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IS THERE A WORLD REAL INTEREST RATE?

Joseph E. Gagnon and Mark D. Unferth

ABSTRACT

This study uses panel data techniques to estimate a common component to the ex post real interest rates of nine countries with liberal capital markets over the past 15 years. We show that the residuals from such a regression have almost no serial correlation, and that each country's real interest rate is highly correlated with the estimated world real interest rate. The primary exception to these findings is the behavior of the U.S. real interest rate, which exhibits large and persistent deviations from the estimated world real interest rate.

Is There a World Real Interest Rate?

Joseph E. Gagnon and Mark D. Unferth[1]

It is a generally accepted proposition in international economic theory that mobility of goods and capital across national borders leads to equalization of the real interest rate in different countries. In practice, the existence of nontraded goods, barriers and adjustment lags for traded goods, and transactions costs and risks in financial markets, create the potential for significant deviations in real interest rates across countries, at least temporarily.

Indeed, the existing empirical literature generally has rejected a strict interpretation of real interest rate parity across countries.[2] These studies have nearly always focused on bilateral comparisons of the real interest rate in pairs of countries, typically with the United States as one of the two countries. Nevertheless, Cumby and Mishkin (1986, p. 20) noted that "there is a significant positive correlation between real rate movements in the United States and those in seven other industrialized countries" even though they were able to reject equality of real rates.

In this study we estimate the world real interest rate using panel data techniques. We then examine the properties of the estimated world real

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1. Gagnon is a staff economist in the Division of International Finance at the Board of Governors of the Federal Reserve System. Unferth is a graduate student at the Kellogg School of Management at Northwestern University and a former research assistant in the Division of International Finance. We are grateful to Tamim Bayoumi and Andrew Levin for extensive discussions. We also thank John Ammer, Hali Edison, Neil Ericsson, Jon Faust, Bill Helkie, Dale Henderson, Karen Johnson, Deb Lindner, Prakash Loungani, Jaime Marquez, Ted Truman, and participants in the Division's Monday Workshop for helpful comments. This paper represents the views of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or other members of its staff.

2. See, for example, Mark (1985), Cumby and Mishkin (1986), Dutton (1993), and Edison and Pauls (1993).

rate, as well as the deviations between individual countries' real rates and the world real rate. We restrict our basic analysis to a panel of countries and time periods for which goods and capital markets are relatively unfettered by government restrictions. We also describe the implications for our results of using countries and time periods with greater restrictions on capital markets and less openness to trade. In addition, we report evidence that suggests that real interest rates are stationary, even though the evidence for nominal interest rates and inflation rates is less conclusive.

Data Description

Our dataset includes monthly-average observations of three-month and twelve-month Euro-market interest rates on certificates of deposit. The data were compiled by the Bank for International Settlements beginning in September 1977.[3] Our sample ends in December 1992. The price series used to deflate the nominal interest rates are monthly consumer price indices (CPIs, not seasonally adjusted) reported by national statistical agencies.[4] The data are available for 14 OECD countries, but most of our results are based on a subgroup of nine countries that were identified by the OECD as having relatively open and unrestricted financial markets for most of our sample: Belgium, Canada, Denmark, Germany, Japan, the Netherlands, Switzerland, the United Kingdom, and the United States.[5] Of these nine countries,

3. We also conducted limited analysis using three-month Treasury bill rates and rates on domestic certificates of deposit for countries that do not report market rates on government debt. These series were obtained from national sources.

4. For the United Kingdom, we use a newly-created series that does not include mortgage interest rates. (None of the other countries include mortgage interest rates in their CPIs.) The results are not substantially altered by the use of the traditional U.K. CPI, however.

5. Japan and the United Kingdom had significant capital controls in the first two years of the sample. Denmark had mild restrictions on capital mobility that were gradually eliminated over the first half of the sample. (Footnote continues on next page)

four were members of the Exchange Rate Mechanism of the European Monetary System for most of our sample: Belgium, Denmark, Germany, and the Netherlands. The remaining five countries experienced varying degrees of managed and freely floating exchange rates over our sample.

The analysis is conducted at the quarterly and annual frequencies, with 60 quarterly and 15 annual observations.[6] The ex post real interest rate is defined as the nominal interest rate observed in the last month of the previous period minus the current period's inflation rate. Three-month nominal interest rates were used to construct the quarterly real interest rates and 12-month nominal interest rates were used to construct the annual real interest rates. The quarterly inflation rate is defined as the percentage change in the CPI between the last month of the previous quarter and the last month of the current quarter compounded to an annual rate. The annual inflation rate is simply the percentage change in the CPI between December of the previous year and December of the current year.

We began our analysis by testing for the order of integration of our time series. Accordingly, we ran augmented Dickey-Fuller (ADF) tests on the quarterly inflation, nominal interest, and real interest rates.[7] The ADF tests were implemented by estimating the following equation using ordinary least squares (OLS):

(Footnote continued from previous page)
See OECD (1990). The other five countries are Austria, France, Italy, Norway, and Sweden. We report some results that include these other countries in a later section.

6. We do not conduct analysis at the monthly frequency because we believe that arbitrage mechanisms are likely to work better at lower frequencies, and because we wish to avoid the econometric difficulties associated with overlapping interest rate horizons.

7. Due to the limited number of observations, we did not conduct ADF tests on the annual data.

$$(1) \qquad \Delta x_t = \mu + \beta\, x_{t-1} + \sum_{i=1}^{q} \gamma_i \Delta x_{t-i} + \sigma_1 D1_t + \sigma_2 D2_t + \sigma_3 D3_t,$$

where D1, D2, and D3 are seasonal dummy variables. For each series, equation 1 was estimated initially with q=12.[8] We then performed sequential tests on the coefficients γ_3-γ_{12} beginning with γ_{12} and working downward. If the t-statistic on the estimated value of γ_i was not significant at the 10 percent level, we constrained γ_i to zero and reestimated the equation. In order to guard against missing dynamics that might affect the size of our ADF tests, we always included the first two lags of Δx in the regression. After testing all of the γ_i coefficients individually, we performed an F-test of the restrictions imposed in the final model against the initial unrestricted model. These F-tests were never significant at the 10 percent level.

If the variable is stationary, the estimate of β (and the associated test statistic) should be negative. The top panel of Table 1 presents the ADF test statistics on β for each of our time series; the number in parentheses is the largest lag of Δx selected by the above procedure. Significance levels for the ADF test are based on Fuller (1976, p.373). According to Table 1, there is significant evidence against nonstationarity of the inflation rate only for Switzerland. There is slightly more evidence against nonstationarity of the nominal interest rate, with significant ADF statistics for three of the nine countries. Finally, there is strong evidence against nonstationarity of the real interest rate, with significant ADF statistics for seven of the nine countries.

8. F-statistics on a restriction from 16 to 12 lags were significant at the 10 percent level for only three of the 27 series, which is roughly equal to the expected number of false rejections for a 10 percent critical value.

Since the real interest rate is a linear combination of the nominal interest rate and the inflation rate, it is not possible for the real interest rate to be stationary unless both the nominal interest rate and the inflation rate have the same order of integration. The evidence for Belgium, Canada, Denmark, Germany, and the Netherlands is consistent with the hypothesis that the inflation rate and the nominal interest rate are nonstationary, but cointegrated such that the real interest rate is stationary. (The ADF test statistic on the Dutch real interest rate has a p-value of .13.) For Japan, Switzerland, and the United Kingdom, one might conclude that all three variables are stationary. (The ADF test statistics on Japanese and U.K. inflation have p-values of around .15.) Only in the case of the United States (and possibly the Netherlands) is one likely to conclude that all three variables are nonstationary. However, given the frequent low power of ADF tests, we cannot rule out that the U.S. real interest rate is stationary. The main conclusion we draw from this section is that real interest rates appear to be stationary in a number of OECD countries since the late 1970s.

Real Interest Rate Behavior

Figures 1-8 plot the twelve-month ex post real interest rates from 1978 through 1992. In each case, the German real interest rate is plotted for comparison. The basic pattern that is common to nearly all of the series is a sharp rise in the real interest rate from 1979 through 1982 and a moderate dip in the real interest rate during 1988 and 1989. A very strong correlation with the German real interest rate is apparent for Belgian, English, Dutch, Japanese, and Swiss rates. The Belgian and Danish real interest rates are consistently higher than the German rate, while the

Swiss real interest rate is consistently lower. The remaining series appear to have similar means. The overall correspondence between the German and Japanese real interest rates is particularly striking. The quarterly series (not plotted) display a similar pattern, although it is partially obscured by high-frequency noise and country-specific seasonal effects in the inflation component.

In order to estimate the common component of real interest rates across countries as well as to examine deviations of individual countries' rates from the world rate, we ran the following panel data regression on the annual data:

$$(2) \qquad RR_{it} = \mu + \alpha_i + \rho_t$$

$$i = B,C,D,E,G,J,N,S,U \ (9) \qquad t = 78\text{-}92 \ (15)$$

where the country subscripts are taken from the first letter of the country name except for the United Kingdom, which uses "E" for England. Because of the inclusion of a constant in the regression, we cannot estimate a full set of country and time effects. Accordingly, the following restrictions were placed on the country effects, α_i, and the time effects, ρ_t:[9]

$$(3) \qquad \alpha_G = - (\alpha_B + \alpha_C + \alpha_D + \alpha_E + \alpha_J + \alpha_N + \alpha_S + \alpha_U)$$

$$(4) \qquad \rho_{92} = - \sum_{j=78}^{91} \rho_j$$

9. The country effect, α_i, is estimated as the coefficient on a dummy variable that takes the value 1 for country i and 0 for other countries. The time effect, ρ_t, is estimated as the coefficient on a dummy variable that takes the value 1 in period t and 0 in other periods.

These restrictions imply that the estimate of μ is simply the average real interest rate across all countries and time periods. The estimate of $\mu+\rho_t$ is the average real interest rate across countries in period t; we will refer to this estimate as the world real interest rate.

Table 2 presents OLS estimates of equations 2-4. The mean real interest rate is 4.22 percent. Deviations of each country's mean from the world mean are often statistically significant, but in only three cases do they exceed one percentage point: these are the same cases that were identified visually in Figures 1-8. Belgium and Denmark have mean real interest rates 1.6 and 1.9 percentage points higher, and Switzerland has a mean real interest rate 2.7 percentage points lower, than the world mean.[10] The existence of significant country effects implies a rejection of the strict hypothesis of real interest rate parity across all countries. However, if we relax the hypothesis to allow for constant risk premiums across countries, we can still test to see if the dynamic behavior of the real interest rate is the same in all countries. Before performing such a test, we examine the properties of the estimated world real interest rate.

The estimated time effects are highly significant and have the same salient features that were discussed in Figures 1-8. Figure 9 plots the estimated value of $\mu+\rho_t$ over time. Our interpretation of the history of the world ex post real interest rate is as follows: The inflationary boom of the late 1970s kept the real interest rate low through 1978. In 1979, the oil price shock lowered ex post rates further through an inflation surprise. Anti-inflationary monetary policy raised the real rate sharply in the early

10. In the case of Belgium, this coefficient may represent a premium to cover the possibility of devaluation and inflation associated with the very high level of the national debt, which is over 100 percent of GDP. In the case of Switzerland, this coefficient may represent a discount in lieu of the tax advantages of Swiss bank accounts that draw tremendous capital inflows to Switzerland. We are at a loss to explain the Danish coefficient.

1980s, followed by a slight easing in the mid-1980s. The slight upward movement in 1986 is associated with the oil price collapse, which unexpectedly reduced CPI inflation. The moderately low real rates in 1988 and 1989 represent monetary easing in the wake of the global stock market crash of late 1987. The return of high real rates in 1990 and 1991 is partly attributable to a reversal of previous monetary easing in light of growing inflationary pressures and partly attributable to the fall of the Iron Curtain in 1989 and the associated rush of investment into the former Soviet Bloc, particularly eastern Germany.

Table 3 presents the variances of each country's real interest rate and each country's regression residual from Table 2, as well as the correlation between each country's real interest rate and the estimated world real interest rate. For every country, the correlation between its real interest rate and the world real interest rate is very high, never falling below 0.5. In most cases, the country-specific ex post real interest rate has a much greater variance than the regression residual, implying that the estimated time effects explain a large share of the behavior of real interest rates over time.[11] The regression residuals indicate that the unexplained portion of ex post real interest rate behavior has a standard deviation of 0.6 to 1.7 percentage points in all countries except Denmark (2.0 percentage points) and the United States (2.5 percentage points).

Table 4 presents the Ljung-Box portmanteau test for serial correlation in each country's ex post real interest rate and in each country's residual from the estimates of equations 2-4. Under the null hypothesis of

11. The exceptions are Belgium, Denmark, and the Netherlands. In the cases of Belgium and the Netherlands, this result is entirely attributable to the first three years of the sample, when these countries did not experience the very low real interest rates that other countries experienced.

no serial correlation, the Ljung-Box Q statistic is distributed as a chi-square random variable with degrees of freedom equal to the number of lags being tested. Table 4 also presents the partial autocorrelations of the ex post real interest rates and the residuals from equations 2-4. The message from both sets of statistics is quite clear: with the exception of Belgium, there is much less evidence of serial correlation in the residuals than in the original real interest rates. We have no ready explanation for the apparent serial correlation in the Belgian residual, but the lack of serial correlation in the other residuals is consistent with the hypothesis that these countries do not experience persistent deviations from a common world interest rate, aside from a fixed risk premium.

Figures 10 through 18 plot each country's residual from the panel regression in Table 2. Except for the Belgian--and possibly the Canadian and U.S.--residuals, there does not appear to be a significant pattern of serial correlation in the residuals.

The panel regression of equations 2-4 was also estimated using quarterly data on three-month ex post real interest rates.[12] The country fixed effects (risk premiums) are practically identical to those estimated with annual data. Figure 19 plots the estimated world quarterly real interest rate. While the general pattern of the estimated world annual real rate is readily seen in the estimated quarterly rate, the quarterly rate appears to be affected by high-frequency noise in the inflation series. These inflation surprises are likely to be positively correlated across countries (e.g., oil shocks) so that they are not canceled out by averaging across countries.

12. The quarterly regression includes seasonal dummies with different seasonal coefficients estimated for each country. The coefficients on the seasonal dummies are constrained to sum to zero for each country.

Table 5 presents the correlations of the estimated quarterly world real interest rate with each country's seasonally-adjusted ex post real interest rate.[13] The quarterly correlations are not quite as high as the annual correlations in Table 3, but they are still quite high, never falling below 0.45. Once again, Denmark, England, and the United States have the largest regression residuals.[14]

Table 6 presents the Ljung-Box Q statistics and partial autocorrelations for the seasonally-adjusted quarterly real interest rates and the residuals from the panel regression. The evidence of serial correlation in the real interest rate is much stronger for the quarterly series, and in some cases it appears that subtracting the world real interest rate does not remove all the significant serial correlation in the data. This result is particularly true for the U.S. real interest rate. We believe that these results differ from the annual results because the quarterly data have many more observations, and hence more power to detect serial correlation. Moreover, they are consistent with a visual inspection of the annual residuals, which appear to be serially correlated in the cases of Belgium, Canada, and the United States. (Note that the Belgian quarterly statistics do not appear as anomalous as the annual statistics.) Overall, Table 6 demonstrates that most of the serial correlation in each country's real interest rate can be explained by a common world real interest rate, with only a small degree of residual serial correlation. The primary exception to this finding is the behavior of the U.S. real interest rate, which exhibits persistent deviations from the world real interest rate.

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13. The seasonally-adjusted rate is the residual from a regression of the original ex post real interest rate on seasonal dummy variables.

14. The residuals from the quarterly regression are much larger than those from the annual regression. We believe this result is due to measurement error in the quarterly inflation series that is smoothed out over longer horizons.

As an alternative test of the significance of serial correlation in the residuals from the quarterly regression, we ran ADF tests for a unit root in each series. The methodology was the same as that used in Table 1. The results are presented in Table 7.[15] Overall, there is strong evidence that the residuals from the panel regression are indeed stationary.

We conclude this section by noting that our results are not inconsistent with the many documented rejections of real interest rate parity in the existing empirical literature. Our study differs from previous studies in three important areas: First, we focus on countries and time periods with the most liberal domestic and international capital markets. Second, we allow for constant risk premiums, which seem to be significant for some countries. Third, we treat all countries symmetrically, whereas most existing studies have focused on bilateral parity between the United States and selected partner countries. This latter point is noteworthy because our results indicate that the U.S. real interest rate has the largest and most persistent deviations from the estimated world real interest rate.

Robustness and Extensions

To explore the robustness of our results, we replicated the above analysis using domestic three-month interest rates (government debt where available, bank deposit rates otherwise) and obtained essentially identical

15. Because the residuals are generated from a panel regression, we ran a monte carlo simulation with 1000 replications to determine the appropriate critical values for the ADF tests. Each replication consisted of generating nine independent random walk variables over 60 periods and then conducting the panel data regression of equations 2-4 with these variables. The variable-lag ADF procedure was then applied to one of the residual series from the panel regression. The resulting critical values are slightly larger in magnitude than the standard ADF critical values, and they were used for the significance levels in Table 7.

results. This finding is reassuring since these countries had few restrictions on international capital flows for most of our sample. We also tried omitting the United States from our sample, since it appeared to have the most significant deviations from the estimated world real interest rate. Again, the results were virtually unchanged for the remaining countries.

Because a number of studies have used ex ante real interest rates, we reran the annual regression using a fitted value of inflation from a regression of inflation on a constant and two lags of inflation. The estimated average world real interest rate and country risk premiums are identical to those estimated with ex post data.[16] The time effects differ primarily by the smoothing of the outliers in 1979 and 1982. The correlation of each country's ex ante real interest rate with the world ex ante real interest rate is either similar to, or slightly lower than, the corresponding correlation using ex post data. The correlations range from 0.40 to 0.84, compared to a range of 0.52 to 0.95 with ex post data. This result suggests that inflation surprises are positively correlated across countries and that they contribute slightly to the observed correlation of ex post real interest rates across countries. Finally, there is no significant evidence of serial correlation in the residuals of seven of the nine countries. Whereas the Belgian residuals exhibit significant serial correlation with ex post data, the Dutch and U.S. residuals exhibit significant serial correlation with ex ante data.

To see whether capital market regulations and restrictions affect the equality of real interest rates across countries, we extended our quarterly panel regression to include the five available countries that had more restricted financial markets during this sample: Austria, France, Italy,

16. This result is not surprising since the fitted values of inflation have the same mean as the actual values.

Norway, and Sweden. Inclusion of these five countries yields an estimated world real interest rate that is quite similar to the one reported above. However, the correlation of each country's real rate with the new world rate is often lower--and never higher--than for the original panel, although the correlation is still fairly high and always positive. The estimated risk premiums for the additional five countries are generally significant, but small (between -0.6 and 1.0). The residual serial correlations rise only slightly for the original nine countries. The residual serial correlations for four of the five additional countries are highly significant, however, lending some support to excluding them from the initial panel. The principal exception is Sweden, which appears to have both a white noise residual and a very small fixed risk premium.

As a final extension of our model, we performed the quarterly panel regression on six countries for which we were able to obtain domestic interest rates and inflation rates back to 1967: Belgium, Canada, Germany, Japan, the United Kingdom, and the United States. We split the 26-year sample into two 13-year subsamples and performed the panel regression on each subsample and on the entire sample. Not surprisingly, the results from the later subsample are nearly identical in all respects to the ones reported above for nine countries. In the earlier subsample and over the entire sample, the correlation of each country's real rate with the world real rate is positive and significant, but the residuals are highly autocorrelated in nearly every country. Moreover, the mean world real interest rate and the country fixed effects are significantly different across the two subsamples. We conclude that a structural break ocurred in real interest rate behavior across countries sometime during the 1970s. We note that restrictions on capital flows were present in most of these countries during the late 1960s

and early 1970s. In addition, deposit interest ceilings were often binding in the United States, and these may have distorted the Treasury bill rates. Finally, the share of trade in GNP was much lower during the earlier subsample for all of these countries.

Conclusion

This paper has two main findings. First, there is evidence that real interest rates are stationary for a number of OECD countries, at least since the late 1970s. Second, the correlation of ex post real interest rates in different countries is quite high. Using panel data techniques we estimate and plot the world real interest rate. The estimated world real interest rate exhibits a sharp increase associated with monetary tightening in the early 1980s and a moderate decrease associated with monetary easing after the stock market crash of 1987. The world real interest rate rises again in 1990 and 1991 with the impact of German unification and the increase in investment demand in reforming countries. There is some evidence that inflation surprises are correlated across countries, particularly due to the oil price shocks of 1979 and 1986.

In most cases the deviations of a country's ex post real interest rate from the world real interest rate (plus a constant risk premium for some countries) are close to white noise. The primary exception to this finding is the U.S. real interest rate, which exhibits large and persistent deviations from the world real interest rate. One potential explanation for the significant deviations between the U.S. and world real interest rates is that the United States is less well integrated into world goods markets. In 1985 (the midpoint of our sample) the ratio of exports plus imports to GDP for the United States was one-fifth of the average ratio for the other

countries in our sample and less than two-thirds of the ratio for the next lowest country in our sample.[17] The smaller role of trade in the U.S. economy would tend to weaken the link between U.S. prices and foreign prices that is an essential part of real interest rate equalization.

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Table 1. Augmented Dickey-Fuller Tests

Country	Inflation Rate		Nominal Interest Rate		Real Interest Rate	
Belgium	-1.40	(2)	-2.01	(11)	-3.78***	(2)
Canada	-1.50	(2)	-2.38	(3)	-2.74*	(2)
Denmark	-0.65	(5)	-2.21	(7)	-3.90***	(9)
England (U.K.)	-2.38	(12)	-3.23**	(7)	-4.24***	(9)
Germany	-1.72	(11)	-1.88	(9)	-2.68*	(11)
Japan	-2.38	(2)	-3.75***	(3)	-3.55**	(2)
Netherlands	-1.36	(3)	-2.29	(7)	-2.45	(3)
Switzerland	-3.09**	(2)	-3.31**	(5)	-3.19**	(2)
United States	-1.37	(2)	-0.42	(8)	-1.83	(2)

Note: The sample period is 1978:1 - 1992:4, quarterly.

*** denotes 1% significance level.
** denotes 5% significance level.
* denotes 10% significance level.

Table 2. Annual Estimates of Country and Time Effects

Coefficient	Estimate (standard error)	Coefficient	Estimate (standard error)
μ	4.22*** (.09)	ρ_{78}	-2.49*** (.32)
α_B	1.56*** (.24)	ρ_{79}	-4.59*** (.32)
α_C	0.29 (.24)	ρ_{80}	-1.84*** (.32)
α_D	1.93*** (.24)	ρ_{81}	-0.93*** (.32)
α_E	0.42 (.24)	ρ_{82}	2.24*** (.32)
α_G	-0.68*** (.24)	ρ_{83}	0.85** (.32)
α_J	-0.92*** (.24)	ρ_{84}	0.63* (.32)
α_N	0.37 (.24)	ρ_{85}	0.97*** (.32)
α_S	-2.66*** (.24)	ρ_{86}	2.01*** (.32)
α_U	-0.31 (.24)	ρ_{87}	0.34 (.32)
		ρ_{88}	-0.42 (.32)
		ρ_{89}	-0.60* (.32)
		ρ_{90}	0.95*** (.32)
		ρ_{91}	1.52*** (.32)
		ρ_{92}	1.36*** (.32)

Note: This table presents estimates of equations 2-4 using annual data from 1978 through 1992. The country subscripts refer to Belgium, Canada, Denmark, England, Germany, Japan, the Netherlands, Switzerland, and the United States.

*** denotes 1% significance level.
** denotes 5% significance level.
* denotes 10% significance level.

Table 3. Covariance of Real Interest Rates, Annual

Country	Variance of Country Real Interest Rate	Variance of Estimated World Real Interest Rate	Variance of Country Residual	Correlation of Country and World Real Rates
Belgium	1.63	3.45	1.22	0.81
Canada	6.16	3.45	1.91	0.84
Denmark	4.96	3.45	4.13	0.52
England	11.12	3.45	2.96	0.94
Germany	4.12	3.45	0.38	0.95
Japan	6.76	3.45	1.60	0.89
Netherlands	2.00	3.45	2.37	0.59
Switzerland	4.52	3.45	1.26	0.85
United States	11.76	3.45	6.11	0.71

Note: Based on estimated time effects and regression residuals from Table 2.

Table 4. Serial Correlation of Real Rates and Residuals, Annual

Country	Lag	Ljung-Box Q Statistic RR	Ljung-Box Q Statistic RES	Partial Autocorrelation RR	Partial Autocorrelation RES
Belgium	1	1.39	8.04***	.28	.67***
	2	1.66	8.20**	-.21	-.63**
	3	6.11	10.80**	-.41	-.08
Canada	1	6.78***	0.12	.61**	.08
	2	8.74**	0.13	-.09	.03
	3	8.78**	0.29	-.18	-.08
Denmark	1	0.00	0.30	.01	-.13
	2	0.26	0.49	.11	.09
	3	1.15	1.21	-.21	-.17
England	1	5.60**	2.42	.56**	.36
	2	7.00**	4.90*	-.06	.26
	3	7.00*	5.19	-.20	-.09
Germany	1	3.22*	0.04	.42	-.05
	2	3.33	0.16	-.13	-.08
	3	4.90	0.95	-.31	-.20
Japan	1	4.98**	0.17	.52*	-.10
	2	4.98*	0.17	-.39	-.01
	3	5.65	0.18	.05	-.02
Netherlands	1	0.27	1.85	-.12	.32
	2	0.30	1.97	.03	-.03
	3	0.31	2.07	.01	-.10
Switzerland	1	0.24	1.17	.12	-.25
	2	0.72	3.01	.14	.26
	3	2.40	4.59	-.33	-.17
United States	1	4.46**	1.65	.50*	.30
	2	4.61*	2.16	-.21	.08
	3	5.40	2.21	-.20	-.13

Note: RR is the ex post real interest rate and RES is the regression residual from Table 2.

*** denotes 1% significance level.
** denotes 5% significance level.
* denotes 10% significance level.

Table 5. Covariance of Real Interest Rates, Quarterly

Country	Variance of Country Real Interest Rate	Variance of Estimated World Real Interest Rate	Variance of Country Residual	Correlation of Country and World Real Rates
Belgium	6.41	3.81	4.65	0.56
Canada	8.32	3.81	5.49	0.58
Denmark	16.75	3.81	12.69	0.48
England	17.18	3.81	9.23	0.72
Germany	5.49	3.81	1.70	0.83
Japan	8.57	3.81	5.54	0.59
Netherlands	4.61	3.81	4.40	0.47
Switzerland	10.62	3.81	5.32	0.71
United States	14.84	3.81	8.48	0.67

Note: Based on estimates of equations 2-4 with 60 quarterly observations from 1978:1 through 1992:4.

Table 6. Serial Correlation of Real Rates and Residuals, Quarterly

Country	Lag	Ljung-Box Q Statistic RR	Ljung-Box Q Statistic RES	Partial Autocorrelation RR	Partial Autocorrelation RES
Belgium	1	0.00	0.33	.00	.07
	4	2.48	9.98**	-.06	.23*
	12	9.76	18.30	-.14	-.05
Canada	1	22.40***	6.03**	.60***	.31**
	4	38.10***	6.97	-.04	-.16
	12	52.00***	12.30	-.22*	-.13
Denmark	1	0.60	0.88	.10	.12
	4	3.40	1.97	-.18	-.12
	12	10.20	13.10	-.17	-.12
England	1	10.40***	2.42	.41***	.20
	4	21.50***	3.57	-.02	-.09
	12	40.90***	19.30*	-.19	-.20
Germany	1	10.80***	0.66	.41***	.10
	4	25.70***	6.05	-.12	.02
	12	41.80***	16.30	-.16	-.04
Japan	1	7.90***	0.02	.35***	-.02
	4	21.20***	3.88	.05	-.23*
	12	28.20***	8.18	-.04	-.08
Netherlands	1	0.88	0.60	.12	.10
	4	10.80**	7.56	.25*	.04
	12	16.50	15.00	-.07	.04
Switzerland	1	5.84**	0.27	.30**	.07
	4	7.34	3.42	.02	-.09
	12	11.40	12.60	-.07	-.09
United States	1	20.60***	16.70***	.57***	.51***
	4	62.70***	47.80***	-.18	-.15
	12	80.60***	62.90***	-.03	.06

Note: See Table 5.

*** denotes 1% significance level.
** denotes 5% significance level.
* denotes 10% significance level.

Table 7. ADF Tests on Quarterly Residuals

Country		
Belgium	-6.72***	(10)
Canada	-3.66**	(2)
Denmark	-4.07***	(9)
England	-2.01	(6)
Germany	-3.03*	(2)
Japan	-3.52**	(10)
Netherlands	-3.33**	(9)
Switzerland	-4.07***	(12)
United States	-1.49	(2)

Note: See Table 5. Significance levels are based on a monte carlo simulation described in the text.

*** denotes 1% significance level.
** denotes 5% significance level.
* denotes 10% significance level.

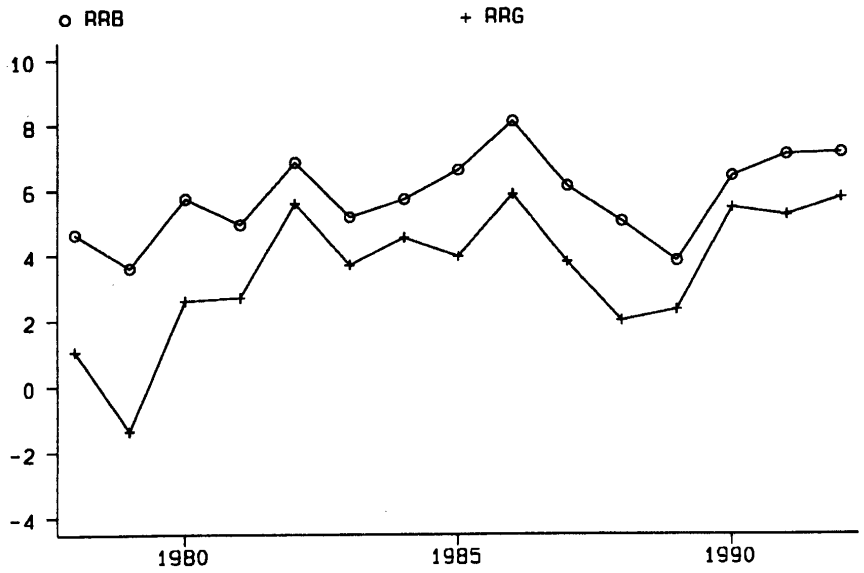

Figure 1. Belgian and German Real Interest Rates

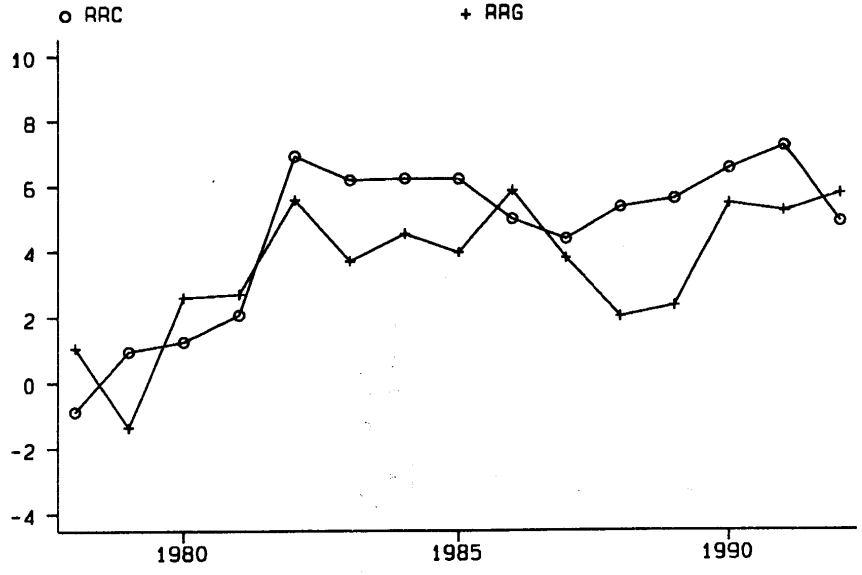

Figure 2. Canadian and German Real Interest Rates

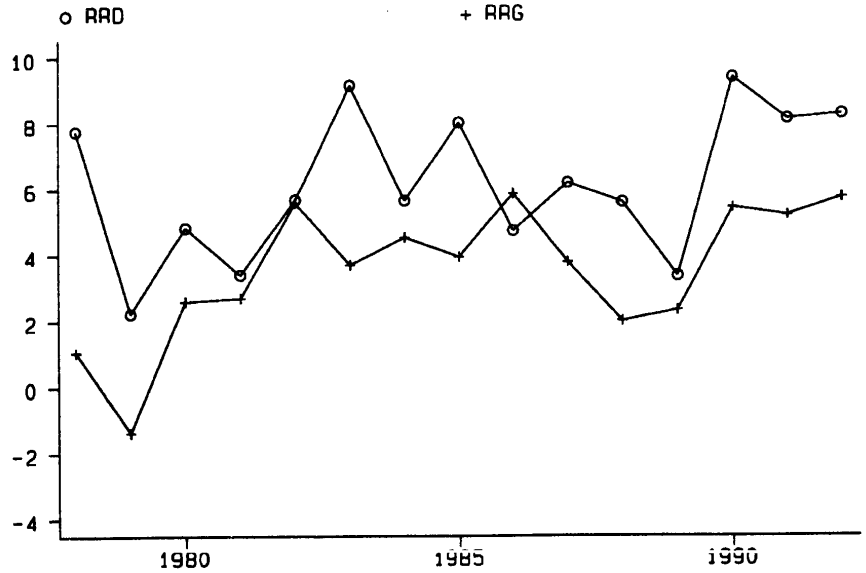

Figure 3. Danish and German Real Interest Rates

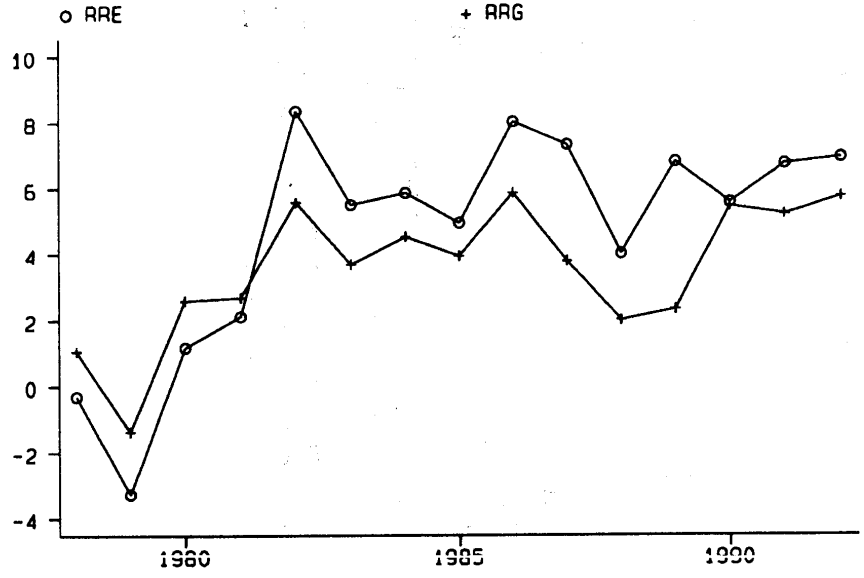

Figure 4. U.K. and German Real Interest Rates

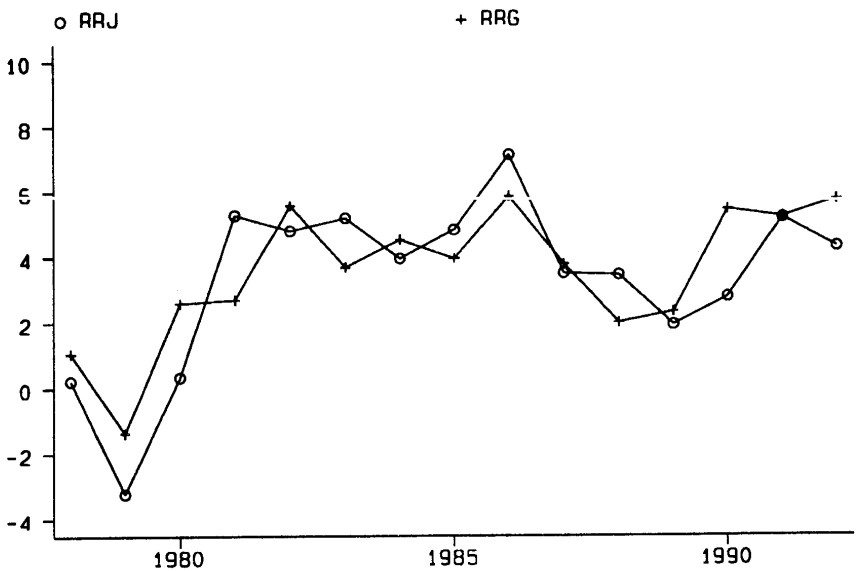

Figure 5. Japanese and German Real Interest Rates

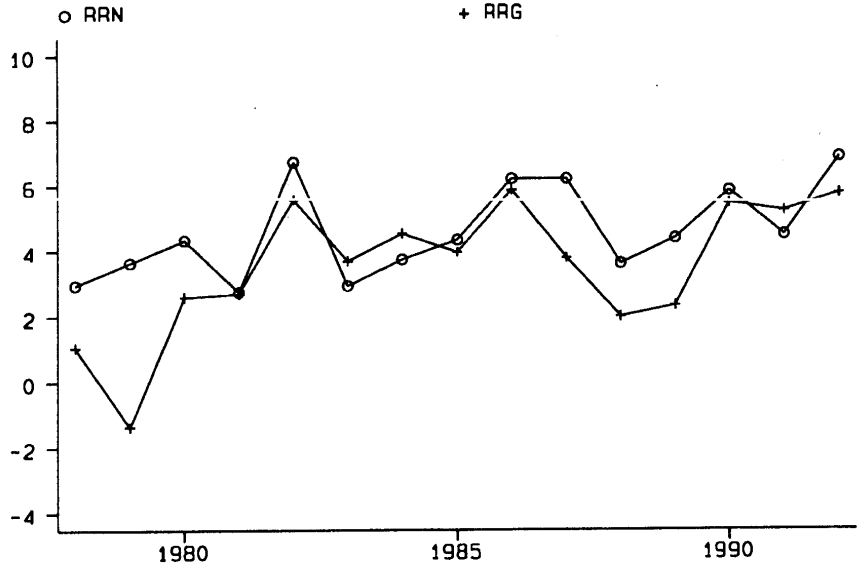

Figure 6. Dutch and German Real Interest Rates

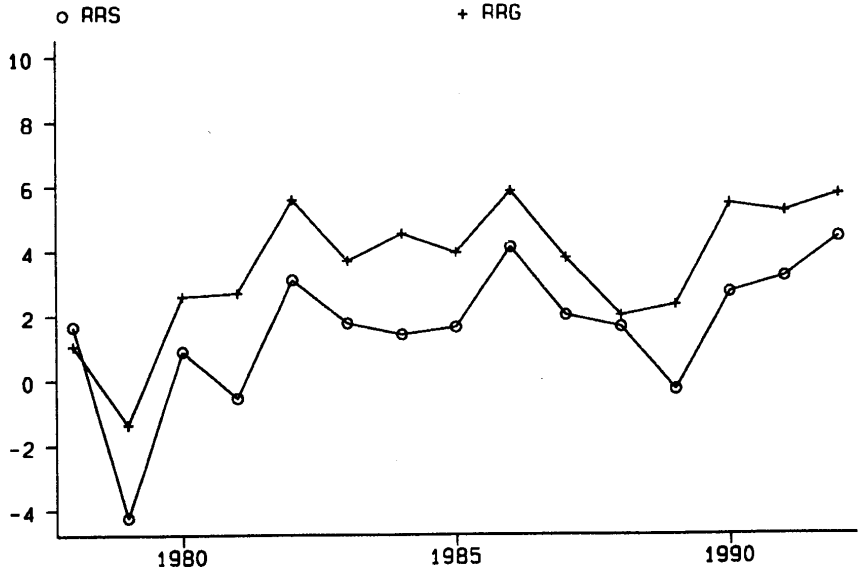

Figure 7. Swiss and German Real Interest Rates

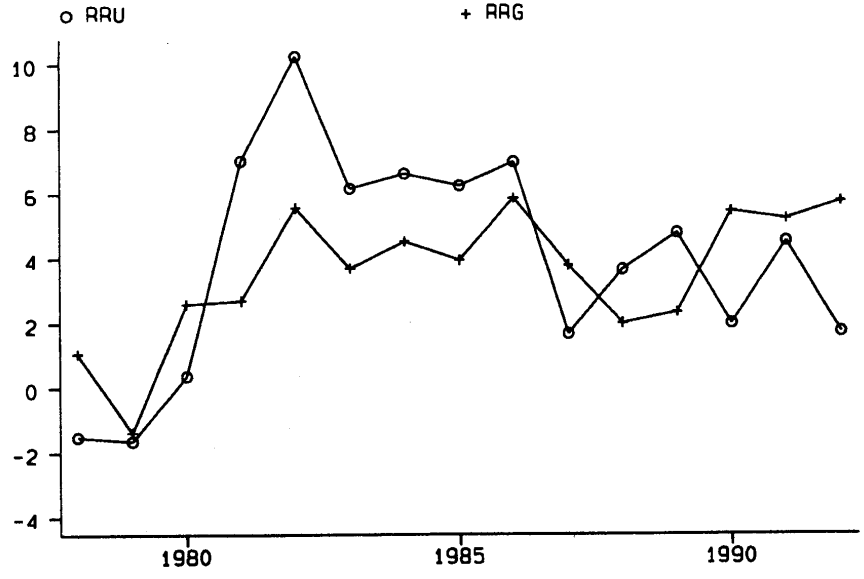

Figure 8. U.S. and German Real Interest Rates

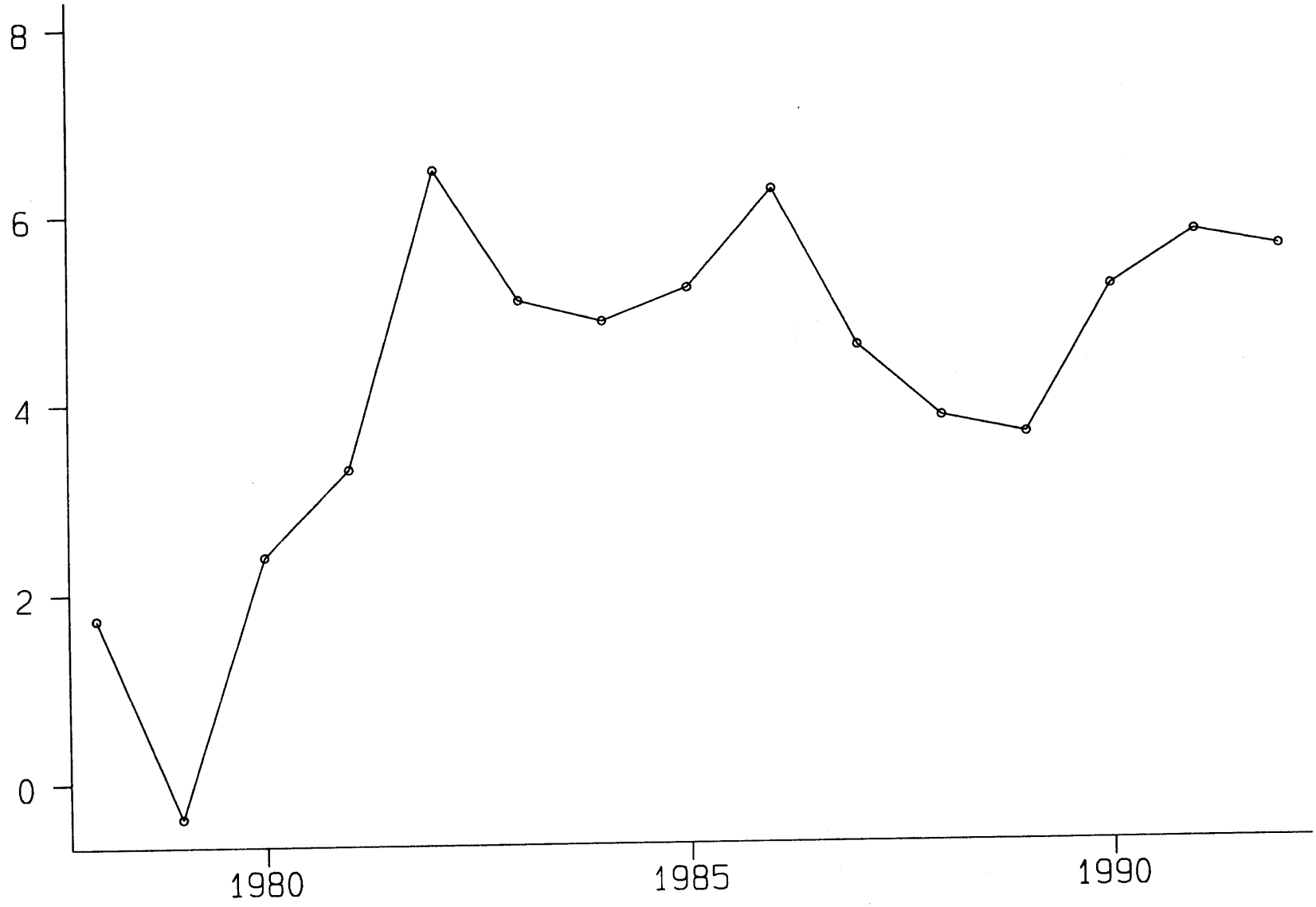

Figure 9. Estimated World Real Interest Rate, 12-Month

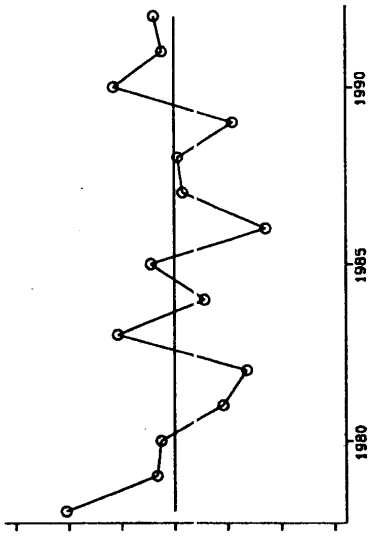

Figure 10. Belgian Residuals

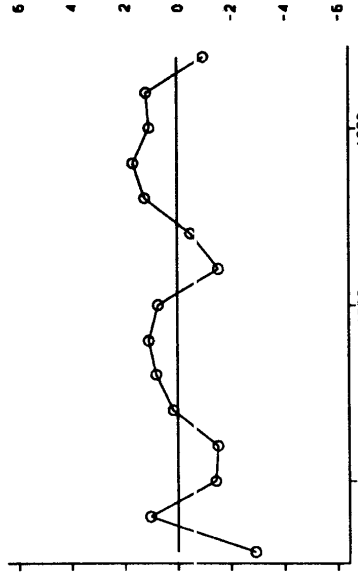

Figure 11. Canadian Residuals

Figure 12. Danish Residuals

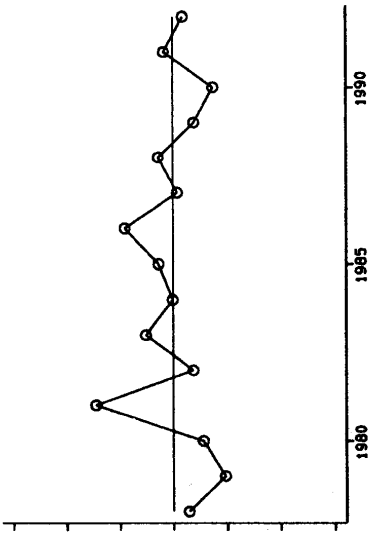

Figure 13. U.K. Residuals

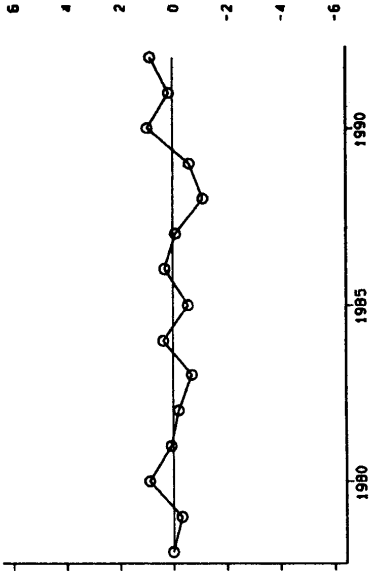

Figure 14. German Residuals

Figure 15. Japanese Residuals

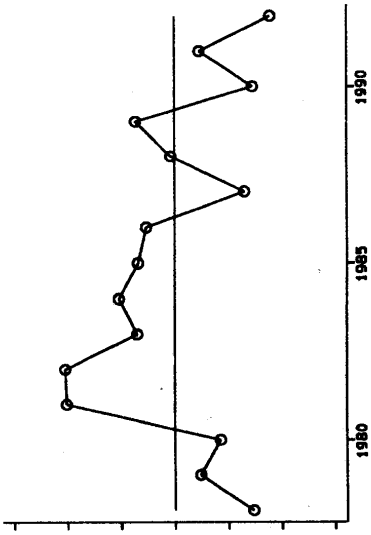

Figure 16. Dutch Residuals

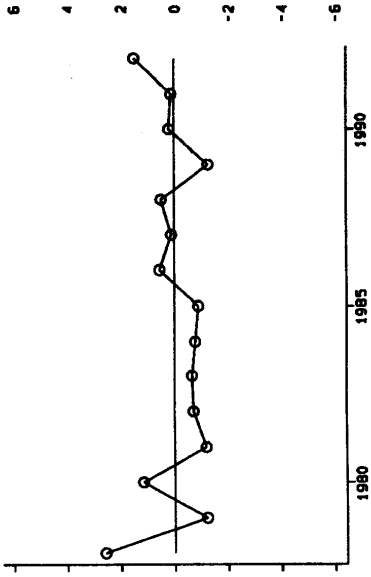

Figure 17. Swiss Residuals

Figure 18. U.S. Residuals

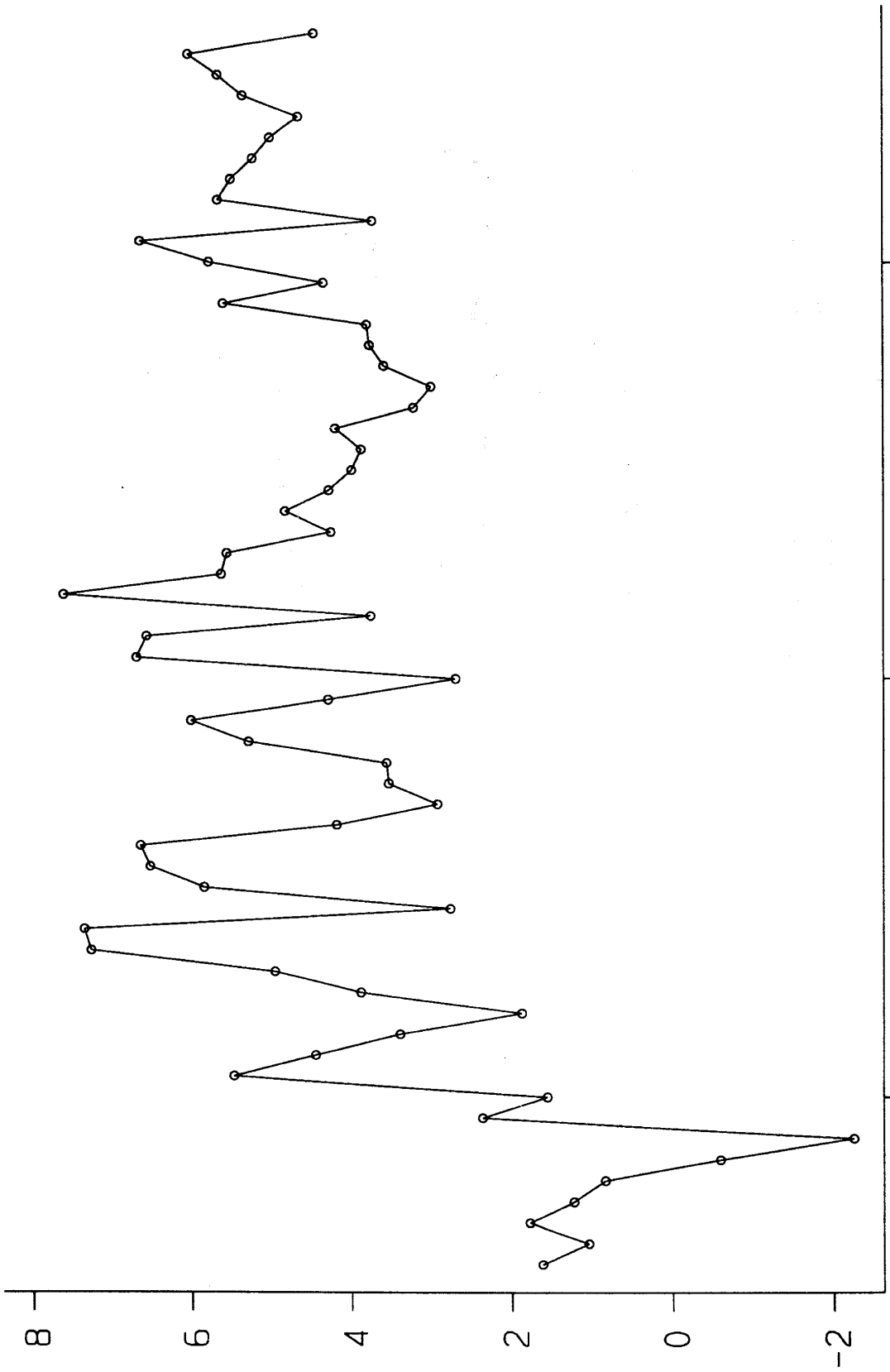

Figure 19. Estimated World Real Interest Rate, 3-Month

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