypotheses in shorter data sets and that contradicts with the findings of Famas' study. This indicates that extreme points in the data are exerting more influence in the sorter samples than in longer ones. Conceivably, each sample has an extreme observation, but they are opposite in sign, as suggested by the negative coefficients. His observation is interpreted as the a negative variation between the risk premium and the expected relative rate of depreciation which is preserved in the sub-samples. However, a good explanation for negative covariation between p_t and $E(S_{t+1} - S_t)$ is difficult to tell.

CHAPTER 7

THE RANDOM WALK MODEL

7.1 Using the Random Walk as a Benchmark to Test Efficiency

Exchange rates appear to be highly unpredictable. If they were actually random walks, their changes would be completely unpredictable. The random walk concept is based on the stock market literature and explains an apparent regularity in time series patterns of stock prices where changes of prices of stocks from one period to the next are purely random.

$$S_t = S^{t-1} + u_t \ \ or \ \ S_t - S^{t-1} = \Delta S_t = u_t \qquad (7.1.a)$$

The time series is said to follow a trend if the change in the spot rate, S_t from one period to the next is said to be equal to a drift factor, d, plus a purely random component u_t

$$S_t = S^{t-1} + u_t + d \qquad (7.1.b)$$

The random walk model is perfectly harmonious with the rational expectations, market efficiency and unbiasedness but it is neither a necessary nor a sufficient condition for market efficiency. If the expected equilibrium return varies considerably, market efficiency requires non-random walk price movements. If the spot follows a random walk drift then the expectation of the spot rate conditional to the information at time t-1 is;

$$E_{t-1} S_t = E_{t-1}S_{t-1} + E_{t-1}d + E_{t-1}u_t \qquad (7.1.c)$$

Since the expected $E_{t-1}S_{t-1}$ is known at time t-1 and the constant drift factor d and because the expected value of the next period's random wall error, u_t is always zero, we conclude that the rational expectations forecast of the next period's spot rate is simply

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the currently observed rate plus or minus the drift . The pure random walk model implies

that agents with rational expectations forecast neither appreciation or depreciation over

the next period.

Suppose the spot does not follow a random walk but a multiple linear function

such as:

$$S_t = \alpha S^{t-1} + \beta S_{t-2} + \gamma Z_t + \delta Z_{t-1} + u_t \tag{7.1.d}$$

Where Z is another variable such relative money stock. Since past values of both s and Z

are assumed known at t-1 the RE forecast of the next period's spot rate is:

$$E_{t-1} S_t = \alpha S^{t-1} + \beta S_{t-2} + \gamma E_{t-1} Z_t + \delta Z_{t-1} \tag{7.1.e}$$

Both efficiency and unbiasedness are potentially consistent with the random walk

process. On the other hand, random walk is not required by either Rational Expectations

or efficiency [Hansen, L.P. and R.J. Hodrick, (1980), (October), 829-853.]. Considering

the formal definition of forward market efficiency for a random walk we will have the

forward rate ruling at t for delivery at t+1 to be equal to the spot rate in the market at t

plus the risk premium. Under unbiasedness (with risk neutrality) the forward rate at any

period would be simply that period's spot rate, so that the forward premium would be

always zero.

An intuitive explanation why the random walk model is not a necessary

implication of efficient market is a follows; it might seem reasonable that any other

process than a random walk leaves open the opportunity for profit. It is true that the

expected return from holding the currency over a single period will only be zero if the

spot rate follows a random walk. Essentially in all other cases the return will be

predictably non-zero. In order to harmonize this with efficiency we go back to Fama's

equation, $f^{t+1}{}_t = ES_{t+1} + p_t$, but this time we represent an efficient market equilibrium using the forward rate because it is assumed that the forward rate reflects both the publicly available information summarized in the rational expectation where

$$f^{t+1}{}_t = S_t + p_t \qquad (7.1.f)$$

the forward rate ruling at t for delivery at $t+1$ will be equal to the spot rate in the market at t plus the risk premium [Fama, E.F. (May 1970), 383-417].

$$E[f^{t+1}{}_t \cdot S_{t+1} | I] = p_{t+1} \qquad (7.1.g)$$

Assuming risk neutrality, the risk premium, p_t, in the above equation can be reduced to zero, giving [Fama, E.F. (May 1984), 319-338]:

$$E[f^{t+1}{}_t - S_{t+1} | I] = 0 \qquad (7.1.h)$$

As long as any predictable component in the spot rate depreciation is fully embodied in the forward rate, as it will be in an efficient market, the opportunity for profit is an illusion. Assuming that both spot and expected spot rate is generate from (7.1.d) and (7.1.e) respectively. The profit made by a speculator paying the rationally expected spot rate at t-1 and selling on the spot in the next period can be found if we subtract (7.1.e) from(7.1.d):

$$S_t - E_{t-1} S_t = \gamma(Z_t - E_{t-1} Z_t) + e_t \qquad (7.1.i)$$

This Profit, $\gamma(Z_t - E_{t-1} Z_t)$, is generated by a speculator paying the rationally expected spot rate at t-1 and selling on the spot in the next period. Although in any particular instance this profit is expected to be non-zero on the average. It would be zero, if we take expectations conditional on t-1 in eq. (7.1.i) and remembering also that under rational expectations the error made in forecasting Z_t, will be random. Note that according to

efficiency theory as long as any predictive component that determines the spot rate is fully embodied in the forward rate the opportunity for profit would be unreal.

We have seen that the variance in a random walk process and the correlation between the adjacent values increases over time revealing a trend. Results from the tests confirm the idea that, in order to outperform the random-walk model in exchange rate forecasting, it is necessary to move away from simple single equation, semi-reduce form models towards suitable economy-wide macro-econometric models.

7.2 Unbiasedness and the Random Walk Model.

Some of the earliest empirical work on forward exchange rates as predictors of future spot rates examined the proposition that the mean forecast error is zero. Aliber, (1974), Cornell (1980), Levich, (1978), Kohlhagen, (1978)Frankel, (1980), Thomas C. Chiang, Agmon (1986) and Amihud (1979), examined the mean error or mean-squared error, and concluded that while forward rate forecast errors are large, they are not unconditionally biased. More recent evidence by Korajczyk, (1985), suggests that forward rates may have unconditional bias during his sample.

The next section begins the exploration of the more interesting question of conditional bias. If the asset pricing theory is correct, the risk premium separating forward rates from expected future spot rates can vary through time and no unconditional bias need to be found, yet at each point in time the forward rate can differ from the expected future spot rate. Hansen , Hodrick [(October 1980), 829-853] and Farma [.(1984), 319-338] show that a non-constant risk premium is very important in the forward foreign exchange markets.

7.2.1 Some Empirical Tests

Thomas C. Chiang and Mrilyng Chiang used in their empirical work the regression estimation by Cornell and Edward to test whether he forward exchange rate is an unbiased predictor of the future spot rate. Cornell and Edward findings show that the coefficient of the forward rate for predicting the actual future spot rate does not differ significantly from one. In addition the error term does not display serial correlation. Their evidence support the unbiasedness hypothesis.

Two extensions have been made in the empirical analysis around the unbiasedness. The first is the alternative for predicting the forward exchange rate using the random walk hypothesis. The second development of the recent work focuses on the role of the risk premium, where the forward rate contains the components of expectations and the risk premium (general efficiency hypothesis).

Hansen & Hodrick [(October 1980), 829-853] and Farma [(1984), 319-338] show that a non-constant risk premium is very important in the forward foreign exchange markets. Their paper uses yen/dollar exchange rates to test for efficiency.

The empirical models pertinent to testing the efficient market hypothesis are based on the efficient foreign exchange market hypothesis implying that the information predicting the future spot rate is fully summarized in the forward rate. The random walk model states that the historical exchange rates can be used to determine the actual future spot rates.

$$E_{t+1} = a_1 + b_1 S_t + e_{1,t+1} \qquad (7.2.1.a)$$

Since the weak form of market efficiency supports that the current asset price summarizes all historical information, C. Chiang and Mrilyng Chiang tested the

significance of b_1 coefficient and a_1 constant as well as whether $e_{1,t+1}$ follow a patent or not. They failed to reject the null hypothesis which means that is valid and we accept a week form of efficient markets.

In another model they incorporated the information reflected in both the forward and the current spot rate.

$$E_{t+1} = a_1 + b_1 f_t b_2 S_t + e_{t+1} \qquad\qquad (7.2.1.b)$$

the above equation states that the one period-ahead prediction of the spot rate is a weighted average of the current forward and spot rates ($b_1 + b_2 = 1$). Note that both $F_t S_t$ are highly correlated which may cause a multicollinearity problem. One way to treat this problem is to express the relationship as follows. This expression is derived if we subtract S_t on both sides from equation (7.1.b) is

$$S_{t+1} - S_t = a_1 + b_1 (F_t - S_t) + e_{t+1} \qquad\qquad (7.2.1.c)$$

which states that the change in the forward rate can be predicted by the forward premium if the unbiasedness hypothesis holds true. The hypothesis to be tested is whether $H_o: = 0$ and $b_1 = 1$. Failure to reject the null hypothesis implies that the forward rate is an unbiased predictor of the future spot rate.

Empirical evidence indicates that the unbiasedness hypothesis of forward exchange rate cannot be rejected for the prior to October 1979. However, the null hypothesis that $a_1 = 0$ and $b_1 = 0$ is rejected for the full-sample and post-October sample periods. Evidence does not uniformly support the sample efficiency hypothesis. Among the alternative reasons, government intervention and the risk premium are the most plausible explanations . This indicates that neither the forward rate of the current spot rate alone may be adequate to describe the exchange rate behavior for all the sample

periods. When both F_t and S_t were simultaneously included in the equation (7.2.1.c), the t-statistic shows that the forward rate and the spot rate are statistically significant but in different sample periods. The estimated coefficient differ significantly . The estimated coefficients of F_t and S_t differ significantly for those two sub-periods while the F-statistics for testing the stability of the parameters do not support the hypothesis that the exchange rate behavior involves no structural change. (so the exchange rate behavior changes in a structural manner).

Even though the results are consistent with the hypothesis that the sum of intercepts is zero and the sum of slops is 1 the explanatory power designated by the R-square values was extremely low indicating that the forward premium is a poor predictor for the change of exchange rate or for measuring the forecasting error .

In summary, the empirical results indicated that the data well fit the simple efficient market hypothesis for the early floating period. However, for the later sample period, the data were more consistent with the general efficiency hypothesis, which accounts for the existence of the risk premium. The standard errors of the estimated coefficients for SUR were consistently smaller that those of OLS. This indicates that the joint estimations across countries are capable of improving the efficiency of the estimated coefficients. In addition evidence show that that there was no serial correlation present in the markers. Recent studies by Chiang [(Spring 1987), 57-67], Gregory and McCurdy [(December 1984), 357-368] show that the market behavior reflected in the estimated coefficients respond sensitivity to ongoing changes, suggesting that the behavior changes is not necessarily with a big shock to the system.

CHAPTER 8

ECONOMETRIC MODELING & EMPIRICAL ANALYSIS

This section discusses basic empirical tests that are used to appraise efficiency of the forward exchange market. Testing market efficiency it is a joint test of several composite hypothesis. There is no one direct way for testing efficiency. Hence, I present various statistical hypotheses about how market efficiency is defined and test these specifications by setting certain assumptions about the data used in this study.

8.1 The Models

The empirical models appropriate to testing the efficient market hypothesis are based on the efficient foreign exchange market hypothesis implying that the information predicting the future spot rate is fully summarized in the forward rate. Algebraically, the notion of the simple efficiency hypothesis is given by E_t $(S_{t-1} | I_1) = F_t$, were S_{t-1} is the is the natural logarithm of the spot rate at time $t+1$ expected at time t and F_t is the logarithm of the spot rate at time t. A derivation of the general efficiency model is based on the following parities and assumptions.

Firstly, the interest rate differential between two countries is zero,(8.1.a). Second, that purchase power parity holds true, (8.1.b), and third that fisher effect,(8.1.c), is convincing.

$$r_t = r_t^* \qquad\qquad (8.1.a)$$

$$r_t = rr_t + E(q_t) \qquad\qquad (8.1.b)$$

$$\Delta s_t = \Delta p_t - \Delta p_t^*$$
(8.1.c)

Following by forwarding eq. (8.1.a) for one period and taking the mathematical expectation, adding and subtracting r_t and substituting the relationship into eqs. (8.1.a), (8.1.b), and (8.1.c), we receive [Malindretos, John and John Kallianiotis, (March 1995), 6]:

$$s_{t-1}^e = E[s_{t-1}|\Pi_t] = p_t + \Delta p_t^e - (p_t^* + \Delta p_t^{*e})$$

$$= p_t + \Delta p_t^e - (p_t^* + \Delta p_t^{*e}) + r_t - r_t^*$$

$$= p_t - p_t^* + r_t + \Delta p_t^e - (r_t^* + \Delta p_t^{*e})$$
(8.1.d)

$$= s_t + i_t - i_t^*$$

$$= f_t$$

Substituting eq. (8.1.a), into (5.1.c), we derive:

$$E[s_{t-1} - f_t|\Pi_t] = 0$$
(8.1.e)

or

$$E[s_{t-1} - f_t|I_t] \cong 0$$
(8.1.f)

The development of recent work focuses on the role of the risk premium, where the forward rate contains the components of expectations and the risk premium (general efficiency hypothesis). In equation (8.1.e) the notion of rational expectations with no risk

premium is formally expressed and is usually called the "simple efficiency" hypothesis

(8.1.g). It has been argued that the forward rate may also contain a risk premium , RP_{t+1},

if the economic agents are assumed to be risk averse. This relationship can be specified

algebraically as [Malindretos, John and John Kallianiotis, (March 1995), 6]:

$$E[s_{t-1} - f_t | I_t] = - RP_{t-1} \qquad (8.1.g)$$

Following, we would like to test the unbiased hypothesis. Two extensions have been

made in the empirical analysis around unbiasedness. First, is the alternative for

predicting the future rate using the random walk hypothesis eq. (8.1.h). Secondly, is the

test for forward market efficiency eq. (8.1.i). and a composite of market efficiency using

the forward and the spot rate eq. (8.1.j). Lastly. we incorporate the information

component known as "news" expressed as a difference between expected and actual

differential interest rates between the home and the host countries eq. (8.1.k) [Wolff, C.

C. P., (1985)]. Exchange rates respond to surprises, news, and to human actions due to

ignorance of P_t, knowledge of I_t only.[2] However. these surprises are unpredictable.

Because exchange rates respond sensitively to the unexpected events that randomly hit

markets, exchange rates themselves also move randomly. Efficiency in this following

model assumes that this differential between expected and actual is zero [Malindretos,

John and John Kallianiotis, (March 1995), 6].

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[1] This risk premium exists due to the unexpected part of the exchange rate $U(s_{t-1})$. because $S_{t-1} = E(s_{t-1}) + U(s_{t-1})$ that we call innovations, surprises or "news", which is the difference between actual and expected values of some macro-variables, i.e., $RP_{t+1} = (i-i^*)_{t-1} - E(i-i^*)_{t-1}$. see Frenkel (1981).

[2] The term Π_t includes all public information whereas I_t is a subset of Π_t

The formulation of the model tested in this research encompasses the following equations:

$$S_t = a_0 + a_1 S_{t-1} + e_{1t} \qquad (8.1.h)$$

Firstly, a random walk process of spot exchange rate can be tested by examining the joint hypothesis that coefficients $\alpha_0 = 0$, and $\alpha_1 = 1$ also that the error term is serially uncorrelated. Secondly, we encompass the forward unbiased hypothesis is as follows

$$S_t = \beta_0 + \beta_1 f_{t-1} + e_{2t} \qquad (8.1.i)$$

The unbiased hypothesis involves the joint hypothesis testing that coefficients $b_0 = 0$, and $b_1 = 1$ and the error term displays no serial correlation. Failure to reject the null hypothesis implies that f_{t-1} reflects all the relevant information for predicting the one-period ahead future spot rate.

$$S_t = \gamma_0 + \gamma_1 S_{t-1} + \gamma_2 f_{t-1} + e_{2t} \qquad (8.1.j)$$

It is reasonable to model the exchange rate equation by using the information reflected in both the forward rate and the one period previous spot to determine the current spot rate. The actual spot rate can be seen as the weighted average of the one period previous spot and forward rates. The restriction $\gamma_1 + \gamma_2 = 1$. It has been argued that the forward rate may also contain a risk premium, RP_{t+1}, if the economic agents are assumed to be risk averse. This relationship can be specified algebraically and tested by the following expression.

$$S_t = \delta_0 + \delta_1 f_{t-1} + \delta_2 [(i-i^*)_t - E_{t-1} (i-i^*)_t] + e_{1t} \qquad (8.1.k)$$

The relationship between s_t and s_{t-1}, f_{t-1} and "Information" is linear; the s_t's, f_t's and "Information" are nonstochastic variables whose values are fixed, and $s^2_{st} ' 0$, $s^2_{ft} ' 0$.

$s^2_{"news"}$ ' 0 and finite; and $E(e_t) = 0$, $E(e_t^2) = s^2$, and $E(e_t, e_{t-1}) = 0$ meaning that e_{1t}, e_{2t}, e_{3t} and $e_{4t} \sim N(0, s^2)$.

Following we perform basic statistics and time series tests for all the variables that we include in our model (Equations. (8.1.g), (8.1.h), (8.1.i), (8.1.j), and(8.1.k). These four equations will be estimated by using OLS and Full Information Maximum Likelihood (FIML) estimation. Over and above the theoretical properties of ML, the principal of choosing parameter estimates to maximize the likelihood of the occurrence of the sample has greater attraction for many econometricians.

Following , we execute tests for coefficient restriction, residual tests and stability testing for the model. Unbiasedness is tested jointly with the hypothesis of risk neutrality and stationarity .

CHAPTER 9

EMPIRICAL INVESTIGATION

9.1 Specification and Diagnostic Test

The model is tested using monthly figures for the spot and forward rate of U.S. dollar ($) with respect to Canadian dollar (C$), British pound (£), and French franc (FF); also, Treasury bill rates (3-months) or other interest rates. All the data come from Main Economic Indicators, OECD and cover the period from March 1973 to June 1994.

First, we started testing the random walk hypothesis by calculating the mean value, the variance, and the coefficient of variation of the error term (ε_t). The results appear in Table 9.1.A Then, the general efficiency hypothesis was tested and in Table 9.1.B the results are presented. The results show that the random walk is not outperformed from the other foreign exchange equations. We use one step ahead spot to determine the magnitude of the variance and the error term.. In Table 9.1.A, some basic statistics are provided. [Theodossiou and Lee(1993), Koutmos, Negakis, and Theodossiou (1993), and Theodossiou (1994)]. These are: mean values, standard deviations, maximum, minimum, skewness, kurtosis, correlation, normality test statistics,. Table 9.1.B shows the correlation matrix for the exchange rates.

9.2 Testing the Random Walk Hypothesis

Statistical time series analysis indicates that exchange rates are so volatile that it is difficult to distinguish them from random walks. In addition Dooley and Shafer (1973-1975), present evidence against the hypothesis that daily exchange rates are normally

distributed . They conclude that different days are characterized by different stable distributions even though the estimates of the characteristic exponent appears to increase a the days are added together. They also report nonparametric run tests of the hypothesis that exchange rate changes in excess of interest differentials are random. Cornell and Dietrich[, (1978), 111-120] report that only the Canadian Dollar exhibits a significantly smaller number of runs than is expected. Such evidence suggests that new information is immediately incorporated into the level of exchange rates near random walks. As we see, the $E(\varepsilon_t)$ is small and the variance is small but it is not constant over time.

Table 9.2.A

Testing the Random Walk Hypothesis: s_t-s_{t-1} =e_t $\quad\quad$ $E(e^2_t)$= s^2 $S_t - S_{t-1} = \varepsilon_t$; $E(\varepsilon_t) = 0$, $E(\varepsilon_t^2) = \sigma^2$						
CCY	$E(e_t)$	$E(e_t^2)$	s^2	MAX	MIN	CV
C$	-0.0012	0.0356	0.00127	0.03058	-0.06258	-10.2249
FF	-0.0007	0.0367	0.00134	0.00112	0.09180	-50.2161
£	-0.0018	0.0337	0.00113	0.13133	-0.12769	-18.1045

Notes: C$=Canadian Dollar, FF=French Franc, £=British Pound

9.3 Testing the General Efficiency Hypothesis

To predict the actual future spot rate at time t S_t we use the forward rate contracted at time t-1 for delivery at t F'_{t-1}. The forward rate become best predictor if the risk premium σRP_t is small. If the forward rate cannot predict very well the future spot rate then the absolute value of risk premium is high and we fail to accept efficiency. U.K, and France display a negative risk premium (RP) denoting that the forward rate contains

a risk premium. On the other hand, Canada exhibit a positive RP which shows that the forward rate does not contain a risk premium and the investors are accepting a lower exchange rate for the safety of the forward market. The smallest risk premium in the forward market appears in France (RP_{t+1}=-0.00042) and the largest in UK (RP_t= -0.00098). The results from the general efficiency model reveals that the foreign exchange market is not very efficient. The most efficient (RP→0) is France (1-month forward) with σRP =2.9E-05 and least efficient (large RP) is UK (3-month forward). The most stable market (σRP→0) is Canada (current spot market, σRP_t) and least stable market (largest σRP_t) are the EC member countries (all the same σ) (σRP_{t+2}). After all, the risk premium is determined in the context of a set of highly specialized assumptions -the mean variance model which depends on the parameter of the probability distribution of the future exchange rate, the attitudes to risk and on the quality of assets in existence.

Hodrick as well as Hakkio[(1985), 47-66], imply that the risk premium depends only on the difference between conditional variances of the two money supplies.

$$E_t(S_{t+1}) - f_t^{t+1} = (1/2)(h_{3t+1} - h_{4t+1}) \qquad (9.3.a)$$

An increase in the conditional variance of the home money, h_{3t+1} increases the risk premium. The result occurs because there is no effect on the expected logarithm of the future spot rate, while the logarithm of the forward rate falls with the decrease in domestic interest rates. Domestic interest rates fall because an increase in the variance of the domestic money increase the variance of the purchasing power of the money. This

contributes positively to the return on nominal assets denominated in that currency.

Assuming that the rational expectations forecast error of the logarithm of the spot rate is

$$\varepsilon_t \equiv S_{t+1} - (S_{+11}) = (u_{3t+1} - u_{4t+1}) \qquad (9.3.b)$$

Table 9.3 Testing the "General Efficiency" Hypothesis
Equation $E[s_{t+1} - f_t | I_t] = -RP_{t+1}$

CCY	RP_t	σRP_t	RP_{t+1}	σRP_{t+1}	RP_{t+2}	σRP_{t+2}
C$	0.002984	2.18E-05	0.00178	0.000199	-0.00049	0.000474
FF	0.001897	2.9E-05	-0.00042	0.009784	0.001203	0.004001
£	-0.00098	0.000104	-0.0029	0.000986	-0.00069	0.004046

Following we can rewrite equation (9.3.a) as

$$S_{t+1} - S_t = p_t + \left(f_t^{t+1} - S_t \right) + \varepsilon_{t+1}, \qquad (9.3.c)$$

here the risk premium is $p_t = (1/2)(h_{3t+1} - h_{4t+1})$, whereas the conditional variance of

e_{t+1} is . if h_{3t+1} and h_{4t+1} , there would be a time varying risk premium and the error

term in (9.2.b)will exhibit conditional hererosckedasticity[1 Robert Hodrick (1991),].

9.4 Descriptive Statistics -Univariate and Means

Descriptive statistics reveal the formal characteristics of value distributions for the series

of spot, forward and there differences between their one lagged period.

Table 9.4.A Univariate Statistics for the Canadian Dollar

	Sc	Δ(sC)	fC	Δ(fC)
Mean	4.4388269	-0.001273	4.4354497	-0.0013168
St. Dev.	0.1032252	0.0130235	0.1037304	0.0134251
Maximum	4.645544	0.0305877	4.644775	0.0345235
Minimum	4.252345	-0.062583	4.243052	-0.0637665
Skewness	0.351968	-0.772486	0.355759	-0.87539
Kurtosis	2.296282	5.345055	2.314819	5.834757
J-B St.	10.56795	83.79111	10.40781	117.9489
B-P Q-St.	2443.32	19.82	2437.63	17.43
L-B Q-St.	2522.41	20.67	2516.57	18.17
D-F t-St.	2.141	3.461	1.606	3.841

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Table 9.4.B Univariate Statistics for the French Franc

	Sc	Δ(sC)	fC	Δ(fC)
Mean	2.8808927	-0.000731	2.8855155	-0.0016546
St. Dev.	0.2221545	0.0336708	0.2589258	0.0332543
Maximum	3.221991	0.0918059	3.230686	0.0943127
Minimum	2.284523	-0.1163733	2.281361	-0.149516
Skewness	-0.612705	-0.312937	-0.606831	-0.02332
Kurtosis	2.70849	3.848947	2.135949	3.822116
J-B St.	16.92379	11.81956	17.01662	517.170135
B-P Q-St.	2448.14	8.18	1823.1	14.95
L-B Q-St.	2527.05	8.45	1906.45	15.54
D-F t-St.	1.606	3.841	1.707	3.058

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Table 9.4.C Univariate Statistics for the British Pound

	Suk	D(Suk)	fuk	D(fuk)
Mean	5.1810762	-0.0018644	5.1824443	-0.0018264
St. Dev.	0.1817159	0.0337542	0.1776945	0.0338342
Maximum	5.553734	0.13135	5.548959	0.1277637
Minimum	4.691348	-0.1276903	4.594371	-0.1326284
Skewness	0.059755	-0.017984	0.012243	-0.159151
Kurtosis	2.468578	4.353324	2.486945	4239338
J-B St.	3.164711	19.4733	2.814129	17.39603
B-P Q-St.	2057.21	11.26	2013.61	11.22
L-B Q-St.	2120	11.65	2075.17	11.58
D-F t-St.	2.421	3.913	2.457	4.005

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Table 9.4.D   Correlation Matrix for Spot & Forward Exchange Rates

CURRENCIES	sC	fC	sUK	fUK	sF	fF[a]
sC	1.000					
fC	0.999	1.000				
sUK	0.717	0.729	1.000			
fUK	0.695	0.707	0.998	1.000		
sF	0.680	0.683	0.859	0.853	1.000	
fF[a]	0.717	0.721	0.896	0.889	0.999	1.000

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Note: a= France's sample range from 1973.01 to
S=spot exchange rate, f=forward exchange rate, C=Canada,
UK=United Kingdom. F=France.

9.5 The Empirical Time Series Regression Results-OLS

We computed the regression estimates and time series test for equations (8.1.g), (8.1.h), (8.1.i), (8.1.k), and (8.1.n), by employing Ordinary Least Squares (OLS). The output has been computed using TSP-Micro for Time Series Analysis and Forecasting version 7.0. The results of coefficient estimates as well as OLS are exhibited at tables 9.3A to 9.3.D, for the four equations respectively . The expected interest rate differential is computed from a regression of the interest differential on a constant, two lagged values of three lagged interest rate differential, two lagged spot exchange rates, two lagged forward rates and time.

$$E(i - i^*) = C_t + \alpha_1 (i - i^*)_{t-1} + \alpha_2 (i - i^*)_{t-1} + \alpha_3 (i - i^*)_{t-1} + \\ + \alpha_4 S_{t-1} + \alpha_5 S_{t-2} + \alpha_6 F_{t-2} + \alpha_7 F_{t-3} + \alpha_8 t \tag{9.5.a}$$

Econometricians have found that equations using raw data are appropriate to a world in which shifts come and last for just one period. Equations using first differences of economic data are appropriate to a world in which shifts come and last and last forever. Another reason is that the presence of lagged differences into a model provides a short of hook on which the serial correlation can he hung, instead of being pushed onto the disturbances. Furthermore, this device is illegitimate if we really know what the correct model for the problem. In addition this technique deals with unobservable expectations about the future on the part of economic decision-making units [Brown, T. M. (1952),.355-371].

Table 9.5.A Regression Estimates of Equation (8.1.h)

$$S_t = a_0 + a_1 S_{t-1} + e_{1t}$$

Coefficients Estimates		Canada	France	U.K.
a_0		0.0369058	0.0372823	0.1149928
	SD	0.0352343	0.0273739	0.060057
	T-stat	1.0474417	1.3619632	1.9147296
	2-tail stat	0.2959	0.1744	0.0567
a_1		0.9913999	0.9868046	0.9774478
	SD	0.0079345	0.0094741	0.0115832
	T-stat	124.94784	104.15835	84.38472
	2-tail stat	0	0	0
OLS				
R^2		0.984053	0.977211	0.965689
Adjusted R^2		0.98399	0.977121	0.965554
S.E. of Regression		0.013019	0.033609	0.03357
Log Likelihood		746.2175	504.3821	504.6735
Durbin-Watson Stat		2.091905	1.946372	1.771308
Sum of Square residua		0.042882	0.285775	0.285122
F-statistics		15611.96	10848.96	7120.781

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Table 9.5.B Regression Estimates of Equation (8.1.i)

$$S_t = \beta_0 + \beta_1 f_{t-1} + e_{2t}$$

Coefficient Estimates		Canada	France	U.K.
b_0		0.0683477	0.0454968	0.006517
	Std.E.	0.0382572	0.0284057	0.0639406
	T-stat	1.7865332	1.6016809	0.1019232
	2-tail stat	0.0752	0.111	0.9189
b_1(forward)		0.9850658	0.9843495	0.99812
	Std.E.	0.0086218	0.009805	0.0123294
	T-stat	114.25329	100.39221	80.954632
	2-tail stat	0	0	0
OLS				
R^2		0.980987	0.982262	0.96283
Adjusted R^2		0.980912	0.982165	0.962684
S.E. of Regression		0.014215	0.034344	0.034941
Log Likelihood		723.7983	360.2454	494.4697
Durbin-Watson Stat		1.834192	1.900755	1.65007
Sum of Square residuals		0.051126	0.21467	0.308879
F-statistics		13053.81	10078.6	6553.652

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Table 9.5.C Regression Estimates of equation (8.1.k)

$$S_t = \gamma_0 + \gamma_1 S_{t-1} + \gamma_2 f_{t-1} + e_{2t}$$

Coefficient Estimates		Canada	France	U.K.[*]
γ_0		0.0326902	0.0157481	0.1060223
	SD	0.0353586	0.028902	0.0652345
	T-stat	0.9245343	0.5448793	1.6252485
	2-tail stat	0.3561	0.5865	0.1054
γ_1		1.2021855	1.5359639	0.9073729
	SD	0.1695192	0.4446508	0.1973782
	T-stat	7.0917379	3.4543149	4.5971287
	2-tail stat	0	0.0007	0
γ_2		-0.2099955	-0.5424462	0.0717872
	SD	0.1686991	0.4420993	0.2018516
	T-stat	-1.2447935	-1.2269783	0.3556436
	2-tail stat	0.2144	0.2214	0.7224
OLS				
R^2		0.98415	0.983359	0.965706
Adjusted R^2		0.984025	0.983175	0.965434
S.E. of Regression		0.013005	0.033357	0.033628
Log Likelihood		746.9991	366.1189	504.7375
Durbin-Watson Stat		2.103625	2.043775	1.771489
Sum of Square resid		0.04262	0.201393	0.284979
F-statistics[1]		7823.711	5347.962	3548.161

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[1] When error distributions have flatter tails than if they are normally distributed. convergence to the asymptotic distribution may be slower than is implied by the theory. The asymptotic distribution theory is correct in large samples as one as the fat-tailed distribution has a finite variance (e.g.. student-t) distributions. The bootstrap (see Hodrick 1991. 114) is mentioned as a nonparametic procedure to produce test statistics for small samples. Specifically the errors from a vector of regression equation s are assumed to be drawn from some specified multivariate distribution function F. An estimate for this joint distribution is provided by the residuals from the original regressions, the empirical error distribution which is denoted as F_r. This distribution is designed by assigning probabilities for each error term $\varepsilon_1 \varepsilon_2, \ldots \varepsilon_n$ j. Following we construct a small sample distribution of the test statistics based on the null hypothesis by (1) sampling from empirical error term distribution, (2) constructing regression equations testing whether the null hypothesis is true, and (3) estimating again the regression and calculating the standard statistics. By following these steps we can derive a distribution for each statistic from which percentiles can be calculated. One thin that we have to consider is the quality of the bootstrap estimates are: meaning how well representative is our empirical error distribution. Does the F_r, approximates the true distribution. F? [Korajczyk (1985), 346-358]states that financial data tend to have fat tails thereby making F_r relatively far from F.

Table 9.5.D Regression Estimates of equation (8.1.n)

$$S_t = \delta_0 + \delta_1 f_{t-1} + \delta_2 [(i-I^*)_t - E_{t-1}(i-i^*)_t] + e_{t1}$$

Coefficients estimates		Regression Estimates of equation (8.1.n)		
		Canada	France	U.K.
δ_0		0.0667333	0.0464852	0.0185081
	SD	0.0387775	0.0272401	0.0649477
	T-stat	1.7209264	1.7065003	0.2849688
	2-tail stat	0.0865	0.0896	0.7759
δ_1		0.9854346	0.9839354	0.9957625
	SD	0.0087417	0.0094098	0.0125299
	T-stat	112.72705	104.56482	79.47087
	2-tail stat	0	0	0
δ_2		0.0017599	-0.0119629	-0.000661
	SD	0.0016695	0.0027732	0.0024559
	T-stat	1.0541278	-4.3136702	-0.269206
	2-tail stat	0.2928	0	0.788
OLS				
R^2		0.980708	0.983915	0.961923
Adjusted R^2		0.980553	0.983736	0.961618
S.E. of Regression		0.014252	0.032846	0.035034
Log Likelihood		717.9834	364.9657	490.4298
Durbin-Watson Stat		1.808972	1.920934	1.655919
Sum of Square resid		0.05078	0.193112	0.306848
F-statistics		6354.304	5474.822	3157.822

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Starting with the F-Statistic a measurement of for the goodness of fit of all linear equations was computed as follows;

$$F = \frac{R^2}{\left[\left(1 - R^2\right)/n\right]} \quad \text{where } n = 293 \qquad (9.5.b)$$

at the 1 percet significance level, and the critical level of F is 7.88. Therefore, we have no hesitation in rejecting the null hypothesis that R^2 could have arisen by chance. All countries display a high F-statistic to reject the null hypothesis at 1 and 5 percent level of confidence.

Following the standard error of the regression for all equations is bellow 0.004, which shows that the coefficient estimates are quite accurate since their probability

density function is quite narrow. However, that does not tell us whether the regression

estimates come from the middle of the function. The higher the variance of the

disturbance term, the higher the standard errors of the coefficients in the regression

equation, reflecting that the coefficient are inaccurate.

Next, the Residuals Sum of Square is another measurement which proves the

accuracy of the tested models. No country under investigation has higher RSS than

0.337. In OLS we wish to fit the regression in such a way so that we make these

differences as small as possible

$$\min \sum e^2 = \sum \left(S_t - \overline{S_t} \right)^2 , \tag{9.5.c}$$

The value of the likelihood function is evaluated at the estimate values of the

coefficient:

$$ML = -\frac{T}{2} - \frac{T}{2}\log(2\pi) - \frac{T}{2}\log\left(\frac{SSR}{T}\right) \tag{9.5.d}$$

where T is the number of observations, and SSR is the sum of squared residuals. LM

ratio test examines the statistic 2(LLU-LLR), where LLU and LLR are the log likelihood

of the restricted and unrestricted versions, respectively, have a x^2 distribution in large

samples with s degrees of freedom where s, is the number of restrictions imposed, under

the restricted version is correct [White, H.(1982), 1-25]

9.6 Detection of Autocorrelation
(Serial Correlation- Durbin-Watson Statistic)

The consequences of autocorrelation are somewhat similar to those of

Heteroskedasticity. The regression coefficient remain unbiased but they become

inefficient and their standard errors are estimated wrongly. Autocorrelation normally

become visible only in time series. The disturbance term picks up the influence of those

variables affecting the dependent variable that have not been included in the regression

equation. If it is reasonable to assume that time t values are only influenced by the

previous period (t-1) and no further back, the Durbin-Watson statistic may be requested

in the definition of the regression model. Autocorrelation is on the whole more likely

the shorter the interval between observations. One important point to note is that

autocorrelation is on the whole more likely to be a problem the shorter the interval

between observations. The well know Durbin-Watson test statistic d is defied as a

variant of the following [Breusch, T. S., and L. Godfrey (1981)]:

$$d = \sum_{t=2}^{T} (e_t - e_{t-1})^2 / \sum_{t=1}^{T} e_t^2 \qquad (9.6.a)$$

If there is no autocorrelation present, p is 0, so d should be close to 2. If there is positive

autocorrelation, d should tend to be less than 2; If there is negative autocorrelation it

should tend to be greater than 2. The critical value of d, at any given significant level

depends on the number of explanatory variables in the regression equation and the

number of observations in the sample. Unfortunately, it also depends on the particular

values taken by the explanatory variables. Thus, it is not possible to construct a table

giving the exact critical values for all possible samples as it happens with t test and F

test, but it is possible to calculate upper and lower limits for the critical value of d. (d_U,

d_L). If the exact value of d_{crit}, is known then a comparison can be made with the value

of the regression. If $d \geq d_{crit}$, the null hypothesis of autocorrelation is failed to be

rejected. If $d \leq d_{crit}$, the null hypothesis is rejected and the conclusions is that there is evidence of positive autocorrelation. Referring to the tables 9.5.A to 9.5.D we conclude that all countries exhibit a d close to 2 which indicates there is no significant serial correlation. However, UK has a $d=1.7713$ which is not close to 2 and that indicates a small positive autocorrelation.

9.7 Detection of First-Order Autocorrelation
The Durbin -Watson Statistics

We may be able to eliminate the autocorrelation in UK by identifying the factor or factors responsible for it and extending the regression accordingly. The so-called first-order autoregressive scheme has received most attention in the literature because it is intuitively plausible and there is usually insufficient evidence to make it worthwhile considering more complicated models.

When the disturbance term of our models are correlated the coefficient estimates of ordinary least squares become inefficient. However, they may be still unbiased. The first order autoregrassive correction of AR(1) correction provides a method to obtain efficient estimates when the disturbance term display first order serial correlation, that is

$$u_t = e_t + u_{t-1} \qquad (9.7.a)$$

The AR(1) computes the residuals from the regression, and then finds the best prediction of the residual from its past value. It computes a new dependent variable by subtracting the predicted residual from the original dependent variable.

$$S^{N}_{t} = S_{t} - S_{pred} \qquad\qquad (9.7.b)$$

where S^{N}_{t} is the new time series of spot rates and S_{t} is the original series. Then it runs a

second regression of the new depended variable S_{t} based on the original independent,

f_{t1}.

Following a new series of predicted residual a third regression is computed

using the new series of spot rates. New values for the values are calculated by applying

least squares to the linearized equation. This process continues until the coefficients

convergence or the maximum number of interations is reached. AR(1) procedure

incorporates the residual from the past observation into the regression model of the

current observation. Note that there are two different kinds of residuals associated with

AR(1) estimation. One kind is the unconditional residual, computed just as is LS; the

Spot rate minus the forward rate multiplied by its regression coefficient. The other kind

of residual is the one-period-ahead forecast error, which is the error made when the

spot rate is forecast by applying the coefficients to the forward rate and then adding the

prediction of the residual from its own past value.

Because of serial correlation, these residuals will tend the be smaller where

forecast is improved by taking advantage of the predictive power of the lagged

residuals. The improvement in the standard error is due to the extra predictive power of

the lagged residual. However, this improvement applies when forecast is made based on

the already known forecast error from the immediately preceding period. A unique

statistic measure for AR(1) is ρ, which is the serial coefficient of the unconditional

residuals. Since ρ, lies between (+1) and (-1) for positive and negative serial correlation

respectively, d must lie between 0 and 4. When ρ, is zero then serial correlation is absent. If the first-order specification is correct, the residuals would be then serially uncorrected white noise[Durbin, J. (1970), 410-421].

We are considering the special case in which autocorrelation follows the first-order autoregressive scheme,

$$u_1 = \rho + u_i + \varepsilon_i \qquad\qquad (9.7.c)$$

The scheme is said to be autoregressive, because u is being determined by lagged values of itself, and first order because the maximum lag is 1. The value of ε in each observation is said is assumed to be independent of its value in all the other observations. We can estimate $\rho +$ by regressing e_i against e_{i-1} using *OLS*. The estimator of $\rho +$ is then

$$Cov\ (\ e_{i-1},\ e_i)/\ Var(e_{i-1}) \qquad\qquad (9.7.d)$$

The validity of standard errors requires the additional assumptions of conditional homoscedastisity and no serial correlation. Both of these hypotheses are questionable in Fama's [(1984), 319-338] smilingly unrelated regression. Hodrick and Srivastava [(1986), S5-S22], discusses a potential bias of Farma's analysis due to the nature of the error term.

CHAPTER 10

NONPREDICTIVE TESTS II: RESIDUALS, SERIAL CORRELATION.
TIME SERIES TESTS, SPECIFICATION AND STABILITY
OF THE REGRESSION MODEL

10.1 General Diagnostic and Specification Tests

The test that would be performed are categorized under Coefficient restrictions, Residual Tests, and Specification and stability tests. For the first category we test for coefficient restrictions (Wald Test), and Added omitted variables. For the second category we test serial correlation (LM Test), Auto and partial autocorrelation (Q-statistics), Normality Tests, Heteroskedasticity- (ARCH and White Test). Finally, for the third category we test Ramsey, Chow (Forecast, Break Points, and Recursive Least Squares which shows the evolution of an estimated relationship as the sample is extended one observation at a time.

10.2 Coefficient Restrictions

10.2.1   Wald Test

The Test(W) command tests hypotheses involving restrictions on the coefficients of the explanatory variables. The restrictions may be linear or nonlinear, and two or more restrictions may be tested jointly. Output from Test(W) depends on the linearity of the restriction. For linear restrictions the output is an F-statistic and a x^2-statistic with associated probability-values. When linear restrictions are tested on a linear equation estimated with the LS command the F-statistic may be started as Robert E. Hall, Jack [Jonston David M. Lilien,(1990), 15-5]

$$F = \frac{\left(e_*'e_* - e'e\right)/q}{e'e/(n-k)} \qquad\qquad (10.2.1a)$$

where

$e_*'e_* = $ residual sum of squares when the restrictions are imposed in

the sample estimation

$e'e = $ residual sum of squares when the equation is estimated

without the imposition of any restrictions

$q = $ number of restrictions in the null hypothesis

$n = $ number of sample points

$k = $ number of coefficients in the unrestricted relation.

Wall tests whether the improvement of the fit on going from the restricted to the

unrestricted version is significant. The degrees of freedom is calculated as n-k-1. If the

restrictions are valid there should be little difference in the fits obtained for the

unrestricted and restricted regressions. Thus, the calculated F-statistic is likely to be

small, the probability-value large, and the restrictions not rejected.

The distribution of the computed F-value only follows this exact, finite sample

distribution when the disturbance terms in the relation are independently and normally

distributed with zero mean and constant variance and the regressors are completely

independent of the disturbances. In any case, too much weight should never be placed on

small differences between test statistics and critical values. Such outcomes should be

treated as inconclusive. Attention should paid to strong rejections, and not marginal

results. The F test is calculated as [Kennedy, Peter E. (1985)].

$$ F = \frac{\text{Improvement in fit / Extra degrees of freedom used up}}{\text{Residual sum of squares / Degrees of freedom remaining}} = \frac{RSS_R - RSS_U}{RSS_U / (n - k - 1)} $$

(10.2.1.b)

where k is the explanatory variables in the unrestricted version and n-k-1 degrees of freedom under the assumption that the restriction is valid.

The critical value of F for equation (8.1.k) is 3.84 at the 5% level of significance and 6.63 at the 1% significance level [E.S. Pearson and H.O. Hartley, (1970)]. Since Canada France U.K. have F-statistic values 1.8079, 1.0324 and 2.28856 respectively, lower values than this critical level, can not be accepted at the 5% confidence level. In addition , the second and forth equation rejects the restriction for Canada with an F value 4.2785 and 8.4812 at a 5%. For the third equation, Canada will also reject the null hypothesis at the 8% confidence level.. All other equations for France and Canada do not reject the null hypothesis.

The asymptotic x^2 distribution with degrees of freedom equal to the number of added variables, presents a critical value of 3.841. The x^2 critical is 3.8415 at 5% and increases for 1% and .01% significance level. All countries except U.K. do not reject the restriction [E.S. Pearson and H.O. Hartley (1970)]

10.2.2 Testing for Additional Variables

A second variable S_{t-2} was added a in every equation and the question was whether the set makes a significant contribution to the explanation of the dependent variable. We test the null hypothesis that the coefficient on the lag is zero. The output gives an F-statistic and a likelihood ratio (LR) statistic, with associated probabilities. The F-statistic is

interpreted in exactly the same way as in Test (W), being based on the difference between residual sums of squares in the restricted and unrestricted regressions. In this case the restricted regression is the equation without the lag; it is the equation in memory and is also referred to as the default equation. The unrestricted equation is the new, expanded equation, also referred to as the test equation. In our sample the F critical is 3.00 at the 5% level of significance and 4.61% at the 1% significance. Since the F statistics for Canada, France and UK are 0.5435, 0.16852, 3.45 we do not reject the restrictions [E.S. Pearson and H.O. Hartley(1970)]. U.K. displayed small probabilities . The F statistic is not rejected at the 5% or 1% confidence level, however, in eq. (8.1.j) the null hypothesis is rejected above the 5% confidence level. The general rejection of hull hypothesis is verified because of the relative large probabilities associated with the F-statistic and LR values . The LR statistic is based on the ratio of the restricted maximized likelihood to the unrestricted maximized likelihood, and under general conditions it has an asymptotic x^2 distribution with degrees of freedom equal to the number of added variables. The LR statistic will be approximately proportional to the F-statistic, where the factor of proportionality is the associated with number of added variables. The LR gives us the same results.

10.3 Residual Tests

10.3.1 Serial Correlation Lagrange Multiplier (LM) test

The model was also tested for autocorrelated disturbances. An order of three and twelve is applied which denotes the process thought to be determining the disturbances. This order has been also specified, so that the default equation is augmented by three and

twelve lags of the residuals from those equations. Output from the command consists of an F-statistic and a x^2-statistic, each with the relevant probability value. The x^2-statistic is the Breusch-Godfrey, Lagrange multiplier test statistic and is nR^2, where n is the sample size and R^2 (R-squared) is the square of the multiple correlation coefficient from the test regression. The exact distribution of the F-statistic is not know but nR^2 is asymptotically $x^2(p)$ under quite general conditions. Under the null hypothesis of no autocorrelation we calculated the Obs.R-squared. If those values are greater than critical and the associated probabilities are very small the null hypothesis is rejected.

For all equations except (8.1.i) & (8.1.j) Canada has rejected the null hypothesis at the 5% confidence level, whereas for eq. (8.1.h) and eq.(8.1.j) it is rejected for both 5% and 1% confidence level. France has not rejected the null hypothesis for eq. (8.1.h) and eq. (8.1.j) but rejecting for equations (8.1.j) & (8..1n) at the 5% confidence level. U.K. has not rejected the null hypothesis at the 5% and 1% confidence level for (8.1.h) and (8.1.j) at 5% but was rejected for (8.1.i) & (8.1.k) at the 5% confidence level. The x^2 critical values used for order 3 at the 5% 1% and 0.1% are the following: 21.0261, 26.2170, 32.909 respectively. For order 12 referring to the same levels of confidence the critical values are: 7.814, 11.3449, and 16.266 E.S.[Pearson and H.O. Hartley. 1970].

10.3.2 Autocorrelations, Partial Autocorrelations and Q-statistics

By deciding how far we wish to cast out net in terms of order of the autocorrelation being detected. The model has also being tested for autocorrelations and partial autocorrelations of the residuals up to twelve lags. Box-Pierce and Ljung-Box Q

statistics were applied for testing serial correlation. The results show no significant auto & partial autocorrelations.

10.3.3 Multicollinearity

By assumption of the classical normal linear regression model we require that none of the explanatory variables be perfectly correlated with any other explanatory variables. When this assumption is violated we are talking about multicollinearity. Multicollinearity is a question of degree and not of kind. Since multicollinearity refers to the condition of explanatory variables that are assumed to be non-stochastic[1], it is a characteristic of the sample and nor of the population, therefore, we are not testing for multicollinearity but for the degree in our sample series.

An important change that occurred as lagged values were added as explanatory variables is that a significant increase in the unreliability of the individual regression coefficients occurred. When the spot S_t appeared by itself, the standard error of its coefficient was 0.0413. When it appears with three lagged values, the standard error of its coefficient raised impressively to 0.782 and this is the fist serious exposure to the effects of collinearity.

Let's now examine the connection between the degree of multicollinearity and the properties of the lest squares estimators of the regression coefficients. Knowing that the least square estimators have the desirable properties assumed based on the classical normal linear regression model , is only cold comfort to us if their variances are such that

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[1] If the explanatory variables are stochastic and there is an underlying relation among them in the population, such relation should be specified as a part of the model. If such a relation does not exist in the

the resulting estimates are highly unpredictable. That is, knowing that our estimators have the smallest possible variance(among all unbiased estimators) is not very helpful if, at the same time, this variance happens to be very large. And this is how multicollinearity comes in.

Considering the regression model of unbiasedness (8.1.j) and the variances of γ_1 γ_2, the higher the variance and covariance of γ_1 and γ_2, the higher would be the degree of multicollinearity [Durbin, J., and G. S. Watson (1950),.409-428]

It is important to note that a high degree of multicollinearity is simply a feature of the sample that contributes to the unreliability of the estimated coefficients, but has no relevancy to the conclusions drawn as a result of this unreliability.

10.3.4 Hereroscedasticity and Autocorrelated Disturbance Term

The conditions set by Gaus-Markov state that;

I. The disturbance terms u_i in the n observations come all from probability distributions that have zero mean $E(u_i)=0$.

II. Population variance is constant for all observations population $Var(u_i)$ Constant for all observations

III. Population $Cov(u_i u_j)= 0$, if i,j

IV. The explanatory variable is nonstochastic.

The term heteroscedasticity refers to any case in which the variance of the probability distribution of the disturbance term is different for different observations.

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population, we still may (and generally will) find some relation between the explanatory variables in the sample. Again, multicollinearity is a feature of the sample, not the population.

There are two reasons why we are concerned about heteroscedasticity [Christopher Dougherty 1992]; One is that the presence of heteroscedasticity minimizes, in a probabilistic sense, precision of the unbiased estimators of the OLS estimators. If there is no Heteroscedasticity, the usual regression coefficients have the lowest variances, of all the unbiased estimators that are linear functions of the observations of y. If heteroscedasticity is present the OLS estimators become inefficient.

A condition of heteroscedasticity exists when there is an appreciable trend in the plot of residuals versus predicted values . This can mean that the standard errors of the coefficient estimates and hence their tests of significance will be incorrect. A pronounced funneling of values of the standard errors vs. the predicted reveals Heteroscedasticity. One way to deal with this problem is to transform logarithmically the depended variable[Glejser, H. (1969), 316-323].

In time series hereroscedasticity arises when both the depended and independent variables are growing over time and also the variance of the error term is growing over time[Glejser, H (1969), 316-323] . We will assume three different assumptions about the relationship between the variance of the disturbance term and the magnitude of the explanatory variables [Glejser, H. (1969).), 316-323].

Heteroscedasticity is likely to be a problem when the values of the variables is the regression equation vary substantially in different observations. If the true relationship is given by

$$S_t = b_0 + b_1 f_{t-1} + e_{2t} \qquad\qquad (10.3.3.a)$$

it may well be the case that the variations in the omitted variables and the measurement errors are jointly responsible for the error term [Bollersiev, T (1987)]. If S_t and f_{t-1} are

growing over time, then it may well happen that the variance of the disturbance term e_2 is also growing over time.

The TEST (E) tests for Auto Regressive Conditional Heteroscedasticity [Econometrica, 50, 987-1008.] This particular specification of heteroscedasticity was motivated by the observation that in working with macroeconomic series the size of residuals appeared to be the size of recent residuals. Thus the test is based on the regression of squared residuals on lagged squared residuals $e_t = b_0 + e_{t-1} \ldots + e_{t-n}$

The ARCH test repeats the number of lags used and gives an F-statistic and an nR^2 statistic (n is the number of observations), each with the relevant probability value. Each statistic provides a test of the hypothesis that the coefficient of the lagged square residuals are all zero. Where the nR^2 statistic has an asymptotic x^2 distribution with degrees of freedom equal to the lagged, squared residuals.

The null hypothesis underlying the test assumes that the errors are both homoscedastic and independent of the regressors and that the linear specification of the model is correct. The probability values associated with the values of F-statistic and Obs.R-square are significantly high, not to reject the null hypothesis. Using n-k-1 for degrees of freedom as mentioned above, the F critical value for eqs. (8.1.h), (8.1.i) 3.84 and for eqs. (8.1.j),(8.1.k) the F test is 3.00. Heteroskedasticity is rejected by all models and all countries since the F values are below the critical.

In a similar fashion consulting the nR^2 value with an x^2 distribution we cannot reject again the null hypothesis of homoscedasticity as shown in tables (10.4A,B,C,D) respectively for the four equations.

10.3.5 Normality of the Error Term (e_t)

The justification for the assumption that the error term follows a normal distribution depends on the central limit theorem. The disturbance term u, is composed of a number of factors not apparently explicitly in the regression equation, so even if we know nothing about the distribution of these factors, we are entitle to assume that they are normally distributed. As we can see in tables 10.2A,B,C,D. All error terms for all equations and countries exhibit low standard deviations in their error terms. Canada seems to have the lowest following France and U.K. In addition the *Pearsonian coefficient of skewness (PCS)* display distributions close to symmetrical. The *PCS* ranges from -3 to +3 with $Sk=0$ being a perfectly symmetrical distribution. Almost all error distributions follow a mesokurtic kurtosis which reveals that data contained in a distribution tend to concentrated less in the mid point.

10.4 Specification and Stability Tests

Stability tests of a regression model are tests designed to evaluate whether the performance of a model in a post sample period is compatible with its performance in the sample period used to fit it. There are two principles on which stability tests can be organized. One approach is to focus on the predictive performance of the model; the other is to evaluate whether there is any evidence of shifts in the parameters in the prediction period. The Ramsey RESET tests for general specification error, whereas the Chow test examines how stable is the model over different time periods, or different sub-samples of cross-section data.

In the postulated model $S_t = b_0 + b_1 f_{t-1} + e_{2t}$ we have assumed that the disturbance term to have the multivariate normal distribution $N(0, s^2 I)$. *Serially correlated, heteroscedastic or non-normal disturbances all violate the assumption that the disturbances are normally distributed.*

Specification errors include some or all of the following:

I.   omitted variables

II.   incorrect functional form of the variables that are required to be transformed to logs, powers or reciprocals.

III.   correlation between the random variables and the disturbance term or simultaneous equations, combination of lagged depended variables and serially correlated disturbances

10.4.1 Ramesey Test

Ramsey [(1969) $B.31$, 350-3781], showed that any or all of these specification errors produce a non zero mean vector for e. Thus the null and alternative hypothesis are

$$H_o: e \sim N(0, s^2 I)$$

$$H_1: e \sim N(0, s^2 I) \quad m'0$$

The test of H_o is based on an augmented regression. Considering equation (8.1.i) as the augmented model is $S_t = Z b_0 + b_1 f_{t-1} + e_{2t}$, where the specification error is then $b_0 = 0$. The question is what variables should enter the matrix Z. In the case of omitted variables there are the variables that constitute the Z matrix and the test of $a = 0$ is simply the TEST (A). A TEST A enables you to add a set of variables to an existing

equation and ask whether the set makes a significant contribution to the explanation of the dependent variable. For example by adding to the initial regression (8.1.i) a one month lag of the forward rate series, it tests whether the coefficients are zero and gives an output that reminds which variables have been added calculating an F- statistic and a likelihood ratio (LR) statistic with associated probabilities.

The F-statistic is based on the difference between residual sums of squares in the restricted equation and the unrestricted. In this case the restricted regression is the equations without lags and the unrestricted regression is the new, expanded equation. The LR statistic is based on the ratio of the restricted maximized likelihood to the unrestricted maximized likelihood, and under general conditions it has an asymptotic x^2 distribution with degrees of freedom equal to the number of added variables. The LR statistic will be approximately proportional to the F-statistic, the factor of proportionality being the number of added variables. In the case of incorrect functional form, the omitted portion of the regression may well be some function of the regression included in x. For example, if a linear relationship $S_t = b_0 + b_1 f_{t-1} + e_{2t}$ is specified instead of the true relation

$$S_t = g_0 + g_1 S_{t-1} + g_2 f_{t-1} + e_{2t} \text{ or} \qquad (10.4.1a)$$

$$S_t = d_0 + d_1 f_{t-1} + d_2 [(\text{i-i}^*)_t - E_{t-1} (\text{i-i}^*)_t] + e_{4t} \qquad (10.4.1b)$$

the augmented models have $Z_1 = S_{t-1}$ and $Z_2 = [(i\text{-}i^*)_t - E_{t-1} (i\text{-}i^*)_t]$ respectively. Ramsey's suggestion is to include in Z, powers of the predicted values of the dependent variable-the actual future spot rate which is a linear combination of powers and cross-product terms of the explanatory variables. Specifically, Ramesy suggests that that Z is the

vector of predicted y values from the LS regression of y on x. The F- values have been

calculated for one forecast vector to be included in the test regression given using 1

fitted term and test the null hypothesis that the coefficient of the forecast vector is zero.

As we see from the test. Since the probability values are quite high, the null hypothesis

is not rejected and this is valid for all countries for every equation.

10.4.2 Chow Test

This is an important step in our investigation to split the time series into two or more

sub-samples and run separate regressions for each subsumable. Specifically the series of

n data are split into n_1 to be used for estimation and the remaining $n_2 = n-n_1$ for testing.

Using all available sample observations for estimation promotes a search for the

formulation that best fits that specific dataset.

We will denote the sum of the squares of the residuals of the separate

regressions for the periods 1970.01 - 1982.01 & 1982.02-1994.06 U_A and U_B

respectively. We will denote $U^p{}_A$ and $U^p{}_B$ of squares of the residuals in the pool

regression for the observations belonging to the two sub-samples. Since the sub-sample

regressions must fit their observations at least as will as, if not better than, the pooled

regression, $U_A \leq U^P{}_A$ and $U_B \leq U^P{}_B$. Hence, $(U_A + U_B) \leq U^P$, where U^P, is the total sum of

squares of the residuals in the pooled regression, is equal to the sum of $U^P{}_A$ and $U^P{}_B$

Equality between U^P and $(U_A + U_B)$ will occur only when the regression

coefficients for the pooled and sub-sample regression coincide. In general there would

be an improvement $(U^P - U_A - U_B)$ when the time series is split up. There is a price to

pay, in that $(k+1)$ extra degrees of freedom are used up, since instead of $(k+1)$

parameters for one combined regression we now have to estimate $(2k+2)$ in all (k being

the number of explanatory variables, one being the constant term). After breaking up the

sample, we are still left with $U_A + U_B$ (unexplained) sum of squares of the residuals, and

we have $(n-2k-2)$ degrees of freedom remaining.

We use F- statistic in order to determine whether the improvement in the fit

when we brake up the sample is significant.

$$\frac{\text{Improvement in fit / Degrees of freedom used up}}{\text{Unexplained / Degrees of freedom}} = \frac{(U_p - U_A - U_B)/(k+1)}{(U_p + U_B)/(n-2k-2)} \qquad (10.4.2a)$$

Precisely this test, evaluates whether the coefficients in the sample period and prediction

period appear to be significantly different. The null hypothesis is that the improvement

in the fit when we break up the sample is significant. For the first break points 79.05,

85.02 the associated probabilities for the F test as well as the Likelihood Ratio for all

test and countries under investigation show that, on average there is no significance in

the improvement in the fit when we break the periods.

Specifically, for the first equation Canada does not reject the null hypothesis

whereas France and UK does at the CL above 1%. For the second and forth eq. all

countries reject the null hypothesis whereas in the third eq. Canada again does not reject

but France and UK do so. In a similar fashion but with small differences between the

previous break point and the second break point 80.03 still the majority of countries

reject the null hypothesis with the exemption of Canada in eq.(8.1.i) and (8.1.1n),

France in eq.(8.1.1) and U.K. above the 8% confidence level.

Test F is the forecast version of the Chow test. The equation estimated with the n_1 observations used to predict the values of the dependent variable in the remaining n_2 series. A vector of discrepancies between predicted and actual values is expected. If the discrepancies between predicted and actual values are small little doubt is cast on the estimated equation. Large discrepancies would cast suspicion on the estimated equation. There are no hard and fast rules for determining the relative zones of n_1 and n_2. One obvious point would be the switch from fixed to flexible exchange rates.

Test results show that the preponderance of countries for the four equations seem not to reject the null hypothesis except U.K. for the equations (8.1.i), (8.1.1m), and (8.1.1n) which means that the vector of discrepancies between the predicted and actual values are not significant.

Table10.4A Specification and Diagnostic Test of Eq. (8.1.h)

$$S_t = a_0 + a_1 S_{t-1} + e_{2t}$$

Tests		CS		FF		£	
			PROB.		PROB.		PROB.
Coefficient Tests							
Wald Test (a0=0, a1=1)	F-Stat	1.80791	0.1661	1.03024	0.3584	2.28856	0.1035
	X^2	3.61581	0.164	2.06049	0.3569	4.57712	0.1014
Add Variable (St-2)	F-Stat	0.54352	0.4617	0.16852	0.6818	3.4334	0.0651
	LR	0.54939	0.4586	0.1705	0.6797	3.45092	0.0632
Residuals Test							
Serial Correlation (12)	F-Stat	2.02084	0.0232	0.79439	0.6561	1.17878	0.2989
	Obs*R^2	23.3095	0.0252	9.70328	0.642	14.1372	0.292
Serial Corr.(3) Cov(e_t, e_t-1)=0	F-Stat	0.53733	0.6571	0.91943	0.432	1.23903	0.2961
	Obs*R^2	1.6338	0.6518	2.78284	0.4263	3.73597	0.2914
Auto & Partial Autocorrelations (12 MOs)	BPQ-Stat.	19.78	0.0714	8.86	0.7151	11.74	0.4664
	LBQ-Stat.	20.63	0.056	9.15	0.6902	12.16	0.4333
	SE	0.063		0.063		0.063	
Normality of ε_t	Mean	1.13E-11		-1.11E-11		-1.66-E12	
	SD	0.01301		0.033608		0.03355	
	Max	0.03052		0.086753		0.12193	
	Min	-0.05966		-0.1147		-0.12573	
	Sk	-0.77666		-0.3206		-0.08271	
	J-B Stat.	78.8220		9.57300		10.5643	
	Kur.	5.20135		3.70238		3.98531	
			2.08E-17		0.00834		0.0050
Heteroscedasticity ARCH Test (12)	F-Stat	0.92427	0.5233	0.38316	0.9686	1.11494	0.3487
	ObsR^2	11.1795	0.5136	4.7633	0.9654	13.3583	0.3435

Table10.4A Specification and Diagnostic Test of Eq. (8.1.h)

$$S_t = a_0 + a_1 S_{t-1} + e_{2t}$$

(Continued)

Tests		C$		FF		$	
Coefficient Tests			PROB.		PROB.		PROB.
Heteroskedasticity	F-Stat	0.92427	0.5233	0.98325	0.3755	2.28875	0.1035
White Reg. & Squares	$ObsR^2$	11.1795	0.5136	1.97454	0.3726	4.54925	0.1028
Specification & Stability Tests							
Ramesy RESET Test	F-Stat	0.4205	0.5173	0.2253	0.6354	0.3739	0.5414
(Fitted terms=1)	LR	0.42423	0.5148	0.22715	0.6336	0.37716	0.5391
Chow Test							
Break-Point	F-Stat	0.36148	0.8359	5.79032	0.0002	4.34822	0.002
(79.05, 85.02)	LR	1.47661	0.8308	22.6784	.0001	17.2168	0.0018
(80.03)	F-Stat.	0.42022	0.6574	2.78007	0.064	1.45246	0.236
	LR	0.85246	0.653	5.58721	0.0612	2.93437	0.2306
Chow Forecast Test	F-Stat.	1.30724	0.1413	0.92751	0.5793	1.40521	0.0874
(92.01)	LR	41.3195	0.0817	29.9936	.466	44.1613	0.0461
Cusum test		IN		S		IN	

Notes: IN= *Instability in the parameters of the equation*

S= *Some instability in the parameters of the equation*

Table 10.4B Specification and Diagnostic Test of Eq. (8.1.i)

$$S_t = b_0 + b_2 f_{t-1} + e_{2t}$$

Tests		C$		FF		£	
Coefficient Tests		Test	PROB.	Test	PROB.	Test	PROB.
Wald Test	F-Stat	4.27856	0.0149	1.28274	0.2798	1.09921	0.3347
$(a_0=0, a_1=1)$	X^2	8.55712	0.0139	2.56548	0.2773	2.19841	0.3331
Add Variable	F-Stat	0.89239	0.3457	0.00889	0.925	2.16962	0.142
(S_{t-2})	LR	0.90148	0.3424	0.00903	0.9243	2.18616	0.1393
Residuals Test							
Serial Correlation(12)	F-Stat	2.29486	0.0088	1.40219	0.1691	1.89711	0.0354
	Obs*R^2	26.1448	0.0102	16.5703	0.1665	22.006	0.0375
Serial Correlation(3)	F-Stat	1.67881	0.1721	2.13717	0.0972	3.04806	0.0293
Cov(e_t, e_{t-1})=0	Obs*R^2	5.03572	0.1692	6.36244	0.0952	8.99739	0.0293
Auto & Partial	BPQ-Stat	33.8	0.0007	17.05	0.1476	20.87	0.0523
Autocorrelations	LBQ-Stat	35.1	0.0005	17.69	0.1255	21.5	0.0436
(12 MOs)	SE	0.063		0.074		0.063	
Normality of ε_t	Mean	-9.14E-12		5.41E-12		3.24E-11	
	SD	0.03621		0.0343418		0.034927	
	Max	-0.05188		0.0895422		0.130387	
	Min	-0.47356		-0.109036		-0.13547	
	Sk	23.5123		-0.205302		-0.22874	
	J-B Stat.	4.15090		3.734296		21.93379	
	Kur.		7.84E-06	3.566699		4.36499	
					0.15456		1.73E-05
Heteroscedasticity/city	F-Stat	0.89926	0.5485	0.42772	0.9506	1.25151	0.2492
ARCH Test (12)	Obs*R^2	10.8905	0.5383	5.38015	0.9441	14.8939	0.2473
Heteroscedasticity/city	F-Stat	0.23056	0.7943	1.22271	0.2969	0.97037	0.3804
White Reg.& Sqs.	Obs*R^2	0.46577	0.7922	2.45285	0.2933	1.94887	0.3774

Table 10.4B Specification and Diagnostic Test of Eq. (8.1.i)

$$S_t = b_0 + b_2 f_{t-1} + e_{2t}$$

(continued)

Tests	C$		FF		£	
Specification & Stability Tests						
Ramsey RESET (Fitted terms=1)						
F-Stat			0.25053	0.6173	2.0687	0.1516
LR			0.25347	0.6146	2.09372	0.1479
Chow Test Break-Point (79.05, 85.02) (80.03)						
F-Stat	3.11499	0.0159	7.13399	0	8.11507	0
LR	12.4512	0.0143	27.3533	0	31.2428	0
F-Stat.	0.37179	0.6899	8.13819	0.0004	11.5203	0
LR	0.75436	0.6858	15.9265	0.0003	22.3926	0
Chow Forecast Test (92.01)						
F-Stat.	1.19387	0.2337	1.93908	0.1468	1.48785	0.0566
LR	37.9906	0.15	3.92249 (88.06)	.1407	46.5341	0.0276
Cusum	INS		INS		ISN	

Notes: INS= Instability in the parameters of the equation

S= Some instability in the parameters of the equation

Table 10.4C Specification and Diagnostic Test of Eq. (8.1.j)

$$S_t = g_0 + g_1 S_{t-1} + g_2 f_{t-1} + e_{2t}$$

Tests		C$	PROB.	FF	PROB.	$	PROB.
Coefficient Tests							
Wald Test	F-Stat	2.52852	0.0818	0.93669	0.3938	1.8697	0.1563
(a$_0$=0, a$_1$=1)	X^2	5.05704	0.0798	1.87338	0.3919	3.7394	0.1542
Add Variable	F-Stat	0.77894	0.3783	0.13392	0.7148	3.36041	0.068
(S$_{t-2}$)	LR	0.79015	0.3741	0.13689	0.7114	3.39142	0.0655
Residuals Test							
Serial Correlation(12)	F-Stat	2.13333	0.0157	1.07095	0.3877	1.17845	0.2922
	Obs*R^2	24.5744	0.017	13.0041	0.3687	14.1894	0.2888
Serial Correlation(3)	F-Stat	0.66414	0.5748	1.21151	0.307	1.23919	0.296
Cov(e$_i$, e$_{i-1}$)=0	Obs*R^2	2.02436	0.5674	3.68212	0.2979	3.75126	0.2896
Auto & Partial	BPQ-Stat	20.74	0.0543	13.11	0.3613	11.71	0.4689
Autocorrelations	LBQ-Stat	21.63	0.0419	13.67	0.3224	12.12	0.4358
(12 MOs)	SE	0.063		0.074		0.063	
Normality of e$_t$	Mean	1.85E-11		-4.92E-11		1.23E-10	
	SD	0.01297		0.03326		0.03355	
	Max	0.03040		0.08810		0.12265	
	Min	-0.06121		-0.11097		-0.1264	
	Sk	-0.83443		-0.04437		-0.0979	
	J-B Stat.	89.5506		3.65666		11.6067	
	Kur.	5.38251		3.68679		4.02875	
			3.58E-20		0.16068		0.0030
Heteroscedasticity	F-Stat	0.83964	0.6095	0.40775	0.959	1.10616	0.3559
ARCH Test (12)	Obs*R^2	10.199	0.5985	5.13657	0.9533	13.2589	0.3505
Heteroscedasticity	F-Stat.			1.92721	0.1079		
White Reg. &	Obs*R^2			7.59638	0.1075		
Squares							

Table10.4C Specification and Diagnostic Test of Eq. (8.1.j)

$$S_t = g_0 + g_1 S_{t-1} + g_2 f_{t-1} + e_{2t}$$

(continued)

	Tests	CS		FF		ß	
Specification & Stability Tests							
Ramsey RESET Test	F-Stat			0.17254	0.6784		
(Fitted terms=1)	LR			0.17551	0.6753		
Chow Test Break-Point	F-Stat	0.28854	0.9421	3.38983	0.0035	3.88701	0.001
(79.05, 85.02)	LR	1.78853	0.9381	20.2304	.0025	23.0962	0.0008
(80.03)	F-Stat.	0.8755	0.4544	2.58935	0.0545	2.1887	0.0899
	LR	2.67589	0.4443	7.86013	0.049	6.63746	0.0844
Chow Forecast Test	F-Stat.	1.30968	0.1398	1.68202	0.1889	1.41289	0.0841
(92.01)	LR	41.5634	0.078	3.42626	.1803	44.5669	0.0423
				(88.06)			
Cusum Test		IN		IN		IN	

Notes: IN= Instability in the parameters of the equation
S= Some instability in the parameters of the equation

Table10.4D Specification and Diagnostic Test of Eq. (8.1..k)

$$S_t = d_0 + d_1 f_{t-1} + d_2 [(i-i^*)_t - E_{t-1}(i-i^*)_t] + e_{t}$$

Coefficient Tests		C$	PROB.	FF	PROB.	UK	PROB.
Walled Test $(a_0=0, a_1=1)$	F-Stat X^2	8.4812	0.0144	2.91927	0.2323	2.55938	0.2781
Add Variable (S_{t-2})	F-Stat	0.87963	0.3492	0.03812	0.8454	2.15004	0.1438
	LR	0.89223	3449	0.03898	0.8435	2.1752	0.1403
Residuals Test							
Serial Correlation(12)	F-Stat	2.37252	0.0067	1.15598	0.319	1.80561	0.048
	Obs*R^2	27.031	0.0076	13.9582	0.3034	21.111	0.0488
Serial Correlation(3) Cov$(e_t, e_{t-1})=0$	F-Stat	2.17838	0.0911	1.56928	0.1985	3.01996	0.0304
	Obs*R^2	6.52135	0.0888	4.74151	0.1917	8.95161	0.0299
Auto & Partial	BPQ-Stat	37.36	0.0002	14.47	0.2719	20.25	0.0626
Autocorrelations	LBQ-Stat	38.73	0.0001	14.98	0.2427	20.85	0.0526
(12 MOs)	SE	0.063		0.074		0.063	
Normality of e_t	Mean	-6.15E-12		6.33E-11		-9.8E-12	
	SD	0.014195		0.03266		0.03489	
	Max	0.035813		0.09579		0.1307	
	Min	-0.05179		-0.11728		-0.1343	
	Sk	-0.41976		-0.02728		-0.218	
	J-B-Stat	19.28733		5.69711		21.437	
	Kur.	4.06058		3.86503		4.3576	
			0.0065		0.05792		2.21E-05
Heteroscedasticity ARCH Test (12)	F-Stat	0.80993	0.6401	0.88682	0.5617	1.1977	0.2856
	Obs*R^2	9.85332	0.6288	10.7916	0.5469	14.292	0.2825
Heteroscedasticity. White Reg.& SqS	F-Stat.	1.71402	0.1474	2.13386	0.0785	1.46067	0.2147
	Obs*R^2	6.80616	0.1465	8.37278	0.0788	5.8232	0.2127

Table 10.4D Specification and Diagnostic Test of Eq. (8.1.1k)

$$S_t = d_0 + d_1 \, f_{t-1} + d_2 [(\text{i-i*})_t - E_{t-1}(\text{i-i*})_t] + e_{4\,t}$$

(continued)

Specification & Stability Tests		C$		FF		UK	
Ramsey RESET	F-Stat	0.19546	0.6588	0.08381	0.7725	1.76482	0.1852
(Fitted terms=1)	LR	0.19793	0.6564	0.08525	0.7703	1.79233	0.1806
Chow Test							
Break-Point	F-Stat	4.52111	0.0002	5.4124	0	6.72358	0
(79.05, 85.02)	LR	26.6707	0.0002	31.3094	0	38.7109	0
(80.03)	F-Stat.	1.75575	0.1562	4.77942	0.0032	7.60195	0.0001
	LR	5.33848	0.1486	14.254	0.0026	22.3435	0.0001
Chow Forecast	F-Stat.	1.14827	0.2812	1.88537	0.1548	1.47989	0.0592
Test							
(92.01)	LR	36.8039	0.1829	3.83653 (88.06)	.1469	46.5072	0.0278
Cusum Test		S		IN		IN	

Notes: IN= Instability in the parameters of the equation

S= Some instability in the parameters of the equation

10.5 Comparative Tests

10.5.1 Testing the Efficient Market Hypothesis between Sample Periods

To test market efficiency hypothesis intertemporarily we employ exchange rates for the Canadian dollar, French franc, and British pound. The data are non-overlapping monthly observations of the spot and 1-month-forward exchange rates . To test the nature of market efficiency intertemporarily we begin with an examination of the time series characteristics f the various exchange rates. The first step is to investigate their serial dependency .

To this end we calculate the autocorrelation functions (ACF) for spot rate changes (in logarithms) from 1-through 12 month lags for the following three periods. The full sample period (April 1973-April 1994) and two sub-periods (April 1973-April 1983 and May 1983- April 1994). The standard formula for calculating coefficients is

$$\rho_k = \left[\sum_t^{n-k} \left(y_t y_{t+k} \right) \right] \bigg/ \left[\sum_t^{n} \left(y_t \right)^2 \right] \qquad (10.5.1a)$$

where ρ_k is the estimate autocrrelation coefficient with kth lag of y_k is defined as the deviation of the change of the natural logarithm of spot rates from its mean value.

Empirically, detection of serial correlation is accomplished by examining the significance of each ρ_k using t- statistic, or by investigating the joint randomness of the residuals using a Box- Pierce statistic, of both. These serial correlation tests for the three sample periods are reported in Table 10.4.E.

Table 10.E Comparative Statistics of the Canadian dollar, British Pound and French Frank between Period April 1973 to 1983 and May 1983 to April 1994

ACF	1973.04 -1994.06			1973.04 -1983.04			1983.05 -1994.04		
	C$	FF	ς	C$	FF	ς	C$	FF	ς
P1	0.0143	-0.00580	0.07630	-0.07550	-0.52730	0.23110	-0.17618	0.0302	0.05640
P2	-0.1875	0.13700	0.10123	-0.17560	0.15730	0.82121	-0.38627	-0.0446	0.12370
P3	0.1204	0.08200	-0.0250	0.21670	0.02300	-0.0324	0.03765	-0.0232	0.04580
P4	0.0311	0.08957	-0.0745	0.06689	0.27384	-0.0749	-0.06613	-0.0871	-0.12529
P5	0.1210	0.04600	0.18790	0.06431	-0.04547	0.04770	0.07602	-0.0428	0.17293
P6	-0.1120	0.00789	0.04675	0.01070	0.02130	0.17640	-0.16371	-0.0749	-0.07620
P7	-0.1026	0.08057	0.01270	-0.09740	-0.06570	0.01070	-0.05450	0.0769	0.03894
P8	0.0675	0.08600	0.05654	0.06390	0.03160	0.06480	0.09710	-0.0769	0.07980
P9	-0.0130	-0.01512	0.03160	-0.17130	0.07840	0.13675	0.00893	-0.3470	-0.16930
P10	-0.0027	0.07600	0.12870	-0.08270	0.01570	0.24385	-0.04590	-0.0381	-0.05830
P11	-0.0146	0.11670	0.19430	0.27468	0.07262	0.14805	0.14722*	-0.0971	0.05928
P12	-0.2860**	0.00450	-0.0120	-0.62290	0.14080	0.17694	-0.17510	-0.4577	-0.19480
Mean (X10³)	-1.6700	4.09820	-3.6350	-2.27430	4.21700	-0.7650	-0.08900	-16.2760	-4.69500
SE. (X 10³)	13.5800	30.01200	27.4100	14.21200	29.3200	25.6520	16.19000	31.5180	24.45000
Q(12)	25.9700	3.31680	17.0600	18.45000	11.5700	14.2900	10.82000	4.7700	4.98200

Note:

a. One asterisk (*) denotes significance at the 0.05 level, and two asterisks (**) denote significance at the 0.10 level.

b. ρ_k is the estimated autocorrelation function (ACF) at the kth lag for the first difference of spot rates $(S_{t-i}-S_t)$.

c. Q(12) is the Box-Pierce statistic, which is distributed as χ^2 with twelve degrees of freedom.

d. All exchange rates are U.S. dollars per unit of foreign currency. All numbers are based on the logarithmic transformation of the original values.

With the exception of higher-order lags for the Canadian Dollar, the estimated autocorrelation coefficients in most cases are quite small in absolute magnitude and are statistically insignificant at the 5% level of confidence.

The Box- Pierce statistic Q statistics for testing the randomness of the residuals indicate the same conclusion as the derived from the individual significance tests. Only for the case of the Canadian dollar can the hypothesis of the randomness of the residual autocorrelation be rejected at the 5% level of confidence. In that case the calculated Q-statistic (26.99) for the full-sample estimation is greater than the corresponding critical value. In general, there is no substantial difference between sample periods.

CHAPTER 11

A COINTEGRATION TEST FOR MARKET EFFICIENCY

11.1   Introductory Concepts of Cointegration Analysis

Recently, much attention has been given to possibility that two or more assets might

share the same stochastic trend i.e., that the assets might be cointegrated. Cointegration

is important because, as shown in Engle and Granger (1987) the presence of common

stochastic trends further restricts the set of statistical models that can be used to test an

implement financial theories. In particular, error correction models, which can be

interpreted as models in which this period's price change depends on how far spot rates

were out of long-run equilibrium last period, become necessary.

The theory behind the computations of cointegration analysis is not so straight

forward. Therefore, it is necessary to start with a depiction of some elementary concepts

of *stochastic process and time series analysis*. Stochastic processes is denoted as the set

$\{X_t\}$ representing a family of real values random variables, $X_1, X_2, ..., X_t$ index by t,

where t represents time. By analogy with the notation describing a single random

variable, μ_t, σ^2_t, denotes the mean and variance of a stochastic process respectively,

where $\sigma_{t, t+i}$, denotes the covariance between two variables such as X_t and X_{t+i}.

which belong to the stochastic process.

One problem that plagues statistical studies of efficient markets is that some

statistical properties must be assumed for the time series used in the analysis. Typical

assumptions include stationarity and ergodicity[Robert J. Hodrick (1991), 19]. Virtually

all rational expectations econometric techniques require that the sample moments from a

large sample of data converge to the true consideration of the population. Unfortunately, financial and economic data may require relatively large samples before we experience all of the possible events on which agents place prior probability. A stochastic process is said to be stationary, if the joint and conditional probability distributions of the process are unchanged over time.

Thus, a stochastic process $\{X_t\}$ is said to be stationary if : $E(X_t) = $ constant $= \mu_t$, $Var(X_t) = $ constant $= \sigma^2_t$, and $Cov(X_t, X_{t+j}) = \sigma_{t, t+i}$. Variances and means of the process are constant over time, while the value of the covariance between two periods depends only on the gap between periods, and not the actual time at which the covariance is considered. If one or more of the conditions above are not fulfilled, the process is nonstationary. Assuming implicitly that a stochastic process and time series are the same, y_t will denote a time series and e_t will denote a series of identically distributed continuous random variables with zero means (white noise).

A random walk process $S_t = S_{t-1} + \varepsilon_t$ as well as the random walk with a drift, $S_t = \mu + S_{t-1} + \varepsilon_t$, is non stationary since the variance of this process is a linear function of time which is not constant.

Nonstationarity of time series has always regarded as a problem in econometric analysis where diagnostic test statistics become unreliable. Regressions subjected to stochastic or deterministic trends often give promising results supporting deceptive relationships. Since almost all economic data series contain trends, it follows that these series have to be detrended. A convenient way of getting rid of a trend in a series is using first differences between successive observations. Hence, for a random walk we

define the detrended variable $\Delta S_t = S_t - S_{t-1} = \varepsilon_t$, and ΔS_t is apparently stationary.

However, if the error term ε_t, is autocorrelated with $\varepsilon_t = \rho \cdot \varepsilon_{t-1} + \xi_t$, where ξ_t is a white noise variable, first differencing y_t guarantee us stationary provided that $|\rho| < 1$. Otherwise, it is necessary to difference a series more than once in order to achieve stationarity. A stationary series which can be transformed to stationary series by differencing d times is said to be *integrated of order* d, $y_t \sim I(d)$. Hence, I(2) is the first differences of the first differences of y_t -to achieve stationary.

$$\Delta\Delta\, y_t = \Delta(y_t - y_{t-1}) = (y_t - y_{t-1}) - (y_{t-1} - y_{t-2}) \qquad (11.1.a)$$

If y_t is stationary, then no differencing is necessary, that is $y_t \sim I(0)$

Before any sensible regression analysis can be performed, it is essential to identify the order of integration. An appropriate and simple method of testing the order of integration of y_t in equation,

$$\varepsilon_t = \rho y_{t-1} + \xi_t \qquad (11.1.b)$$

proposed by Dickey and Fuller (1979) (DF). DF is a test of the hypothesis that in (10.1.1b), $\rho = 1$, the so-called *unit root test*. This test is based on the equivalent regression equation to (10.1.1b),

$$\Delta y_t = \delta\, y_{t-1} + \varepsilon_t \quad (5.7) \text{ or } \quad y_t = (1+\delta)\, y_{t-1} + \varepsilon_t, \qquad (11.1.c)$$

where $\rho = (1+\delta)$. The DF test consists of testing the negativity of δ in the OLS regression. Rejection of the null hypothesis: $\delta = 0$ in favor of the alternative $\delta < 0$ implies that $\rho < 1$ and that y_t is integrated for order zero $y_t \sim I(0)$. To test the null hypothesis it is necessary to know the distribution of the statistic used for the test and the

associated critical region for its evaluation. If the computed Student-t statistic is smaller than the lower critical value for a particular critical observations (n), the null (unit root) hypothesis has to be rejected and the alternative of stationarity of y_t is accepted.

If the calculated Student-t statistic is greater than the upper critical value, then the null hypothesis cannot be rejected. There is an indecisive range between the lower and upper limits that one is unsure whether or not to reject the null hypothesis. If the null hypothesis cannot be rejected then y_t is integrated of order higher than zero or not integrated at all. Consequently, the next steps are to test whether the order of cointegration is one or greater than one. Wasserfallen and Kyburz (1985), found strong evidence of unit roots in, their investigation of the Deutsche mark, the French franc, the British pound, and the Italian lira. If the levels of the logarithms of exchange rates were stationary, the first differences would show significant serial correlation.

The traditional solution of first differencing the data imposes too many unit roots in the system, invalidating standard inference procedures. These problems become particularly important in finance when testing for market efficiency, or when implementing many other financial models using multivariate time series analysis, [Robin J. Brenner and Kenneth F. Kroner (1995), 29-36]. Over-differencing normally results in a very high positive (instead of negative) value of the DF test accompanied by a very high coefficient of determination for the fitted regression. A weakness of the original DF test, is that it does not take account of possible autocorrelation in the error process. In such case the Augmented Dicker-Fuller test (ADF) is regarded as being the most efficient test from among the simple test for integration. The ADF uses lagged left-

hand side variables to approximate the autocorrelation. The ADF equivalent of (10.1.1c) is the following:

$$\Delta y_t = \delta \cdot y_{t-1} + \sum_{i=1}^{k} \delta \cdot \Delta y_{t-i} + \varepsilon_t \qquad (11.1.d)$$

where k is the number of lags for Δy_{t-1}. The testing procedure is the same as before with the examination of the Student-t ration for δ. Another quick way of testing whether a variable is integrated of order zero is to compute for the variable y_t the Durbin-Watson statistic, IDW;

$$IDW = \frac{\Sigma(y_t - y_{t-1})^2}{\Sigma(y_t - \bar{y}_t)^2}, \qquad (11.1.e)$$

where $\bar{y}_t$ stands for the arithmetic mean of y_t. If ρ is equal to one in (10.1.1b), the numerator in (11.1.1e) is equal to $\Sigma \varepsilon_i^2$, where y_t represents the 'fitted' value for a regression of y_t on y_{t-1}, under the restriction that the coefficient of y_{t-1} is equal to one. In such a case the value of IDW should be equal to zero.

According to Engle and Granger time series x_t, y_t are said to be cointegrated of order d, b where $d \geq b \geq 0$, written as:

$$x_t, y_t \sim CI(d,b), \qquad (11.1.f)$$

if:

1.   both series are integrated of order d.

2.   there exist a linear combination of these variables such $\alpha_1 x_t + \alpha_2 y_t$, which is integrated of order $d - b$. The vector $[\alpha_1, \alpha_2]$ is called *cointegrating vector*.

Suppose that S_{t-1}, f^t_{t-1} are cointegrated with order one I(1) and the long run relationship between them is $S_{t-1} = f^t_{t-1}$ then ; if both variables are CI(1,1) and their cointegrating vectors [b,-1], so that the deviations of S_{t-1} from its long run path S_t. then a model of first differences, incorporating an error correction mechanism can be developed ;

$$\Delta S_t = \beta_1 \Delta f^t_{t-1} + \beta_2 \left(S_{t-1} - b \cdot f^t_{t-1} \right) + \varepsilon_t \tag{11.1.g}$$

where ΔS_t and the regressors, Δf^t_{t-1} and $\left(S_{t-1} - b \cdot f^t_{t-1} \right)$ are I(0). The model incorporates both a long run solution and has an error correction mechanism (ECM) when β_2 is negative The term u_t reflects the error correction aspect of that equation.

$$\text{ECM} = S_t - S^{ex}_t = \left(S_t - b \cdot S_t \right) = u_t \tag{11.1.h}$$

Following , it is my intention to list the different possibilities of integration and cointegration that exist[Drymes , Phoebus J. Econometrics(1970) 147];

1.   if $S_t \sim$ I(1) and $f^t_{t-1} \sim I(0)$, then $u_t \sim I(1)$; and the variables , $S_t \sim$ are not cointegrated;

2.   if $S_t \sim$ I(1) and $f_{t-1}{}^t \sim I(1)$, then it might be that $u_t \sim I(0)$, and the variables $f^t_{t-1}, S_t \sim$ cointegrated given that [b,-1] constitutes a cointegrated vector;

3. if $S_t \sim \mathrm{I}(0)$ and $f_{t-1}{}' \sim I(0)$, then $u_t \sim I(0)$, and the variables f_{t-1}^t, $S_t \sim$ are

cointegrated;

4. if $S_t \sim \mathrm{I}(0)$ and $f_{t-1}{}' \sim I(1)$, then $u_t \sim I(1)$, and the variables f_{t-1}^t, $S_t \sim$ are

not integrated;

In a long run relationship between two variables both must be integrated of the

same order if the error term is to be $I(0)$. Stationarity of the error term is especially

important if one is going to examine models incorporating error correction mechanisms.

If the number of variables involved in the long run relation increases, the problem

becomes much more complicated. Considering the four model

$$S_t = \alpha_4 + \beta_1 f_{t-1}^t + \beta_2 S_{t-1} \beta_3 (i - i^*) + \varepsilon_t \qquad (11.1.i)$$

some one has to consider that it is possible for the variables to be integrated for different

orders in order the error term u_t to be stationary. A common situation would be

$$S_t \sim I(1), f_{t-1}^t (2), S_{t-1} \sim I(2) \text{ and } (i - i^*) \sim I(2) \qquad (11.1.j)$$

Despite the different orders of integration , the error term could still be stationary

provided $\beta_1 f_{t-1}^t + \beta_2 S_{t-1} + \beta_3 (i - i^*) \sim I(1)$ This lead to a major complication of the

entire concept of cointegration in a long run relationship and in the stationarity of the

error term. A general rule is, that if the variables in a long run relationship are of

different order of integration and the order of the dependent variable is lower that the

highest order of integration of the explanatory variables, there must be at least two

explanatory variables integrated of this highest order if the necessary condition for stationarity of the error term is to be met.

11.2 Testing for Cointegration

11.2.1 A Suggested Algorithm

ADF is used to determine whether the linear combination of two or more variables for each of the four models is $I(0)$. Special attention is given to the Student-t values and the critical values of the cointegrating test since both depend on the number of the unknown cointegrating coefficients.

An algorithm developed by Enlgle and Granger (1987) is as follows:

StepOne:

First stage in this process is to test for the order of cointegration of the variables involved in the postulated long run relationships. For equation (8.1.i), where two variables appear S_t and f_{t-1}^t, both have to be of the same order of integration.

For equation (8.1.j) where the number of explanatory variables is greater than two, the order of integration of the dependent variable cannot be higher than the order of integration of any of the explanatory variables. In addition, there must be either none of at least two explanatory variables integrated to an identical order higher that the order of integration of the dependent variable.

Step Two:

Second order in this process is to decide whether the cointegrating vector is known, or has to be estimated. Sometimes the cointegrating vector may be known a

priori. For example, if it is believed that the long run spot rate S_t appears to be equal to the forward rate f^t_{t-1} then , is such case the Cointegration vector would be [1,-1] given by [1,-β] or [1, -γ_1,- γ_2] respectively for model (8.1.i) and (8.1.j). Coefficients of these vectors have to be estimated, usually by OLS. If the cointegrating vector is known a *priori* we test the order of integration and then we perform SF Cointegration test to determine the significance of Student-*t* for δ in the OLS regression $\Delta u_t = \delta_1 \Delta u_{t-1} + \varepsilon_t$ where $u_t = S_t - f^t_{t-1}$. The critical values of the test are same as used for testing integration. AFD uses the Student-*t* ration for δ from the equation[Engle, R.F., and C.W.J. Granger.(1987), 251-276]:

$$\Delta u_t = \delta \cdot u_{t-1} + \sum_{i=1}^{k} \delta \cdot \Delta u_{t-i} + \varepsilon_t \qquad (11.2.1.a)$$

If the cointegrating vector is not known a *priori*, and this applies to equations(8.1.k) and (8.1.j) where we are dealing with long run relationships of the type

$$S_t = \beta_1 x_{1t} + \beta_2 x_{2t} + ... + \beta_m x_{mt} + u_t , \qquad (11.2.1.b)$$

and the cointegrating vector s are: [1, -β_1 , - β_2 ,..., -β_m]. In that occurrence the cointegrating vectors have to be estimated. Computationally speaking we use the same ADF equations(11.2.1a) and (11.2.1b) but this time we estimate the residuals from(11.1.2b). The important difference between the two cases is the fact that in the second case coefficients in the cointegrating vector are estimated and the distribution of the student *t* ratio depends on the number of coefficients estimated. In equation (8.1.j) where there are two explanatory variables, and the number of observations is 295, the

approximate critical values for the cointegration test are for the 5% level of significance :
-3.31(lower bound) and -.3.15 (upper bound). The null hypothesis of no cointegration is
rejected if the Student-t value is bellow -3.31, and is not rejected if the value was above -
3.15, and unsure whether to reject or not if the value lies between -3.31 and -3.15.

In the same fashion a 'rough and ready' method for testing cointegration is to
use the an analog of Durbin-Waston test for cointegration which tests estimated
deviations form a long run path which, under the cointegration hypothesis, are stationary:

$$CIDW = \frac{\Sigma(u_t - u_{t-1})^2}{\Sigma(u_t - \bar{u_t})^2},$$

(11.2.1.c)

where $\bar{u_t}$ is the arithmetic mean for the residuals u_t. The power of $CIDW$ depends
positively on the goodness of fit of the OLS of the long run relationship (11.1.2.b). A
'rule of thumb' proposed by Banerge $et.$ $al.$(1986) asserts, if $CIDW$ computed for u_t on
an equation (8.1.1m) is smaller than the coefficient of determination (R^2) for this
equation, the cointegration hypothesis is likely to be false; otherwise, when $CIDW > R^2$
cointegration may occur. If the Durbin-Watson statistic, computed for the residuals of a
static model representing a long run relationship, is close to 2, there is no danger of lack
of cointegration of the variables.

11.2.2 Modeling Cointegrated Series through Error Correction Models

When we dealing with cointegrated nonstationary variables we can estimate a model with
an error correction mechanism. The fact the variables are cointegrated implies that there
is some adjustment process which prevents the errors in the long run relationship

becoming larger and larger. Engle and Granger (1987)have shown that any cointegration series have an error correction representation. The converse is also true where cointegration is a necessary condition for error correction models to hold [(Engle and Granger (1991, 7-8)]

If we assume that in equation (8.1.i) both S_t, f^t_{t-1} are nonstationary with order $I(1)$, and the coefficient β is unknown, but for its *OLS* estimate of β, the DF/ADF tests indicate stationarity of the *OLS* residuals u_t , then we can deduce that there is cointegration between S_t, f^t_{t-1} of order $(1,1)$ and a cointegrating vector $[1,-\beta]$ is accepted. Reasonably, the next step is to switch to a short run model with an error correction mechanism and direct estimate

$$\Delta S_t = \beta_1 \Delta f^t_{t-1} + \beta_2\left(S_{t-1} - b \cdot f^t_{t-1}\right) + \varepsilon_t \qquad (11.2.2.a)$$

where β_2 is negative. Since stationarity of the residuals in $y_t = \beta x_t + u_t$ is not rejected we will estimate (11.2.2a) replacing β by its previously computed OLS estimate β^*. As a result of this substitution, the condition of identical cointegration for the variables in (11.2.2a) is met;

$$\Delta S_t, \quad \Delta f^t_{t-1} \text{ and } \left(S_{t-1} - b \cdot f^t_{t-1}\right), \varepsilon_t \text{ are all } I(0)$$

However, a note should be made here that using Engle-Granger method, we should be aware of the fact that we do not confirm that the relation (11.1.2d) is really a long run one. This is an assumption and cannot be statistically verified. We have to have a strong belief in a long run equilibrium relationship between the variables that is supported by relevant economic theory. Assuming that interest rates are stochastic and

using widely accepted no-arbitrage arguments this section would test cointegration in the currency spot and forward market.

Because of the importance of the unbiased hypothesis in financial theory , many tests for it have been developed. In past literature researchers advocate that cointegration is likely to hold in currency markets and that optimal hedging and forecasting models are market specific. Since market efficiency implies that the price at each point in time should include all available information and, given past prices, no other information should improve prediction of forward price , then cointegration of two speculative markets of two different assets, spot and forward, implies efficiency. The cointegration approach is attractive in that it can properly account for the non-stationarity in price series. Following Engle and Granger (1987) we will test for an equilibrium relationship between S_t and f^t_{t-1} .

The approach is estimating equations   (8.1.i), (8.1.j) and (8.1.k) as the cointegrating or equilibrium regression, and check its least squares residual for stationarity using unit-root tests. If the residual is found to be stationary, the null hypothesis of no equilibrium relationship between S_t and f^t_{t-1} is rejected.

Cointegration between these two variables implies that they never drift part. This is what market efficiency hypothesis implies that the forward and spot rate are "close together". If these two price series are not cointegrated, they will tend to deviate apart without bound, which is contrary to market efficiency hypothesis.

Recent developments in the cointegration analysis by Jonathan (1988,1990) provide a new technique for testing market efficiency. Jonathan devises a statistical

procedure for testing cointegration using maximum Likelihood ratio method. This method tests the parameters of the equilibrium relationship between nostationary variables. In the contrary to the Engle-Granger single equation procedure, Jonathan's procedure is based on the vector autoregressive model that allows for possible interactions on the determination of spot prices and forward prices.

A time series is integrated of order d, denoted $I(d)$. The series can achieve stationarity only after differencing d times. A $I(0)$ series is thus, by definition, stationary; whereas, an $I(1)$ series contains a unit root and is nonstationary. The simplest example of an $I(1)$ series is a random walk. [1]

When the spot price and, S_t, and the forward price, f^t_{t-1} are cointegrated, $I(1)$ then the following linear relationship would be also contains a unit root.

$$e_t = S_t - b_0 - b_1 f^t_{t-1} \qquad (11.2.2.b)$$

Cointegration between S_t and, f^t_{t-1} is a necessary condition of market efficiency. The hypothesis of market efficiency suggests that f^t_{t-1} is an unbiased predictor of S_t on average. If S_t and, f^t_{t-1} are not cointegrated, the error term, e_t is nonstationary and S_t and, f^t_{t-1} tend to deviate apart without bound. Hence, f^t_{t-1} has little predictive power about the movement of S_t which is inconsistent with market efficiency hypothesis. The cointegration is, however, only one of the necessary conditions for market efficiency. Market efficiency also requires that $b_0 = 0$ and $b_1 = 1$ in equation

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[1]. Edam and Dixon (1988) and Shen and Wang (1990) discuss the problem in testing market efficiency when the spot price follows a random walk. Usual F-tests are not valid as the series has a unit root $I(1)$.

(8.1.i), otherwise, f^I_{I-1} is not an unbiased predictor of S_I, even when S_I and, f^I_{I-1} move "closely" together over time. Consequently, a test for market efficiency involves formal testing of restrictions on cointegrating parameters namely $b_0 = 0$ and $b_1 = 1$ which can be conducted using standard asymptotic chi-square tests under the Jonansen approach.

The test for market efficiency thus consists of two parts. The stationary series S_I and, f^I_{I-1} are first examined for cointegration. *Unit root tests* are important in examining stationarity of a time series. Non stationary regressors invalidate menu standard results and require special treatment. In cointegration analysis, an important question is whether the disturbance term is the cointegrating vector has a unit root. Each unit root requires to be first differentiated. Given the importance of stationarity in determining the asymptotic distribution of the coefficient vector, Meese and Singleton[(1982), 1029-1035], were led to test whether the univariate processes of the natural logarithms of spot and forward exchange rates contain unit roots. Their tests are based on the work of Fuller (1976), and Hasza and Fuller (1979). Meese and Singleton (1982) use weekly observations on spot and three month forward rates for the U.S. dollar values of the Swiss franc, the Deutsche mark, and the Canadian dollar. They state [(1982), 1032] "These results suggest that in S, and in F, do not have stable univariate autoregressive representations, even after removing a linear trend."

11.2.3 Testing Cointegration for the three currencies; FF , £, and C$

In this paper, we permit interest rates to be stochastic. Because of the importance of the unbiasedness hypothesis in financial theory we use our cointegration results to demonstrate why we reject unbiasedness and why shocks to the basis and forward premium are persistent and why serial correlation exists in the forward forecast error. We test for unit roots and cointegration. Stationarity seemed not to be present thus we took the first differences to make our series stationary. Tables 11.A and 11.B give the results performing unit root and cointegration test for the British Pound, Canadian Dollar and the French Franc.

Table 11.A Augment Dickey-Fuller : U-root(T,2)

First Difference & a Trend	Canada		France		U.K.	
	Spot	Forward	Spot	Forward	Spot	Forward
U-ROOT (T,1) ADF Statistic Dickey-Fuller t-statistic MacKinnon Critical Values	-1.0171	-1.06	-1.4036	-0.9915	-2.1078	-2.1424
1%	-3.4285	-3.4285	-3.4285	-3.4657	-3.4285	-3.4285
5%	-2.8647	-2.8647	-2.8647	-2.8769	-2.8647	-2.8647
10%	-2.5684	-2.5684	-2.5684	-2.5749	-2.5684	-2.5684

Note: Rejection of the a unit root implies that there is stationarity in the series.

Table 11.B Results of Cointegration Tests

	Canada	France	U.K.
U-ROOT (T,1)			
Cointegrating Vectors			
LGS	1	1	1
LGF(-1)	-0.99967	-0.97056	-0.965364
TREND	-2.88E-05	9.38E-05	0.000141
ADF Statistic			
Dickey-Fuller t-statistic	-10.5144	-3.745	-3.6348
MacKinnon Critical Values		-3.9784	-4.0731
1%	-4.3657	-7.745	-9.9348
5%	-3.8083	-3.8322	-3.8083
10%	-3.5217	-3.5354	-3.5217
Hypothesis testing b=1	2.57031	1.6245	0.61742
b=1 & α=0	37.3491[a]	24.749[a]	15.290[a]
Parameter Estimates for α=(1,-b,-α)	(1, -1.0012, -0.0012)	(, -0.9962 -0.0689)	(1, -1.0011, -0.00114)

Notes: a = 1% level of significance

ADF unit root test is applied to the residuals from the cointegrating regression. This procedure is known as the Engle-Granger Cointegration (EG) test. Under the hypothesis that the series are not cointegrated, and the residual series has a unit root, the expected value of the t-statistic is zero. For a stationary disturbance, the t-statistic will be negative and, as in ADF procedure the hypothesis of a unit root is rejected if the t-statistic lies to the left of the relevant MacKinnon critical value[Econometrica, vol. 55, 251-276].

The statistical results reported at table (10.B) illustrate that the null hypothesis of no cointegration or $r = 0$ is rejected at the 1% 5% and 10% level for all currencies under consideration are cointegrated. The efficient pricing condition, α=0 and b=1, is also tested as a restriction on the cointegrating vector α= (1,-1,0). In addition, a test is conducted to see if b = 1 and $\alpha \neq 0$, which in that case forward prices would explain movements of the spot rates. The statistics for testing the hypothesis b=1 and the hypothesis $-2\ln Q_G$ has a chi square distribution with one degree of freedom . In no case

the hypothesis $b=1$ can be rejected statistically even at 10% confidence levels. However, the hypothesis testing b=1 & α=0 indicates that this hypothesis is rejected at the 5% confidence level of better; hence, while the forward exchange rate seems able to explain movements in the spot exchange rate in the sense of Martin and Garcia (1981), the forward rate appears to be a biased predictor of the future spot rate.

Exhibit 11.A,B,C show the relationship between the spot and lagged forward exchange rates shared by all the three major currencies. Unbiasedness requires the spot rate on average equals to the one month forward rate that ruled the market one month before.

11.3 Pairwise Granger Causality Test (PGC)

Since correlation does not necessarily imply causation in any meaningful sense, the Granger approach questions whether F_t causes S_t to see how much of the current S_t can be explained by past values of S_t and then to see whether adding lagged values of F_t can improve the explanation. S_t is said to be Granger-caused by F_t if F_t helps in the prediction of S_t, or equivalently if the coefficients on the lagged F_t's are statistically significant. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

The PGC tests whether all the coefficients of the lagged F_t's in the first equation may be considered to be zero, and similarly ,whether the coefficients of the lagged S_t's in the second equation are zero. Thus, the null hypotheses being tested states that F_t does not Granger-cause S_t and that S_t does not Granger-cause F_t. Output from the regressions gives the relevant F-statistics for these hypotheses. Table 11C shows the results of

Pairwise Granger Causality after achieving stationarity in the series of spot and forward

for the three currencies.

Table 11.3.C Pairwise Granger Causality

	Canada	France	U.K.
Null Hypothesis Spot, Forward			
Spot is not Granger Caused by Forward			
F-Statistic	1.0311574	1.545326	0.415378
Probability	0.3916	0.1913	0.7975
Forward is not Granger Caused by Spot			
F-Statistic	3.586887	1.871276	0.187408
Probability	0.0073	0.1177	0.9448
Null Hypothesis Spot, Interest Rates			
Spot is not Granger Caused by i - i*			
F-Statistic	1.503302	0.473345	1.2533826
Probability	0.2019	0.7553	0.2889
i - i* is not Granger Caused by Spot			
F-Statistic	2.257269	3.240625	1.444122
Probability	0.0636	0.013	0.2201

TSP-Micro For Time Series and Forecasting V-7

Using just two lags, and testing three series, spot forward and interest rate differential, we

concluded that the forward adds significantly less to the explanation of the spot, than the

opposite. In addition, the interest rate differential adds significantly less to the

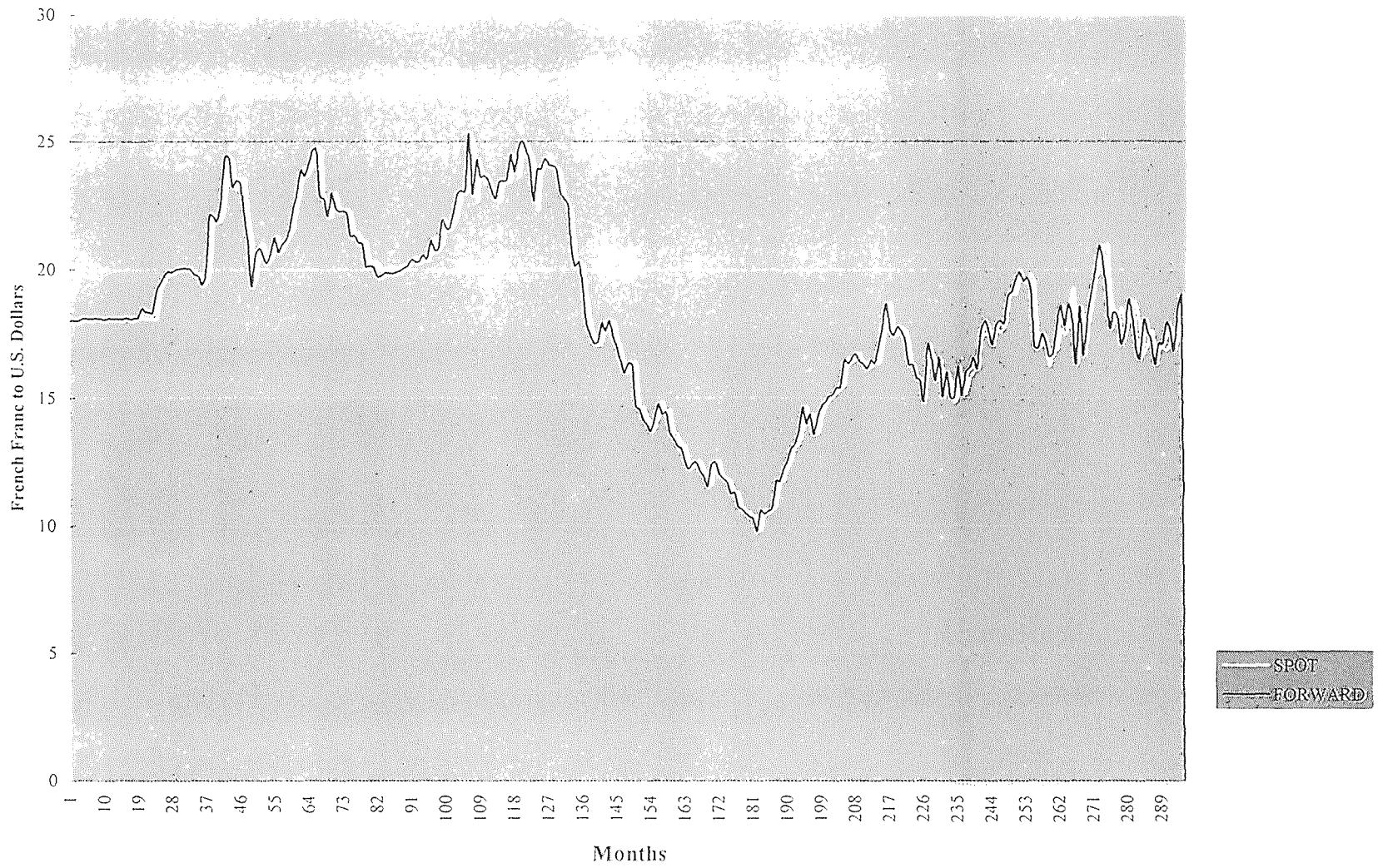explanation of the spot than the spot adds to the interest.

Months

Exhibit 11.A Movement of the Spot and Forward Exhcange
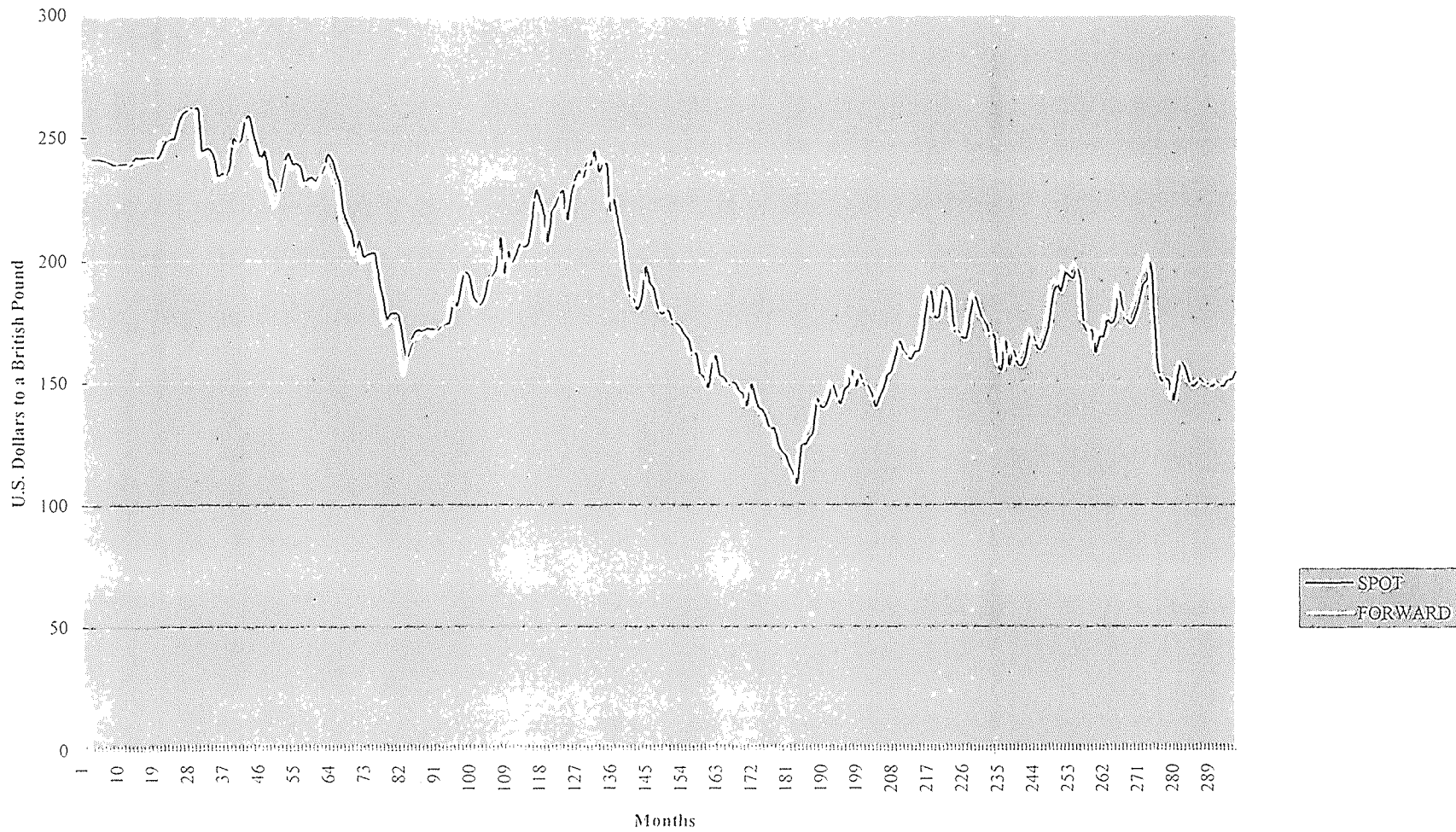Rate of the French Franc between Jan 1970 and June 1994

Exhibit 11.B Movements of the Spot and Lagged Forward Exchange Rate of the British Pound between Jan 1970 and June 1994
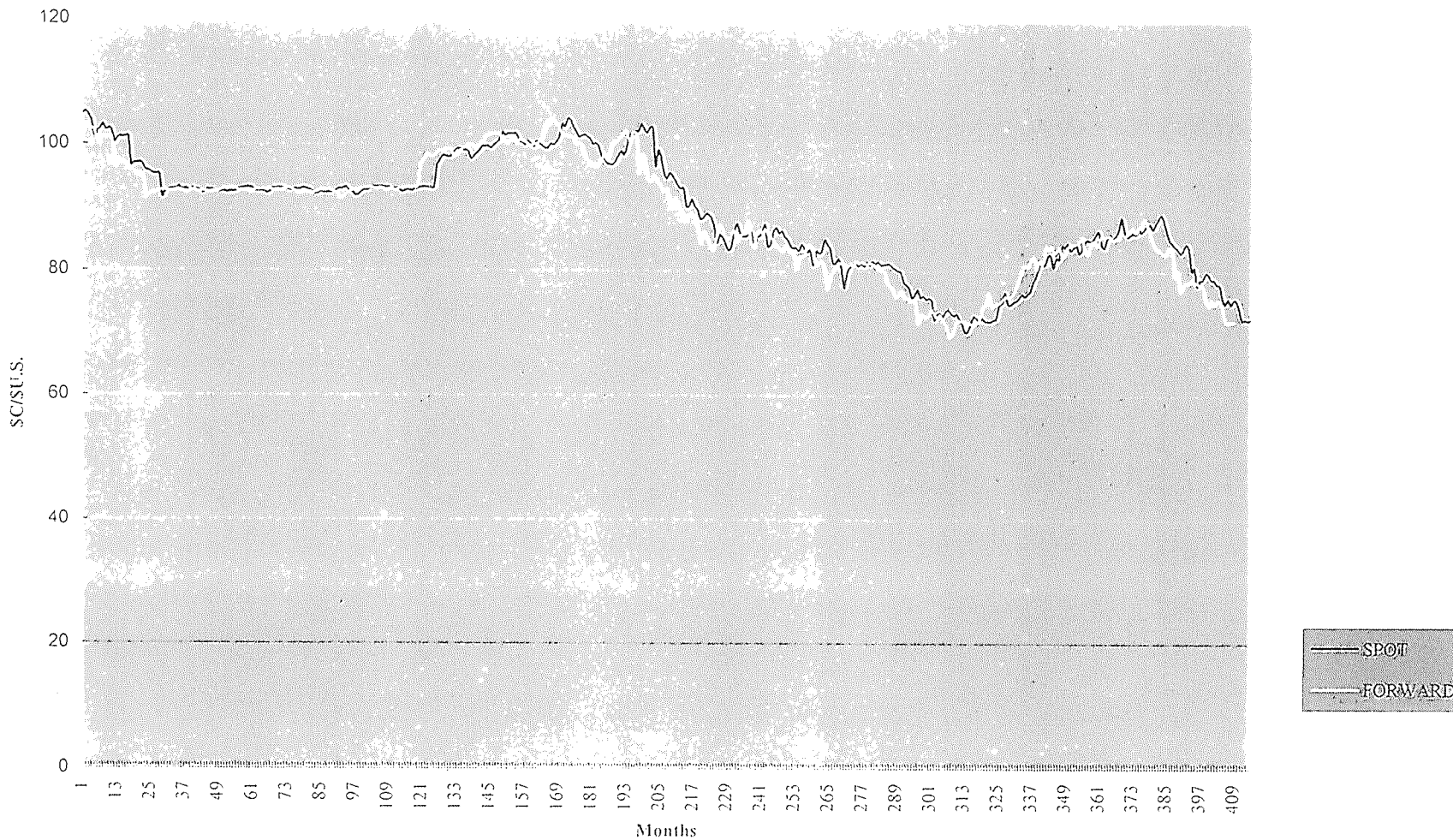
Exhibit 11.C Movement of the Spot and Lagged Forward Rate of the Canadian Dollar between Jan 1960 and June 1994
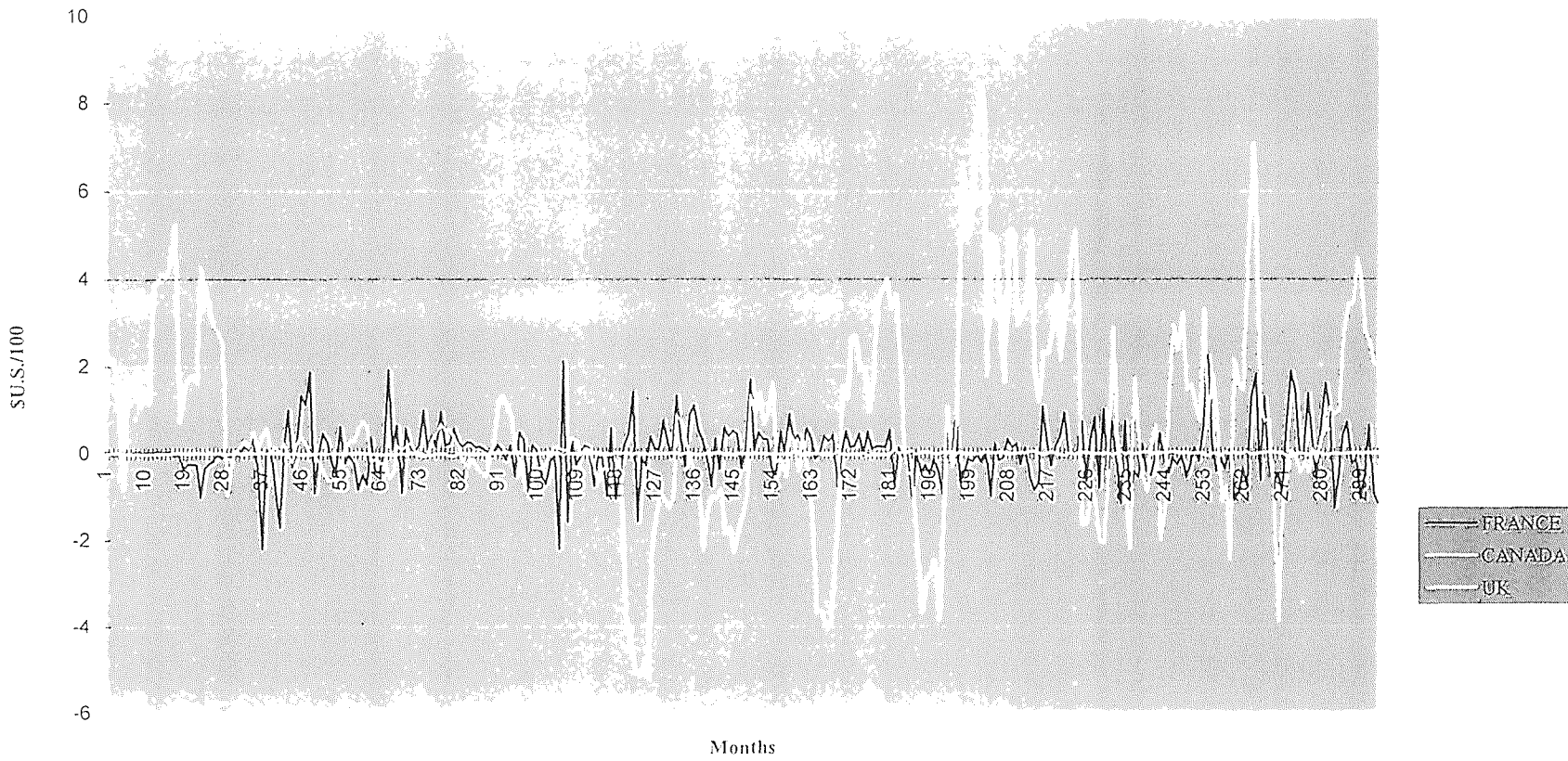
Figire 11.D Movements of the lagged premium for the French Franc, Canadian Dollar and the British Pound

CHAPTER 12

RATIONALIZING INEFFICIENCY FINDINGS

12.1 Possible Reasons

One of the most popular explanations of inefficiency findings is that agents are risk averse and therefore the risk premium, λ_t is nonzero in the next following equation (12.1b). If agents are risk neutral and a profit is expected to be made when the forward rate differs from the expected future spot rate (by taking forward open market positions), one might expect the forward rate for maturity k periods ahead to be forced into equality with the market's expectation the spot rate at time $t+k$.

$$ft = St+k \qquad (12.1.a)$$

On the other hand, if agents are risk averse, then the forward rate will not be driven into a complete inequality with the expected future spot rate because of the risk premium associated with the act of taking an opening position. Under this assumption [Ronald MacDonald and Mark P. Taylor, (1992),.30] we express the risk premium as:

$$lnp = \Delta S^e_t + k + \lambda_t \qquad (12.1.b)$$

where ln denotes the logarithm of the forward premium (fpt= ft-St) and λ_t represents the risk premium necessary to induce agents running open risky positions in the currency in question.

To a great extend, however risk premium has proved elusive. Researchers have recommend to explain rejection in terms of a failure of the expectations component of the joint hypothesis; the view of equilibrium returns and the assertion that agents are

endowed with rational expectations. Bilson (1981) suggested the inefficient information processing and Krasker (1980) suggest the rational bubbles phenomenon of the Peso.

A problem with each of these rationalizations is that in order to test for a failure in one lag period of the efficient market hypothesis, a researcher must assume that the other component is valid. Franker and Froot (1987b, 1990), Macdonald and Torrance (1988b, 1990) and Taylor (1987) all used various surveys of exchange rate expectations from variety sources to test their models. The broad conclusion emerging from this research is that the joint hypothesis fails both because agents are risk averse and because their expectations do not conform to the rational expectations hypothesis [Tryon (1979) and Macdonald R. and Taylor M.P (1989)].

On the other hand, there is staggering evidence to suggest that the forward foreign exchange rate is a biased an inefficient predictor of the future spot rate. The simple version of efficient market hypothesis which assumes risk neutrality has been convincingly rejected for the foreign exchange market. This result is explained in terms of a time-varying risk premium and speculative efficiency

In order to rationalize efficient market hypothesis it is suggested that we analyze a joint hypothesis that foreign exchange market participants in an aggregate sense are: Firstly rational in their expectations, secondly they are risk neutral. If efficient market hypothesis holds true, according to interest parity, the expected foreign exchange gain from holding one currency rather the other, must be offset by the opportunity cost of holding funds in this currency rather the other. The following relationship would hold true:

$$k^S{}_{t+k} = i_t - i^*{}_t \tag{12.1.c}$$

where i_t and $i^*{}_t$ are the nominal interest rates available on similar domestic and foreign securities respectively (with k periods to maturity) and

$$k^{se}{}_{t+k} = s_{t+k} - s_{t+k} \tag{12.1.d}$$

where se denotes the markets expectation based on information at time t.

Testing for randomness of exchange rates if the nominal interest differential is identically equal to a constant, and expectations rational, then this implies a random walk in the exchange rate. Robert and Obstfeld's (1981) tested and rejected the randomness of deviations firm uncovered interest rate parity. Ignoring this, however, it remains true in time series for major nominal exchange tares over the recent float that is hard to distinguish empirically currency movements from random walks[Mussa, M. (1979), 9-57].

12.2 The Profitability of Filter Rules

A simple j-percent profitability filter rule involves buying a currency whenever it rises j percent above its most resent trough and selling the currency whenever it falls j percent below its most resent peak. If the market is efficient and uncovered interest parity holds, the interest rate and commissions cost of such a strategy would eliminate any profit.

Filter rules can also be thought as attempts to test the profitability of trading strategies proposed by chartists. Chartists and proponents of inefficient markets often argue that processes are subject to dynamics induced by trading. One variant of the price dynamics viewpoint is the "bandwagon" hypothesis Dooley M. P. J. and Shafer [(1983),

190-192]. According to this hypothesis small set of market leaders are known, or thought to have more accurate information concerning the factors that will affect future prices. When this group of market participants buys or sells currency, it generates a change in price, a signal is provided to other market participants to jump on the bandwagon. The followers are thought to overshoot the new equilibrium price.

The filter rule methodology is designed precisely to look for this overshooting which is a characteristic of an inefficient market. Dooley and Shafer (1983) use overnight Eurocurrency interest rates as their investment and loan interest rates. The strategy suggest is as follows:

Assuming that the dollar depreciates relative to the British Pound by X percent, a trader borrows dollars and invests in pounds and holds this position until the pound depreciates relatively to the dollar by X percent . Then he reverses his position by borrowing pounds and lending dollars . At the end of the period after loans are repaid, profits and loses are evaluated. express profits and loses as annual rate of return on the size of the position. Dooley and Shafer (1983) examined the profitability of one, three, five, fifteen, twenty, and twenty five percent filter rules for three different sample periods which revealed consistent profitability of the filter across different currencies except for the larger rules fifteen and twenty which produced several large losses.

One argument against the analysis of data with filter rules is always that efficient search across alternatives will produce a profitable filter. Moreover, in their analysis they included three artificially constructed random walks to test whether positive profitability could occur by chance. However, the majority of positive profitability suggests that chance is an unlikely explanation of the results.

Sweeney R. J [(1986),.163-82] argues that the absence of statistical tests of the significance of the profits from filter rule analysis and the lack of adjustment for an appropriate model of risk and return make interpretation of the results of filter rules difficult. Dooley and Shafer's (1983) model of risk and return was the unbiased hypothesis that predicts a white noise for the profits from borrowing dollars and investing in foreign currency. Dooley and Shafer reported the variance of daily changes in the natural logarithms of exchange rates . Their results show that the variance of daily profit is overstated, to the extend that the it leaves out the expected change in exchange rates due to the interest differential.

Mussa (1976) argues that over 90 percent of changes in exchange rates are unanticipated. Statistically only three of the 27 separate cases reveled an annual percentage profit greater that two standard deviations from zero. Also twelve of the observations are within one standard deviation from zero. Hence, even by the criterion of providing profit compared to the naive adjustment implied by the unbiasedness hypothesis, the filter rule profits of Dooley and Shafer do not appear to be particularly significant different form zero by this standard. The fact that all observations showed positive profits, though, suggests that this approach may overstate the lack of statistical significance of the filter rule profits.

Sweeney R. J [(1986), 163-82] compares the one percent filter rule to a benchmark strategy of buying an holding the foreign currency. He recognizes that the benchmark strategy requires an expected return due to risk and that the unbiasedness hypothesis is an inappropriate characterization of the equilibrium risk-return trade-off. He applies his analysis to the US dollar- British Pound exchange market. After an

appreciation of the British Pound relative to the dollar of X percent the US speculator invests a dollar in an overnight denominated that pays the riskless British Pound rate of return. The position is maintained until an X percent depreciation of the British Pound relative to the dollar when the investor repatriates the funds and invests in the riskless asset.

Sweeney tests profitability against the static capital asset pricing model with the following risk adjustment.

$$E_t (S_{t+k} - f_{t,k})/S_t = \beta^G_t E_t (R^b_{t+k,k} - R_{t,k}) \qquad (12.2.a)$$

where

$$\beta^G_t = Cov_t [(S_{t+k} - f_{t,k})/S_t ; R^b_{t+k,k}]/Var_t (R^b_{t+k,k})$$

S_{t+k} = expected spot rate

$f_{t,k}$ = forward rate

$R^b_{t+k,k}$ = expected return on the market portfolio

$R_{t,k}$ = risk free return

Sweeney treated this excess return as a constant denoted g. For a sample of N days, the average risk adjusted profit on buy and hold would provide an estimate of g. Assume that the sample of buy and hold return be denoted $\overline{BH}$

If a filter rule indicates uncovered investment in the foreign currency asset for $(1-f)$ percent of the sample then the sample average excess of returns due to the filter, F

is the sum of excess profit on the days at the foreign currency divided by the total number of days since the time the investor has repatriated his investments he bears no risk holding the foreign currency. His expected value is $(1-f)g$.

In order to determine whether filter rule beat the naive buy and hold strategy, Sweeney examines the statistic $X = {}_F - (1-f) {}_{BH}$ Notice that the percentage X can be still positive even if the average filter rule returns from investing in foreign currencies are smaller than the average buy and hold returns. The speculator bares no risk f percent of the time during the sample.

His results of one-percent filter indicate values after transaction cost that are statistically different form zero at conventional levels. Testing also the profitability of the filter rules without adjusting for the interest differential he found in the case of the Deutsche mark that the test statistics with interest and without interests differentials are quite similar.

Sweeney offers several explanations of the profitability of the filter rules. First, they can be interpreted as evidence against the static capital asset pricing model in which case they might be consistent with another pricing for risk and return. Second, there might be evidence of market inefficiency and insufficient speculative capital. Third, indeed there are present profits gained by speculators because of central bank intervention which systematically looses money trying for example to support week currencies.

More often researchers have tested efficiency by regression based analysis of spot and forward exchange rates. The forward premium at a certain maturity is the percentage difference between the current forward rate of that maturity and the current spot rate. Assuming interest parity

$$(i_t - i^*_t) - f^{(k)}_t - s_t = 0 \qquad\qquad (12.2.b)$$

Under rational expectations, the expected change in the exchange rate should differ from the actual change only by a rational expectations forecast error. Hence, the uncovered interest rate parity condition can be tested by estimating a regression equation of the form

$$s^{ex}_{t+k} = \alpha_t + \beta_t (f^{(k)}_t - s_t) + u_{t+k} \qquad\qquad (12.2.c)$$

where s_t is the current spot rate, $f^{(k)}_t$ is the logarithm of the forward rate for maturity in k periods ahead and u_t is the disturbance term. If there is efficiency then we should expect the parameter, β_t, to be equal to one and the disturbance term u_{t+k} (the rational expectation forecast error under the null hypothesis) to be uncorrelated with information available at time t.

Empirical studies generally report result which are unfavorable to the efficient market hypothesis under risk neutrality (e.g.,Eugene Fama 1984). Froot. K. A and Richard Thaler 1990 found estimates of β_t, usually for exchange rates against the dollar, to be close to negative unity which called that "forward discount bias " which reveals that the forward premium miss-predicts the direction of the change of the subsequent change in the spot rate.

This implies that the foreign currency is at a premium at the forward market at a certain term k, and the less the dollar is expected to depreciate over the k period to maturity. This may imply an expected appreciation of the home currency. Moreover, because the best predictor of the future values of the spot rate is under the assumption of

a random walk, then the simple efficiency hypothesis combined with the random walk

hypothesis would imply

$$f^{(k)}{}_t = s^{se}{}_t \qquad\qquad\qquad (12.2.d)$$

Another difficult area of research is quantifying the influence of government

policies on asset, prices. The rational expectations revolution in macroeconomics leads

to determine the role of the influence of expected future policies on variables such

interest rates exchange rates and stock prices. The question that is imposed is, can we use

historical data to determine the expected future path of government policies or

prerequisite of this finding relies more on theory and fundamental analysis? Hodrick

advocates that simple extrapolations of the past (or autoregressive time series models) are

not very useful in determining expectations of future government policies.

12.2.1 A Critical Analysis on Profitability Rules

Sweeney offers several potential explanations of the profitability of the filter rules. First,

they can be interpreted as evidence against the static capital asset pricing model in which

case they might be consistent with alternative explanations of risk and return. Second,

they may be evidence of market inefficiency and insufficient speculative capital. Third,

they may represent profits that are available to speculators because of central bank

intervention which systematically loses money by leaning against the wind. Following

we want to examine whether there is evidence on alternative models of risk and return

other than the unbiasedness hypothesis. An interesting challenge for these models is to

see whether they explain the apparent profitability of the filter rules.

other than the unbiasedness hypothesis. An interesting challenge for these models is to see whether they explain the apparent profitability of the filter rules.

Saunders and Mahajan (1988) tested price efficiency of stock index futures and contracts and concluded that that they can not reject the hypothesis. However they note that failure to reject "efficiency" does not necessarily preclude the existence of arbitrage profits. In addition to that, the validity of slop test used is questioned , given that in the absence of perfectly elastic arbitrage in the future contracts exhibits some mismatching relative to a cash index. The following normative equilibrium is examined [Pradeep K. Yadav, Peter F. Pope]

$$E(R_t^F)\left[\prod_{w=t}^{T}e^{-E(r_{w,w+1})}\right] = E(R_t^I) \qquad (12.2.1.a)$$

where $r_{w,w+1}$, is the one-period risk-free rate at time w; T, is the value of the time parameter at futures maturity; and (R_t^F) and (R_t^I) are the period t futures "return" and cash return respectively, defined in terms of the t period futures price $R_{t,T}$, the t , period cash index price I_t , and the t period dividend d_t , as:

$$E(R_t^F) = \frac{\{E(F_{t,T}) - F_{t-1,T}\}}{I_{t-1}} \qquad (12.2.1.b)$$

$$E(R_t^I) = \frac{\{E(I_t) - I_{t-1} + d_t\}}{I_{t-1}} \qquad (12.2.1.c)$$

SM suggest that if pricing mechanisms are different, the following regression eq. (8.1.i) should have OLS estimated coefficient of $\alpha = 1$ and $b = 1$

$$R_t^F e^{-r}t, T(T-t) = a + bR_t^I + u_t \text{ where } E(u_t) = 0 \qquad (12.2.1.d)$$

and $ECov(R_t^I, u_t) = 0$

SM state that "...the prevalence of a significant intercept parameter would support the hypothesis that the arbitrage relationship was systematically violated" (SM, p. 214). Their findings show that the null hypothesis $\alpha = 0$ is "...unambiguously accepted and that no systematic excess returns are possible by maintaining a position in the index futures contract", implying that the market is in equilibrium and pricing efficiently. If the slop parameter is significantly different from one this supports the hypothesis that the arbitrage relationship is violated systematically.

Regression eq.(8.1.i) requires SM to assume that cash returns are independent of error term. Studies of index future markets based on the levels of future prices, [Merick (1988,1989), Mackinlay and Ramaswamy(1988), Yadav and Pope (1990) attempted to identify opportunities for riskless returns, using trading strategies rules which exploited the known change in cash futures between the day of the trade and the expiration day. The relevant measure of efficiency in these studies is implicitly the number of cases in which the deviation of actual prices from non-arbittrable prices exceeds transactions cost-based starting point. Merick(1988)(for US data) and Pope (for U.K) data tested OLS regression of equation (8.1.i). Judgment based only on the regression line can obviously mask significant characteristics of the data- in particular the systematic pattern in mispricing returns. (i.e., the regression residuals). They reported that the returns on one-

day hedges are significant and positive (negative) if such hedges are established when mispricings initially were positive (negative), even though the average returns on one day hedges are zero.

In almost all cases, OLS regressions reveal that the residuals are autocorrelated and that the residuals could be best modeled as AR(1) prices. The hypothesis $\alpha = 0$ is almost never rejected. Futures returns are significantly more volatile than the cash returns, but because of the lower correlation between them, b remains below unity. Furthermore, for every contract, the implied correlation between cash returns and mispricing returns is consistently greater in magnitude than the implied correlation between cash returns and mispricing returns. Following we intend to mention some evidence against market efficiency and giving some explanations for arbitrage extra returns above risk premia.

12.3 Evidence Against Market Efficiency

Historically interest parity is not validated; when foreign interest rates rise above U.S. rates, the foreign currency rends to rise in value rather than fall. These results suggest a profit-making strategy for investors. Looking at the data over the period 1973-93 collected by Grefory P.Hopper [Business Review May/June 1994] on spot and forward exchange rates of Canadian/U.S. dollar we see that the forward exchange rate for Canadian vs. U.S. dollars does not tend to fluctuate randomly around the one-month-ahead spot exchange rate., but rather tends to stay below the spot rate for extended periods when the spot rate is rising and to stay above when the spot rate is falling. Hence the forward rate under-predicts and other times over-predicts the future spot exchange

rate. But it does not systematically over- or underpredicts the future exchange rate as a

biased predictor would.

Biasedness of the forward exchange market predicting the one-period ahead

future spot exchange rate suggest that the foreign exchange market may not be efficient.

However , economists are not convinced that forward exchange rate bias proves that the

foreign exchange market is inefficient.

12.4 Testing Efficiency : Risk Premia

We established the assumption that in the foreign exchange markets participants are risk

averse . Thus, the uncovered interest parity conditions may be understated by a risk

premium, ρ_t , since investors would demand a higher rate of return than the interest

differential of holding the foreign currency.

$$i_t - i^*_t = k^s_{t+k} + \rho_t .$$ (12.4.a)

If the risk premium is time-varying and correlated with the forward premium or interest

rate differential, this would perplex efficiency tests on the assumption of rational

expectations. Based on the capital asset pricing model which establishes a theoretical

relationship between risk and asset returns distributions, researchers have often tested

for a risk premium as a function of the variance of forecast errors or of exchange rate

volatility. (Frankel 1982b; Ian Domowitz and Hakio 1985; Alberto Giovanni and Philipe

Jorion 1989). As noted by Lewis, for acceptable   degrees of risk aversion, empirical risk

premium models have so far been able to explain the variation in the excess return from

forward market speculation. Next, I we would like to examine what happens when

market participants, even they are rational are influenced by the so called 'market psychology' which is a situation where a self reinforcing movement drives the price of the currency away from equilibrium. Specifically, this is the question; how can someone be adequately compensated for the risk of a holding a currency which as rational agent, is fully aware from market fundamentals that is overvalued. Such case did occur in the past where the majority of investors kept dollars for a big period of time, thus a high exchange rate was maintained. This lead us to talk a little bit more about expectations and efficiency.

12.5 Efficiency and Expectations

If expectations are formed rationally the market will still make wrong forecasts but its errors will be random. The rejection of the efficient market hypothesis is that there is a failure, in certain ways, of the expectations component of the joint hypothesis. Examples in this group are the 'peso problem' suggested by Rogoff (1979). The peso problem refers to the situation where agents attach a small probability to a large change in the economic fundamentals, which does not occur in sample. This will tend to produce a skew in the distribution of forecast errors even if agents' expectations are rational, and thus may generate evidence of non-zero excess returns from forward speculations. Similarly when agents are learning fundamentals of a certain environment they may be unable to exploit arbitrage opportunities which are apparent in the data ex post.

Assuming that investors participants in the foreign exchange expect that the accession of England in the European Monetary System would set the exchange rate of sterling to the dollar at a fixed rate $151^{\$/£}$. However, in the short run the likelihood of

this acceptance is very small. This will result, though to an appreciation of the British

Lira assuming the current exchange rate is $145^{\$/£}$, and this because of the small

probability that during the probability of the trading period the sterling will be

appreciated. Furthermore this is expected to influence the forward rate too, where the

premium or discount will be less favorable to the dollar than it seems justified according

to the market fundamentals.

The above example shows that models based on rational expectations will

simply fail because of the news factor which seemed to overstate the value of the pound.

There are two main reasons given where the relationship between the fundamentals and

the exchange rate behavior.

First, is the possibility of missing variables in the list of market fundamentals

that should have been considered otherwise, since many apparent departures from

rationality are due to unobservable or limitless variables. Secondly, is due to a sampling

problem such as the well known Peso Problem. Next, we would like to explain some of

the unexpected variation in exchange rates bringing into the platform the 'news'

approach .

12.6. Incorporating Information "NEWS"

12.6.1 How "NEWS" Contributes to Exchange Rate Volatility.

In this section I will focus on the error term ε_t .The error term here will be seen as an error

arising from mistakes made from economic agents in forecasting the future actual spot

rate. Assuming rationality this error term is attributable to newly arrived information -
"news" or "innovations" relevant to exchange rates.

Such information may be political changes, socioeconomic statistics,
international monetary arrangements, and so on. It remains a problem of isolating the
element of news. For example, it is not England's deficit that has an impact on the British
Pound exchange rate but rather the extent to which the announced deficit is grater or less
than the anticipated *ex-ante*. Thus, in order to have measure for the variable news we
need to know the *ex-ante* expectation of the news variable in question.

12.6.2 The "NEWS" Model: A Simple Example

The simplest form of news model would be the following.

$$S_t = \gamma \cdot z_t \tag{12.6.2.a}$$

where γ is a slop coefficient and z_t is the fundamental variable or variables at time t,
determining the exchange rate. Assuming rational expectations, agents will form their
expectations of next period's spot rate based on equation 12.2.2a Thus at time t-1 they
will use available information in the set I_{t-1} to form conditional expectations of

$$E_{t-1}S_t = \gamma E_{t-1}S_t z_t \tag{12.6.2.b}$$

Forming a rational expectations of the exchange rate involves, as prerequisite, forecasting
the fundamentals. To derive the forecast error of the expected spot rate we can subtract
equation (12.6.2.b) from (12.6.2.a).

$$S_t - E_{t-1}S_t = \gamma (z_t - E_{t-1}S_t z_t) \tag{12.6.2.c}$$

Equation (12.6.2.c) shows that the difference between the unexpected exchange rate and the expected exchange rate is equal to a multiple, γ of the deviation between the actual fundamental variable and its mathematical expected value.

Assuming rational expectation this model is very important in regard to what they implying. Firstly, it assumes that economic agents know the model that links the endogenous variable, S_t to the fundamentals, z_t -and allow as to conclude that the same model will link expectations of those variables. Secondly, rational expectations allows us to understand that the "news" is that part of the fundamental variables which is unforeseeable using the data set I_{t-1}. Also theses deviations of the actual outcome of the fundamental variable/s from its/their mathematical expectation are random with a an average value of zero and display no systematic pattern overtime.

Equation (12.6.2.c) supports a direct relationship to the efficient market hypothesis model

$$f^t_{t-1} = E_{t-1}S_t + P_{t-1} \qquad (12.6.2.d)$$

subtracting S_t +for both sides of the equation we get

$$f^t_{t-1} - S_t = (E_{t-1}S_t - S_t) + P_{t-1} \qquad (12.6.2.e)$$

The crucial term u_t has been substituted for the expression in the angles on the right side which is simply the percentage gap between the market expected the exchange rate to be at time t-1 and what is the actual outcome.

Substituting equation (12.6.2.c)into (12.6.2.e) we get

$$f^{t}{}_{t-1} - S_{t} = \gamma \left(z_{t} - E_{t-1} S_{t} z_{t} \right) + \rho_{t-1} \qquad (12.6.2.\text{f})$$

Now equation (12.6.2.f)is a general version of the efficiency model with the expectational error u_t written out explicitly for 'news'. Theoretically, equation (12.6.2.e) is acceptable, however, it imposes some problems for testing it since we don't know first to measure market expectations of the exchange rate its self; second we don't know which are the fundamental variables that we have to consider and third how do we measure market expectations..

Pertaining to the first question most researchers have been used the forward rate as a proxy for the expected spot rate. It is obvious that this solutions is not ideal since it simply involves replacing two unobservable variables, the expected spot rate and the risk premium with the an observable, the forward rate. If can safely assume that the risk premium is zero, or constant at least, this substitutions will not bias the results. If the risk premium is variable is variable, it will definitely distort the conclusions.

For the second question, researchers have used mostly monetary and current account variables. There are many 'news' variables or at least strong participants, which have never been employed simply because they are inherently difficulty to quantify: for example, information bearing on the likelihood of a change of government or UK joining the European Monetary System , and so on.

The issue which has received most attention has been the measurement of expectations with respect to the fundamentals. A number of different approaches have been taken:

12.6.3 Univariate Time Series Predicting the Error Term.

Researches included in their models fundamental variable in the form of univariate time series. This methodology supports the weak rational expectations assumption. market expectations are conditioned only on the past history of the variable in question, so that the innovations (news) in each of the fundamentals is simply that part which could not be predicted by looking at the pattern of fluctuations in the variable in question, taken in isolation. So, for example, this approach would involve extracting an estimate of the future actual spot rate , $E_t\, s_{t+1}$ form a linear combination of s_t , s_{t-1}, s_{t-2} and so on, that is:

$$s_t = \,\alpha_0 + \alpha_1\, s_{t-1} + \alpha_2\, s_{t-2} + ... + \alpha_n\, s_{t-n} + u_t \qquad (12.6.3)$$

Then the 'news' is simply the residual from the estimating equation, u_t . Unless one believes that market expectations are only weakly rational this approach is unsatisfactory, though it has the attraction of simplicity.

12.6.4 Predicting the Error Term Using Multivariate Time Series and Vector Autoregression

Theoretically speaking if we can assign a broader information for each variable we can get closer to the prediction of the future actual spot rate. In a similar way we can consider forecasting the future spot rate in the context of rational expectation using a special array of relevant variables selected such as, a countries external deficit past and present, the rate of inflation, interest rates differential, the growth rate of the economy and so forth.

To illustrate this procedure we suppose that we have m variables in the set

of fundamentals. Assume the first is z^1, the second, z^2, and so on, so that z^2_{t-3}, for example, denotes the value of the second fundamental variable three periods ago. Then generate a forecast of z^1_t by using past values of z^1, in combination with past values of all the other fundamentals, z^2 to z^m. In general, the jth fundamental is modeled as:

$$z^j_t = f\left(z^1_{t-1}, z^1_{t-2} \cdots z^1_{t-L}, z^1_{t-1}, z^1_{t-2} \cdots z^1_{t-L} \cdots z^m_{t-1} \cdots z^m_{t-L}\right)$$

$$(12.6.4)$$

where L is the maximum lag (the 'memory length') judged relevant on the basis of the standard tests used in time-series statistics. The 'news' about z^j is simply the residual error from this equation.

A number of studies have been published attempting to relate movements in the exchange rate to the 'news' content of discontinuous variables - like the money stock, national current account money supply announcements etc.. Notice that, the impact of individual 'packages' of 'news', is not really a test of the standard 'news' model. Announcements tend to wrap up several 'news' items in the same 'package' and is hard to this work to perform a test of the standard 'news' model.

For example, the figure for the U.K. narrow money supply is released at the same time as that for broad money, as is the data on the volume of bank advantages. Most of the times a number of different price index announcements occurs simultaneously. It therefore becomes impossible to isolate the effect of any single element in the package. Secondly, the other approaches all relate to the impact of 'news' aggregated over the whole of the time period involved, whereas the announcement

approach attempts to provide equal access for the impact of 'news' by concentrating on very short periods of at most a few hours, so as to be sure of isolating the impact of a single 'news' package. Thirdly, and most importantly, using directly observed expectations involves no assumption of rational expectations. It is quite possible to imagine a scenario where money supply announcements are consistently and closely associated with exchange rate fluctuations, but where the 'news' content of the announcements is the residual from a non-rational forecasting process.

12.6.5 Financial Variables

Financial variables may manifest the same information as the spot exchange rate, even though within a different structure. There are some considerable implied advantages in using financial variables. Firstly, they share with the major currencies the intrinsically forward-looking characteristics of continuously traded assets: prices are continuous, instantaneously reflecting (or so one might hope) daily or hourly changes in market perceptions about the level of all the relevant variables, whether they are unbounded (like political factors or market 'confidence'), or more straightforward macroeconomic variables. Secondly, since the same agents are often active in both markets, there seems reason to suppose what is true of understanding in one will equally hold good in the other market.

On the other hand, a major obstacle with this approach is that, if it is to avoid being completely arbitrary, it requires a model relating the stock price index or other financial variable to the fundamentals which may be hard to get. Share prices *ought* in principle to be discounted (probably risk-adjusted) sums of expected future cash flows.

If share prices are directly related to expectations with regard to levels of economic activity, then stock market indices embody useful 'news'. We should note here that, evidence support that no combination of 'news' variables has come anywhere explaining the volatility of exchange rates. Some researchers suggested that lagged 'news' terms could significantly predict movements of the foreign exchange. However, in some cases that resulted simply because of exchange controls. One variable though, which consistently yields significant results is definitely the interest rate differential. Nonetheless, there is some doubt as to the direction of the effect if has , with a positive coefficient during 70's (denoting unexpected inflation) and negative during the 80's.

CHAPTER 13

SUMMARY AND CONCLUDING REMARKS

This work has surveyed a rich set of empirical results that address questions regarding the efficiency of the forward foreign exchange markets.

We started our introduction mentioning the factors most likely to determine the value of currencies. These factors are related to the relative money supplies, relative real incomes, relative prices, differences in inflation, the interest rate differential, and the relative asset supplies and demands in the two national economies. These arguments are organized as exchange rate theories; the balance-of-payments approach, the monetary approach, and the portfolio balance approach.

Chapter two, introduces the guiding principles that dictate international trade flows and capital movements. These principals are summarized as international parity conditions.

Chapter three discussed the different forms of market efficiency, beginning with the weakest hypothesis and ending with the hypothesis against efficient markets. Each hypothesis is associated with the degree in which new information is quickly understood by market participants and immediately incorporated into market prices such as forward and spot rate. Conventional approach in explaining. irregularities in the currency markets is to regard the foreign exchange as an asset price, that is a relative price of two national currencies. Chapter four covers important aspects of efficiency, expectation, and risk in the forward exchange market. First, it examines the efficient market hypothesis as applied to both spot and forward market; secondly, it presents several expectation

hypotheses and discuses their implications in the foreign exchange market. If the efficient market hypothesis can explain the behavior of exchange rates, it should not be possible for investors to obtain abnormal returns. If it is inapplicable, then such methods as trading rules and fundamental analysis may afford investors superior results. The evidence is somewhat mixed, but consistent with the efficient market hypothesis. A casual examination of the facts reveals that the forward rate, is without doubt, a poor forecast of the future spot rate. The forward premium statistically underestimates the amplitude of subsequent spot rate fluctuations . Explicit examples of the failure of the rational expectations assumption, such as the study conducted by Lewis (1986), questions the assumption of rational expectations and demonstrate how serially correlated forecast errors could result if agents are learning about a government policy. These events must always be kept in mind in interpreting the results of any study employing the rational expectations econometric methodology.

Most evidence appears to support the hypothesis that the current spot rate outperforms all other models in predicting the future spot rate. Is the current spot rate really the best predictor of the future spot rate?

Chapter five furnishes a thorough examination of the unbiased concept. Research results indicate fairly conclusively that the forward rate is not an unbiased predictor of the future spot rate. This was strongly supported in the case of the British Pound and the French Franc. We give two possible reasons for rejecting it. As Fama demonstrated, the nature of the rejection of the unbiased hypothesis (if the statistics are taken as correct) relies on two arguments; first, that the risk premiums and expected rates of depreciation co-vary negatively and secondly, that the variability of risk

premiums is greater than the variability of expected rates of depreciation. Fama found such results troublesome and suggested that they might represent evidence against an efficient market. The outstanding issue appears to be what would be the source of the volatility. Most of the existing tests for the unbiased hypothesis should be expected to result in rejections. This theoretical result, combined with the vast empirical literature that supports it, should cause us to question the common assumption of the unbiased hypothesis in financial models. The evidence appears to be very strong and consistent across currencies, maturities and time periods. The nature of the tests of unbiasedness is that they rely on asymptotic distribution theory to generate distributions of test statistics. The empirical research is forced to assume that the data satisfy an ergodicity assumption.

One possibility is that the small sample distributions of the test statistics simply do not coincide with the asymptotic theoretical distributions. A second line of criticism of the typical tests in this area concerns the validity of the ergodicity assumption. It is relatively easy to envision scenarios that lead to failure of the ergodicity assumption. Whenever there are potential changes in government policy processes that have not occurred in the sample, the data is not ergodic. Ergodicity is also a problem if there are events that occur during the sample but not with the appropriate frequency to correspond to their a priori probability. This is the classic 'Peso Problem' of too few devaluations during a fixed rate regime discussed in chapter nine. Lizondo (1983) demonstrates how prospects of a devaluation that does not occur during a sample can distort inference. Obstfeld (1986) provides a nice example under flexible exchange rates of the incorrect inference that arises if agents are rationally expecting an event that does not occur during the sample.

Chapter six uses the random walk as a benchmark for efficiency and associates with unbiasedness by presenting some empirical findings. Much confusion has been generated by claims that the exchange rate ought to follow a random walk in an efficient market. This is simply false. The statistical time series analysis indicates that exchange rates are so volatile that it is difficult to distinguish them from random walks. A potential problem with such studies is that they typically assume that the conditional variance of exchange rates is constant.

Chapter seven introduces the models that are going to be tested in this research as well as how they are derived.

Chapter eight presented the statistical results of basic time series regression test pertaining to the models mentioned in chapter seven, whereas chapter nine continues testing the models for validity and specification.

All countries exhibited small variances when the general efficiency model was tested but were not constant over time. The most efficient currency seems to be the French Franc and the least efficient, the British Pound. The Canadian dollar exhibited a positive risk premium which suggests that investors will accept a lower exchange rate for the safety of the forward market. In general, the results are not encouraging for the "general efficiency" hypothesis. There is substantial, but not overwhelming, evidence of unexploitative profit opportunities in the currency markets. Moreover, the deviations from market efficiency that have been uncovered seem difficult to square with any simple pattern of risk premium variation. Recent research indicates that the explanation may lie in irrational expectations as we elaborate in chapter twelve. The OLS tests reveal that the coefficient estimates are quite accurate since their probability density function is quite

narrow. No country under investigation displayed a high residual sum of square, only England showed some autocorrelation. Heteroscedasticity is rejected by all models for all currencies. The Ramsey test showed that we could not reject the fact that by adding additional variables we can explain better the dependent spot rate. Canada does not reject the premise that improvement occurs for the first equation in the regression fit when the sample was broken into two different periods. However, this is not true though for the second and forth equation.

Comparative tests between two periods did not show any significant difference. Restriction test revealed that all countries can not reject the fact that the improvement of the fit of the equation from the unrestricted to restricted version, is significant except the Canadian dollar in the second and fourth equation. Residual tests suggest some serial correlation. France and England display some serial correlation, mostly on the first third and forth equation.

Chapter ten tests for general diagnostic and specification. First, I tested for overall fit. Almost all equations showed satisfactory F-statistics with their associated probabilities. Secondly, I examined the sign, magnitude and precision of the estimated coefficients. Almost all coefficients comply with *a priory* expectations and are statistically significant. Third, I tested for serial correlation of the residual term. France and England showed some serial correlation when we applied the Lagrance Multiplier test but no significant auto & partial when I applied BP and LBQ statistics.

Chapter eleven, talks about cointegration and how this concept applies in testing the efficiency of the foreign exchange markets. The problem in testing the forward or futures market efficiency is that financial price series are generally

nonstationary. When the series are nonstationary, conventional statistical procedures are no longer valid in providing a test for market efficiency. Stationarity was not present in this research; thus, we took the first differences to make our series stationary. The results of cointegration-based unbiasedness test depends entirely on the stochastic properties of the differential, and need say nothing about the rationality of risk neutrality of market participants. When I tested for cointegration it was clear that the null hypothesis of no cointegration was rejected for all currencies. However, the unbiased hypothesis of forward efficiency is questionable. While the forward rate seems to explain movements of the spot, the forward though appears to be a biased predictor of the future spot. A test for Pairwise Granger Causality showed that the forward as well as the interest rate differential between the home and host countries adds significantly less to the explanation of the spot rate as oppose the spot defining either the forward or interest rate changes.

Finally, chapter twelve attempts to rationalize the results. The claims of excessive trading rule profitability are explored, and the findings of some studies are examined statistically. Unfortunately, without having a rejected model of expected returns that vary through time, it is difficult to know whether the apparent profitability of some of the trading strategies is simply consistent with changes in the riskiness of currencies or whether the evidence is truly a market inefficiency. Reconciliation of the filter rule studies with the models of time varying risk premiums is a challenging area of future work.

The volatility of unanticipated exchange rate movements remains largely unexplained. Under rational expectations, it ought to be the case that the variance of the

observed spot rate is no greater than that of the fundamentals which determine it.

However, learning about the change on the exchange rate process may possibly explain

the forward rate bias for some currencies during episodes, its relevance for explaining the

prolonged periods of systematic forward rate bias of many different currencies is likely to

be limited.

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