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An Analysis of the Behavior of the Risk Premium in the German Deutschemark Forward Market: A Comparison of Pre- and Post-German Reunification of 1990 Exchange Rates

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AN ANALYSIS OF THE BEHAVIOR OF THE RISK PREMIUM
IN THE GERMAN DEUTSCHEMARK FORWARD MARKET:
A COMPARISON OF PRE- AND POST-GERMAN
REUNIFICATION OF 1990 EXCHANGE RATES

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Table of Contents

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The German reunification of 1990 and the methods of
economic integration exerted considerable pressure on
both the German economy and the deutschemark. This
thesis addresses the issue that the reunification
undermined the stability of the deutschemark,
detectable through a change in the implied risk
premium. Emphasis is placed on the forward deutschemark
in the context of interest rate parity in order to
detect a change in the implied risk premium. By using
three month U.S. and German bank Certificate of Deposit
rates as the basis for the IRP calculations, a
considerable shift in this implied risk premium was
detected and attributed to a riskier deutschemark.

1. Statement of Purpose

Over the past decade, the West German economy, with steady growth in real GNP and low inflation, has been regarded as one of the world's strongest economies. Although paling in comparison, the East German economy was considered one of the stronger among Eastern Bloc nations. In October of 1990, the German Democratic Republic (GDR) formally ceded to the Federal Republic of Germany (FRG), creating an new economy made up of western ideals and technologies but containing considerable eastern bloc inefficiencies.

The cession ultimately became the focus of numerous economic and political discussions ranging from the ability of the west to absorb the east to questions about inflation and a devaluing of the deutschemark. The latter point will be examined by exploring the effects of the reunification of Germany on the deutschemark. In particular, the existence of a non-zero risk premium will be determined and examined to ascertain whether or not any structural changes in the forward exchange rate model for the deutschemark can possibly be attributed to the reunification of Germany.

The main reason why one may even expect any sort of structural change in the deutschemark during the ex post

1

period lies with the deliberate overvaluation of the East German Ostmark by the German Bundesbank. This disparity, as will be discussed below, was likely to be interpreted as a prelude to inflation in the "New Germany." The West German economy and, hence, the deutschemark, had long been considered somewhat removed from the pressures of inflation; it was this sudden anticipated inflation increase that could be expected to cause the structural change in the deutschemark, via the risk premium. Prior to reunification, investors perceived major increases in inflation as unlikely due to the Bundesbank's effectiveness in maintaining price stability. The incorporation of East into West Germany confronted investors with the specter of increasing inflation in a previously stable economy.

This examination will be conducted on a two country model, Germany and the United States. Any data collected before the unification was West German statistics due to availability and accuracy considerations and because West Germany is more reflective of the current Germany than was East Germany. The U.S. Dollar was chosen for the simple fact that any other cross-currency trading, through arbitrage can be linked to include the dollar; thus, we maintain the two country model.

The data that will be examined covers the period of March, 1973 (1973.03) to March, 1993 (1993.03). There are

sufficient observations prior to reunification to base any findings. There are also sufficient post reunification observations to conduct at least small sample tests. Ideally more observations would have been preferable; however, some statistical faith can be put into the findings.

The structure of this thesis is as follows:
In Section 2, the historical background, I address the issue of why one could expect a change in the risk premium to occur as a result of reunification. The political history of German reunification is touched upon in this section, and the specifics of the currency conversion and its effects are discussed.

An examination of the relevant economic literature is contained in Section 3. The problem of discerning between the presence of a risk premium and/or the breakdown of rational expectations is introduced and is an integral part of all discussions contained in this paper. The remainder of the section is focused on the various theoretical models that have contributed to the analysis.

A description of the data and the reasoning behind the chosen sample periods can be found in Section 4. Section 5 contains a discussion of the interest rate parity which is the basis upon which my null hypothesis and ultimately all conclusions rest.

Section 6 contains the data analysis wherein the results of all tests are reported and discussed. Section 7 is the conclusion of this paper.

2. Historic Background

It would not seem unreasonable to ask "why one would expect a change in the risk premium for the deutschemark." The answer lies in the fact that since the end of World War II, West Germany (the Federal Republic of Germany - FRG) and East Germany (the German Democratic Republic - GDR) have been two totally separate states that have pursued two distinct economic ideologies with contrasting success. The free market philosophy of the FRG has undoubtedly been more successful that the centrally planned economy of the GDR with respect to real income and growth levels. Thus, with the incorporation of the less productive East Germany into the robust West German economy, one would certainly expect total productivity to decline. Further, when combined with the inherent costs of the unification (mostly subsidies) and inflationary threats, the deutschemark may well be considered a riskier currency to hold.

The inflationary threats stem primarily from the expected increased monetary base that will be required to 1) finance the exchange of ostmarks to deutschemarks at a considerably overvalued rate, and 2) support (mainly through

subsidies) the East German population and industries, even if only temporarily. The ensuing decrease in nominal interest rates would cause the deutschemark to devalue, relative to the rest of the world, ceteris paribus. With this possibility, investors would require a larger premium to hold deutschemarks.

In fact, in these particular circumstances, it would not be unreasonable to assume the rest of Europe and possibly the U.S. would follow suit in an attempt to decrease their domestic nominal interest rates. The reason for such an assumption would be that the Bundesbank had previously maintained a high domestic interest rate, thereby forcing most of the major governments to also maintain a high interest rate in order to sustain a targeted exchange rate level and attract foreign capital. With their central banks under local pressure to reduce rates, a fall in German rates may allow foreign governments to reduce interest rates. All this considered, investors may still require a premium for holding deutschemarks as the increased uncertainty remains.

Before becoming involved in the analysis of the deutschemark, it will be insightful to digress a little into the historical background of the reunification of Germany.

The first free legislative elections in the GDR were held on March 18, 1990, and resulted in a coalition

government led by the Christian Democrats, who were closely aligned to their sister party in the FRG. The subsequent abolition of travel restrictions between the two states led to ideas and then demonstrations for a united Germany. In November 1989, Chancellor Helmut Kohl had presented to the Bundestag a 10-point plan for eventual unification of the two Germanies; the plan had received broad approval both from within West Germany's borders and from such instrumental players as Mikail Gorbechev and the NATO leaders. After promises that German borders would remain as they were and continued EC membership, the path for reunification was left entirely to agreement by the two Germanies.

On the 31st of August 1990, a treaty between the GDR and the FRG was signed on the "Establishment of German Unity," indicating the cession of the GDR to the FRG on October 3, 1990. According to the treaty East Germany was to become one with Germany and was accorded NATO and EC membership, - thus began the period of post reunified Germany.

Underlying the political and nationalistic desire for unification was a certain wariness by the West Germans (and world financial markets) of the type of economic burden they would essentially be undertaking in order to truly unite Germany. Although the GDR was the most highly developed

economy in the CMEA, (Council for Mutual Economic Assistance -which included mostly Eastern Bloc nations and other centralized economies such as Cuba and Vietnam), combined with the anticipated inflow of funds and technology, the decentralization of industry and relatively less productive workers of the GDR were going to prove an economic and social burden to their western brethren.

Prior to 1989 the East German economy was, by official estimates of real GDP, growing approximately 3-4% annually. By mid 1989 this rate was estimated to have declined to 1-2%, the cause of which former Prime Minister Modrow attributed to the mass exodus of young and skilled workers to the FRG. Two thirds of all GDR foreign trade was conducted with CMEA partners, 40% of which was with the Soviet Union. Between 1988 and 1989, the GDR current account balance went from a western estimate of $100 million surplus to an official $1 billion deficit. In an economy that imports mostly intermediate goods and also experienced a decline in GDP growth, the subsequent build up of substandard finished goods could be construed as an indication of the inefficiencies of the old East German economy. Furthermore, the GDR national debt was growing at twice the rate of national income.

After much debate and anticipation, the German Parliament decided (April 23, 1990) that upon unification

ostmarks could be converted to deutschemarks (the official currency of the new Germany) at the rate of 1:1. Although the GDR had accepted the economic and political reality that the market value of the ostmark was not equal to the value of the deutschemark, in May of 1990 the commercial value was still published at the rate of 1:1. A GDR-FRG travel board adopted a tourist rate of 3EM:1DM, and the GDR government even acknowledged that the economic conditions of the time implied an exchange rate of around 4.5:1. Black market transactions, which are normally more indicative of the intrinsic value of the ostmark than are official rates, allowed the deutschemark to be bought for seven or as many as thirteen ostmarks.

Specifics of the currency unification were that wages and pensions were to be converted at the 1:1 rate. This rate would apply to savings and cash holdings only on a graduated scale according to age. GDR citizens below the age of 15 could convert cash and savings at a rate of 1EM:1DM up to 2,000 ostmarks per person. For those between the ages 15-59 4,000 ostmarks could be converted at 1:1, while citizens 60 years and older could convert 6,000 ostmarks. For cash and savings above these amounts the rate of 2:1 would apply. Mortgage and industrial debt would be converted at 2:1, but at the rate of 3:1 for ostmarks held outside the GDR. Non-GDR citizens and entities with accounts in the GDR would be

given a rate of 3:1 based on the amount they held in ostmarks on December 31 1989. (United States Dept. of Commerce - American Embassy in Berlin 1990)

As can be seen from the actual currency exchange specifics, the transaction rate of 1:1 :: EM:DM for initial exchanges and then 2 or 3 to 1 thereafter provided the East Germans with an opportunity for short-term gains and the German economy with a considerably increased monetary base. Typically the German Bundesbank has maintained a tight monetary policy in order to combat its inflationary concerns. Such an inevitable increase in the monetary base would probably raise fears of inflation which in turn would likely undermine the global perception of the deutschemark's stability. If Germany were not a country with an extremely strong anti-inflationary stance, investors' expected inflationary increase would simply be a direct function of their perceived increase in the monetary base. However, investors in the deutschemark also must consider the extent of Bundesbank intervention in domestic financial markets.

Accordingly, after reunification one would expect investors to require additional compensation in the form of a risk premium for holding either spot or forward deutschemarks, not only because of expected increases in inflation but also because of a slight possibility of little or no inflation due to sterilization. It is this

anticipation of an increased risk premium due to perceptions about inflation and/or the amount of sterilization that the deutschemark has become riskier that will be examined during the course of this paper.

3. Literature Review

Due to extensive past studies, it is now commonly accepted that the forward discount is a biased predictor of future exchange rate changes (Hansen and Hodrick 1980, Cumby and Obstfeld 1982). A common test (Fama 1984) for forward market bias is to regress the future change in the spot rate on the forward discount where $\delta S(t+k)$ is the percentage currency change (difference in the log of the spot price for foreign exchange) and $FP(k,t) = F(k,t) - S(t)$ is the current k-period forward discount/premium (i.e., log of forward rate less the log of the spot rate); thus,

$$\delta S(t+k) = \alpha + \beta \; FP(k,t) + \varepsilon(t+k) \qquad (1)$$

where α = constant term
k = k future periods from t
$\varepsilon(t+k)$ is a random error term

The null hypothesis of unbiasedness is that $\beta=1$ and $\alpha=0$.

Previously conducted tests typically show β to be less than unity indicating a tendency of the forward rate to overpredict the future spot rate. The presence of

unbiasedness or "speculative efficiency" (Bilson 1981) implies a rejection of the joint hypothesis of market efficiency and no risk premium.

Early tests of forward bias calculated the mean forecast error, $S(t+1) - F(t)$, (Frankel 1980), and found it not significantly different from zero. It was concluded that such findings provided evidence of a zero risk premium. However, more recently, weight has been assigned to the fact that these results are also consistent with a risk premium that changes its sign and has a mean of zero. (Kaminsky and Peruga 1990)

A difference of opinion arises from attempting to distinguish what is responsible for the rejection of the hypothesis of unbiasedness. It must be considered whether this forward bias is evidence of a risk premium or a breakdown of rational expectations theory or a combination of the two.

If one were to assume that investors were risk neutral, then the systematic component of exchange rate changes in excess of the forward discount could be interpreted as evidence of a failure of rational expectations (Froot and Frankel 1989). They further add that the same systematic component of unbiasedness has been thought to arise from a time varying risk premium that separates the forward discount from expected depreciation. It is this concept of a

time varying risk premium that will be of central concern in this analysis of the deutschemark.

It is generally acknowledged that there is little empirical evidence in favor of a time varying risk premium. However that, in itself, does not constitute an outright rejection of the hypothesis. Many of the works taken from a portfolio balance model point of view reveal no evidence of a risk premium. Boothe and Longworth (1986) group models that allow for the existence of a risk premium into two groups: those that require the presence of outside assets to explain the existence of a risk premium and those that do not. The portfolio balance model falls into the former category. The author will be looking at a model that allows for the existence of a risk premium without reliance upon assets such as current and capital account figures that are incorporated in the portfolio balance approach.

Although there may be little evidence to support it, the risk premium will continue to be a topic of serious discussion as it implies the verification of one of economics most basic premises - that agents act rationally. Boothe and Longworth and Hodrick and Srivastava (1984) found that other financial markets have shown an incorporation of a risk premium into their returns. One would, therefore, expect to find similar results in currency markets. Given an improvement in both data testing and gathering (namely

survey) data, it will more than likely be possible to prove or disprove the rational expectations assumption and the existence of a risk premium.

A model that approaches the risk premium outside the framework of the portfolio balance model was presented by Domowitz and Hakkio (1985). It suggests that not only is a risk premium required to explain deviations from simple market efficiency but that the risk premium should also be time varying. Their analysis of the risk premium depends on the conditional variances of the independent variables in a regression on the rate of forward premium depreciation. They found the German mark's estimated risk premium to frequently change from positive to negative in the presence of substantial movement of the conditional variance. Such movements in the risk premium would be consistent with Frenkel's (1982) observations that the risk premium should fluctuate between negative and positive so that the absence of conditional bias can be adequately accounted.

Another popular approach to addressing the risk premium question has been through the Efficient Market Hypothesis (EMH) where agents form their expectations rationally and are also risk neutral.

In such a model, the risk premium (RP) can be expressed as

$$RP(t) = [F(t+1,t) - S(t)] - [S(e,t+1) - S(t)] \qquad (2)$$

where: $F(t+1,t)$ = t+1 Forward Rate in time t
$S(t)$ = Spot Rate at time t
$S(e,t+1)$ = t+1 Expected Spot Rate

and will equal zero under the conditions of risk neutrality and rational expectations.

Many such tests including a rejection of the EMH have assumed that investors do not make systematic forecasting errors and accordingly any systematic observed errors are due to risk factors. A number of authors have shown that under the assumption of risk neutrality agents are irrational (Bilson 1981) and that if one assumes agents to be both rational and risk averse then a risk premium does exist but cannot be specifically attributed to either factor. It hardly seems plausible for the two views to, in fact, be valid since both arguments used $F(t+1,t)$ as their proxy for $S(e,t+1)$ while differing only in their assumptions of risk neutral and risk averse investors. Therefore, they are not avoiding the jointness of the hypothesis (rational and risk averse investors) under consideration, since by substituting $F(t+1,t)$ for $S(e,t+1)$ one automatically assumes markets and hence investors to be rational. MacDonald and Torrance (1988) used weekly survey data to overcome this proxy problem and found that the forward rate was a biased predictor of the actual future spot rate for the deutschemark over the period 1985.02 to 1986.04. The use of

survey data allowed them to attribute this bias to the irrationality of investors. However, the use of survey data itself has frequently been criticized, and the authors acknowledge that in their sample there was a consensus view that at that time the dollar had depreciated "too far." This means that a dollar appreciation out of the sample validates the speculators' in-sample expectations. A further question then arises (which will not be adressed here): to what extent are these expectations then validated?

Given that our analysis will be based around conditions before and after a given event (reunification), it would be prudent to consider implications from previous conditional variance tests for a risk premium. Kaminsky and Peruga (1990) point out that the risk premium will not be uniquely determined by the covariance of consumption, but could be influenced by the risk derived from the possibility of a changing exchange rate regime. This is analogous to the problem of out of sample expectations outlined above and is commonly referred to as the "peso problem," where long-term expected movements are not realized in the short-term thus investors may appear irrational in the short-term.

If the dollar/deutschemark exchange rate were to follow a random walk with drift (ie., uncovered interest parity), the relationship could be shown in regression form as

$$S(t) = \alpha\ S(t-1) + \beta\ (i - i')(t-1) + \upsilon(t) \qquad (3)$$

where: i = US interest rates
i'= German interest rates.

The joint hypothesis of uncovered interest rate parity and rational expectations implies that $\alpha=1$, $\beta=1$ and υ is a white noise error process (MacDonald 1988).

Typically, it has been found that α and β are as expected but υ is usually a non-white noise error term. As with the forward discount bias, such deviations are usually attributed to the existence of a variable risk premium (Cumby and Obstfeld 1981) or a breakdown in rational expectations. Should the above hypothesis not hold, further tests for $\alpha, \beta,$ and υ will be performed in order to determine whether deviations from covered interest parity became structurally different before and after the period of reunification.

4. Data Description

The analysis is based on monthly data from 1973.01 to 1993.02 which amounts to 240 observations in all. The data prior to unification contains 205 observations and is therefore a sufficiently large enough data set for comparisons to be made. March of 1973 was chosen as the starting point of my data set since all post WWII exchange rates quotes prior to this date are influenced (tainted) by

the Bretton Woods agreement on fixed exchange rates. February 12, 1973 saw the final collapse of the Bretton Woods system when Japan and European nations allowed their currencies to float freely. Thus, March of 1973 was the first postwar month containing flexible exchange rates. A further consideration does arise in the post-unification data set. The sample up to the end of 1992 contains only 35 observations, a smaller number than would be ideally available, this is however unavoidable because the close proximity of the study simply makes any further observations impossible.

An important concept to be considered lies in the dissolution of European economic barriers. As of January 1st 1993, Germany and all its trade partners became active members in the European Economic Community. The dissolution of economic borders between the members of the EEC is expected to bring considerable economic gain in the form of free trade and standardized product taxes to the twelve member nations. It seems logical to deduce that if one were to prove that unification did indeed cause a significant change in the foreign exchange risk premium, then it is likely that the birth of the EC (and pure free-trade etc.) would exert some influence on currencies; and the question of a further change in the risk premium arises. Thus, by including 1993 data, it is arguable that one also would have

to address the same question twice since the data contains influences from the two events which are not mutually exclusive. For now, this concept will merely be afforded some consideration in my conclusions. The formation of the EEC had been common knowledge for approximately a decade before 1993, and accordingly it is arguable that any significant changes occurred as a result of official recognition of the EC in 1993. Similarly, if German unification took place over a number of years, there would probably be little or no structural break in any time series exchange rate model.

Germany's current reluctance to break away from the ERM (even after Britain and Italy), is keeping the deutschemark at an artificial rate. Any post reunification (ex ante) observations that were to include current figures would first need to eliminate this effect. Using implied forward rates as has been done here is one way to deal with this issue. Otherwise, 35 or so observations may be all that is useable in testing the ex ante data.

The variables consist of the log of the spot exchange rate (measured in dollars per Deutschemark) which is represented by S. The forward rate $F(t+j,t)$ represents the forward rate for delivery in period $t+j$. Consequently, $[F(t+j,t) - S(t)]$ is the forward premium which can also be expressed as $FP(t+j,t)$. Comparable interest rates are drawn

from the U.S. 3-month bank certificates of deposit and a similar German commercial bank equivalent security, measured as i and i', respectively. All primary data sets were obtained through the National Trade Data Bank system.

5. Uncovered Interest Rate Parity

The Interest Rate Parity theorem (IRP) relates the discount or premium on forward exchange to the term structure of interest rates on financial assets. Briefly, IRP states that the forward and spot markets are so related, that an investor will be indifferent between borrowing/lending in either domestic or foreign currency, when considering currency exchange immediately in the spot market and exchange risk being covered by a reverse transaction in the forward market. Economic equilibrium is maintained where there is equality between the rates of return on domestic and covered foreign assets which can be expressed by the IRP condition:

$$FI(T,t) = S(t) \frac{[1 + i(T/360)]}{[1 + i'(T/360)]} \qquad (4)$$

(The 360-day year is used in this equation since we are dealing with US dollars and German deutschemarks, both of which are quoted in 360-day year terms.)

By applying the three-month certificate of deposit

yields, i and i' to the above condition, the x-month implied forward rate can be calculated and applied to the analysis. However, it should be noted that the IRP condition assumes the markets to be rational (all arbitrage opportunities exhausted), thus any forward bias could only be attributed to the presence of a risk premium as the possibility of the breakdown of rational expectations is overcome by this condition.

Fama's (1984) test for forward market bias was conducted as

$$\delta S(t+k) = \alpha + \beta \ FP(k,t) + \varepsilon(t+k), \qquad (1)$$

where the expected values for unbiasedness are $\alpha=0$ and $\beta=1$. Table 1 displays the results of the period 1973.03 - 1990.03. The coefficient on the implied one-month forward discount (FP1) can be seen to have a value of -0.054 which is statistically different from zero, as it is from unity. The constant term is also shown to be different from zero. Similarly, the forward discount for the implied three-month rate (FP3) is a biased predictor of future spot rate changes as the coefficient on FP3 is -0.028, which is also significantly different from zero and one. The coefficient of the constant term is once again statistically different from zero. The results of the test using both one-and three-month implied forward rates for the period 1973.03 - 1993.02. are not shown here, but confirm the findings above.

Thus it can be deduced that the implied forward discount is a biased predictor of future exchange rate changes.

TABLE   1

Dependent Variable: Difference in Log of Spot Rate
Sample Range: 1973.03 - 1990.03
Number of Observations: 205

Variable	Coefficient	Std Error	T-Statistic
C	0.0096	0.0031	3.0777
FP1	-0.0540	0.0185	-2.9121
C	0.0088	0.0032	2.7551
FP3	-0.0277	0.0112	-2.4754

(FP1 and FP3 are expressed in logged terms.)

Bilson (1981) noted that the presence of unbiasedness implied a rejection of the joint hypothesis of market efficiency and no risk premium. By using the implied forward rate (FI) from IRP we have (as stated previously) inherently assumed that there are no arbitrage opportunities and, hence, the market is acting efficiently. The question therefore arises whether this implied bias can be attributed solely to an implied risk premium.

As mentioned earlier, another common approach to addressing the risk premium has been through the incorporation of the EMH, wherein investors are assumed to act rationally and are risk neutral. Because of this rational investor assumption, incorporating IRP into the

model is consistent with this approach; and the previous problem of attempting to attribute failure of the EMH to a risk premium or breakdown of rational expectations is now overcome. IRP implicitly assumes rational investors and, consequently, systematic prediction errors in EMH can be attributed to a risk premium.

By removing ourselves from the possibility that agents can act irrational (by definition of IRP), we hope to have alienated any fluctuations sufficiently enough to attribute them to changes in the risk premium.

Having calculated the implied forward rate, the now inherent assumption of rational expectations is used to form the model for identifying the presence of a non-zero risk premium.

Because of rational expectations, the spot rate will equal its expected value plus a random error term and can be shown as $S(t+1) = E(t) S(t+1) + \varepsilon(t)$, where $E(t) S(t+1)$ is the expected value of the spot rate in the period $(t+1)$. In efficient currency markets, it is the forward rate that equals the expected future spot rate and with risk averse investors who require a risk premium. Foreign exchange market efficiency can be shown as follows: $E(t) S(t+1) = F(t) + RP$, where RP equals the risk premium.

By applying the implied forward rate to the above two equations the following equation is derived:

$$S(t+1) = FI(T,t) + RP + \varepsilon(t+1) \qquad (5)$$

where FI(T,t) is the implied forward rate as calculated above. What concerns us is whether or not RP can be shown to be non-zero.

That is, the null hypothesis is that

$$Ho: RP = 0,$$

while the alternative hypothesis is

$$H1: RP \text{ does not equal } 0.$$

To test the previous equation, the following linear regression will be run:

$$S(t) = \alpha + \beta [FI(T,t-1)] + \varepsilon(t). \qquad (6)$$

Testing will be performed to determine whether the null hypothesis, which in this regression is shown as $\alpha=0$ and $\beta=1$, can be rejected. Unless both conditions are met, the null hypothesis must be rejected. The risk premium is a non-measurable quantity (with current statistical techniques and data generating procedures). Accordingly one cannot simply run a linear regression to determine its magnitude. By using equation (6) to test for a risk premium, we hope to find evidence of a missing variable. It has already been established that a breakdown of this equation (and equation (1)) is due either to irrational investors or to a risk premium and the inclusion of the implied forward rate has eliminated the possibility of irrational markets. Therefore

rejection of the null hypothesis (partial evidence of a missing variable) can only be attributed to the presence of a risk premium.

Similarly, the joint condition of $\alpha=0$ and $\beta=1$ can also be tested by an examination of the residuals of the above regression. The dependent variable simply becomes

$$S(t+1) - FI(T,t) = \upsilon(t+1) \tag{7}$$

and a test is conducted to determine whether the residuals are in fact white noise. A conclusion of a non-white noise error term will lead us to reject the null hypothesis of no risk premium.

It should be pointed out that this study is based largely on IRP and equation (6). Although a number of tests are run on the data, they are mainly a deviation of (6) and serve to make any findings thereof more robust.

6. Data Analysis

By obtaining the implied forward rate (FI) we can compare the period prior to unification to the period after it. On the regression $S(t) = \alpha + \beta[FI(t-1)] + \upsilon(t)$, we can test for the presence of a risk premium by testing for $\alpha=0$ and $\beta=1$. If the risk premium (RP) equals zero then the above condition will hold because with rational markets and risk neutrality (or no perceived risk considering risk aversion) the implied forward rate in time t will equal the

spot rate in t+1.   If the above condition does not hold, then we must consider the probability of a non-zero risk premium.

Because we are working with implied (theoretical) forward rates, it is possible to calculate any x-month forward rate. Only two "reasonable" x-month forward rates were considered: namely, the one-and the three-month rates. The one-month forward rate was, in general, a better predictor of future spot rates. Accordingly, the one-month rate better represents market efficiency and would therefore be a better proxy for expected future spot rates than would the three-month rate.

Actual incorporation of East Germany into West Germany took place on October 3, 1990. A model that better reflects the explanatory power of the implied forward rate incorporates the beginning of the post reunification period being in April as opposed to September 1990. The reasoning behind this "split date" of March 1990 is that during April 1990 the official transfer exchange rate of 1:1 :: EM:DM was made official. Any investor either buying or selling Deutschemarks after the announcement would have to consider the inevitable forthcoming increased world supply of Deutschemarks. Thus if an investor were to take any action regarding the Deutschemark, it would be well before the political unification that followed in October.

A question arises regarding the number of post unification observations. Because these events are rather recent, there only 35 observations available since the "split date." (Only 28 if one were to consider October as being the relevant date.) Accordingly, conclusions reached about changes in the Deutschemark after reunification should perhaps be accorded some degree of consideration. The fact that the 35 observations provide at least 20 degrees of freedom which makes the tests workable does allow one to put some weight behind the conclusions reached.

With the exchange transfer announcement coming mid-April 1990, it could be argued that the end of April would have been a more accurate "split date" than the end of March. The March date was chosen for two reasons: 1) it was felt that rumors circulating at the beginning of April were fairly accurate, and therefore less likely to bias any results than would the inclusion of post-announcement activity with pre-announcement data even though there were a large number of observations; and 2) it allows us one more observation of post reunification data.

An examination of the regression shown in (6) on the one-month implied forward rate prior to April 1990 reveals that $\alpha = -0.36$ with a t-statistic of -18.853 (hereafter shown in parentheses following the coefficient's value) and therefore differs significantly from zero. The coefficient β

was found to equal 0.6463 (24.038) and is not only significantly different from zero but it also differs from one as the 95% confidence interval for β is 0.6463 +- 0.0527. The R-squared value of 0.740 indicates that the implied forward rate was an extremely good predictor of future spot rates, prior to April 1990. Further, the F-statistic of 577.82 indicates the significance of both the implied forward rate and the constant (intercept) terms in the model. These figures are reported in Table 2 where LFI = Log of the implied rate.

TABLE 2

Dependent Variable: S (Log of Spot Rate)
Sample Range: 1973.03 - 1990.03
Number of Observations: 205

Variable	Coefficient	Std Error	T-Statistic
C	-0.3643	0.0193	-18.8534
LFI(-1)	0.6463	0.0269	24.0379

R-Squared: 0.740   Adjusted R-Squared: 0.739
Durbin-Watson: 0.239   RSS: 1.625
F-Statistic: 577.82

The period after reunification (1990.04-1993.02) shows that $\alpha=-0.404$ (-7.846) and β has a value of 0.106 (1.363). Further, β is not significantly different from zero at the 5% or 10% level of significance. After reunification the R-squared of the same model drops to 0.053 with an adjusted R-

squared of 0.025. This decline in the predictive power of the model is attributable to the insignificance of the implied forward rate variable after April 1990. Consistent with such a decline is the low F-statistic of 1.858. Results are shown in Table 3.

TABLE 3
Dependent Variable: S (Log of Spot Rate)
Sample Range: 1990.04 - 1993.02
Number of Observations: 35

Variable	Coefficient	Std Error	T-Statistic
C	-0.4040	0.5149	-7.8465
LFI(-1)	0.1058	0.0776	1.3632

R-Squared: 0.053   Adjusted R-Squared: 0.025
Durbin-Watson: 0.293   RSS: 0.105
F-Statistic: 1.858

Over the entire data range of 1973.03 - 1993.02, the R-squared value of 0.57 and F-statistic of 310 are of little value since they are merely a combination of the extremely good and an extremely poor predictive power the independent variable exhibited, of future spot rates.

TABLE 4

Dependent Variable: S (Log of Spot Rate)
Sample Range: 1973.03 - 1993.02
Number of Observations: 240

Variable	Coefficient	Std Error	T-Statistic
C	-0.320	0.030	-10.714
LFI(-1)	0.645	0.042	15.377

R-Squared: 0.498   Adjusted R-Squared: 0.496
Durbin-Watson: 0.087   RSS: 4.774
F-Statistic: 236.44

To eliminate this combination of data ranges containing a poor and a strong predictive element of future spot rates by the independent variable, a dummy variable was incorporated into the model. Prior to April 1990 the dummy variable was assigned a value of zero and a value of one thereafter. The regression can be shown as follows:

$$S(t) = \alpha + \beta \ FI(t-1) + \phi \ D \qquad (8)$$

where D = Dummy variable

Most impressive is that now the R-squared is 0.806 over the entire period of 1973.03 - 1993.02. In addition, $\alpha = -0.38$ (-20.241), while $\beta = 0.621$ (23.758) but is significantly different from one. The coefficient on the dummy variable is 0.313 (23.96) indicating, a structural change in the composition of the spot rate at the time of reunification. The F-statistic is 493.38, indicating significance of all

the independent variables.

TABLE 5

Dependent Variable: S (Log of Spot Rate)
Sample Range: 1973.03 - 1993.02
Number of Observations: 240
```
------------------------------------------------------------
Variable      Coefficient      Std Error      T-Statistic
------------------------------------------------------------
   C            -0.3814          0.0188         -20.2416
  FI(-1)         0.6213          0.0261          23.7582
   D             0.3135          0.0161          19.4138
------------------------------------------------------------
R-Squared: 0.806           Adjusted R-Squared: 0.805
Durbin-Watson: 0.261       RSS: 1.843
F-Statistic: 493.38
------------------------------------------------------------
```

Another method of determining whether there was a structural break in the composition of the deutschemark is to apply the Chow test to equation (6), the results of which are shown in Tables 2,3 and 4. It is the Residual Sum of Squares (RSS) that will be of concern here. The calculated F-value with k=2 and (N1 + N2 - 2k) = 236 is 217.43. The critical value $F(2,236) \sim F(2,200) = 3.04$. Because 217.43 > 3.04 we can confirm our conclusion found using the dummy variable. There was a change in at least one component of the deutschemark. The only two variable components that are not explicitly included in the model are the rationality of investors and the risk premium. We have already alleviated the possibility of irrational investors and accordingly one

can conclude that there was a change in the risk premium after the reunification of Germany.

The author suggests that the risk premium did in fact increased after German reunification. The presence of a risk premium was detected by evidence of its omission in the various regressions that were run. After reunification, equation (6) was no longer even an adequate predictor of future spot rates indicating the omission of at least one significant independent variable. Assuming the model was missing no other independent variables besides the risk premium (and the author has no reason to think otherwise), then the risk premium now exerts a larger influence on the determination of spot rates than prior to German reunification. Similarly, if the post reunification risk premium had in fact become zero, then the models would no longer exhibit the properties of a specification bias due to an omitted variable. If such were to be the case, it seems logical to deduce that, because the specification bias seemed to get worse after March 1990, the risk premium can be said to have increased with respect to the pre-unification risk premium.

The three regressions presented above exhibit positive serial correlation (with Durbin-Watson statistics of no greater than 0.30). Accordingly, the reliability of the above regression is likely to be overstated, and it is not

considered the best estimator of the dependent variable. For our analysis, this overstating is of little or no concern.

Efficient markets, which we have inherently assumed in deriving our implied forward rate, also assume semi-strong form efficiency for financial markets. This definition means that we have already assumed that all previous and presently available information is included in our calculated forward rate. To attempt to correct for autocorrelation by including any dependent variable lags would be, by definition, an inconsistency in our testing methods. For this reason alone, there is little that can be or should be done in the model to avoid any positive serial correlation.

It would probably be surprising if positive serial correlation were not detected. The above tests have shown that the stated condition wherein investors are rational and there is no risk premium does not hold (which I believe is due to the presence of a non-zero risk premium). The exclusion of a significant variable (albeit nonmeasurable) is likely to bias the errors toward being serially correlated.

In addition to the above test for determining whether the null hypothesis of RP = 0 should be rejected or not, one could also examine the residuals using $S(t+1) - FI(t) = \upsilon(t+1)$. As explained previously, if the residuals are white noise in the equation then the null hypothesis of RP = 0

cannot be rejected. The autocorrelations of the dependent variable were tested by use of the Box-Pierce Q-statistic. Under the null hypothesis, the Q-statistic follows a Chi-squared distribution, but since we have over 100 degrees of freedom we could also use a standard normal distribution.

For the entire data range of 1973.03 to 1993.02 the dependent variable exhibited a Q-statistic of 1467.8. At the 5% significance level and 100 degrees of freedom, the critical Chi-squared value is 124.3. These results translate to a zero probability of the series being considered as white noise over the range of data.

The Q-statistic for the period 1973.03 - 1990.03 is shown to be 572.1, while the Q-statistic for the period 1990.04 - 1993.02 is 166.5. Consequently, neither series can be considered as white noise at the 5% (or the 1%) significance level, and the null hypothesis of RP = 0 can be rejected in this context. The evidence of autocorrelations is further evidence of the probability of an omitted variable in the regression above.

7. Conclusion

Ideally, it would be possible to take actual forward and spot rates and determine whether or not a change in the risk premium for the deutschemark was present after German reunification had occurred. Because the existence of a risk

premium and the breakdown of rational expectations are indistinguishable in being the cause of any structural change in the deutschemark, actual forward rates prove to be of little use in detecting the presence of a risk premium. By incorporating interest rate parity, it becomes possible to isolate changes in the risk premium through a detected structural change in the interest rate parity condition. This approach was undertaken and it was found that the reunification of Germany did in fact cause a change in the risk premium of the deutschemark.

Given the evolution of statistical testing methods, it will (probably) become possible to use actual forward rates to isolate the risk premium and detect changes in its magnitude. Until then we are reduced to using survey data and implied forward rates. However with the advent of the ERM (and currencies being on and off it), one must wonder whether these will provide a helpful inroad to gaining a more thorough understanding of this complex relationship.

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