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AN EMPIRICAL TEST OF MARKET EFFICIENCY HYPOTHESIS IN THE CURRENCY FUTURES AND FORWARD MARKETS

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EVALUATION DE BONS DE SOUSCRIPTION D'OBLIGATIONS

UN TEST EMPIRIQUE DE L'HYPOTHESE D'EFFICACITE DU MARCHE DANS LES CONTRATS A TERME SUR DEVISES ET LES MARCHES A TERME

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RESUME

Comme Cornell & Reinganum (1981) l'ont montré, la différence de cours entre les marchés à terme et les contrats à terme sur devises est négligeable. Le test d'efficacité des marchés devrait donc donner des résultats similaires pour ces deux marchés.Toutefois, des études concernant l'efficacité de contrats à terme sur devises et de marchés à terme donnent des résultats non comparables, même pour la même devise, du fait de différences entre les périodes d'intérêt, les données, et d'ordre différences méthodologiques. Pour permettre une comparaison des résultats du test d'efficacité du marché, les deux marchés ont été analysts en appliquant les mêmes méthodes d'estimation, et sur des données obtenues durant la même période.

La forme semi - forte du test d'efficacité a été appliquée à quatre devises, à savoir le dollar canadien, le mark allemand, la livre britannique, le yen japonais et le franc suisse, durant la période 1974 à 1986. Le test d'efficacité a été conduit en faisant l'hypothèse que les taux de change reflètent toutes les informations publiquement disponibles.

Les données concernant cinq &vises provenaient des Recueils annuels des données des marchés monétaires internationaux (International Monetary Market Yearbook). Dans la collecte des données concernant les contrats à terme et les taux interbanques, on s'est assuré de la coïncidence des dates de cotation et de fourniture pour les taux de change des marchés à terme et des contrats à terme sur devise.

Pour mettre en évidence la relation entre devises, des modbles sont estimés conjointement en applicant la technique de regression de données aapparemment non correlées. Au stade de l'estimation les corrélations sérielles et la matrice de variance - covariance sont dirigées en appliquant respectivement les techniques de Cochran - Orcut et de White.

La statistique de Wald a été utilisée pour tester l'hypothèse d'une équatio,n unique et d'un système d'équations. Le résultat de la statistique de Wald indique, comme prévu, d'étroites similitudes entre les marchés.

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ABSTRACT

As Cornell & Reinganum (1981) shows that the price differential between forward and currency futures markets is negligible. This implies that the market efficiency test has to give similar results for both markets. Although, there are studies relating to the efficiency aspect of the forward and futures markets, the results of these studies are not comparable even for the same currency market due to the period of interest, data and methodological differences. In order to be able to compare the results of the market efficiency test, in this study both markets have been analyzed by applying the same estimation methods on the data obtained from the same time period.

The semi-strong form of the efficiency test has been applied on five currencies, namely the Canadian Dollar, German Mark, British Pound, Japanese Yen and Swiss Franc, for the period 1974 to 1986. The efficiency test has been carried under the assumption that the exchange rates reflect all publicly available information.

The data related to five currencies have been obtained from the International Monetary Market Yearbooks. In collecting data for futures and interbank rates, it has been ensured that both the quoted date and delivery date coincide for forward and futures exchange rates.

In order to capture the cross currency relationship, models are estimated jointly by applying the seemingly unrelated regression technique. In estimation stage serial correlations and the variance-covariance matrix are corrected by using Cochran-Orcut and White techniques, respectively.

Wald statistic has been used to test the efficiency hypothesis for single and system of equations. The result of Wald statistic indicates close similarities between markets, as it is expected.

1. INTRODUCTION:

Volatility created by the flexible exchange rate system has introduced additional risk or uncertainty in the future price of foreign currencies in terms of the domestic currency, which also caused uncertainty in the domestic future price of imports and exports[1]. Prior to the flexible exchange rate system the net risk exposure of a currency transaction was negligible due to the central banks and/or governments interference in the market to keep exchange rate within predetermined bands. However, in the flexible system these interventions are not frequent and there is no specifically established currency fluctuation band (except within European Monetary System). Therefore, the level of net risk exposure in the flexible system is relatively high compared to the fixed exchange rate system.

As in other markets, the future price uncertainty in the currency market forced economic agents to establish mechanism, to eliminate the price risk. In 1972, International Monetary Market (IMM), as a division of Chicago Mercantile Exchange (CME), began to offer futures contracts on various major currencies along with forward contracts offered by banks[2].

Since international trade is an important part of the world economy and the transfer of commodities, services, and financial assets among agents of different countries require transactions in different currencies, it was no surprise that there was a quick expansion of these markets. It is also important to note that the introduction of financial instruments (e.g. treasury bonds, treasury bills, equities) in the futures exchanges and the deregulation of capital movements towards a mode tolerant structure by industrial countries have contributed to the expansion of currency trading by easing the flow of capital funds between countries. Another reason for this success is the exchange rate volatility experienced over the last 15 years. As Dornbusch (1986) stated the real exchange rate movement was 30-40% in this period.

Recently, other currency futures exchanges (e.g. Singapore International Monetary Exchange) have been established around the world following the success of IMM. However, IMM is still the largest currency futures in terms of volume and the variety of currency contracts offered. In 1986, in terms of transaction volume, the share of currency futures in the IMM was 35%, and between 1983 and 1986 trading volume of currency futures increased by 27%.

With the expansion of currency futures and forward markets, both theoretical and empirical studies on these markets have increased. In the last decade, there have been many empirical studies addressing the efficiency aspect of currency markets with special interest in the forward market[3]. To be effecient in an economic sense is very important for markets because the prices determined in these markets have to give accurate signals, for resource allocation. Market efficiency in these markets requires that forward and futures exchange rate. are the best indicators of the future spot rates at the time they are quoted. In case of currency markets, whether spot or forward or futures market, efficiency is highly important because of the potential widespread effects of currencies on both domestic and international economies.

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The number of studies relating to the efficiency aspect of the forward market are greater than the same type of studies on the currency futures. This also reflects the relative importance of each market with respect to size. There is no consensus on the test results and they are not comparable even for the same market due to the differences on the methodology, data used, and the period of interest. The aim of this study is to test the market efficiency hypothesis for both markets in a period of 12 years by applying the same methodology to both markets examined and ensuring that both quoted and delivery dates coincide for forward and futures exchange rate.

Although futures and forward markets serve the same purpose, they differ in terms of operational structures and services they provide. Therefore, it is important that these aspects have to be elaborated before testing the market efficiency hypothesis.

1.1. Currency Futures Market:

The futures exchange brings sellers and buyers together in a predetermined trading place, giving participants the opportunity of obtaining the best possible offer at a given point in time. Selling and buying orders are matched by "out crying" of floor brokers, that is by auction. When the representative floor brokers of both members agree on a transaction, they register the transaction with the clearing house. Afterwards, the clearing house becomes buyer (seller) to seller (buyer), so that parties are responsible to the clearing house rather than to each other.

Someone who wants to enter forward trading in futures exchange, has to place an order with a futures commission merchant who will charge a commission a brokerage fee for their service. The fee is variable depending on the type of transaction (e.g. long, short), the size of the transaction and the risk level of the order.

When a transaction is registered at the clearing house, in addition to the payment of a brokerage fee, customers are required to deposit a specified amount of money into their accounts for each contract they buy or sell. This is called the "initial margin" or simply "margin" which is viewed as a performance or good faith bond[4]. The required minimum amount of margin is usually less than 20% of the total value of order, and it is determined by the exchange. However, a broker may request higher margin payment from a customer depending on price volatility, type of position (e.g. long, short) and the objective of the trade (e.g. speculation, hedging). Nevertheless, the broker is not allowed to decrease the margin payment below the minimum level set by the futures exchange.

The clearing house requires daily settlement in cash for every price movement for all contracts registered. This is called the "mark to market" which means that at the end of a trading day, each clearing house member's account is either debited or credited depending on the price movement. In case of an unfavorable price movement, the account is debited up to a certain level which is called the "maintenance margin". This margin is also set by the exchange and it is lower than the initial margin. If the amount of deposit in the account is less than the maintenance margin, then the customer will be called by his broker requesting variation of the maintenance margin. All credits and debits have to be finalized before the next trading day. If someone fails to pay the necessary amount, his position is liquidated by the broker.

1.2. Forward Market :

Since the major participants of this market are banks and most of the transactions are carried out by banks, this market is also called the "interbank market". In fact, there is no predetermined physical trading location as in future exchanges, instead the banks are connected to each other by a communications network which makes various quotations on currencies available. The buying and selling take place via this communications network

The bank's quotation for a currency consists of two different prices: bid and ask prices. The bid-price (ask-price) shows the bank's buying (selling) price for the quoted currency. The difference between the bid and the ask price is called the "spread", and creates sufficient funds for banks to operate in currency markets. The spread is highly correlated with the volatility of the market. When markets are volatile banks increase the size of spread in order to accumulate sufficient funds to cover the potential loss in case of an unfavorable price movement.

Although a security deposit is unnecessary to obtain a forward contract, the requirement of financial credibility makes it difficult to get a currency contract for small and new traders.

Due to the costly research involved in matching buyer with seller at the desired quantity and price, the use of an intermediary (e.g. broker, local bank) is also common.

1.3. Comparison Of Forward Market To Currency Futures Market:

Futures exchange contracts are standardized with respect to : i. type of currency, ii. the amount of currency, iii. delivery point, iv. delivery time. Contract specifications of the major currencies traded at the IMM is given in Table 1. The contracts of forward market are highly flexible with respect to the above points. In futures exchange, contracts are standardized and are therefore easily transferable. In other words, participants can change or close or reverse their positions easier and quicker as compared to participants of the forward market. Therefore, most of the contracts are finalized by delivery in the forward market compared to only very small number of contracts in futures exchanges.

TABLE 1. Currency Futures Contract Specification of IMM.

	British Pound	Canadian Dollar	German Mark	Japanese Yen	Swiss Franc
Trading Day	16.05.1972	16.05.1972	16.05.1972	16.05.1972	16.05.1972
Contract Size	£ 25000	C$ 100000	DM 125000	¥ 12500000	SF 125000
Daily Price Limit	500 Points	75 Points	100 Points	100 Points	150 Points
Delivery Months	March,June September, December	March,June September, December	March,June September, December	March,June September, December	March,June September December
Delivery Date	3rd Wed of Delivery Month	3rd Wed of Delivery Month	3rd Wed of Delivery Month	3rd Wed of Delivery Month	3rd Wed of Delivery Month

In futures exchanges, cost is related to the volume of transactions. Usually a broker's charge is based on per contract transaction However, in the forward market, most of the cost is in the form of a fixed cost of searching f a and matching the buyer with seller. This cost is transferred to the customer by brokers or banks; which means that the smaller the amount of the currency contract the higher is the percentage cost to the customer. Therefore, the size of contracts in the forward market is usually 10 to 20 times larger than the futures contracts.

In the forward market, the loss or the profit incurred is realized at the time of delivery, while in the futures exchange, it is settled at the end of each trading day.

Although there are daily price limits set by the futures exchange, these limits do not affect price formations in these markets and they can be altered when required. However, the main aim of these limits is to protect small traders from the large traders who may affect the price movement in their favour.

In addition to the above differences, the legal and financial regulations in which they operate are also different.

The link between the forward market and the currency futures market are provided by the "Class-B Clearing Members" of the IMM. It is estimated that 25% of the trading on currencies at the IMM has been carried out by these members for the purpose of conducting arbitrage between forward and futures exchange rate [Sinclair(1984)].

Cox, Ingersoll & Ross (1981) have demonstrated that forward and futures rates have to be different under the perfect markets where no tax and transaction cost are incurred, if the interest rates are stochastic. The price diierence stems from the fact that futures and forward prices create different cash flows because of the difference in their settlement procedures.

Cornell & Reinganum (1981) test this hypothesis for the futures and forward exchange rates and found that the price differential has neither economic nor statistical significance. Since they used closing prices, it is likely that the arbitrage between both markets creates such across exchange rates, trading between markets is not profitable afterwards. Therefore, these results do not indicate that there is a lack of profit opportunity by trading between these markets. Hence, the appropriate data f a this type of test has to be constructed from transaction prices for each contract traded rather than closing prices.

2. MARKET EFFICIENCY HYPOTHESIS:

There seems very little evidence that short-term exchange rate movements are related to macro-economic variables. Therefore, the models based on the macro variables are far from explaining the variation of exchange rates [Dornbusch(1986)]. The possible explanation of this problem is the difference between adjustment speeds of exchange rates and those of other macro variables such as relative prices, money supply and other assets of the economy.

Another type of modelling has been developed as an alternative to the macro models. One of these models looks at the international asset-pricing relationship between forward rates and spot rates. This type of modelling can be regarded as micro-economic modelling as it is based on the maximizing behavior of an economic agent in an infinite time horizon. One of the widely used models was developed by Lucas (1982) and it was based on the two countries, with two goods and two moneys. In his model, agents of both countries have identical tastes while they have different endowment of goods. Initially, it is assumed that economic agents have only one type of good in their endowments and when they are required to purchase other goods, payment has to be made in the other country's currency. Although, this model was difficult to test empirically, Hodrick (1987) has shown that the reduced form equation for this type of model can be written as:

$$F_{t,t+k} = E(S_{t+k} | \Phi_t) + R_t \tag{1}$$

where;
$F_{t,t+k}$ is the forward rate[5] quoted at time t for time t+k.
S_{t+k} is spot rate at time t+k.
Φ_t is information set at time t.
R_t is risk premium.
E is mathematical expectation operator.

In fact Eq.(1) is the general form of the market efficiency hypothesis or the rational expectation hypothesis as it is known in the economics literature. This hypothesis states that an efficient market can be defined as a market in which participant agents do no expect to earn above normal profits[5] by systematically using available information, in other words the expected average return to speculation is zero. [Bilson(1981)].

The above definition of the market efficiency hypothesis requires the following conditions to be fulfilled [Goss(1983)]: a. the market is competitive, b. information is costless to acquire and it is used rationally, c. transaction cost is zero, d. no non-random innovation between contract time(t) and actual delivery time(t+k).

In order to be an efficient market, it is also necessary that there is no risk-free gains in that market. In currency markets, this condition is satisfied through triangular arbitrage by which equilibrium rates across the currencies are established such that no one is making profits by trading one currency for another at any point of time. In summary, market efficiency is defined not only for a point of time (spot market), but over time (futures and forward market) as well [Levich (1979)].

The interpretation of the above definition of market efficiency is that the forward rate by itself is the best forecast of the future spot rate. This means that participant agents cannot make better forecasts than the forward rate by systematically using the available information, in other words, the available information is already fully utilized and reflected by forward rate.

In the early literature a special, importance is given to test the unbiasedness hypothesis which is the special case of the market efficiency hypothesis with an additional assumption on the risk neutrality of the participants. In this case the risk premium parameter (R_t) in Eq.1 needs to be dropped.

According to the definition and the conditions stated above, the rejection of the unbiasedness hypothesis does not lead us to rejection of the market efficiency hypothesis. Forward rates can differ from the future spot rate because of transaction costs and/or risk premium. It is also important to note that exchange rate, whether it is a spot or forward rate, reflect current information at the time of quotation. Hence one *cannot* expect these rates to reflect future information after their quotation. Therefore some events (e.g. government intervention) cannot be reflected in forward exchange rate although this can be reflected in future spot rates. As a result, the rejection of the unbiasedness hypothesis is actually a rejection of the joint hypothesis:
a. market efficiency,
b. the fulfillment of condiitons on which the hypothesis is based on.

From the above formulation, it becomes clear that the market efficiency hypothesis is conditional on the set of information available at the time forward rates are quoted and it is valid under the fulfillment of all conditions. Therefore, the test of the hypothesis is heavily dependant upon the definition of the information set. According to the level of information, following the work of Fama (1970), the test of market efficiency can be made as a weak form, a semi-strong form or as a strong form efficiency test.

In the weak form of the test, the information set contains only the own historical exchange rates of the currency in question. In the case of a semi-strong form test, the set contains all publicly available information in addition to its own historical exchange rates. In the strong form of the test, inside information in addition to publicly, available information is included to the set. The difficulty of obtaining knowledge about the distribution and the level of inside information makes it impossible to test the hypothesis in the strong form. In this study the market efficiency will be tested in semi-strong form.

The semi-strong form of the test can be divided into two sub-groups according to the variables which have been used to construct the information set. The first group may be called "simple semi-strong form" and the information set m i s t s of its own and other exchange rates, while the second group whose information set may contain the information related to other variables such as GNP, money supply, interest rates of relevant countries in addition to the information on currencies. Therefore, the second group can be named as "structural semi-strong form". The underlaying assumption of the simple semi-strong form is that exchange rates reflect all publicly available information. The simple semi-strong form is widely used in the studies on currency markets because the following factors create difficulties in the use of structural semi-strong form:
a. the relevant information about structural variables (e.g. GNP) of each country is available at different times,

b. the relevant information is only published with a lag (e.g. most recent figures may be several months out of date),
c. the published information covers different time periods,
d. the definition of structural variables may vary form country to country (e.g. definition of money supply among countries).
e. as it is mentioned above the adjustment speeds of currencies and other structural variables are different and it may change within time.

In addition to the above difficulties exogenous variables have to be estimated in order to conduct out-of-sample forecasts. Estimation of these variables bring various unknown disturbances into the test. Secondly there is no agreed model'for exchange rate determination. Thirdly in case of such modelling the number of variables is very large so that estimation and getting significant parameters is highly difficult. Fourthly, exchange rates are affected by the world political environment in general and the political and economic structure of industrial countries in particular. Such qualitative variables are very difficult to quantify.

Under the assumption that exchange rates reflect all publicly available information, the most common models for simple semi-strong form of efficiency test are :

$$(F_{t,t+k}-S_{t+k})^i = \alpha + \beta_i (F_{t-k,t}-S_t)^i + \beta_j (F_{t-k,t}-S_t)^j + u_{t+k} \tag{2}$$

$$[(F_{t,t+k}-S_{t+k})/S_t]^i = \alpha + \beta^i [(F_{t-k,t}-S_t)/S_t]^i + \beta^j [(F_{t-k,t}-S_t)/S_t]^j + u_{t+k} \tag{3}$$

where;

$F_{t,t+k}$ is the forward rate[6] quoted at time t for time t+k
S_t is spot rate at time t.
u_{t+k} is uncorrelated error term.
superscript denotes currency $i \neq j$.

Equations (2) and (3) are also called "multi market" test. The efficiency hypothesis requires that all parameters equal to zero, which means that no information is useful to predict the current forecast error. These type of equations are used Hansen & Hodrick (1980). Gregory & McCurdy (1984), Geweke & Feige (1979).

As we can see from the above models of semi-strong form of the test, the main interest is to test the hypothesis assuming that the agents form their expectations on the information from different currencies of identical maturities. However, Rose & Selody (1984) construct the information set assuming that agents form their expectations on the information from varying maturities of the same currency. In other words, in Rose & Selody's case an agent is interested with a specific currency market (e.g. Swiss Franc market) while in other studies an agent is interested in a particular maturity (e.g. 3-months market).

The above equations can be estimated either individually for each currency or as a system for all currencies in question. The test based on the system estimation can be regardcd as the joint-multimarket test [Geweke & Feige (1979)]. The system estimation has an advantages over the single estimation because the cross-currency relationship can be reflected in the parameter estimates.

There are many problems related to empirical test of the hypothesis, some of these problems related to the construction of data while some of them related to the estimation technique;

Siege1 Paradox : The results of test depend on the measurement of exchange rates. Since the exchange rate can be defined in two ways either domestic currency per foreign currency or foreign currency per domestic currency. Test f a market efficiency may be affected because of Jensen inequality [E(1/x) is greater than 1/E(x) if Var(x) > 0]. This problem can be solved by taking logarithm of exchange rates.

Serial Correlated Error Terms Due To The Construction of Data: If the sampling interval is finer than the contract length error terms shows serial correlation in the form of moving average process. For example using weekly data for one-month contracts can create moving average process in the order of three to four depending on the day chosen within a week. In the literature this problem has been overcome by either sampling non-overlapping data or correcting covariance matrix of estimation by Generalized Method of Moments (GMM) technique which has been used by Hansen & Hodrick (1980).

Homoscedasticity vs. Heteroscedasticity : Currency markets may be affected from tranquil and turbulent periods of economy and it is likely that exchange rate variance may be different. Therefore, the estimated covariance matrix has to be heteroscedastic consistent. Hsieh (1984) has developed a methodology for estimating correct covariance matrix for any type of estimation technique. He has tested the unbiasedness hypothesis without correction of the covariance matrix and rejected the hypothesis for three cases out of seven at the 10% level of significance then tested with heteroscedastic consistent covariance matrix and he rejected the hypothesis for all seven currencies at 1% significance level.

Stationarity Of The Exchange Rates : The result of the efficiency test depends on the stationarity of the exchange rates. The equations using forecast errors has an advantage over others in a way that even if the exchange rates are not stationary the forecast errors are likely to be stationary.

Beside the satisfaction of stationarity assumption, models uses forecast errors [e.g. Eq.(2) and Eq.(3)] have another advantages in testing whether there exists a constant risk premium or not. The statistically significant intercept term (a) in the equations indicates the size and the sign of risk premium (discount). However, this model *cannot* separately test the joint elements of the hypothesis. Hence, even if the hypothesis is rejected this does not necessarily mean that the market is inefficient. Rejection may be the result of time-varying risk premium and/or other unfulfilled conditions.

In general, there is no consensus either on the constructcion of information set or the estimation technique and the end results of the test. However, the simple semi-strong forms of the test is the most common and the system estimation methods are preferable because of the better reflection of real world.

3. TESTING THE MARKET EFFICIENCY HYPOTHESIS FOR FUTURES AND FORWARD MARKETS:

3.1. Data:

In this section, the joint hypothesis will be tested for the forward and futures market, assuming the existence of a constant risk premium[7] by using semi-strong form test. As stated above, the Eq.(2) is the most appropriate for this purpose. The test will cover the period 1974 to 1986 and the currencies to be tested are British Pound, Canadian Dollar, German Mark. Japanese Yen and Swiss Franc. The interested maturities are 1-month, 2 and 3-months.

The data related to exchange rates were the closing prices reported in the IMM year books (1974-1986). The data is measured as foreign currency per US Dollar. In collecting data for the futures and forward rates, it has been ensured that both the quoted date and the delivery date coincide in both the markets for different exchange rates. This approach limits the number of observations to 46, due to the four delivery dates in a year in the futures market. Spot rates were chosen in a way that coincide for delivery dates of futures market, that is 3rd Wednesday of March, June, September and December; forward and futures exchange rates for 1-month, 2-months and 3-months were 30, 60 and 90 days prior quotations to the corresponding spot rates, respectively.

33 Equations:

In equations used to test the efficiency hypothesis, the left-hand and the right-hand side variables are the current forecast error and the prior forecast errors, respectively; forecast errors are constructed after log transformation of exchange rates.
Current forecast error = $f_{t,t-k} - s_t$
where;
$f_{t,t-k}$ is the logarithm of forward or futures exchange rate quoted at time t-k to time t.
s_t is the logarithm of spot rate at time t.

$$
\begin{aligned}
BP_t &= \alpha_{BP} + \beta_{BB}\, BP_{t-1} + \beta_{BC}\, CD_{t-1} + \beta_{BJ}\, JY_{t-1} + \beta_{BS}\, SF_{t-1} + u_t\\
CD_t &= \alpha_{CD} + \beta_{CC}\, CD_{t-1} + \beta_{CB}\, BP_{t-1} + \beta_{CJ}\, JY_{t-1} + \beta_{CS}\, SF_{t-1} + u_t\\
GM_t &= \alpha_{GM} + \beta_{GG}\, GM_{t-1} + \beta_{GC}\, CD_{t-1} + \beta_{GJ}\, JY_{t-1} + \beta_{GS}\, SF_{t-1} + u_t\\
JY_t &= \alpha_{JY} + \beta_{JJ}\, JY_{t-1} + \beta_{JC}\, CD_{t-1} + \beta_{JG}\, GM_{t-1} + \beta_{JS}\, SF_{t-1} + u_t\\
SF_t &= \alpha_{SF} + \beta_{SS}\, SF_{t-1} + \beta_{SC}\, CD_{t-1} + \beta_{SG}\, GM_{t-1} + \beta_{SJ}\, JY_{t-1} + u_t
\end{aligned}
$$

where;
BP_t British Pound current forecast error,
CD_t Canadian Dollar current forecast error,
GM_t German Mark current forecast error,

JY_t Japanese Yen current forecast error,
SF_t Swiss Franc current forecast error,
$t-1$ denotes the prior forecast error of the relevant currency, respectively.

As can be seen from the above equations, either the German Mark or the British Pound exists in any single equation, because both are members of the European Economic Community and joint existence may cause multicollinearity problem. Therefore, in any single equation the number of right hand side variables are limited to four. This has an additional benefit as the right-hand side of equations consist of different variables (at least one of them), we can estimate the system of equations by seemingly unrelated regression.

3.3. Estimation And Results:

The test were carried out by estimating a system of equations using seemingly unrelated regression (SUR) and three-stage least square regression (3SLS) technique. The idea of applying two different estimation techniques is to test whether there is a simultaneity in the model. In case of simultaneity where the forecast errors are endogenous to the system, the right-hand side variables are correlated with the error terms at the limit; therefore, SUR estimates would not be consistent and efficient. However, 3SLS estimates are at least consistent. The same problem also exists in case where the variables are measured with error.

The test is conducted on the parameter estimates of SUR and 3SLS methods by using the Hausman Specification Test[8] (HST). HST has X^2 distribution with a degrees of freedom equal to the number of parameters tested. HST values obtained were not significant which indicates that SUR estimates are consistent and efficient. Therefore, only the results of SUR estimation will be reported.

The variance-covariance matrix of the parameters is estimated by the method suggested by White (1980). In this method, the variance-covariance matrix is consistent even in the case of the errors are not homoskedastic.

Tests for the first order serial correlation is carried out in two stages. Firstly, the autocorrelation parameters ($\Phi_{BP}, \Phi_{CD}, \Phi_{GM}, \Phi_{JY}, \Phi_{SF}$) have been introduced to the system one at a time, t-statistics were used whether the particular autocorrelation parameter is significant or not. Then the autocorrelation parameters which are significant are included into the model. In the second stage, the model with autocorrelation parameters and model without them are estimated. Testing of the autocorrelation in the system of equations context is done by using the Log-likelihood Ratio Test[9] (LRT). LRT has X^2 distribution with the degrees of freedom equal to the number of parameters (in this case the number of autocorrelation parameters) tested. Depending on the LRT test the equations are transformed by the relevant autocorrelation parameter (Φ) in order to eliminate first-order serial correlation. The market efficiency test is conducted to the transformed (where necessary) set of equations.

Wald statistic was used to test the joint hypothesis of the market efficiency for both a single equation and a system of equations. The null hypothesis requires that all the parameters are equal to zero. The economic interpretation of the null hypothesis is that there is no risk premium and the prior forecast error(s) cannot be utilized in the determination of current forecast error. The Wald statistic has X^2 distribution with the degrees of freedom equal to the number of parameters. The significance of Wald statistic indicates that at least one of the coefficients are not equal to zero. In terms of joint hypothesis of the efficiency concerned, this means that there is at least one variable which can help to predict the current forecast error and/or there is at least one unfulfilled conditions which the hypothesis is based on. However, the main aim of this study is to find out whether there is a similarity in the test results obtained from both markets.

Testing whether there is a constant risk premium or not was based on the asymptotic t-values of the intercept terms (a's) of the relevant equations. The significance of t-values means that there is possibly non-zero constant risk premium for the relevant currency market.

Table 2. SUR PARAMETER ESTIMATES - SEMI-STRONG FORM 1 - MONTH FUTURES MARKET

Dependent Variable	Parameter	Estimate	T Statistic	Wald Statistic
BP				2.4822
	α_{BP}	0.0030	0.6535	
	β_{BB}	0.0682	0.3313	
	β_{BC}	0.2837	0.9145	
	β_{BJ}	-0.0533	-0.3854	
	β_{BS}	-0.0163 -	0.0138	
CD				4.9031
	α_{CD}	0.0049	2.1769*	
	β_{CC}	-0.1014	-0.7026	
	β_{CB}	-0.0610	-0.6926	
	β_{CJ}	-0.1358	-2.0263*	
	β_{CS}	0.0756	1.0207	
GM				9.3888
	α_{GM}	-0.0017	-0.4742	
	β_{GG}	-0.1032	-0.3099	
	β_{GC}	0.3710	1.6576	
	β_{GJ}	-0.0256	-0.1973	
	β_{GS}	0.3576	1.4524	
	Φ_{GM}	-0.4192	-2.1289*	
JY				5.7474
	α_{JY}	-0.0055 -	1.0350	
	β_{JJ}	0.2187	1.4973	
	β_{JC}	0.6564	2.0707*	
	β_{JG}	0.0453	0.1353	
	β_{JS}	-0.2302	-0.7499	
SF				32.5841*
	α_{SF}	-0.0047	-0.5015	
	β_{SS}	0.1204	0.2944	
	β_{SC}	0.5244	1.6272	
	DSG	-0.7533	-1.6995#	
	ßSJ	0.0813	0.3841	
	Φ_{SF}	0.3601	1.9022#	

Wald Statistic for the System = 55.3361*

* signifies statistical signifiance at the 5% level
#signifies statistical signifiance at the 10% level

Table 3. SUR PARAMETER ESTIMATES - SEMI-STRONG FORM 1 - MONTH INTERBANK MARKET

Dependent Variable	Parameter	Estimate	T Statistic	Wald Statistic
BP				2.2726
	α_{BP}	0.0025	0.5381	
	β_{BB}	0.0880	0.6288	
	β_{BC}	0.3110	1.1548	
	β_{BJ}	-0.0376	-0.2777	
	β_{BS}	-0.0300	-0.2137	
CD				16.4882*
	α_{CD}	0.0038	2.0878*	
	β_{CC}	-0.1628	-0.7809	
	β_{CB}	-0.0903	-0.1598	
	β_{CJ}	-0.1386	-2.1202*	
	β_{CS}	0.1397	2.0335*	
	Φ_{CD}	-0.3833	-1.9062#	
GM				7.9375
	α_{GM}	-0.0020	-0.5616	
	β_{GG}	-0.0424	-0.1972	
	β_{GC}	0.3524	1.5042	
	β_{GJ}	-0.0194	-0.1847	
	β_{GS}	0.3027	1.9111	
	Φ_{GM}	-0.3925	-2.6881*	
JY				6.3645
	α_{JY}	-0.0060	-1.3298	
	β_{JJ}	0.2350	1.5611	
	β_{JC}	0.6950	2.3596*	
	β_{JG}	-0.0267	-0.1047	
	β_{JS}	-0.1617	-0.7124	
SF				30.4307*
	α_{SF}	-0.0030	-0.3261	
	β_{SS}	0.1099	0.5228	
	β_{SC}	0.3651	1.4582	
	β_{SG}	0.1079	0.7948	
	β_{SJ}	-0.7106	-3.4855*	
	Φ_{SF}	0.3910	2.7488-*	

Wald Statistic for the System = 140.9122*

* signifies statistical significance at the 5% level.
#signifies statistical significance at the 10% level.

Results for the futures market: The semi-strong forms of the test were carried out and related parameter estimates are reported in Tables 2, 4 and 6. The joint-multimarket efficiency is rejected for all three maturities in the futures markets. For multimarket efficiency test the hypothesis is rejected for one-month Swiss Franc, two-months Canadian Dollar, German Mark and Swiss Franc, and three-months British Pound, German Mark, Japanese Yen And Swiss Franc futures.

Table 4. SUR PARAMETER ESTIMATES - SEMI-STRONG FORM 2 - MONTHS FUTURES MARKET

Dependent Variable	Parameter	Estimate	T Statistic	Wald Statistic
BP				4.9830
	α_{BP}	0.0045	0.7771	
	β_{BB}	0.1958	1.2255	
	β_{BC}	0.1749	0.7044	
	β_{BJ}	-0.0194	-0.1475	
	β_{BS}	0.0455	0.3509	
CD				11.7159*
	α_{CD}	0.0091	2.9966*	
	β_{CC}	-0.1429	-0.9815	
	β_{CB}	-0.1551	-1.9366#	
	β_{CJ}	0.0536	-0.6169	
	β_{CS}	-0.0061	-0.0728	
GM				11.0089#
	α_{GM}	0.0087	1.4179	
	β_{GG}	-0.3254	-1.3420	
	β_{GC}	0.2339	0.9095	
	β_{GJ}	0.0497	0.2963	
	β_{GS}	0.2888	1.3542	
JY				7.3128
	α_{JY}	-0.0006	-0.0832	
	β_{JJ}	0.3665	2.1314*	
	β_{JC}	0.554	1.5514	
	β_{JG}	-0.0254	-0.0929	
	β_{JS}	-0.2785	-1.0772	
SF				19.3376*
	QSF	0.0098	0.9777	
	β_{SS}	-0.2802	-1.1082	
	β_{SC}	0.7944	2.5561*	
	β_{SG}	0.2501	1.1015	
	β_{SJ}	-0.3190	-1.1992	
	Φ_{SF}	0.3527	1.6842#	

Wald Statistic for the System = 79.8046*

* signifies statistical signifiance at the 5% level
# signifies statistical signifiance at the 10% level

Table 5 SUR PARAMETER ESTIMATES - SEMI-STRONG FORM 2 - MONTHS INTERBANK MARKET

Dependent Variable	Parameter	Estimate	T Statistic	Wald Statistic
BP				5.0076
	α_{BP}	0.0040	0.6794	
	β_{BB}	0.1937	1.2313	
	β_{BC}	0.1754	0.7134	
	β_{BJ}	-0.0091	-0.0668	
	β_{BS}	0.0530	0.4268	
CD				10.5959#
	α_{CD}	0.0089	2.8918*	
	β_{CC}	-0.1480	-1.0227	
	β_{CB}	-0.1563	-1.9561#	
	β_{CJ}	0.0584	0.6612	
	β_{CS}	-0.0049	-0.0609	
GM				9.4957#
	α_{GM}	0.0200	1.6362	
	β_{GG}	-0.3325	-1.3383	
	β_{GC}	0.2803	1.0867	
	β_{GJ}	0.1386	0.7992	
	β_{GS}	0.2396	1.1049	
JY				14.5443#
	α_{JY}	-0.0013	-0.1820	
	β_{JJ}	0.3989	2.2536*	
	β_{JC}	0.6216	1.8858#	
	β_{JG}	0.6216	0.0243	
	ßJS	-0.3020	-1.2800	
SF				25.5305*
	α_{SF}	0.0103	0.9480	
	β_{SS}	-0.3248	-1.3306	
	β_{SC}	0.8679	2.8290*	
	β_{SG}	0.3269	1.4377	
	β_{SJ}	-03255	-1.2225	
	Φ_{SF}	0.3943	2.0183#	
Wald Statistic for the System = 92.048*				

* signifies statistical significance at the 5% level.
# signifies statistical significance at the 10% level.

Results for the forward market: The parameter estimates of the weak and semi-strong forms of the test were reported in Tables 3, 5 and 7. The joint-multimarket efficiency is rejected for all three maturities in the forward markets. For multimarket efficiency test, the hypothesis is rejected for one-month Canadian Dollar and Swiss Franc, two-months currency contracts except British Pound, and three-months currency contracts other than Canadian Dollar.

Table 6 SUR PARAMETER ESTIMATES - SEMI-STRONG FORM
3 - MONTHS FUTURES MARKET

Dependent Variable	Parameter	Estimate	T Statistic	Wald Statistic
BP				22.7063*
	α_{BP}	0.0018	0.2711	
	β_{BB}	0.3579	2.7770*	
	β_{BC}	-0.0604	-0.1504	
	β_{BJ}	-0.0692	-0.5811	
	β_{BS}	0.1359	1.0321	
CD				6.5170
	α_{CD}	0.0063	2.3141*	
	β_{CC}	0.0255	0.1508	
	β_{CB}	0.0004	0.0074	
	β_{CJ}	0.0322	0.4376	
	β_{CS}	-0.0531	-0.9001	
GM				17.0560*
	α_{GM}	0.0038	0.4700	
	β_{GG}	-0.2312	-1.1972	
	β_{GC}	0.3085	0.9764	
	β_{GJ}	0.0893	0.5944	
	β_{GS}	0.4107	2.3739*	
	Φ_{GM}			
JY				46.0670
	α_{JY}	-0.0024	-0.1096	
	β_{JJ}	-0.1632	-0.6895	
	β_{JC}	0.3644	0.9184	
	β_{JG}	-0.376	-1.4390	
	β_{JS}	0.1266	0.5748	
	Φ_{JY}	0.5832	4.4809*	
SF				39.9864*
	QSF	0.0048	0.2853	
	β_{SS}	-0.1435	-0.6941	
	β_{SC}	1.0344	2.5064*	
	β_{SG}	0.3625	1.7601#	
	β_{SJ}	-0.4665	-1.7971#	
	Φ_{SF}	0.4666	2.4184*	

Wald Statistic for the System = 301.0242*

* signifies statistical signifiance at the 5% level
# signifies statistical signifiance at the 10% level

Table 7 SUR PARAMETER ESTIMATES - SEMI-STRONG FORM
3 - MONTHS INTERBANK MARKET

Dependent Variable	Parameter	Estimate	T Statistic	Wald Statistic
BP				23.8202*
	αBP	0.0012	0.1791	
	BBB	0.3493	2.8393*	
	BBC	-0.0426	-0.1059	
	BBJ	-0.0413	-0.3427	
	BBS	0.1157	0.8782	
CD				5.6972
	αCD	0.0060	2.1452*	
	BCC	0.0309	0.1882	
	BCB	-0.0041	-0.0718	
	βCJ	-0.0345	-0.4529	
	BCS	-0.0528	-0.8687	
GM				17.4196*
	αGM	0.0033	0.4063	
	BGG	-0.2145	-1.1715	
	βGC	0.2639	0.8336	
	BGJ	0.1210	0.7939	
	BGS	0.3766	2.3629*	
N				45.3123*
	αJY	-0.0039	-0.1833	
	BJJ	-0.1102	-0.4584	
	BJC	0.4076	1.0446	
	BJG	-0.3535	-1.5162	
	BJS	0.0894	0.4376	
	ΦJY	0.5868	4.3694*	
SF				40.9664*
	αSF	0.0049	0.2797	
	βSS	-0.2067	-1.0249	
	βSC	1.0791	2.5183*	
	βSG	0.3971	1.8666#	
	BSJ	-0.4562	-1.8947#	
	ΦSF	0.4709	2.5206*	

Wald Statistic for the System = 331.4466*

* signifies statistical significance at the 5% level.
# signifies statistical significance at the 10% level.

Comparison of the results: Since closing prices have been used f a both markets and it has been shown that price differentials are not significant, it is expected that the results relating to the efficiency test have to be similar.

As can be seen from Tables 2 to 7, the test based on system of equations gave the same results for both markets. However, while the hypothesis that all parameters equal to zero .are rejected for one-month Canadian Dollar and two-months Japanese Yen in the forward market, the hypothesis cannot be rejected for the same currencies in the futures market.

Comparison based on the significance and the sign of the individual parameters also show minor differences. Four parameters out of more than sixty are significant in only one market. When the signs of the parameters are concerned, eight parameters show conflict.

Accordingly, we can conclude that the results obtained from both markets are consistent with our expectations, and the minor differences can be attributable to the structural differences between markets and/or the sampling error.

4. CONCLUSION:

In the last decade, with the expansion of forward and currency futures market, there have been many empirical research on these markets in general, on the efficiency aspect in particular. Most of the research has been done on the forward market because of its size. However, at the present, currency futures has been also getting attention of the researchers due to their quick expansion and becoming an alternative to the forward market. It is also important to note that, there is no any other good where it is possible to trade on two different organized markets, in this respect currency markets are unique.

Cornell & Reinganum (1981) have shown that the price differential between these markets are negligible. This implies that the market efficiency test has to give similar results for the forward and the futures markets. The market efficiency tests of various researcher on these markets may not be comparable due to the difference in the estimation technique used, the construction of data and the period of interest. In this study, in order to be able to compare these markets same estimation technique has been applied for the same type of models. It has been also ensured that the forward and futures exchange rates are quoted in the same day for the common spot exchange rates. These details make possible to compare the results. In comparison, it has been found out that they gave similar results as it is expected. The test of constant risk premium shows that only in case of Canadian Dollar the relevant parameter is different from zero and significant for all maturities in both markets.

These results may not indicate the market inefficiency of forward and/or futures market due to the jointness of the hypothesis; however, the results are importance in its own by showing that the behaviour of both markets are not different from each other as market efficiency concerned.

FOOTNOTES:

[1] Prior to the flexible system, trading on commodity futures or private contracts was sufficient to fix the future price of a commodity.

[2] Forward market has been operational prior to 1972.

[3] Due to the space limitations, the summary of the earlier studies have not been given. However, references given at below covers most of the early studies in this area.

[4] Margin payments can be made by Treasury Bill and Treasury Bond. This makes the opportunity cost of the margin is negligible.

[5] The above normal profit has to be understood as the profit excess of the necessary amount to compensate the exchange rate risk.

[6] Forward rate will be used as a common name for forward and futures rates.

[7] Since constant term is the measure of the risk premium, testing whether constant equals to zero or not means testing whether there is a risk premium or no risk premium.

[8] Hausman Specification Test $= q'V(q)^{-1}q$

where;

$q = \beta_{SUR} - \beta_{3SLS}$

$V(q) = V(\beta_{SUR}) - V(\beta_{3SLS})$

β_{SUR} is the coefficient vector of the SUR estimation.

β_{3SLS} is the coefficient vector of the 3SLS estimation.

$V(\beta_{SUR})$ is the variance-covariance matrix of the SUR estimation.

$V(\beta_{3SLS})$ is the variance-covariance matrix of the 3SLS estimation.

[9] Log-likelihood Ratio Test $= 2(L_u - L_r)$

where;

L_u is the log-likelihood value of unrestricted model, in this case model includes autocorrelation parameter(s).

L_r is the log-likelihood value of restricted model, in this case model does not include autocorrelation parameter(s).

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