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THE INTERNATIONAL LINKAGE OF REAL INTEREST RATES: THE EUROPEAN - U.S. CONNECTION

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ABSTRACT

Casual observation indicates that in recent years real interest rates in the United States appear to have risen sharply and have remained high relative to historical standards. Many observers have claimed that these high real rates have been transmitted abroad and have lead to high real rates in the rest of the industrialized countries. Concern over the level of real rates has been widespread in the analyses by economic policy makers both in Europe and in the United States.

In this paper we present evidence on several questions regarding the movement in short term real interest rates in eight countries that have been raised by the recent policy debates in Europe and the United States: Have ex ante real rates in the United States and Europe been high during recent years? Has there been a link between U.S. real rates and those in other countries? Can this link be quantified?

The basic finding in this paper is that real rates have climbed dramatically from the 1970s to the 1980s in both the European countries and the United States. Indeed, real interest rates in the United States are currently at high levels unprecedented in the post war period, which rival the levels that occurred during the Great Depression. Complaints that real interest rates in the United States are exceedingly high seem to be well justified. There is also strong evidence that there is a positive association between movements in U.S. real rates and those in Europe. However, European real rates typically do not move one-for-one with U.S. real rates, still leaving open the possibility that European monetary policy can influence domestic economic activity.

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I. Introduction

In recent years real interest rates in the United States have risen sharply and remained high relative to historical standards.[1] Many observers have claimed that these high real rates have been transmitted abroad and have lead to high real rates in the rest of the industrialized countries. Concern over the level of real rates has been widespread in the analyses by economic policy makers both in Europe and in the United States. The current focus on the high worldwide level of real interest rates and their effect on the economies of the world calls for an econometric examination of the recent movements in real rates and the degree of linkage between real rates in different countries.

Several attempts have been made recently to test whether there is complete international linkage of real rates by testing for the equality of real rates across countries (for example, Hodrick (1979), Mishkin (1982), Mark (1982), and Cumby and Obstfeld (1984).) These tests have generally provided evidence against the hypothesis that real short term interest rates in the industrialized countries have been equal during the past decade. However they have not provided any evidence concerning the extent to which real rates in the major industrial countries move together over time.

In this paper we present evidence on several questions regarding the movement in short term real interest rates in eight countries: Have ex ante real rates outside of the United States been high during recent years? Has there been a link between U.S. ex ante real rates and those

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[1] This widely-noted change in the level of real rates in the U.S. has been carefully documented by Huizinga and Mishkin (1984a).

in other countries? Can this link be quantified? Have real rates within Europe been more closely linked together than they are with real rates in the United States? We also examine the issue of the equality of real rates across these countries because our sample period contains data at least two years more recent than in previous studies. These two years are important since they are characterized by extreme movements in real rates and consequently including them should lead to conclusions that are stronger and possibly different from previous work.

Determining the extent to which real interest rates in different countries move independently of one another is important for issues involving stabilization policy in general as well as for shedding light of the recent policy debate. If real interest rates in an economy move one-for-one with those abroad, an important avenue for monetary policy to influence the domestic economy emphasized in many open economy macroeconomic models is removed. In many of these models, equality of real rates fails due to relative price changes. Deviations from purchasing power parity that are due to sticky prices give rise to independent real interest rate movements in the models of Dornbusch (1976), Frankel (1980), and Mussa (1983). Changes in the relative price of home goods account for real interest rate movements in the intertemporal optimizing model of Dornbusch (1983) and in the imperfect information model of Stockman and Koh (1983). Obstfeld (1983) presents an intertemporal maximizing model in which real interest rate differentials arise from terms of trade changes. Deviations from uncovered interest parity are behind real interest rate inequality in other models. For example, the portfolio balance models of Branson (1979) and Girton and Henderson (1977) exhibit independent real interest rate movements arising from

changes in the supply of outside assets.[2]

In the next section we turn to the econometric methodology for estimating ex ante real rates and testing the linkage between real rates in different countries. We then produce estimates of real interest rates in the United States, Canada, and six European countries and test to what extent real rate movements outside of the U. S. are associated with movements in the U.S. real rate. We also test the association of European real rate movements with each other. Our basic finding is that real rates have climbed dramatically from the 1970s to the 1980s in all countries studied and that there is a significant positive association between movements in U.S. real rates and those abroad. However, European real rates typically do not move one-for-one with U.S. real rates, still leaving open the possibility that monetary policy can influence domestic economic activity. The association of movements of European real rates with each other is not found to be any stronger than the association of European with U.S. real rates.

II. Methodology

For each country, the ex ante real interest rate (which we will also refer to as the real rate) on a j period bond which is held for j periods is defined from the Fisher (1930) equation as,[3]

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[2] For further references see the surveys of Frenkel and Mussa (1984) and Obstfeld and Stockman (1984).

[3] The methodology outlined here has been discussed more extensively in Mishkin (1981, 1984) and Huizinga and Mishkin (1984a). All returns, inflation and interest rates in the analysis here are continuously compounded so that the additional second order term is not needed in equation (1).

$$(1)\quad rr_{t,j} = i_{t,j} - \pi^{e}_{t,j}$$

where,

$rr_{t,j}$ = the expectation at time t of the real return earned by holding the j-period bond from time t to t+j,

$i_{t,j}$ = the nominal interest rate at time t on the j-period bond, which equals the expected nominal return earned by holding the bond from time t to t+j,

$\pi^{e}_{t,j}$ = the expectation at time t of the inflation rate in that country from t to t+j.

This real rate is unobservable so that we are forced to work with the observable, ex post real rate defined as,

$$(2)\quad eprr_{t,j} = i_{t,j} - \pi_{t,j}$$

where,

$eprr_{t,j}$ = the realized real return on the j-period bond from t to t+j,

$\pi_{t,j}$ = the inflation rate from t to t+j in that country.

Combining equations (1) and (2) the ex post real rate can be expressed as

$$(3)\quad eprr_{t,j} = rr_{t,j} - (\pi_{t,j} - \pi^{e}_{t,j}) = rr_{t,j} - \varepsilon_{t,j}$$

where,

$\varepsilon_{t,j} = \pi_{t,j} - \pi^{e}_{t,j}$ = the forecast error of inflation.

The underlying assumption behind the econometric methodology used here is the rationality of expectations in the bond market which implies

$$(4)\quad E(\varepsilon_{t,j} | \phi_t) = 0$$

where,

ϕ_t = all available information at time t.

This condition implies that the forecast error of inflation $\varepsilon_{t,j}$ is unforecastable, that is, it is uncorrelated with any information available at time t.

The econometrician observes a set of variables X_t that are included in the available information set ϕ_t and are correlated with the real rate $rr_{t,j}$. A logical choice for an estimate of the real rate is the best linear predictor of $rr_{t,j}$ given X_t, that is the linear projection of $rr_{t,j}$ into X_t which we represent as

$$(5) \quad P(rr_{t,j}|X_t) = X_t\beta$$

The projection equation for $rr_{t,j}$ can then be written as

$$(6) \quad rr_{t,j} = X_t\beta + u_{t,j}$$

where,

$u_{t,j}$ = the projection equation error, $rr_{t,j} - P(rr_{t,j}|X_t)$, which by construction has the property $E(u_{t,j}|X_t) = 0$,

and substituting (6) into (2) we obtain the regression equation,

$$(7) \quad eprr_{t,j} = X_t\beta + u_{t,j} - \varepsilon_{t,j} = X_t\beta + \eta_{t,j}$$

Because $eppr_{t,j}$ and X_t are observable, this equation is can be estimated by ordinary least squares (OLS). We can then use as our estimates of ex ante real rates in each country, $\hat{rr}_{t,j}$, the fitted values from the OLS regression (7),

$$(8) \quad \hat{rr}_{t,j} = X_t\hat{\beta}_{OLS}$$

To understand the properties of the resulting estimates, there are two important features of the error term of this equation, $\eta_{t,j}$, that merit discussion. The assumption of rational expectations implies that the forecast error of inflation, $\varepsilon_{t,j}$, is uncorrelated with any information available at time t which includes X_t. Therefore, $\varepsilon_{t,j}$ is orthogonal to X_t and by construction, $u_{t,j}$ is also orthogonal to X_t. As is shown in Mishkin (1981), the resulting orthogonality of the error term, $\eta_{t,j}$, with X_t then implies that estimating equation (7) by OLS produces consistent estimates of the projection equation β's. This indicates that, although we cannot observe the ex ante real rate $rr_{t,j}$, we can infer information about its relationship with variables known at time t via ex post real rate regressions.

The usual case in the literature, that of non-overlapping data, has j equal to 1, so that the holding period and the observation period are the same. On the other hand, in the empirical analysis in this paper, j equals 3 (one month observation intervals and three month holding periods), so that the data will be overlapping. For example, $rr_{t,3}$ will be a three period return which equals the sum of the one period returns in t, t+1 and t+2. $rr_{t+1,3}$ then overlaps $rr_{t,3}$ because both include the one period returns for t+1 and t+2.

In order to obtain confidence intervals around our estimates of real rates, we must have a consistent estimate of the variance-covariance matrix of $\hat{\beta}_{OLS}$. Unfortunately, the variance-covariance matrix from OLS regressions reported by standard regression packages can be very misleading when there is serial correlation in the $\eta_{t,j}$ error term. In the non-overlapping case where j=1, $\varepsilon_{t-1,1}$ is realized at time t and so is included in the available information set ϕ_t. The rational expectations condition then implies that $E(\varepsilon_{t,1}|\varepsilon_{t-1,1}) = 0$, implying that

$\varepsilon_{t,1}$ will be serially uncorrelated. Even though the $u_{t,1}$ error term does not have to be serially uncorrelated, if X_t includes most of the relevant information used to predict the real rate, then the variance of $u_{t,1}$ will be small and $\eta_{t,1}$ will be dominated by the serially uncorrelated movement of $\varepsilon_{t,1}$. This means that $\eta_{t,1}$ will be serially uncorrelated and the estimated variance-covariance matrix of will be consistently estimated by OLS regression packages.

When the data are overlapping, as in our analysis here where j=3, then $\varepsilon_{t,3}$ is not realized until 3 periods in the future. Thus, $\varepsilon_{t-1,3}$ and $\varepsilon_{t-2,3}$ are not in the information set ϕ_t and can be correlated with $\varepsilon_{t,3}$. This means that $\varepsilon_{t,3}$ will follow a second order moving average process (MA(2)). Even if the $u_{t,3}$ error term has small variation relative to $\varepsilon_{t,3}$ then $\eta_{t,3}$ will be serially correlated, and the variance-covariance matrix of $\hat{\beta}_{OLS}$ will be inconsistently estimated by OLS regression packages.

Consistent estimates of the $\hat{\beta}_{OLS}$ variance-covariance matrix are calculated with a method outlined by Hansen (1982) and Cumby, Huizinga and Obstfeld (1983), which allows for serial correlation in the error term of rational expectations, regression equations. The estimates we use here are similar to those used by Hansen and Hodrick (1980), but they are more general because they allow for conditional heteroscedasticity in the regression residuals. This is a particularly attractive feature of this technique since the assumption of conditional heteroscedasticity is usually rejected in financial markets.[4]

An accurate measure of the ex ante real rate using the methodology

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[4] Huizinga and Mishkin (1984a,1984b) reject the hypothesis of conditional homoscedasticity of inflation forecast errors for the United States as do Cumby and Obstfeld (1984) for five countries, including the United States.

described here requires that most of the relevant information for predicting the real rate be included in X_t so that $u_{t,3}$ is small. When this is the case, $\eta_{t,3}$ will have the time series properties of the forecast error of inflation term, $\varepsilon_{t,3}$. Thus a diagnostic check of the adequacy of the X_t specification is to see whether the residuals from the ex post real rate regressions have the MA(2) time series process implied by rational expectations for $\varepsilon_{t,3}$.

After obtaining measures of ex ante real rates in the both European countries and the United States, we want to test whether there is a linkage between the European real rates and the U.S. real rates and to test the international equality of real rates. We construct a test of this linkage as follows. Consider a regression of the ex ante real rate in country m on the U.S. real rate,

$$(9) \quad rr^{m}_{t,j} = \alpha + \gamma^{m} rr^{US}_{t,j} + \omega_{t,j}$$

The hypothesis that real rates in the U.S. and those abroad are fully linked implies $\gamma = 1$ while the hypothesis that there is no link between U.S. real rates and European real rates implies that $\gamma = 0$. Equality of real rates between the U.S. and country m implies that $\gamma = 1$ and $\alpha = 0$.

Because these ex ante real rates are unobservable, this regression equation cannot be estimated. Using the expression for the ex post real rate in equation (3), we can rewrite equation (9) as:

$$(10) \quad eprr^{m}_{t,j} = \alpha + \gamma^{m} eprr^{US}_{t,j} + \omega_{t,j} - \varepsilon^{m}_{t,j} + \gamma^{m} \varepsilon^{US}_{t,j}$$

Because the ex post real rates for country m and the U.S. are observable, this equation can be estimated. However, the error term of this equation is not orthogonal to the explanatory variable, $eprr^{US}_{t,j}$, because $eprr^{US}_{t,j}$ is realized only at time t+j and is thus likely to be correlated

with the inflation forecast error terms. McCallum (1976) pointed out that consistent estimates of this equation could be obtained by estimating it with instrumental variables, provided the instruments are in the available information set ϕ_t so that the instruments will be uncorrelated with the expectation errors, $\varepsilon^{m}_{t,j}$ and $\varepsilon^{US}_{t,j}$. Consistency also requires that the instruments be uncorrelated with $\omega_{t,j}$, the disturbance in (9). This disturbance is, by construction, the part of movements in the real rate in country m that is not explained by movements in the U.S. real rate. Therefore, the instruments should exert no additional influence on the real rate in country m apart from their influence on the real rate in the U.S.[5]

However, if the data are overlapping so that the ε's and hence the error term of the equation are serially correlated, then the McCallum procedure will not lead to consistent estimates of the estimated parameters' standard errors and misleading inference can result. The solution to this problem is to use the two-step, two stage least squares (2S2SLS) procedure developed by Cumby, Huizinga and Obstfeld (1983). Not only does this procedure provide consistent estimates of the covariance matrix of the coefficient estimates when the error is serially correlated or conditionally heteroscedastic, but it produces more efficient parameter estimates as well.[6] There are two criteria for choosing the instruments to be used in this procedure. First, the instruments must be

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[5] The instruments in our empirical analysis are U.S. nominal interest rates, past U.S. inflation rates, a constant term and a time trend. These instruments should satisfy the criteria described above.

[6] In the special case where the number of parameters to be estimated is equal to the number of instrumental variables, two-step two stage least squares reduces to McCallum's instrumental variables estimator with the correct standard errors and hence provides no gain in efficiency.

in the available information set ϕ_t in order to achieve consistent estimates. Second, the instruments should have good explanatory power for the ex post real rate on the right-hand-side of the equation so that the power of the test is as high as possible. A natural choice for instruments are then the variables in X_t that have been found to predict the U.S. ex post real rate well.

In summary: measures of real interest rates when the data are overlapping, as in the empirical analysis of this paper, can be obtained by estimating ex post real rate regressions with ordinary least squares and using the fitted values as estimates of the ex ante real rates. Correct statistical inference requires that the standard errors of these estimates be corrected for the serial correlation due to overlapping data using the 2S2SLS procedure outlined by Cumby, Huizinga and Obstfeld (1983). Tests of the linkage between U.S. and European real rates can be conducted by estimating a regression of the European country's ex post real rate on the ex post real rate in the U.S. with the 2S2SLS technique using as instruments the same variables that were used to estimate the measures of the real rates.

III. The Data

In this paper we study short-term real interest rates in the euro deposit and domestic money markets using monthly data from June 1973 until December 1983 for eight industrialized countries: the United States, Canada, the United Kingdom, Italy, the Netherlands, France, West Germany and Switzerland. Since capital controls, both actual and potential, may drive a wedge between onshore money market interest rates and the corresponding euro deposit rate, we examine both of these interest

rates in our tests here. We have chosen to examine real rates calculated using changes in the consumer price index (CPI) as the relevant measure of price inflation since this is the most reliable price index available for the countries in our sample. We study three-month real interest rates on euro deposits and domestic money market instruments because the timing problem of the inexact dating of the monthly price indices is somewhat lessened by looking at real interest rates of maturities longer than one month.[7] The time period is chosen to begin shortly after the onset of generalized floating exchange rates and to include the most recently available data.

The dating convention is as follows. The ex post real rate at month t is the actual real return on a three-month euro deposit or domestic money market instrument held from the end of that month to three months in the future: for the observation in January, it is the real return from January 31 until April 30. For each country, the ex post real rate is constructed by subtracting the continuously compounded inflation rate for that country from the continuously compounded nominal return on the euro deposit or money market instrument denominated in that country's currency.

The three-month eurocurrency deposit rates come from a variety of sources. Prior to January 1976, the euro rates are taken from Data Resources, Inc. for the United States, Germany, and Switzerland and from the Weekly Review of the Harris Bank of Chicago for the remaining countries. Following January 1976, all rates (except the euro lira rate) are taken from Morgan Guaranty Trust's World Financial Markets. The money market rates are taken from Morgan Guaranty Trust's World Finan-

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[7] See Mishkin (1981).

cial Markets. These are representative three-month rates measured at or near the end of the month. Interbank rates are used for France, Germany, Italy, the Netherlands,[8] Switzerland, and the United Kingdom. For Canada three-month prime finance company paper is used and for the United States three month prime industrial paper is used.

The consumer price index for each country except the United States are obtained from the International Financial Statistics (IFS) tape (line 64). The U. S. consumer price index is the CPI-UX1, which uses the new rental equivalence procedure for measuring housing costs.[9]

IV. Measuring Real Rates in the Eight Countries

We employ a constant term, a time trend, the nominal interest rate, $i_{t,3}$, and three values of lagged inflation, $\pi_{t-3,3}$, $\pi_{t-6,3}$, and $\pi_{t-12,3}$ as our X_t variables in the regressions used to generate the ex ante real rate estimates.[10] (The regressions for each country contains only domestic variables.) There is quite strong evidence that the stochastic structure of real rate movements in the United States undergoes a major shift sometime around the change in the Federal Reserves's operating procedure in October 1979 (see Huizinga and Mishkin (1984a)) and we find similar evidence of a shift in the stochastic

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[8] Prior to January 1977, three-month municipal loans are used.

[9] This series is described more extensively in Huizinga and Mishkin (1984a).

[10] The programs used to perform all of the calculations in this paper are available from the authors upon request.

[11] As Huizinga and Mishkin (1984a) point out, the breakpoint of October 1979 is somewhat arbitrary. It is entirely possible that the breakpoint occurred somewhat before or after this date.

structure for six of the other countries studied.[11] Only in the Swiss case are we unable to reject the null hypothesis of stability at standard significance levels. In the case of the United Kingdom, the sample is split at the beginning of the Thatcher government in June 1979. For the other european countries the beginning of the European Monetary System in April 1979 is chosen as the break point. The estimated real rates for each country are thus constructed from a separate regression for each of the two sub-periods.[12]

Before looking at the estimated real rates obtained from these regressions, we should first look at the autocorrelations of the residuals, reported in Table 1. Because there may be spurious seasonality of the ex post real rates,[13] the small but significant autocorrelations at lag twelve are not of great concern. What is more important is the fact that, except for the autocorrelations at the seasonal lags, there are rarely significant autocorrelations at lags greater than 2. Since X_t does not include lagged values of the ex post real rates, this provides some indication that enough relevant information is included in X_t so that the $u_{t,3}$ are small relative to $\varepsilon_{t,3}$ and that our estimates of the real rates will be reliable.

Figures 1 through 8 display the estimated real rates using the consumer price index for the eight countries studied here for domestic money market instruments.[14] The heavy solid lines show the estimated ex

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[12] We have also split the sample period for all the countries at October 1979 and the results did not change appreciably.

[13] See Mishkin (1981).

[14] We have not presented the estimated real euro deposit rates in the interest of saving space. The estimates of the real euro rates were similar to the estimates of the real domestic money market rates except in the case of the French franc, as is noted below.

ante real rates, while the lighter, dashed lines surrounding the estimated real rates provide 95% confidence intervals for these estimates under the assumption that the variances of the forecast error term, $\varepsilon_{t,3}$, are large relative to the variance of $u_{t,3}$.[15]

The estimated real rates for the U.S. in Figure 1 exhibit a sharp change in behavior after 1979, having a substantially higher level and increased volatility. The U.S. real rates were low from the middle of 1973 until October 1979, have a substantial rise after the change in the Fed policy regime, a brief decline in the middle of 1980 when nominal interest rates decline temporarily, and a sustained period of high real rates thereafter. An important finding here is that in the 1980s real rates in the U.S. have approached 10% at an annual rate, a level unprecedented in the post war period, and they remain statistically significantly different from zero continuously from 1981 through 1983. The only period in U.S. history where real interest rates appear to be as high was during the contraction phase of the Great Depression.[16] Complaints that real interest rates in the United States are exceedingly high seem to be well justified.

The estimated real rate for Canada seems to follow the U.S. pattern reasonably closely, although Canadian real rates are actually declining from mid 1979 to mid 1980, when they begin their big rise. The U.K. real rates start their climb in late 1979 coincident with the rise in the U.S. real rate, but are significantly positive only after August 1981.

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[15] The formulae for the standard error bounds are given in Mishkin (1981). This assumption on the relative importance of the two components of the composite error term in equation (7) is supported by the correlogram of the residuals in Table 1.

[16] See Mishkin (1981)

The Italian and Dutch real rates do appear to be higher on average in the 1980s than in the 1970s, but they both have a brief period in late 1976 when they are particularly high. The timing of the real rate movements for these countries also does not appear to be as closely tied to real rate movements in the U.S. The increase in real rates in the Netherlands occurs in 1978 with substantial upward and downward movements thereafter. The Italian real rates have a very sharp decline and rise in late 1979 and in early 1981 the real rates are near zero.

The German and French real rate movements are particularly interesting. Although German real rates do rise in late 1979 as U.S. real rates do, the rise is much smaller. The major climb in German real rates does not begin until late 1980, several months after the U.S. increase. The increase in the French real rates is even more delayed. French real rates remain quite low until early 1981, hovering around zero. An increase then occurs, taking the real domestic money market rate rate to approximately 6%.[17]

The Swiss real rates do appear to have a somewhat different pattern from the other real rates we have been looking at. Although there is a rise in Swiss real rates which reach their highest levels in 1981, the extent of the rise is much less than in other countries, and they are only statistically significantly different from zero for a one year period in 1981. The amount of variation in Swiss real rates seems to be smaller than in other countries. In addition, the climb in real rates in Switzerland begins in early 1979, well before the increase in U.S. real rates.

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[17] The real rate on euro French franc deposits shows a very similar pattern, although we do see the effect of capital controls. The real euro rates rise much less than the real domestic money market rates, reaching a level of over 15%.

The general conclusions from these estimates of real rates in the eight countries is that they all show a tendency to have higher real interest rates in the 1980s than in the 1970s.[18] However, there are differences in the timing and extent of real rate movements in these countries. In light of the sometimes substantial confidence intervals around the real rate estimates, we need to examine more closely the degree to which real rates in different countries move together. We conduct statistical tests on this issue in the next section.

V. Testing the Linkage Between Real Rates

Table 2 contains the first set of results on the degree of international association of real rates obtained from the regression of the real rates in the seven countries on the real rate in the United States. Of particular interest in these tables is the coefficient γ which describes the amount of movement in a country's real rate for a given movement in the U.S. real rate. We test three hypotheses about real rate movements between the U.S. and these other countries. The first is that real rates are fully linked internationally ($\gamma = 1$); the second is that there is no linkage between real rates in different countries ($\gamma = 0$). The third is that real rates are equal across countries ($\alpha = 0$ and $\gamma = 1$).

Panel A contains the results on euro deposits and Panel B the results on domestic money market instruments. In general the evidence is not favorable to either the hypothesis that real rates are fully linked

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[18] Mishkin (1984) presents estimates of ex ante real rates for the countries studied here but his sample ends in the second quarter of 1979. His estimates therefore do not include the widespread dramatic increase in real rates we find here.

or to the hypothesis that no international linkage exists. For both the euro deposit rates and the domestic money market rates, the hypothesis of no linkage ($\gamma = 0$) can be rejected at the five percent level for all countries except Switzerland. The hypothesis of full linkage ($\gamma = 1$) is rejected at the five percent level for four countries for both instruments studied. In all cases the γ coefficients lie between 0 and 1. Canada has the highest coefficients, which are quite close to 1, especially for the domestic money market real rate. Germany has coefficients around .4; and Switzerland has the lowest coefficients which are below .3. The remainder of the countries have coefficients between .5 and .8[19]

Table 2 also contains the χ^2 statistics for the hypothesis that real rates in each country are equal to real rates in the U.S. The hypothesis of real rate equality is rejected in all cases but France for the three-month euro rates and in all cases but Canada for the domestic money market rates.[20]

In general then it appears that while real rates in all of the countries studied exhibit a statistically significant association with U.S. real rate movements, this linkage is not complete. We then would want to ask whether there is a close association among real rates in the European countries? We explore this question by running regressions of the ex post real rate in European countries on the West German ex post

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[19] It would also have been interesting to test the joint hypothesis that all γ's equal 0 and the joint hypothesis that all γ's equal 1. However, this did not prove to be computationally feasible.

[20] The critical value for a χ^2 with 2 degrees freedom is 5.99 at the 95% level and 9.21 at the 99% level. It is interesting to note that the rejections of real rate equality we obtain are stronger than those obtained in the bilateral tests in Cumby and Obstfeld (1984) except in the case of Canada.

real rate using the techniques outlined in Section II.

The results from these regression can be found in Table 3, which gives roughly similar results to those we found in Table 2. The association between European real rates and West German real rates appears to be no closer than the association of European real rates with U.S. real rates. The γ coefficients are no closer to one and the Swiss coefficients continue to be the lowest. It is also interesting to note that real rates in the the EMS countries are no more closely related to German real rates than are real rates outside of the EMS. The standard errors of the γ coefficients are generally larger than those in Table 2, so that although we see significant rejections of both hypotheses that $\gamma = 0$ or 1, these rejections are not as frequent.

VI. Conclusions

In this paper we demonstrate that real interest rates have risen significantly in recent years and have been considerably higher since 1980 than during the 1970s. This increase in the general level of real rates has occurred in Canada and several european countries as well as in the United States. We also find that there is a significant positive correlation between real rate movements in the United States and those in seven other industrialized countries and that the degree of international linkage in real rates, while significantly positive, is also significantly less than complete. In addition, the evidence suggests that real rates within europe are not more closely linked with one another than they are with U.S. real rates.

Recent claims that real interest rates are currently at levels unprecedented in recent history receive strong support from our findings that real rates have increased significantly. In addition, our evidence

that there is a significant positive association between real rates in the United States and those in other countries is consistent with the frequently advanced argument that high U.S. real rates have been transmitted abroad. However, it should be emphasized that, while consistent with these arguments, our estimates provide no evidence on the direction of causation of real rate movements: they do not necessarily imply that high U.S. real rates have caused high real rates elsewhere.

The evidence we present also points to significant independence in real rate movements in the countries in our sample, a point that has received little attention in recent discussions. This finding of a less than complete linkage in real rates has important implications for questions concerning the ability of domestic stabilization policies to influence the economy by affecting real interest rates. Our evidence is consistent with models that, for example, allow monetary policy to have real effects. However, since we do not provide evidence on the source of these significant differences in real rates, our results cannot rule out models in which money is neutral and real rate differences arise due to relative price movements resulting from real shocks to the economy.

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Table 1: Autocorrelations of Residuals

A. Three Month Eurocurrency Deposits

Country	Lag 1	2	3	4	5	6	7	8	9	10	11	12
US	0.69	0.26	-0.04	-0.04	-0.02	-0.03	-0.16	-0.22	-0.12	0.05	0.12	0.05
CA	0.66	0.34	0.03	0.05	0.02	0.02	0.04	0.08	0.03	-0.06	-0.11	-0.10
UK	0.73	0.31	-0.05	-0.08	0.01	0.05	-0.05	-0.22	-0.33	-0.32	-0.21	-0.10
ND	0.57	0.38	-0.04	-0.10	-0.13	-0.05	0.03	0.07	-0.07	-0.15	-0.19	-0.11
IT	0.65	0.21	-0.22	-0.28	-0.16	0.03	0.01	-0.07	-0.19	-0.17	-0.09	-0.02
FR	0.73	0.32	-0.09	-0.23	-0.21	-0.10	-0.07	-0.08	-0.09	-0.01	0.04	0.08
WG	0.60	0.11	-0.22	-0.18	-0.04	-0.02	-0.13	-0.17	-0.17	-0.10	-0.06	-0.10
SW	0.74	0.41	0.04	-0.04	-0.04	-0.01	-0.04	-0.04	-0.01	0.06	0.03	-0.03

B. Domestic Money Market Instruments

Country	Lag 1	2	3	4	5	6	7	8	9	10	11	12
US	0.68	0.23	-0.08	-0.08	-0.03	-0.03	-0.15	-0.20	-0.13	0.01	0.06	0.03
CA	0.66	0.34	0.04	0.06	0.02	0.02	0.04	0.08	0.03	-0.06	-0.11	-0.10
UK	0.72	0.32	-0.05	-0.08	-0.02	0.02	-0.07	-0.22	-0.31	-0.31	-0.19	-0.09
ND	0.56	0.38	-0.04	-0.09	-0.13	-0.05	0.02	0.06	-0.08	-0.15	-0.20	-0.11
IT	0.70	0.21	-0.20	-0.28	-0.16	-0.02	-0.02	-0.14	-0.24	-0.14	0.03	0.12
FR	0.74	0.34	-0.06	-0.19	-0.18	-0.08	-0.08	-0.12	-0.13	-0.06	0.03	0.08
WG	0.60	0.09	-0.25	-0.19	-0.05	-0.01	-0.13	-0.18	-0.17	-0.08	-0.03	-0.05
SW	0.71	0.33	-0.02	-0.06	-0.04	-0.08	-0.17	-0.22	-0.15	-0.01	0.03	0.04

Table 2: The Link with U.S. Real Interest Rates

Consumer Prices

(June 1973 - December 1983)[a]

A. Three-Month Eurocurrency Deposit Rates

Country	α	γ	Test of Equality of real rates[b] (α=0, γ=1)
Canada	-.0013	.8585	13.50
	(.0010)	(.0984)	
United Kingdom	-.0035	.5544	22.28
	(.0042)	(.2865)	
Netherlands	.0001	.5275	375.53
	(.0010)	(.0435)	
Italy	.0024	.5416	8.72
	(.0027)	(.1923)	
France	.0009	.7541	4.53
	(.0013)	(.1159)	
West Germany	.0020	.4281	86.18
	(.0010)	(.0773)	
Switzerland	.0026	.0703	123.46
	(.0012)	(.1024)	

B. Domestic Money Market Interest Rates

Country	α	γ	Test of Equality of real rates[b] (α=0, γ=1)
Canada	.0005 (.0008)	.9128 (.0674)	1.67
United Kingdom	-.0063 (.0033)	.7673 (.2853)	22.01
Netherlands	.0010 (.0009)	.5175 (.0434)	241.36
Italy	-.0032 (.0022)	.6370 (.1477)	89.85
France	-.0028 (.0007)	.5814 (.0940)	55.41
West Germany	.0037 (.0010)	.4373 (.0915)	38.51
Switzerland	.0023 (.0009)	.1635 (.1043)	73.97

[a]The regressions begin in January 1976 for the Swiss money market interest rates. Standard errors are in parentheses. The instruments used in all cases were a constant, inflation and money growth over the previous quarter in the United States, the nominal interest rate in the U.S., and a time trend. These variables are also included multiplied by a dummy variable that is set equal to zero prior to October 1979 and one thereafter.

[b]Distributed as $\chi^2(2)$ under the null hypothesis. The critical value at the 5% level is 5.99 and at the 1% level is 9.21.

Table 3: The Link Among European Real Interest Rates

Consumer Prices

(June 1973 - December 1983)[c]

A. Three-Month Eurocurrency Deposit Rates

Country	α	γ	Test of Equality of real rates[b] (α=0, γ=1)
France	.0032 (.0018)	.5668 (.3035)	56.09
Switzerland	.0003 (.0014)	.1288 (.1146)	213.34
Netherlands	.0021 (.0007)	.4968 (.1014)	26.88
Italy	.0052 (.0019)	.3531 (.1778)	13.30
United Kingdom	.0021 (.0035)	.1538 (.2762)	15.44

B. Domestic Money Market Interest Rates

Country	α	γ	Test of Equality of real rates[b] (α=0, γ=1)
France	-.0013 (.0014)	.2395 (.1460)	56.09
Switzerland	.0004 (.0005)	.1254 (.0419)	758.12
Netherlands	.0025 (.0011)	.3776 (.1408)	32.73
Italy	-.0063 (.0016)	.7913 (.1594)	39.94
United Kingdom	-.0011 (.0033)	.1210 (.2431)	29.41

[c]The instruments used in all cases were a constant, inflation and money growth over the previous quarter in West Germany, the nominal interest rate in West Germany, and a time trend. These variables are also included multiplied by a dummy variable that is set equal to zero prior to April 1979 and one thereafter.

FIGURE 1

EX ANTE REAL RATES: UNITED STATES

DOMESTIC MONEY MARKET RATES

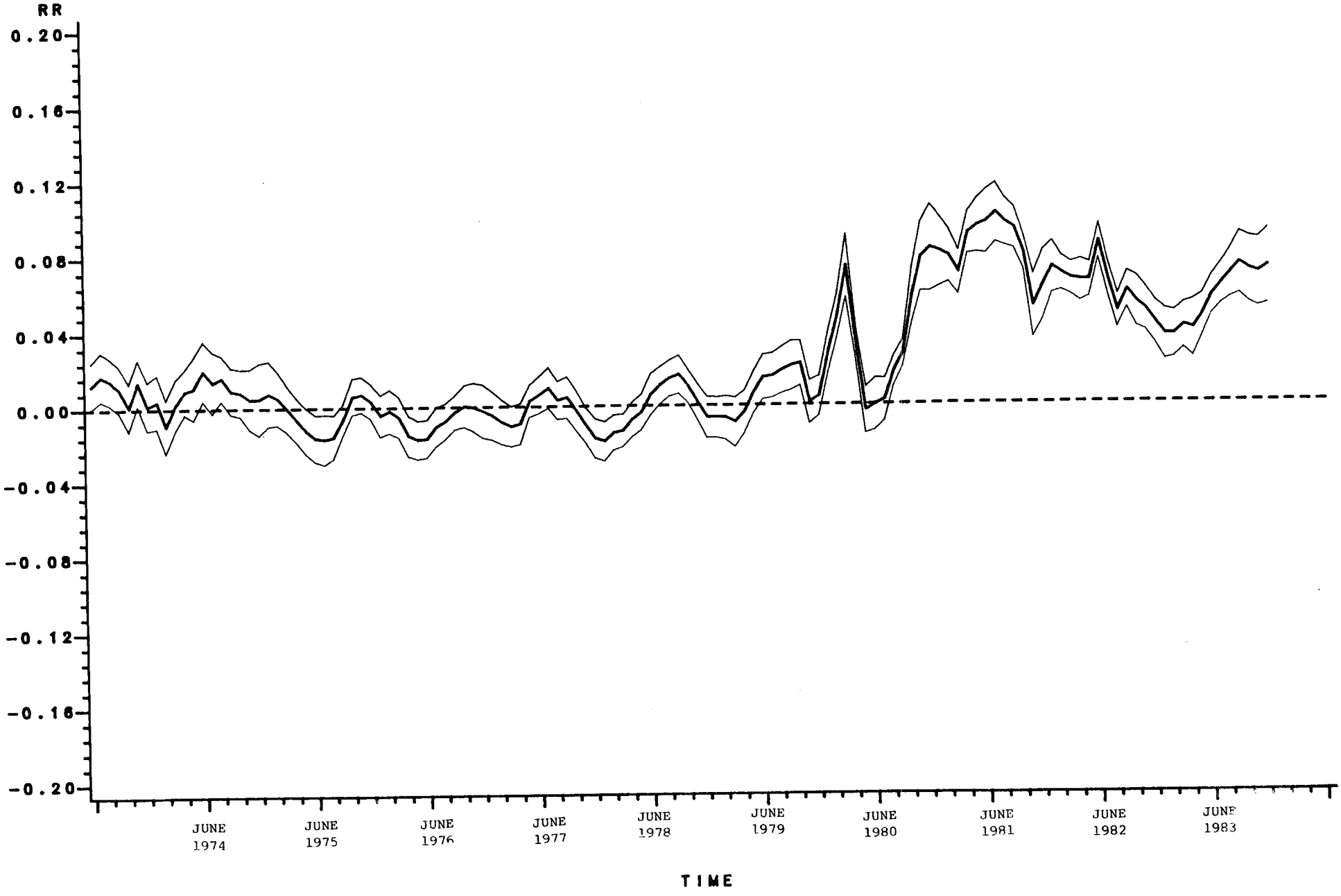

FIGURE 2

EX ANTE REAL RATES: CANADA

DOMESTIC MONEY MARKET RATES

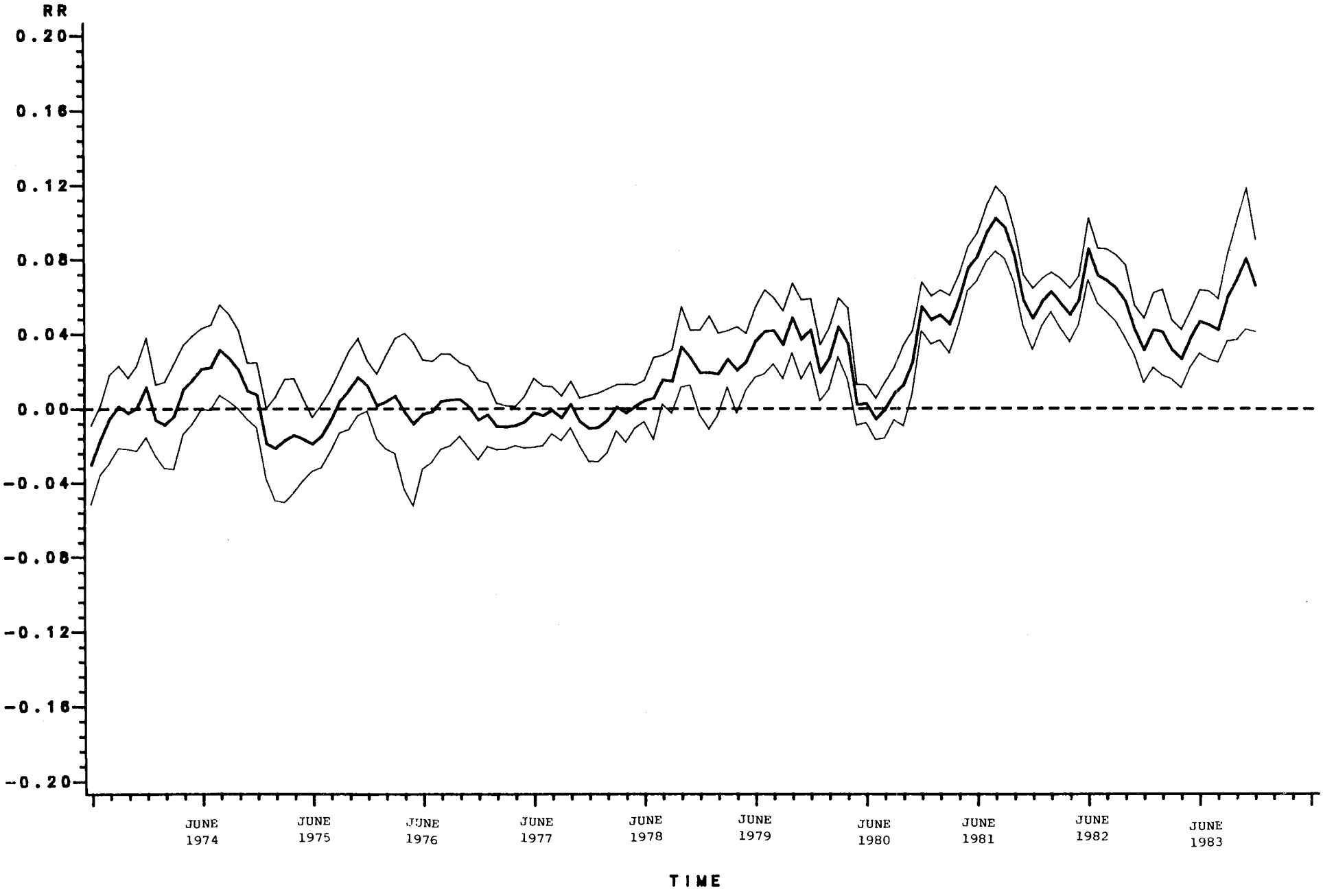

FIGURE 3

EX ANTE REAL RATES: UNITED KINGDOM

DOMESTIC MONEY MARKET RATES

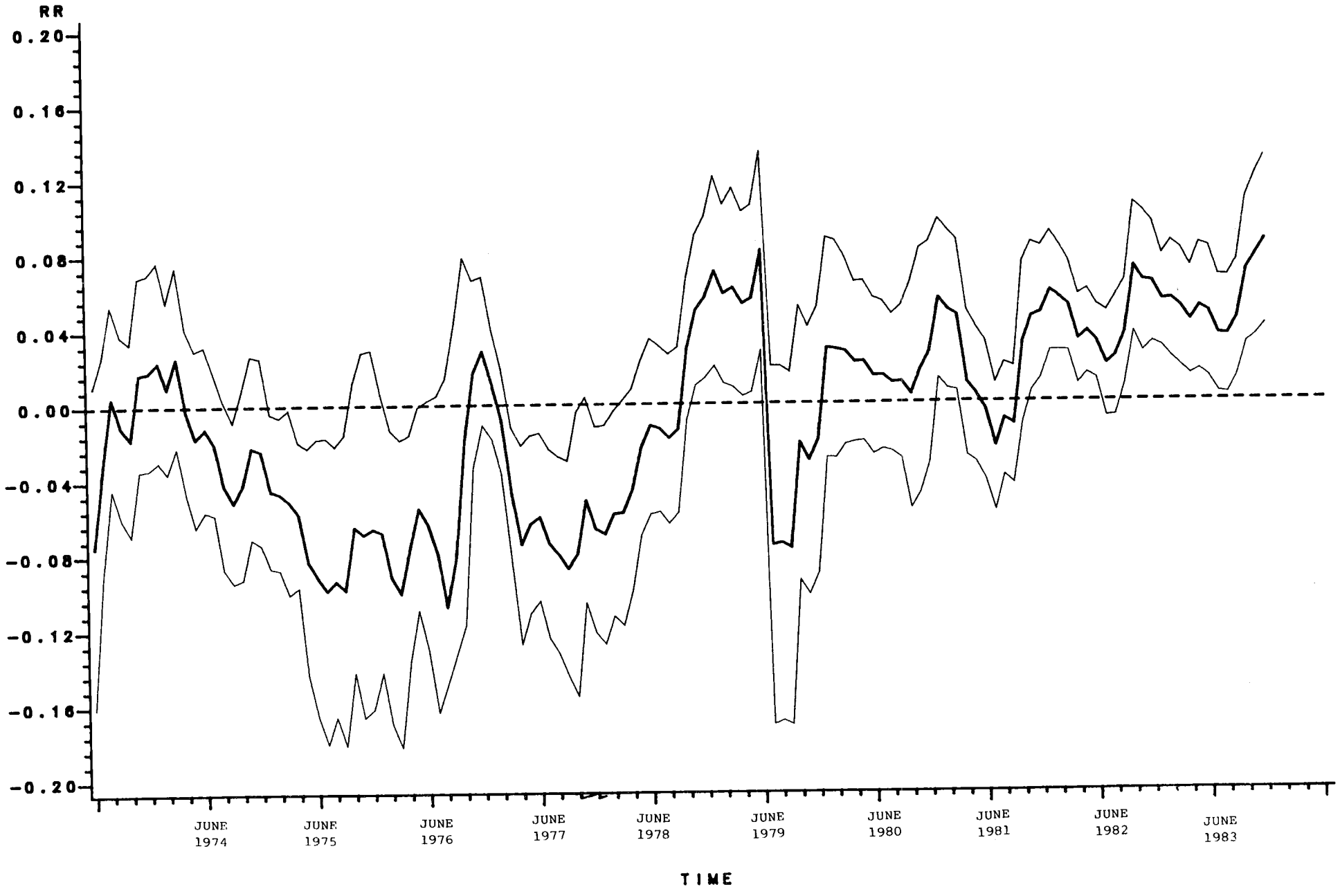

FIGURE 4

EX ANTE REAL RATES: NETHERLANDS

DOMESTIC MONEY MARKET RATES

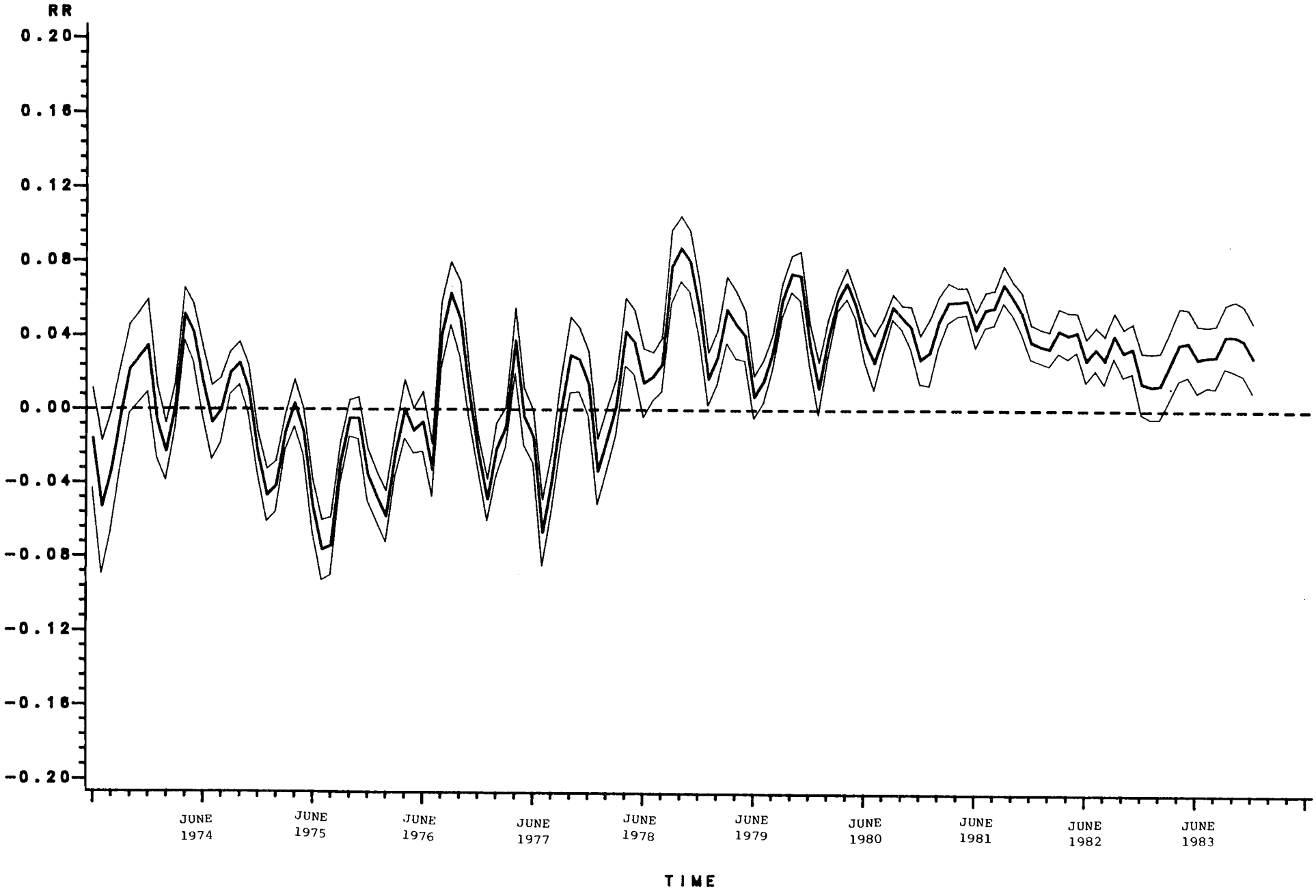

FIGURE 5

EX ANTE REAL RATES: ITALY

DOMESTIC MONEY MARKET RATES

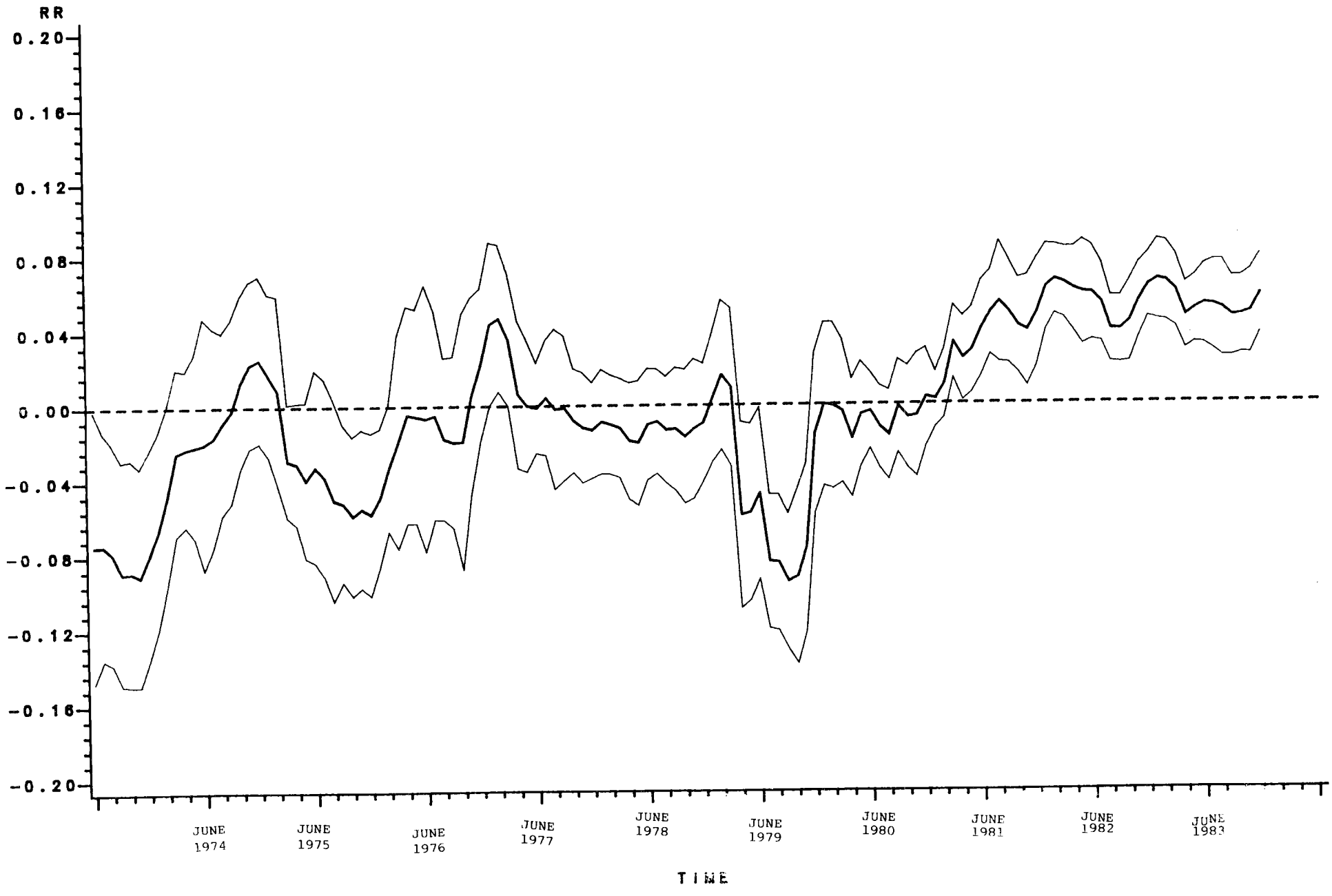

FIGURE 6

EX ANTE REAL RATES: FRANCE

DOMESTIC MONEY MARKET RATES

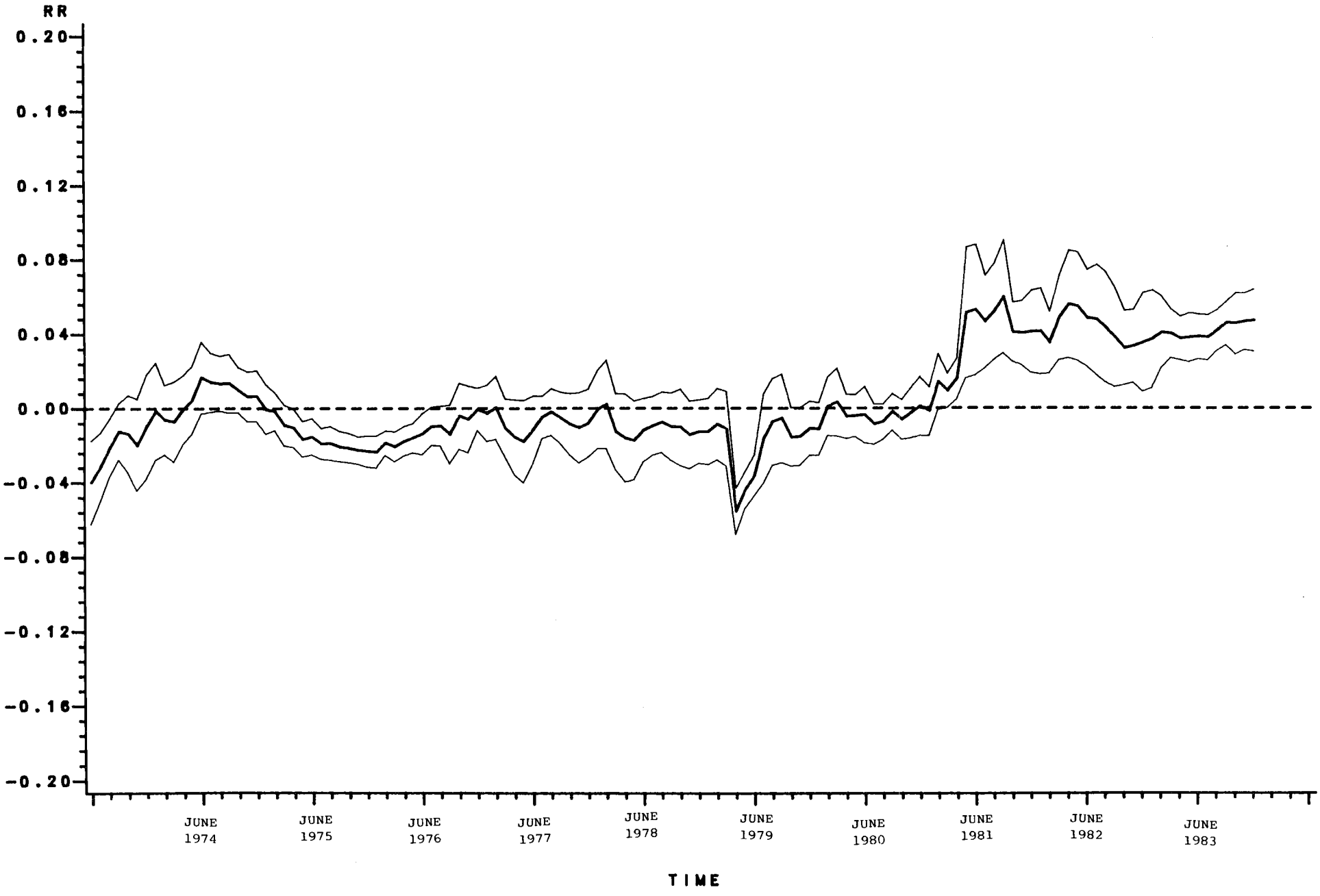

FIGURE 7

EX ANTE REAL RATES: GERMANY

DOMESTIC MONEY MARKET RATES

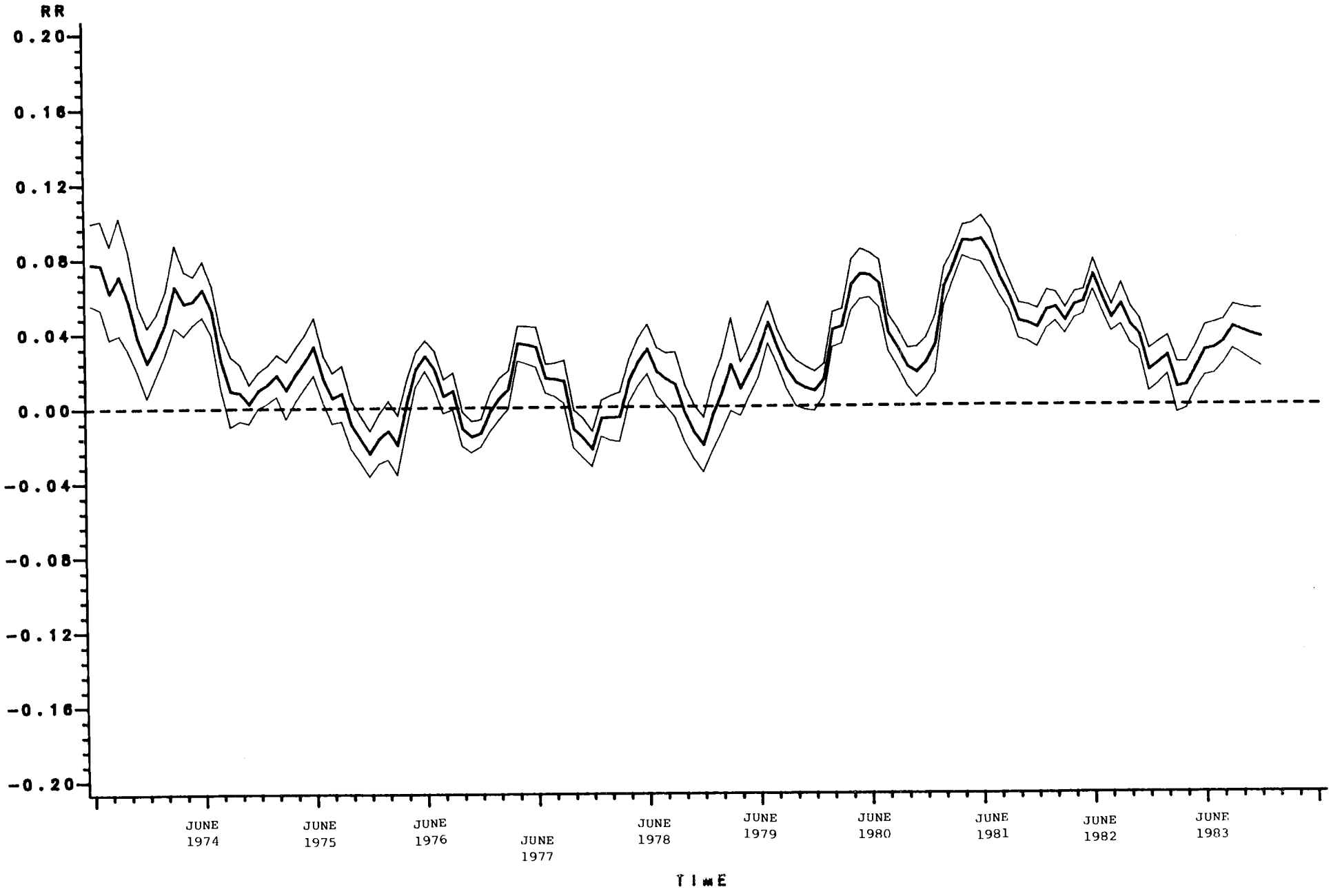

FIGURE 8

EX ANTE REAL RATES: SWITZERLAND

DOMESTIC MONEY MARKET RATES