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A Study of the Efficiency in Four Foreign Exchange Markets Using the Survey Data

Jiamei Zhu

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A STUDY OF THE EFFICIENCY
IN FOUR FOREIGN EXCHANGE MARKETS
USING THE SURVEY DATA

A Thesis

Presented to

the Faculty of the Department of Economics

Western Kentucky University

Bowling Green, Kentucky

In Partial fulfillment

of the Requirements for the Degree

Master of Arts

by
Jiamei Zhu

May 1996

A STUDY OF THE EFFICIENCY
IN FOUR FOREIGN EXCHANGE MARKETS
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May, 1996

30 Pages

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The purpose of this paper is to reexamine the efficiency condition in four foreign exchange market: U.S.--British, U.S.--Canadian, U.S.--Japanese, U.S.--German. Survey data was used to separate the risk premium arguments from irrationality. Only two markets are considered efficient based on the statistical test: U.S.--Canadian, U.S.--Japanese. Three models were conducted to explain the risk premium which is the factor causing the bias between the forward and the spot rate in the U.S.--German and the U.S.--Japanese markets. Lag Model (Model 2) turns out to be the only model that can explain the risk condition in the U.S.--Japanese market. All the three tested models could to some degree explain the risk condition in the U.S.--German market. Further analysis shows model (1a) is the best.

CHAPTER I

INTRODUCTION

The purpose of this paper is to reexamine the hypothesis of the efficiency of the foreign exchange market by utilizing survey data. The survey data for various foreign exchange rates were obtained from Money Market Services (MMS) International in order to decompose the bias between the forward rate and the future spot rate into the non-rationality and the risk premium components and to determine which factor is more relevant in causing the bias. According to the efficient market hypothesis, the market can still be considered to be efficient if the forward rate differs from the spot rate only by the risk premium. Therefore, the aim in this study is to measure and estimate the risk premium directly.

The main feature of this paper is that it provides analysis on the efficiency in four of the most actively traded foreign exchange markets: ¹U.S.(\$)--British (bp), U.S.--Canadian (c\$), U.S.--German (dm) and U.S.--Japanese (yen). Except for the U.S.--Canadian market, the regression results show that bias exists between the forward and the future spot rate in the other three markets.

¹ Bp denotes British Pound, c\$ denotes Canadian dollar, dm denotes Denmark, yen denotes Japanese Yen.

The hypothesis that there is no bias in the U.S.--British market is rejected because investors apparently do not form their expectation rationally. In the U.S.--Japanese market, it is the risk premium rather than nonrational expectation that explains the bias. For the U.S.--German market, the regression results show that both the risk premium and the nonrational hypothesis are responsible for the bias.

Followed by the market analysis, three risk premium models are tested respectively in this paper for the U.S.--German and the U.S.--Japanese markets where risk premium is the main factor causing the bias. Model 1 uses the variation of the forecast errors between the forward rate and the spot rate to explain the risk premium. In model 2, risk premium last period is tested as the estimator of the current period risk premium. Model 3 tries to explain the risk premium with the variation of two macroeconomic variables--money supply and interest rate.

This paper is divided into four sections. The first section is the brief introduction of this paper. Section II outlines the studies done by previous researchers. Section III gives the description of the sources of the data, especially the survey data. Section IV reports the analysis and the empirical results. Section V is the conclusion.

CHAPTER II

REVIEW

The increasing academic interest in the foreign exchange markets intensified after 1973 when the Bretton Woods system collapsed and major industrial countries changed to a floating exchange rate system. Most of the studies focus on the determination of the exchange rates and the efficiency of the foreign exchange market. The goal of these studies is to see whether government intervention in the foreign exchange market is necessary. In theory, the market is efficient if the prices reflect all the available information. In the foreign exchange market this means that the spot and forward exchange rates will quickly adjust to any new information. If the prices could not be adjusted quickly, it would be possible for a well-informed investor to make profits consistently from foreign exchange trade and the profits are larger than the risk premium which is based on the risk undertaken.

The typical equation used by most of the studies testing the efficiency of the market is

$$(1a) \quad S_{t+1} = \alpha_0 + \alpha_1 F_t \quad \text{or}$$

$$(1b) \quad \Delta s_{t+1} = \alpha_0 + \alpha_1 \Delta fp_t ,$$

where, 2S_t is the spot rate in current period, S_{t+1} is the future spot rate, 3F_t is the forward exchange rate; $\Delta s_{t+1} = S_{t+1} - S_t$, the change of the spot rate between the next period and the current period; $\Delta fp_t = F_t - S_t$, the difference between the forward rate and the current spot rate (forward premium). We accept the hypothesis that the market is efficient if $\alpha_0 = 0$ and $\alpha_1 = 1$. Numerous studies have shown that α_1 is significantly different from unity, thus the forward premium does not fully reflect the actual changes in the spot rate.

Because of the unavailability of the data for the expected future spot rate for a long period of time, previous studies could not separate the risk premium argument from irrationality. However, the forward rate can be different from the future spot rate by the risk premium and the market is still considered to be efficient. So, the conclusion whether the market is efficient or not should not be made in haste.

The availability of the survey data for future spot rates makes it possible to discern whether non-rationality, or risk premium, or both, should be responsible for the rejection of the unbiasedness hypothesis. Unbiasedness hypothesis here means the forward rate should be an unbiased estimator for future spot rate.

Almost all of the forementioned studies agree on the conclusion that there exists bias between the forward and the future spot rate; however, their explanations of why this

² To compare and be consistent with former studies, the exchange rates in this paper are all in natural logarithmic form, including the forward and spot rates.

³ The Forward rate is estimated from the spot rate and interest rate differentials between two countries : $F_t = S_t * (1+I) / (1+I')$, S_t is the current spot rate, I is the domestic interest rate, I' is the foreign country's interest rate.

is the case are contradictory. Some of them assume that investors are risk neutral and find $[S_{t+1} \neq ES_{t+1}]$, which means the bias can be interpreted as the failure of rational expectations of market participants (Bilson 1981; Longworth 1981; and Cumby and Obstfeld 1984). Others attribute the differences to the risk premium of investors: $[ES_{t+1} \neq F_t]$, and believe investors make expectations rationally (Fama 1984; Hodrick and Srivastava 1984; Hsieh 1984 and Wolff 1987). Recent studies attempt to combine these two factors to explain the rejection of the unbiasedness hypothesis in the foreign exchange market (Dominguez 1986; Froot Kenneth and Frankel Jeffrey 1987; MacDonald and Torrance 1988; Taylor 1988).

A risk premium is required by investors who are not risk neutral (i.e., risk averse investors). For these kinds of market participants, they would not put money on risky assets unless they know they will be compensated by an “excess” return compared with risk free assets. For example, comparing two kinds of assets where one is risk free and the other one is risky, they both have the same amount rate of return, a rational and risk averse investor will choose the risk free assets. So when the required return for risky assets has to be higher than that for risk free assets, the difference is called the risk premium. In this paper, risk premium also refers to the difference in the required return between two risky assets.

Economists generally assume that people are rational. ⁴Expectations are rational if, given the economic model, they will produce expected values of variables that will, on average, equal the actual values. Expectations will diverge from the actual values only

⁴ According to “Rational Expectations” Steven M. Sheffrin p9

because of some unpredictable information in the system. Here, we need to understand that investors in the market make rational expectations based on how much information they collect. Sometimes even when the information is available, because of the cost, investors would rather make their expectations without the relevant information. They don't collect all the available information because in their thoughts the cost to obtain the information is higher than its worth.

The rationality test (whether investors make expectation rationally or not) could be done by the following regression:

$$(2) \quad S_{t+1} = \beta_0 + \beta_1 ES_{t+1} ,$$

here, ES_{t+1} is the expected future spot rate -- the survey data. The null hypothesis is $\beta_0 = 0$ and $\beta_1 = 1$. If we find β_0 is not significantly different from zero and β_1 is not significantly different from unity, we believe that investors in this market make their expectations rationally; otherwise, they are not. We call any difference between S_{t+1} and ES_{t+1} the nonrational component.

A risk premium is required by investors because foreign currency is not a risk free asset. For some currencies, holders need to be paid more, or the purchase price should be lower compared with less risky currencies. The following regression tests the existence of the risk premium in the foreign exchange market :

$$(3) \quad ES_{t+1} = \gamma_0 + \gamma_1 F_t .$$

If the null hypothesis of $\gamma_0 = 0$ and $\gamma_1 = 1$ is accepted, there is no risk premium, which means the investors are risk neutral. Otherwise, they are risk averse and the difference between ES_{t+1} and F_t is the risk premium. From the direct information in the market for

the spot rate and the interest rate, we could calculate the forward rate. But it is probably different from the traders' expectation, because traders also include those indirect relevant information such as the economic condition in this country, the variation of the country's money supply, and real interest rate fluctuations into their expectation. Since the variation of these factors affects the expectation of the currency's price and the traders' decisions whether or not to hold this currency, if we want to forecast the currency price correctly, we need to take these additional factors into consideration. The effects of these factors are included in the risk premium.

Some research has been done using survey data to separate the bias into two components. For example, Froot and Frankel (1989) use a variety of the survey data collected from the Amex (12), Economist(38) and Money Market Services(47) to separate the bias into risk premium and irrationality. Then they test the statistical significance of the two components. Their research doesn't reject the hypothesis that all of the bias is attributable to systematic expectation errors, and none to the risk premium.

Other researchers also use the survey data to apportion the bias, like Dominguez(1986), MacDonald and Torrance (1988) and Taylor (1988), but they reach a different conclusion. MacDonald and Torrance (1988,1990) find the unbiasedness hypothesis fails both because of the deviation of expectation from the actual spot rate and also because of the existence of ⁵time-varying risk premium. Taylor used the survey data collected from a British management consultant firm (Godwin) to conduct his analysis.

⁵ Time-varying risk premium means the risk premium changes overtime. There are two other kinds of risk premium, one is the term structure risk premium which changes with different term of assets. The other one is constant risk premium, it remains the same for a period of time.

From his empirical results, he finds that it is probably risk premium rather than nonrational expectations that is the major factor explaining the foreign exchange market inefficiency. Although all of these studies went further trying to explain the bias between F_t and S_{t+1} , there is no general agreement on whether the bias between the forward rate and future spot rate should be attributed to risk premium, irrational expectations, or both of them.

Because of the analysis which finds the reason for rejection efficiency is the risk premium, some studies have also been conducted trying to explain the risk premium in the market. The most direct evidence as to the existence of a non-zero risk premium is to find some independent variables to explain the risk premium. This task was first examined by Hansen and Hodrick (1983), who show that the fluctuations in the risk premium could be explained by a variable representing the excess return from some portfolio. However, their studies don't show any clear evidence that the risk premium has a direct connection with the macroeconomic variables. Domowitz and Hakkio (1985) try to use the variances of the forecast errors between the forward and the spot rate to explain the risk premium. Baillie and Bollerslev (1987) extended their analysis by substituting the variance with the conditional covariance matrix of the forecast errors. They found little support that the risk premium is a linear function of the conditional covariance of the forecast errors.

In Taylor's 1988 paper, he examines two empirical explanation models of the foreign exchange risk premium. One model suggested by Domowitz and Hakkio (1985) postulates that risk premium follows an autoregressive conditional heteroscedasticity (ARCH) process. The other one is suggested by Taylor (1987) himself. He believes risk

premium may be directly related to the measures of asset yield volatility. The greater the volatility of an asset, the more risky the asset should be. Risk makes the open forward position relatively less attractive thereby depressing the forward rate. The procedure is to regress the risk premium onto the measures of the domestic asset and the foreign asset yield volatility which should provide a significantly positive and negative coefficient respectively. His test results confirm his hypothesis. However, at present, there is no agreement as to which model could give a complete estimation for the risk premium in the foreign exchange market.

CHAPTER III

DATA

The survey data in this paper is a set of market participants' expectations that covers four most actively traded currencies against the U.S. dollar spanning ten years from 1985 to 1994. One of the main advantages of such data is that, in principle, it allows a researcher direct insight into market operators' expectations mechanism without resort to dubious assumptions.

All the survey data were collected from the Money Market Services (MMS) International, California. There are a total of 446 survey points in this paper distributed in four foreign exchange markets: U.S.--British (120), U.S.--Japanese (120), U.S.--German (120), U.S.--Canadian (86). As is customary, the initial data is in the form of units per dollar in the case of the last three countries, while in the case of British, the original data specifies the number of dollars per pound. This company conducts the survey every Friday in the foreign exchange market by asking the professional investors for their forecasts of the spot rate one week later and one month later. Finally, they choose the median value of all the survey results as the forecast value.

The time period for the data is from January 1985 to December 1994. Ten years worth of data for the other three markets were collected except U.S.--Canada. Because

the survey for the U.S.--Canada market began in November 1987, only eight years worth of data were collected. Data for the last Friday every month was chosen in order to be consistent with the following risk premium analysis where the data for the money supply and interest rate is at the end of the month. For the same reasons, if there was no survey data on the last Friday, the last data point in that month was used. The reason monthly data was used is that the forward rate can only be collected is at least one-month in advance. So if the survey data of the spot rate is for January 30, 1985, the corresponding forward rate should be one month ago (on December 30, 1984). If there is no data that day (weekend), the last trading day (last Friday) in that month was chosen as the data day. The real spot rate is selected corresponding to the date of the survey data, which means on the same trading day. All the forward rates were collected from the "Wall Street Journal".

The data for the interest rate and the money supply were taken from the "International Financial Statistics". The Treasury bill (T-bill) rate was chosen as the interest rate for Germany and United States, Money market interest rate (T-bill rate not available) was chosen for Japan. The Treasury bill is usually believed to be reliable, "risk free" asset. Its rate is considered as the base for other interest rates. The required rate of return for other assets is usually equal to this rate plus the risk premium term. So the variation of the interest rate in Germany could be represented by the ⁶standard deviation of the T-bill rate. The variation of other rates include the risk premium variation. The market interest rate for Japan by definition is the rate for short-term borrowing between financial

⁶ Standard deviation is a statistical term which is usually used as the measure of the variation of the variable. It is defined as the positive square root of its variance. Variance of a variable with a series of values is the sum of its squared difference from the mean.

institutions. It also has the same feature as the T-bill rate--risk free asset rate.

A narrow measure of money supply (M1) was used in this paper as the measure of the variation of the money supply, by definition M1 includes demand deposits and the currency outside banks. M2 and M3 are broad measure of monetary liabilities, that includes the financial assets in M1. Since the variation of the narrow money causes most of the variation of the broad money, M1 was chosen to represent the money supply for each country.

CHAPTER IV
MODEL AND ANALYSIS

Before beginning the main analysis, a brief explanation of the bias in the foreign exchange market is presented. One of approach to determine the existence of forward bias is to compute the forecast error--($S_{t+1} - F_t$), and to calculate the mean error. The results below show the value is very close to zero, except for yen. These results indicate no bias between S_{t+1} and F_t , because the forecast error ($S_{t+1} - F_t$) changes its sign which may result in a zero mean.

Table 1: Mean of the forward premium among four currencies

currency	\$/bp	c\$/	dm/\$	yen/\$
$S_{t+1} - F_t$	-.01	.00	.02	2.22

This finding gives us an idea that the average of a variable sometimes may not represent the actual condition in the market. The mean for the absolute value of that variable may be a more reliable measure to decide whether bias exists. This topic will be examined later in the risk premium analysis: whether average risk premium or average of the absolute risk premium represent the actual risk condition in the market ?

Following the basic process of former studies, three regressions were conducted for each country. The test results for equation (1a) which measure the bias between the

forward rate and the future spot rate is shown in Table 2, the null hypothesis for α_0 and α_1 is accepted or rejected based on the ⁷T-test. Equation (2) and (3) test the irrationality and the risk premium, respectively, and the results are listed in Table 3 and Table 4.

1. Test of the Foreign Exchange Market Efficiency

A. A Joint Hypothesis Test

Table 2: Testing results for the equation (1a)

$$S_{t+1} = \alpha_0 + \alpha_1 F_t$$

	equation	T-test for α_1	T-test for α_0
\$/bp	$S_{t+1} = .0929 + .8206F_t$ (4.907) (-4.6)	reject	reject
c\$/	$S_{t+1} = -.001 + 1F_t$ (28.533) (0)	accept	accept
dm/\$	$S_{t+1} = .0401 + .9159F_t$ (2.896) (-3.85)	reject	reject
yen/\$	$S_{t+1} = .2349 + .9497F_t$ (2.77) (-2.925)	reject	reject

The acceptance and rejection of T-test are based on 5% ⁸significant level.

Although the test results show that changes of the forward rate do affect the future spot rate, the coefficient between them is not always equal to unity, which indicates the information in the forward rate does not fully reflect what in the future spot rate. For most

⁷ T-test is conducted to test the null hypothesis that a particular coefficient is zero.

⁸ The significant level is a low level of the probability at which Type I error (true null hypothesis is rejected) occurs. In this paper, the level is 5%, which means the probability of the occurrence of Type I error is 5%.

of the cases, a one unit change in the forward rate will cause less than a one unit change in the spot rate. There must be other factors affecting the spot rate.

From the table, we can see that there is no bias between the forward and the spot rate in the U.S.--Canadian market, because the hypothesis for both α_0 and α_1 is accepted. According to the efficient market hypothesis, this market is efficient. This conclusion is very encouraging and surprising. But for the other three markets, the hypothesis for both α_0 and α_1 is rejected. Whether or not these markets are efficient cannot be decided based only on this table; because if the bias between the forward rate and the future spot rate is explained only by the risk premium, the market may still be considered efficient.

B. Rational Expectation Test

Table 3: Testing results for the equation (2)--rationality

$$S_{t+1} = \beta_0 + \beta_1 ES_{t+1}$$

	equation	T-test for β_1	T-test for β_0
\$/bp	$S_{t+1} = .0702 + .8666ES_{t+1}$ (5.195) (-4.8)	reject	reject
c\$/	$S_{t+1} = .0013 + .9928ES_{t+1}$ (.237) (-.2872)	accept	accept
dm/\$	$S_{t+1} = .0271 + .9466ES_{t+1}$ (2.742) (-3.4)	reject	reject
yen/\$	$S_{t+1} = .0950 + .9799ES_{t+1}$ (1.603) (1.675)	accept	accept

The acceptance and rejection of T-test are based on 5% significant level.

Equation (2) tests the rational expectations of the market participants. The null hypothesis here is that $\beta_0 = 0$ and that $\beta_1 = 1$. For the U.S.--Canadian and the

U.S.--Japanese markets, both β_0 and β_1 are accepted equal to their hypothesis values, indicating that in these two markets ES_{t+1} is equal to S_{t+1} , investors make their expectations rationally. In the U.S.--British and the U.S.--German markets, the rejection for both β_0 and β_1 shows that there are apparent differences between the investors' expectation rate and the actual rate, investors do not make their expectations rationally. They may not want to collect enough information because of the high cost, or the information is not available in the market.

C. Risk Premium Test

Table 4: Testing results for equation (3)--no risk premium

$$ES_{t+1} = \gamma_0 + \gamma_1 F_t$$

	equation	T-test for γ_1	T-test for γ_0
\$/bp	$ES_{t+1} = .0265 + .9463F_t$ (1.73) (-1.7)	accept	accept
c\$/	$ES_{t+1} = -.0014 + 1.003F_t$ (-.248) (.115)	accept	accept
dm/\$	$ES_{t+1} = .0168 + .9626F_t$ (1.423) (2)	reject	accept
yen/\$	$ES_{t+1} = .1506 + .9676F_t$ (2.219) (-2.365)	reject	reject

The acceptance and rejection of T-test are based on 5% significant level

A risk premium exists in the market where investors are risk averse and the assets are not risk free. The hypothesis for equation (3) is $\gamma_0 = 0$ and $\gamma_1 = 1$. If the hypothesis is rejected, a difference exists between ES_{t+1} and F_t , which is the risk premium. Investors in the market are risk averse. Test results show that in different markets, situations are

different. For the U.S.--British and the U.S.--Canadian markets, there is no risk premium. Since foreign exchange is believed to involve risky assets, the only explanation here is that investors in these two markets are risk neutral. The information included in the forward rate also reflects the information investors' expectations. And both the forward rate and the spot rate can adjust to the new information quickly. In the U.S.--German and the U.S.--Japanese markets, investors are found to be risk averse. As can be shown from the rejection of the hypothesis. The risk averse investors in the two markets are different. In the U.S.--Japanese market, γ_0 and γ_1 are both rejected, which indicates not only that the forward rate affects the investors' expectations of the spot rate, but it is also affected by a constant term. In the U.S.--German market, investors' expectations are only affected by the forward rate and the constant term is not significantly different from zero. For the reason of γ_1 significantly different from 1, some information affecting investors' expectation is not included in the forward rate.

D. Conclusion

The hypothesis for the three regressions is found accepted for all three regressions in the U.S.--Canadian market. This acceptance tells us that there is no bias between the forward rate and the spot rate in this market, investors are risk neutral, and they also make rational expectation for the future spot rate. This market is efficient.

For the U.S.--British market, the hypothesis for both equations (1a) and (2) is rejected which means bias exists between the forward and the spot rate in market and it is explained by the irrational expectations of the investors. Equation (3) is found accepted which means no risk premium exists in this market and investors are risk neutral. This

market is not efficient.

In the U.S.--German market, the hypothesis for all the three regressions is found rejected. The results indicate the investors in this market are risk averse and their expectations are not rational. The combination of these two components causes the bias between the spot rate and forward rate. This market is not efficient

In the U.S.--Japanese market, equations (1a) and (3) are rejected, whereas equation (2) is accepted, meaning that investors in this market make expectations rationally. Risk premium is the major factor causing the bias in equation (1a). This market could be considered to be efficient.

The results for the U.S.--Germany and U.S.--Japan markets are very interesting, where risk premium is the factor, at least one of the factors for the bias between the forward and spot rate. As we know, both yen and dm have been appreciated for the past ten years. However, investors still believe these two kinds of foreign exchange are risky. In fact, in their eyes, it is probably not the price of the currency making foreign exchange risky or not, it is the deviation of the price that affects the investors' decision whether this asset is risky or not. Although those investors who purchase yen and dm ten years ago are better off because of the appreciation, they still require a risk premium to compensate their holding of these assets. Investors, especially long term investors in the market, would rather choose less risky assets than risky assets even with higher return. This conclusion brings us to the next part of risk premium analysis. In essence, what determines the risk premium in the foreign exchange market?

2. Risk Premium Model

As we mentioned in section II, some models have been tested to explain the risk premium in the market. While each of the models have their own advantages, none of them could fully explain it. The analysis in this paper includes three models: the first one uses the standard deviation of the forecast errors between the forward and the spot rate to explain the risk premium. Model 2 is a pure time series model, the risk premium last period is tested as the estimator for the risk premium in current period. In model 3, risk premium is estimated by the variation of two macroeconomic variables: the standard deviation of the money supply and the interest rate. The first model is suggested by Domowitz and Hakkio (1985). This model is tested again with more data and a different data source from previous studies. The variance of forecast error was changed to the standard deviation of forecast error. The test results for these three models in the U.S.--German and the U.S.--Japanese markets are presented in Table 5, Table 6, Table 7 and Table 8.

Before the model analysis is presented, let us return to the discussion at the beginning of this section: can the average risk premium represent the actual risk condition in the market? The problem is we do not know. From my own opinion, the average of the absolute value of the risk premium is a better estimator. Since the risk premium could be positive and negative, the sum of all these positive and negative values reduces the actual difference between ES_{t+1} and F_t , and reduces the actual risk premium. The graphs on page 20 present the actual risk premium and the average of the risk premium (yearly) in the U.S.--German and the U.S.--Japanese market. From these, we can see clearly that the

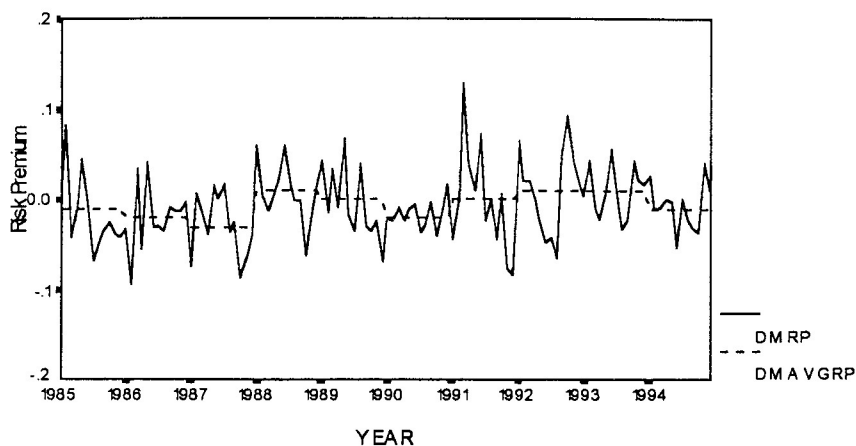
average risk premium each year is much more stable than the actual risk premium and it is close to zero, which is obviously contrary to the actual condition in the market. The average of the absolute value of the risk premium appears reflect more information than the actual risk premium, at least it is significantly different from zero.

To compare the difference between these two, model 1 and model 3 are employed where average risk premium (avg r) is the dependent variable again simply by the change of the dependent variable to the average of the absolute risk premium (avg abs r).

A. Forecast Error Model (Model 1)

This model is to regress the average risk premium with the standard deviation of the forecast errors between the forward and the spot rate. Here, the average risk premium and the average of the absolute value for risk premium were calculated each year, they are the dependent variable in this regression. Standard deviation of the forecast errors is the independent variable in this model to explain the risk premium. The test results are shown in Table 5. In model (1a), avg abs r is the dependent variable, whereas, avg r is the dependent variable in model (1b).

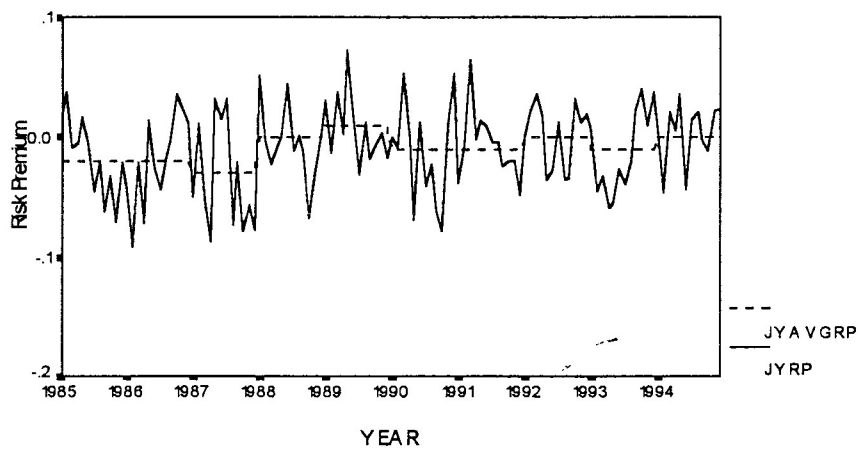
Graph 1: Risk Premium in the U.S.--German market



DM RP: actual risk premium for dm/\$

DM AVG RP: yearly average risk premium for dm/\$

Graph 2: Risk Premium in the U.S.--Japanese market



JY AVG RP: yearly average risk premium for yen/\$

JY RP: actual risk premium for yen/\$

Table 5: model 1, $r_t = a_0 + a_1 {}^9V(S_{t+1} - F_t)$

	U.S.--German			U.S.--Japanese		
	a_0	a_1	F-test	a_0	a_1	F-test
abs avg r_t	.0143	.3571	7.273	.0108	.3945	2.1192
model 1a:	(2.321)	(2.697)	*(5.32)	(.944)	(1.456)	*(5.32)
conclusion	reject	reject	reject	accept	accept	accept
avg r_t	-.0284	.5089	3.6842	.0064	-.3761	1.0863
model 1b:	(-2.304)	(1.919)	*(5.32)	(.421)	(-1.042)	*(5.32)
conclusion	accept	accept	accept	accept	accept	accept

The significant level is 5%.

The number in the () is the T-test value for the coefficient, the number in *() is the ¹⁰critic value for ¹¹F-test.

The regression results show model (1b) fails to explain the average risk premium with the variation of the forecast errors between the forward and the spot rate. The T-tests show the coefficient and the constant are not significantly different from zero. And the F-tests even show the null hypothesis $a_0 = a_1 = 0$ is accepted for both countries, which indicated there is no linear relationship between the $V(S_{t+1} - F_t)$ and avg r_t .

Model (1a) with avg abs r as the dependent variable is a little bit better. It shows the variation of the forecast error in the U.S.--German market has some power to explain the risk premium in this market. Both a_0 and a_1 are significantly different from zero and the

⁹ $V(S_{t+1} - F_t)$ denotes the standard variation of the variable inside.

¹⁰ Critic value is the value in the distribution table used to compare with the model calculated value.

¹¹ F-test is to test the null hypothesis that all the regression coefficients are zero; that is $a_0 = a_1 = 0$. If this hypothesis is accepted, the independent variables would have no linear influence on the dependent variable.

F-test is also rejected. However, this model does not fit in the U.S.--Japan market, we can't use the variation of the forward difference to explain the risk premium in that market. The relation between the two variables in the U.S.--German market can be expressed as $\text{avg abs } r_t = .0143 + .3571 V(S_{t+1} - F_t)$.

B. Lag Model (Model 2)

This model is relatively simple compared to the other two models. The implication for this model is that we always believe the value of a variable includes some information that could be passed on to the next period. In this case, the risk premium in the current period is tested to see whether it can affect its value in the next period. A regression is conducted between the risk premium and its lagged value, the results are shown in the Table 6.

Table 6: model 2, $r_t = b_0 + b_1 \text{ lag } r_t$

	U.S.--German			U.S.--Japanese		
	b_0	b_1	F-test	b_0	b_1	F-test
r_t	-.0075	.2143	5.6245	-.0049	.1935	4.5615
Model 2:	(-2.289)	(2.372)	*(3.92)	(-1.358)	(2.136)	*(3.92)
conclusion	reject	reject	reject	accept	reject	reject

The significant level is 5%.

The number in the () is the T-test value for the coefficient, the number in *() is the critic value for F-test.

This model is better than the first model in explaining the risk premium for both countries. For the U.S.--Japanese market, the F-test shows the joint hypothesis of $b_0=b_1=0$ is rejected, which means there exists a linear relationship between r_t and $\text{lag } r_t$. The T-test for constant b_0 shows it is not significantly different from zero, whereas, b_1 is significantly

different from zero. The relationship can be expressed in the equation $r_t = .1935 \text{ lag } r_t$.

For the U.S.--German market, the F-test shows this model is also accepted. The T-tests indicate the null hypothesis for both b_0 and b_1 is rejected which means the risk premium next period could be affected by the risk premium in the current period plus a constant term. This relation can be expressed as $r_t = -.0075 + .2143 \text{ lag } r_t$

C. Macro Model (Model 3)

Model 3 tests the risk premium by the variation of two macroeconomic variables-- money supply and interest rate. The variation of money supply and interest rate are expressed by the standard deviation (s.d.) and are calculated yearly. Risk premium is the excess return required by investors for risky assets compared to less risky asset. In this case, foreign exchange is also considered as an asset, the price of currency is expressed as dm/\$ and jy/\$, which implies the price will be affected by the economic conditions in both countries. For example, dm has appreciated because of Germany's GDP growth rate (7%) higher than many other countries, but it may be depreciated by comparing it with the GDP growth rate (9%) in the United States. This example reminds us that when we consider the macroeconomic variables, the relative changes are more important than absolute changes. For the money supply, the relative change can be measured by dividing M1 in U.S. by the M1 in Germany. The natural logarithm value of the money supply was chosen to be consistent with the risk premium. So the variation of money supply we see in the model is the log value of standard deviation of M1 in United States divided by the s.d. of M1 in Germany [$\ln(M1_{u.s.} / M1_{dm}) = \ln M1_{u.s.} - \ln M1_{dm}$]. The same approach was used for the interest rate. The test results for this model are listed in Table 7.

Table 7: model 3, $r_t = c_0 + c_1 V(M1_{u.s.} / M1_{dm(yen)}) + c_2 V(I_{u.s.} / I_{dm(yen)})$

	U.S.--German				U.S.--Japanese			
	c_0	c_1	c_2	F-test	c_0	c_1	c_2	F-test
model 3a:	.0299	.008	0.002	3.373	.0312	-.0029	-.0035	.4134
avg abs r_t	(14.307)	(2.366)	(-.112)	*(4.74)	(2.986)	(-.444)	(-.902)	*(4.74)
	reject	reject	accept	accept	reject	accept	accept	accept
model 3b:	-.0060	.0038	-.0033	.6055	-.0032	-.0037	.0009	.2368
avg r_t	(-1.266)	(.492)	(-.73)	*(4.74)	(-.241)	(-.434)	(.173)	*(4.74)
	accept	accept	accept	accept	accept	accept	accept	accept

The significant level is 5%.

The number in the () is the T-test value for the coefficient, the number in *() is the critic value for F-test.

The test results show that model 3 is not a good model to explain the risk premium. However, we find for the U.S.--German market where avg abs r_t is the dependent variable (3a), the coefficient of $V(M1_{u.s.} / M1_{dm})$ is significant from zero, which means this variable may have some power to explain the avg abs risk premium in that market. Although the model (3a) in the U.S.--German market is rejected at the 5% significant level, if the significant level is increased to 10%, the model will be accepted. Based on this, the avg abs r_t was regressed on the $V(M1_{u.s.} / M1_{dm})$ in that market. The test results are shown in Table 8.

Table 8: model 3', $\text{avg abs } r_t = d_0 + d_1 V(M1_{u.s.} / M1_{dm})$

U.S.--German			
	d_0	d_1	F-test
avg abs r_t	.0299 (15.282)	.0081 (2.772)	7.6815 (5.32)
result	reject	reject	reject

The significant level is 5%.

The number in the () is the T-test value for the coefficient.

The test results confirm the analysis above, the variation of the relative money supply does have the power to explain the avg abs risk premium. The T-test shows both d_0 and d_1 are significantly different from zero. The relations can be expressed as:

$$\text{avg abs } r_t = .0299 + .0081 V(M1_{u.s.} / M1_{dm}) .$$

D. Conclusion

Three models were tested trying to explain the risk premium in the foreign exchange market. Model 2 which uses the lag variable as the estimator turns out to be a good model in both the U.S.--German and the U.S.--Japanese market. The test results of model 1 with abs avg r_t as the dependent variable shows the variation of the forecast error has some power to explain the risk condition in the U.S.-German market. The results of model 3 including both interest rate and money supply as the independent variables show the model should be rejected. However, the modified model 3--model 3' shows the variation of money supply in the U.S.--German market can explain abs avg r_t very well .

Model 2 is the only one among the three tested models which can explain the risk condition in the U.S.--Japanese market. The three models are found to explain the risk premium in the U.S.--German market. The following analysis is to determine which model

fits most in this market. The three equations in the U.S.--German market are as follows:

$$\text{model (1a) avg abs } r_t = .0143 + .3571 V(S_{t+1} - F_t)$$

$$\text{model (2) } r_t = -.0075 + .2143 \text{ lag } r_t$$

$$\text{model (3') avg abs } r_t = .0299 + .0081 V(M1_{u.s.} / M1_{dm})$$

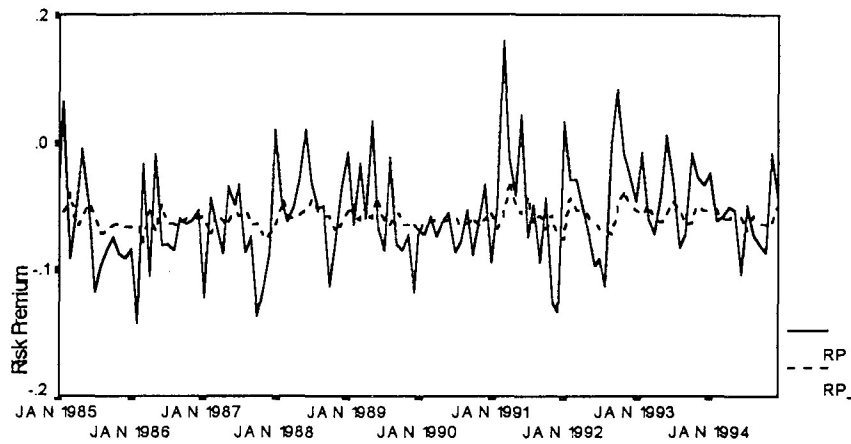
As we all know, the model that could estimate the dependent variable best is usually considered the best model. Model (2) can't be compared to the other two models based on this criteria, because its dependent variable is different.

The actual risk premium and the estimated risk premium from model (2) are drawn in graph 3. This graph shows the estimated values do not fluctuate as much as the actual values. Although model (2) is accepted by the statistical tests, there a lag appears to exist. When the risk premium reaches its highest point in the current period, the estimated value will show the same feature in the next period. The reason for this phenomena could be explained by the regression equations lag r is the explanatory variable for r .

The estimated results for model (1a) and model (3') are listed with the actual avg abs risk premium in graph 4. In this graph, model (1a) looks better than model (3'), especially during the period between 1989 and 1993, the estimated values from model (3') are almost equal to the actual value, which is considered as the perfect estimation. But, during the time period 1985--1989, none of the two models could estimate the actual risk condition. They are not even able to estimate the correct trend of the risk premium. After 1993, model (3') looks better as an estimator for the actual risk. However, there is not much data after that to confirm the estimate. Generally speaking, model (1a) is the best model to estimate the Avg abs risk premium in the U.S.--German market.

Graph 3: Estimated Risk Premium for Model 2

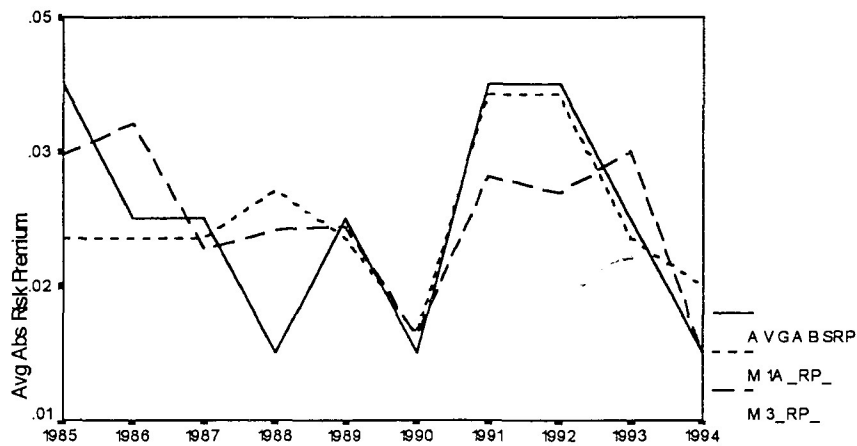
Comparing with the Actual Risk Premium



RP: Actual Risk Premium
 RP_: Estimated Risk Premium for Model 2

Graph 4: Estimated Avg Abs Risk Premium for Model (1a) and Model (3')

Comparing with the Actual Avg Abs Risk Premium



AVG ABS RP: Actual Avg Abs Risk Premium
 M1A_RP_: Estimated Avg Abs Risk Premium from Model (1a)
 M3_RP_: Estimated Avg Abs Risk Premium from Model (3')

CHAPTER V

CONCLUSION

This researches find that the U.S.--Canadian foreign exchange market is efficient, that there is no bias between the forward and the spot rate, that investors are risk neutral, and that they make expectation for the future spot rate rationally.

Further analysis is conducted for the other three markets to explain the existence of the bias between the forward and the spot rate. Inefficiency conclusions cannot be made based only on the test results of equation (1a) because the efficient market hypothesis assumes the market is still efficient if the bias could be explained by the risk premium. Equation (2) and equation (3) are to test whether the risk premium or the irrational expectations should be responsible for the bias. The results show the reason for the bias in the U.S.--Japanese market is that investors are risk averse. Whereas, nonrational expectations turn out to be the major reason for the bias in the U.S.--British market. Both risk premium and nonrational expectations explain the bias in the U.S.--German market. The U.S.--Japanese market is considered as an efficient market, because the bias is only by the risk premium. The other two markets (U.S.--British, U.S.--German) where irrational expectations of investors are the factor for the rejection of the hypothesis cannot be considered efficient.

The test results of the risk premium model show that model 2 which uses the risk premium last period as an estimator for its current period can explain the risk condition in both U.S.--German market and U.S.--Japanese market. Model (1a), which uses the variation of the forecast errors as the estimator fits only in the U.S.--German market. Model 3' is also a good one for explaining the risk premium in the U.S.--German market. The comparison of model (1a) and model (3') shows that model (1a) is better in explain the avg abs risk premium during 1985-1994 period.

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