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OF REAL BOND RATES

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A NOTE ON ALTERNATIVE MEASURES OF REAL BOND RATES

by
Palle Andersen*

Abstract

The purpose of this note is to derive measures of *ex ante* long-term real interest rates that satisfy Fisher's notion of a long-run relationship between expectations of inflation and nominal interest rates. We do so by adopting a backward-looking approach that also takes account of the increasing integration of financial markets by allowing for global influences on national bond rates. The results point to long memories in the inflation formation process as well as to significant international linkages. Moreover, once these effects are allowed for, expectations of inflation and long-term bond rates appear to be co-integrated with co-integration vectors of unity. However, whether the measures derived provide better estimates of agents' actual perceptions of *ex ante* real rates than those commonly used remains to be seen, as we do not test their forecasting ability.

Key words: expectations of inflation, real bond rates, co-integration.

JEL classification: E43.

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Contents

1. Introduction

"Fisher did not state that there should be a strong short-run relationship between expected inflation and interest rates. Rather he viewed the positive relationship between inflation and interest rates as a long-run phenomenon." Mishkin (1992), p. 213.

A principal link in the transmission of monetary policy changes to the real economy is the real long-term interest rate. Since most central banks implement policy by operating at the very short end of the yield curve, a first step in evaluating the transmission process requires estimates of the yield curve. However, since most economic decisions (consumption, investment, etc.) are based on real rather than nominal rates, an equally important step involves going from nominal to real rates.[1] The rather modest aim of this note is to explore various approaches to extracting agents' perception of real rates. The next logical step would be to test whether the real rates thus derived lead to better forecasts than more commonly used procedures; however, such tests are beyond the scope of this note.

A fundamental problem with expected or *ex ante* real interest rates is that they are not observable. Generally accepted measures of expectations of inflation are hard to find and those available rarely provide information corresponding to the time horizon of long-term bond rates. Consequently, perceptions of *ex ante* real rates are often calculated by subtracting one-year lagged or contemporaneous inflation rates from, say, 10-year bond rates. In periods of relatively stable inflation, this procedure probably provides a fairly reliable approximation to *ex ante* real rates and is likely to satisfy the conditions for the long-run Fisher equation.[2] It has the further advantage that it can easily be applied to a wide range of countries, thus facilitating calculations of internationally comparable real rates. However, in periods of large supply shocks and associated unstable rates of inflation, lagged or contemporaneous price changes may give a misleading gauge of agents' perceptions of future price trends, especially when the shocks are only transitory and affect the level of prices and not their rate of change.[3] Perceptions of real rates are also difficult to extract following policy-induced changes in inflation regimes. In such conditions, both nominal rates and contemporaneous rates of inflation are

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1 Real rates are also relevant in other respects, such as for evaluating the sustainability of fiscal policy or assessing long-run growth. However, these issues will not be further discussed in this note.

2 The Fisher equation states that, in the long run, the real interest rate equals the nominal interest rate less the expected rate of inflation. See Fisher (1930) and (1992).

3 For instance, following the first oil shock, real interest rates, calculated using the contemporaneous rate of inflation, were negative in many countries. Real interest rates also turned negative after the second oil price rise in the late 1970s, but the decline was less pronounced as several central banks tightened monetary policy. See Graph 1 and the country graphs at the end of this note.

likely to be well above their long-run values. Typically, estimated real rates rise following such policy shifts, but whether these increases correspond to agents' perceptions of future real rates is not clear.[4]

Another problem with calculating *ex ante* real interest rates as nominal bond rates less current rates of inflation is that the two series are generally not co-integrated and, when they are, the co-integrating coefficient is significantly less than unity.[5] As can be seen from Table 1, which presents both co-integration and integration tests for nominal rates and rates of inflation for the 17 countries in our sample, only Germany, the United Kingdom, Canada and Switzerland satisfy (or almost satisfy) the 5% critical value for not rejecting co-integration, with co-integration coefficients ranging from 0.3 to 0.55. Denmark obtains the highest co-integration coefficient (0.75) but the t-value is below the 10% critical value while, Ireland satisfies the 10% critical value with a coefficient of only 0.42.

2. Various approaches to deriving expectations of inflation

Against this background, there are essentially two approaches to deriving a closer approximation to Fisher's notion of a long-run relationship than the traditional or more "pedestrian" estimates provide.[6] One approach would be more forward-looking and calculate expectations of future inflation from either survey-based measures or econometric estimates. The literature provides numerous examples but, except for certain periods, the real rates obtained do not differ significantly from those derived using more simplistic measures.[7] Survey measures usually cover only one or two future years and respondents seem to be heavily influenced by recent past rates of inflation.[8] Econometric methods typically derive future inflation from autoregressive regressions of inflation, which give an equally high weight to the immediate past.

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4 This was evident in the early 1980s, when most central banks took steps to reduce inflation (Graph 1). Bleaney (1997) uses regime-switching techniques in an attempt to overcome the problem of high real interest rates associated with regime shifts and finds promising results for Australia, Canada, Germany, the United Kingdom and the United States.

5 This implies that the calculated real interest rates are non-stationary. A common finding in the literature is that tests on the stationarity of real interest rates provide conflicting results depending on the test applied, the sample period used, the countries included and whether or not deterministic mean shifts are allowed for. For instance, it might be argued that the deregulation of financial markets and the removal of quantitative restrictions have led to higher equilibrium real rates. On the other hand, as financial markets have expanded and become more liquid, liquidity premia may have fallen.

6 A third possibility would be to use index-linked bond rates. However, such rates are only available for a small number of countries and for rather short time periods. Moreover, since markets for index-linked bonds tend to be illiquid, the implied real rates may not be representative.

7 See, for instance, Group of Ten (1995) as well as various issues of IMF *World Economic Outlook* and OECD *Economic Outlook*.

8 This is also true for the 10-year ahead forecasts produced by Consensus Economics (see Table 4 below). A large influence of recent inflation does not necessarily mean that respondents are not reporting their true expectations; it might just reflect the fact that they weight recent data more heavily than those from further back.

The second approach is more backward-looking and essentially derives real interest rates on the assumption that the past history of inflation provides the best guide to agents' perceptions of future inflation. In particular, such an approach would offer an opportunity to explore differences in the speed with which expectations of inflation appear to adjust and how such differences affect the level and distribution of real rates across countries.

Yet another, but totally different, approach would be to assume that the integration of financial markets has advanced to a point where real long-term interest rates are determined in global rather than in national markets. Under such conditions, central banks and changes in national short-term rates would have only a limited influence, and real long-term rates would be largely insensitive to developments in national bond rates and rates of inflation as well as to differences in expectation formation processes across countries. Accordingly, this approach would initially attempt to identify the factors determining real long-term rates in global markets and then model the transmission of global rates to each country, taking account of various risks, such as currency, liquidity and credit risks. Such an approach has several appealing features and some recent contributions are briefly reviewed in the Annex. However, since wide differences across countries in institutions and financial structures remain and there are several reasons why real rates may differ across countries even if capital markets are fully integrated,[9] a global approach still seems premature.[10]

3. Approach adopted in this note

In this note we opted for the backward-looking or second approach and have, to a very large extent, relied on Gagnon's (1996) procedure for assessing the "long memory in inflation expectations".[11] However, to take account of possible international linkages, we extended his specification to include the influence of foreign rates.[12] Essentially, the procedure adopted amounts to using co-integration analysis and estimating an error-correction equation on monthly data for countries that have long-term bond rates going back to 1970 or earlier:

(1) $$\Delta i = \eta + \alpha i_{-1} + \beta \pi_{-1} + \phi \pi_{movavg} + \varphi i_{-1}^{us} + \nu i_{-1}^{de} + \delta \Delta \pi_{-1} + \gamma \Delta i_{-1}^{us} + \theta \Delta i_{-1}^{de} + \lambda \Delta i_{-1} + \varepsilon$$

9 See Group of Ten (1995).

10 Another reason for focusing on real national rates of interest is that all the global approaches use country-specific real rates as an input to estimating the global real rate; see the Annex.

11 Gagnon's procedure might be seen as a constrained version of the autoregressive determination of expectations of inflation commonly used in econometric models.

12 As shown in Graph 1, we also constructed global rates from the country-specific nominal and real rates, using 1990 PPP GDP weights.

with i = nominal bond rate, $i^{us(de)}$ = foreign nominal bond rate (usually the United States or Germany), π = 12-month rate of inflation (CPI), π_{movavg} = moving average of π, included to capture "long memories", ε = random error and Δ = first-difference operator.

Starting with the easiest, and actually most frequent, case where bond rates are not cointegrated across countries and the long-run homogeneity condition ($-\alpha = \beta + \phi$) is met, the nominal bond rate in country i should satisfy:

(2) $$i_{i,t} = (\eta + \beta\pi_t + \phi\pi_{movavg,t})/(\phi + \beta)$$

from which we can derive a real long-term rate as:

(3) $$r_t = i_t - (\beta\pi_t + \phi\pi_{movavg,t})/(\phi + \beta)$$

with a steady-state value of:

(4) $$r^* = \eta/(\phi + \beta)$$

Similarly, when only the contemporaneous rate of inflation is significant, we have $r^* = i - \pi = \eta/\beta$.

If one of the foreign rates,[13] say the US rate, is cointegrated with the rate in country i and the homogeneity condition ($-\alpha = \beta + \phi + \varphi$) is met, the nominal bond rate must satisfy the condition:

(5) $$i_{i,t} = (\eta + \beta\pi_t + \phi\pi_{movavg} + \varphi i^*_{us,t})/(\phi + \beta + \varphi)$$

By combining the two inflation components in country i into one term (π^*) and defining the real rate as $r_{i,t} = i_{i,t} - \pi_{i,t}^*$, (5) can be rewritten as:

(6) $$r_{i,t} = (\eta - \varphi\pi^*_{i,t} + \varphi(r_t^{us} + \pi_t^{us})/(\phi + \beta + \varphi) = (\eta + \varphi r_t^{us} + \varphi(\pi_t^{us} - \pi^*_{i,t})/(\phi + \beta + \varphi)$$

from which we get the steady-state condition:

(7) $$r_i^* = (\eta + \varphi r^{us} + \varphi(\pi^{us} - \pi_i^*)/(\phi + \beta + \varphi)$$

In other words, when we define the real rate in country i by "overweighting" the domestic inflation components, we need to make a correction for possible long-run inflation differentials.

The estimation procedure involved five steps. First, (1) was estimated including two foreign rates together with lagged values of changes in domestic and foreign rates as well as the domestic rate of inflation. The exact memory length was determined so as to maximise R^2, and only a few trials were required. Second, all variables with t-values below 1 were eliminated, starting with the least significant ones. Third, the homogeneity condition was imposed on the remaining level variables and

[13] We found no countries for which two or more foreign rates were cointegrated with domestic rates, but the derivations below can easily be extended to two or more foreign rates.

again variables with t-values below 1 were eliminated. Fourth, this more parsimonious version was re-estimated and tested for homogeneity, using an F-test. Finally, in those few cases where the homogeneity condition was strongly violated (F-value in the interval < 1%), we went through steps 1−4 again until an acceptable specification was obtained.

4. Empirical estimates

4.1 Main results

The results for the constrained version of (1) are shown in Table 2; the main features are:

(i) Although not evident from the table, cointegration was not rejected for any country. Thus the lagged levels of domestic nominal interest rates were always negative and highly significant in step 1 and this coincided with at least one other significant level variable.[14] Moreover, except for Switzerland, the homogeneity condition was satisfied, implying cointegration vectors with unit coefficients on the combined inflation and foreign rate components.

(ii) As can be seen from the ϕ-coefficients in Table 2, the memory lengths vary from 7½ to 15 years, with more than half the countries having lags of 10 years. Except for Switzerland, all the coefficients are significant, although for Germany this is only true after the homogeneity constraint was imposed.[15]

(iii) The one-month lagged rate of inflation appears to be less important. For Belgium, Denmark and the Netherlands, we found no influence and the coefficients for Finland and Norway are only significant if the acceptance criterion is lowered to t-values ≥ 1.[16]

(iv) While in several cases we found significant level effects of foreign rates for the unconstrained version, only for four countries (Canada, Australia, Ireland and the Netherlands) did these "survive" after imposing the homogeneity condition. In fact, for some countries a positive level effect in step 1 turned negative in step 3. On the other hand, there is evidence of transitory external

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[14] However, for about one-thirds of the countries, cointegration is rejected when the homogeneity condition is imposed; for further details see Table 2 bis.

[15] It should be recalled that Germany and Switzerland were the two countries for which the absence of co-integration between nominal interest rates and current rates of inflation was mostly strongly rejected in Table 1. However, as noted in discussing the results in Table 1, the co-integration coefficients are significantly below unity, notably for Switzerland.

[16] Except for Denmark, all the countries with no or only a small influence of contemporaneous rates of inflation obtained low co-integration coefficients and t-values in Table 1.

influences in virtually all countries; in some cases, two significant foreign rates were actually found.[17]

(v) Given the nature of the dependent variable (month-to-month changes), it is not surprising that most of the R^2s are rather low, though for some countries further work might have produced more satisfactory results. As already noted, the homogeneity condition is not satisfied for Switzerland and the standard errors are relatively high in some cases (notably the United Kingdom, Ireland and Spain), though to some extent this may reflect the convergence among EU countries.

(vi) The steady-state real interest rates (r^*) shown in the penultimate column of Table 2 range from 0.45 to 3.90, being lowest in Japan and highest in Germany. Switzerland also obtains a rather low rate, while three of the four countries (Australia, Canada and the Netherlands) with significant level effects for foreign interest rates have steady-state rates of 3.0% or higher.[18] The large differences across countries in steady-state real interest rates seem, in some cases, to reflect changes in bilateral exchange rates and differences in rates of inflation.[19] However, a "deeper" explanation goes well beyond the scope of this note.

4.2 Average lags, volatilities and sensitivity to inflation

From the estimated coefficients and the length of the moving average components, it is possible to calculate average lags or "memory lengths" for each country. As Table 3 shows, the lags range from 79 months in Japan to just one month in Switzerland, averaging 46 months for the 17 countries as a group. The median (Australia) is very close to the mean and about half the countries have lags within a six- to seven-month interval around the median.

Table 4 compares the means and volatilities of the real interest rates derived from Table 2 (henceforth called rate 2) with those of real rates calculated from contemporaneous rates of inflation (rate 1). As the table shows, average values are somewhat lower when longer memories are taken into account,

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[17] After testing several specifications, including a slope change on the influence of changes in German rates during the period of UK participation in the EMS, a specification with contemporaneous changes in foreign rates was chosen for the United Kingdom. This respecification significantly improved the R^2 without materially affecting coefficients on other variables or the main properties of the real interest rate derived.

[18] Without the intercept shift dummy, Denmark would have obtained a steady-state rate of 5.5%. The significant decline in r^* after 1981 seems indicative of a regime shift and an associated lower risk premium. In 1982, the Danish Government suspended wage indexation (later abolished) and committed itself to keeping the krone stable against the Deutsche mark. This commitment seems to have gained a high degree of credibility when the Government decided against following the Swedish devaluation in October 1982.

[19] For instance, the difference between the steady-state rates in the United States on the one hand, and Japan and Switzerland on the other, seems, in part, to reflect the fact that during the last 35 years both the yen and the Swiss franc have appreciated by some 3½% per year against the US dollar while, on average, the inflation rate in Japan and Switzerland has been one-half of 1 percentage point below that of the United States. However, changes in bilateral exchange rates and inflation differentials do not explain the low steady-state rates in Japan and Switzerland compared with Germany or why Germany has the highest steady-state rate of all the countries.

with particularly large declines observed for the United Kingdom and Japan, both of which have moving average components going back more than 10 years.[20] Even more striking is the more than 50% decline in average volatilities, presumably because year-to-year fluctuations in inflation are given a smaller weight (see also the graphs at the end of the note).

While lower volatility is probably a desirable feature, it is more difficult to say which of the two rates provides the more plausible assessment of recent real rates.[21] The last three columns of Table 4 compare the two alternative measures of end-1998 real rates with consensus forecasts based on expectations of inflation 10 years ahead. For about half the countries, the real rate based on long memories is closer to the consensus forecast; for the other half, rate 2 seems to understate the end-1998 real rates, presumably because it assigns a larger weight to the high inflation rates of the mid-1980s than those responding to the consensus survey.

A common finding in the literature is that nominal bond rates tend to be sticky, so that changes in the current rate of inflation are negatively correlated with real interest rates, as usually measured. Since this implies that transitory changes in the rate of inflation generate volatile real rates, the marked drop in standard deviations observed in Table 4 when moving from rate 1 to rate 2 can probably be attributed to the lower weight given to contemporaneous rates of inflation. As Table 5 shows, the results from bilateral regressions for both levels of and changes in real rates and inflation are consistent with this hypothesis.

4.3 Cross-country correlations

Tables 6−8 explore the extent to which nominal and real interest rates are correlated across countries.[22] Starting with Table 6, three features are worth noting. First, for most countries, the correlation of nominal rates is higher than for real rates, though Australia, Finland, Norway and Switzerland are exceptions to this finding. Second, even though correlation coefficients should not be given a causal interpretation, there is no clear "leading rate setter" emerging for either nominal or real rates. For nominal rates, the highest average correlation is found for Spain (0.78), and for real rates, Finland (0.72). Switzerland appears to be rather insulated from other countries, with the lowest average correlation for nominal rates and the second lowest for real rates. Third, the most striking feature of Table 6 is the very low correlations between nominal and real rates within each country (shown in bold on the diagonal). For almost half the countries, the correlation is actually negative or

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[20] Except for Denmark, for which the calculated means do not allow for the intercept shift, all the means for rate 2 are quite close to the steady-state values shown in Table 2.

[21] As mentioned earlier, the plausibility of real rates should be assessed from their forecasting ability.

[22] For earlier, and far more sophisticated, studies of international linkages of nominal and real interest rates, see Mishkin (1984a) and (1984b), Cumby and Mishkin (1986) and Kashman and Pigott (1988).

insignificantly different from zero and for the 17 countries as a group the correlation is only 0.08. Given the results in Table 5 on the sensitivity of rate 1 to changes in inflation, the low correlations may be seen as further evidence of the "inflation wedge".

Table 7 presents bilateral correlations for *levels and changes* in the real rates derived from Table 2. A first impression from this table is that, except for Denmark, the correlations of the levels are smaller than, or at best equal to, those shown in the previous table. In other words, even though for most countries a 10-year moving average seems to be the appropriate memory length and about half the countries have average memory lags of 38-50 months, the differences across countries are sufficiently large to produce marked drops in the bilateral correlations. This is particularly noticeable for the two "extreme" cases, the United Kingdom and Switzerland, which, according to Table 3, have the second longest and shortest memory lengths respectively.

Second, the bilateral correlations for c*hanges* in real rates are, in all cases, lower than those for *levels*, with particularly marked drops observed for the smaller countries. Third, as further evidence of the influence of the inflation wedge, the correlations with nominal rates are much higher for rate 2 than for rate 1 (figures on the diagonal). Even though there are still a few countries for which levels of nominal and real rates are negatively correlated, the average correlation is 0.28, compared with an insignificant 0.08 for rate 1. Moreover, for changes in nominal and real rates, the average correlation increases to 0.83.

Finally, Table 8 presents bilateral correlations for *changes* in nominal and real rates (rate 1) respectively. It is notable that the bilateral correlations for changes in real rates are smaller for rate 1 than for rate 2. This is also true for correlations between changes in real and nominal rates, as shown for each country on the diagonal. As regards changes in nominal rates, the relatively high bilateral correlations for the EU countries with close links to Germany are worth noticing and, though not an EU member, Switzerland might be included in this group.

5. Conclusion

In the absence of generally accepted measures of expectations, *ex ante* long-term interest rates are typically calculated as nominal rates less contemporaneous rates of inflation. When inflation is stable, this "short cut" may provide a satisfactory approximation. However, in periods of large supply shocks, contemporaneous rates of inflation are unlikely to capture agents' perceptions of future price trends. Moreover, nominal bond rates and contemporaneous rates of inflation are usually not co-integrated and, when they are, the cointegration coefficients are significantly below unity. As a result, real *ex ante* bond rates calculated using contemporaneous rates of inflation as proxies for future rates do not satisfy Fisher's long-run equilibrium conditions.

The aim of this note has been to derive measures of expectations which better approximate these conditions and it does so by estimating an error correction model which allows for both long memories in inflation expectations and international linkages of nominal and real bond rates. For the 17 countries included in the sample, memory lags appear to average almost four years, being longest in Japan and shortest in Switzerland. The estimates also imply significant international linkages, though for most countries these are only transitory. In addition, the volatility of the real rates derived is much smaller than for those obtained from nominal bond rates and contemporaneous rates of inflation and, except for one country, the Fisher condition for long-run equilibrium is satisfied.

Despite these encouraging features, it remains an open question whether real interest rates based on long memory lags provide a realistic picture of agents' perceptions of future real rates as the note stops short of testing their prediction ability. Another issue is the *determination* of movements in real rates, including, for instance, the influence of cyclical factors, changes in risk premia, private sector saving and investment and fiscal conditions. Similarly, the wide variation across the 17 countries of steady-state real interest rates is left unexplained. Consequently, the note should mainly be seen as providing a potentially promising tool for future work.

Annex: Global models of nominal and real interest rates

During the last 10-15 years, several analysts have addressed the issue of whether long-term interest rates are primarily determined in global markets or whether domestic fundamentals and monetary policy still have an influence. To cite two recent contributions, Helbling and Wescott (1995) regard the global real interest rate, or the rate at which the global demand for investment equals the global supply of savings, as one of the most important prices in world financial markets and, in their empirical work, mainly rely on global determinants. Christiansen and Pigott (1997), on the other hand, find that while long-term interest rates are increasingly influenced by common factors, domestic fundamentals continue to be the principal determinants of movements in long-term rates. Moreover, monetary authorities retain sufficient influence on long-term rates to achieve their targets.[23]

Even if one takes the view that long-term rates are determined in global markets, several issues remain. For instance, how should a global rate be measured, what is the most relevant time horizon and which factors determine fluctuations in global real rates? As regards *measurement*, most of the methods applied essentially attempt to extract a common component from national rates and then define this as the global real rate. Barro and Sala-i-Martin (1990) construct this component as a weighted average of national short-term rates. Gagnon and Unferth (1993) also use short-term rates, but apply a panel data model, from which, after imposing various restrictions, they back out the global rate as an unweighted average of national rates. In Ford and Laxton (1995), the global real rate is constructed from the first principal component of national real rates while Brunner and Kaminsky (1994) use the common trend in cointegrated national real interest rates. However, having applied three of these extraction methods in deriving both short- and long-term real rates, Helbling and Westcott (1995), *op cit* conclude that, in general, differences between the various estimates are only minor.

Regarding the *determination* of real rates in a global context, most recent studies have applied co-integration and error correction analysis to reduced-form equations, and within this framework two basic approaches may be distinguished:[24]

- in one approach, global rates are explained by global determinants, typically some measure of the global return on equities and the net or gross government debt/GDP ratio, while country-specific

[23] The equation estimated by Christiansen and Pigott for real national bond rates is very similar to equation (1), except that they also include national three-month rates and exclude the moving average component.

[24] Ford and Laxton (1995) "fall between the two" as they estimate country-specific as well as global real interest rates as functions of the global debt/GDP ratio.

variables are ignored. For instance, Helbling and Westcott (1995) estimate the co-integration model:

(i) $$r_t^w = \alpha + \beta\rho_t^w + \phi(B/GDP)_t^w$$

with *r* = real interest rate, ρ = return on capital, *B/GDP* = government debt/GDP ratio and *w* denoting global values. Knot (1995) may also be included under this approach, although he confines "global" to the European market. [25] Applying a four-equation loanable funds model, Knot finds that movements in the European after-tax real three-month rate are mainly driven changes in temporary income, expected inflation, lagged investment, money growth, the oil price and the US real three-month rate.

- The second approach attempts to explain country-specific real rates within a common framework, in which both global and national variables appear among the long-run fundamentals as well as the short-run and transitory influences. A typical example of this approach is Orr et al. (1995), who derive and estimate the following multi-country model:

(ii) $$r_{it}^* = \delta_1\rho_{it} + \delta_2 gd_{it} + \delta_3\beta_{it} + \delta_4 ca_{it} + \delta_5(\pi^* - \pi^e)_{it}$$ and

(iii) $$\Delta r_{it} = \lambda(r_{it-1}^* - r_{it-1}) + \gamma_i z_{it}$$

with *r** = trend long-term real interest rate, ρ = return on capital, *gd* = indicator of government saving position relative to GDP, β = indicator of risk in holding domestic bonds, *ca* = current account balance relative to GDP, π* = long-term average of past inflation, π^e = expected future inflation, *z* = various short-term influences and *i* and *t* country and time subscripts. In estimating the model, Orr et al. constrain λ but not γ to be equal for all countries.

Although mostly focused on estimating the influence of inflation on ex post real interest rates, the model proposed by Gregory and Watt (1995) may also be considered under this approach as both real interest rates and inflation rates are assumed to contain a global as well as a country-specific component:

(iv) $$r_i = \phi_i r^w + \delta_i \pi^w + \alpha_i \eta_i^\pi + \eta_i^r$$

(v) $$\pi_i = \beta_i \pi^w + \eta_i^\pi$$

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[25] Moreover, Europe is confined to France, Germany, the Netherlands and the United Kingdom and Europe-wide variables are constructed as GDP-weighted averages or by aggregating data for the four countries. Recognising that the degree of integration is less than perfect, the main model is complemented with system estimates, including country-specific as well as area-wide variables.

with r_i = real interest rate in country *i*, r^W = global component of real interest rate, π^W = global component of inflation, π_i = rate of inflation in country *i*, η_i^r = specific component of real interest rate in country *i* and η_i^π = specific component of inflation in country *i*.

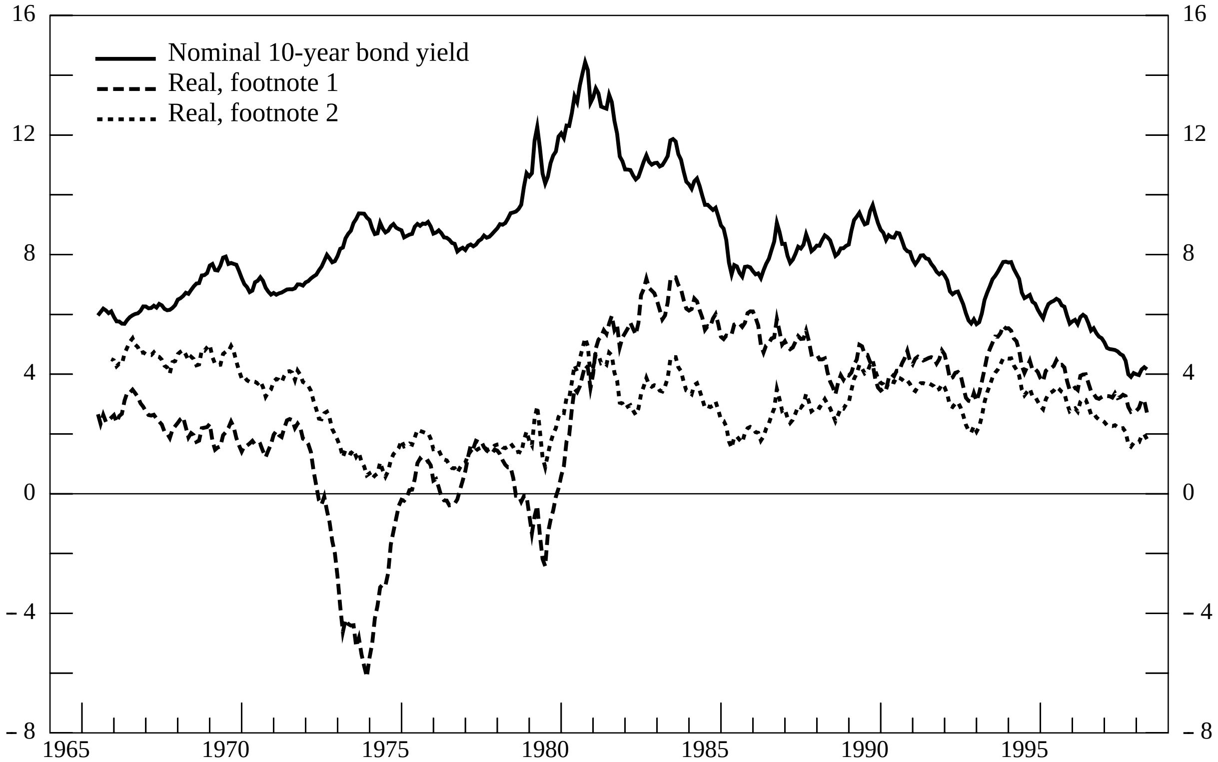
While Gregory and Watt estimate their model using dynamic factor component analysis, Gagnon and Unferth (1993) *op cit* rely on a panel data technique based on country and period dummies to derive a common component from ex post real rates for nine countries. As mentioned above, their method might best considered as a way to *derive* rather than *explain* movements in global rates. Nonetheless, it is worth noting that, except for the United States, they find each country's real rate to be highly correlated with the global rate.

Tables and graphs

Graph 1

Global nominal and real interest rates

In percentages and percentage points



Note: Weighted averages of the G10 countries, Austria and Denmark using 1990 PPP and GDP weights.

[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and ten-year moving average rates of inflation.

Table 1

Integration and co-integration tests for nominal interest rates and inflation

t-values, unless otherwise noted

Countries	Level[1]		1st difference[1,2]		Co-integration[3]	
	i	π	Δi	Δπ	β	λ
United States	- 1.73	- 2.79*	- 9.00	- 10.7	0.60	- 2.14
Japan	- 0.78	- 2.23	- 12.5	- 11.6	0.24	- 1.73
Germany	- 2.13	- 3.56***	- 9.85	- 12.8	0.55	- 3.80***
France	- 1.13	- 1.20	- 10.3	- 9.67	0.53	- 1.83
Italy	- 1.15	- 2.10	- 10.1	- 12.3	0.49	- 2.48
United Kingdom	- 1.75	- 2.27	- 13.9	- 8.58	0.40	- 3.51**
Canada	- 1.76	- 2.54	- 13.1	- 11.1	0.53	- 3.42**
Australia	- 1.42	- 1.45	- 9.79	- 10.1	0.28	- 1.51
Belgium	- 0.81	- 1.81	- 10.1	- 12.1	0.41	- 1.21
Denmark	- 1.35	- 2.86*	- 10.0	- 12.5	0.75	- 2.75
Finland	- 0.33	- 2.49	- 8.78	- 11.9	0.17	- 0.57
Ireland	- 1.32	- 1.86	- 10.2	- 15.3	0.42	- 3.03*
Netherlands	- 2.04	- 1.92	- 10.6	- 14.1	0.25	- 2.03
Norway	- 0.99	- 2.60*	- 10.7	- 10.4	0.36	- 1.45
Spain	- 0.24	- 2.16	- 7.33	- 12.3	0.49	- 2.57
Sweden	- 1.54	- 2.44	- 10.3	- 12.5	0.41	- 2.33
Switzerland	- 2.13	- 3.56***	- 9.85	- 12.8	0.29	- 3.33**

[1] The results were obtained by estimating the equation: $\Delta y_t = \alpha - \lambda y_{t-1} + \sum_1^4 \Delta y_{t-i}$ with *y* successively = *i*, π, Δi and Δπ and *i* and π denoting nominal interest rates and rates of inflation respectively and Δ the first difference operator. Critical values for the t-statistics are: 2.57 (10%, marked by *), 2.88 (5%, **) and 3.48 (1%, ***). [2] All t-values satisfy the 1% significance criterion. [3] The results below were obtained by estimating the equation: $i_t = \alpha + \beta\pi_t + \varepsilon_t$ and subsequently testing cointegration from the residuals, using a Dickey-Fuller test, with λ indicating the coefficient on the lagged residual. As for the integration test, the equation was initially estimated with four lags but, in all cases, one or two lags were sufficient. Critical values for t-statistics are: 2.98 (10%, marked by *), 3.25 (5%, **) and 3.78 (1%, ***).

Table 2 bis

Co-integration tests for level terms in Table 2

Countries	α [1]	β [1]	Lags (i) [2]	Durbin's h
United States	- 0.000	- 0.041 (3.66)	1, 2, 43	0.04
Japan	- 0.000	- 0.033 (2.05)	1, 2, 4	0.05
Germany	0.000	- 0.053 (3.96)	1, 3	0.97
France	- 0.000	- 0.033 (2.83)	1, 2, 3, 4	1.19
Italy	0.000	- 0.029 (2.81)	1, 3, 4	1 .07
United Kingdom	0.003	- 0.092 (3.81)	1	0.14
Canada	0.000	- 0.098 (4.62)	1, 2	0.27
Australia	- 0.000	- 0.032 (2.31)	2	2.00¤
Belgium	- 0.000	- 0.023 (2.22)	1, 3	- 0.75
Denmark	0.001	- 0.053 (4.19)	1, 2, 3, 4	- 0.64
Finland	- 0.000	- 0.017 (1.89)	2	1.97¤
Ireland	- 0.001	- 0.133 (5.03)	1, 2	0.53
Netherlands	- 0.000	- 0.036 (2.54)	1, 3	- 0.83
Norway	0.000	- 0.019 (2.25)	1, 3	0.77
Spain	- 0.007	- 0.068 (4.05)	1, 2	0.15
Sweden	0.000	- 0.075 (4.35)	1, 2, 3	0.08
Switzerland	- 0.000	- 0.035 (3.15)	1	- 0.78

[1] The results were obtained by estimating the equation: $\Delta y_t = \alpha - \lambda y_{t-1} + \sum_1^4 \Delta y_{t-i}$ with *y* constructed from the level terms in Table 2 and their associated coefficients and Δ denoting the first difference operator; t-values for β in brackets. [2] Lags with t-values > 1.67. [3] denotes Durbib-Watson coefficients

Long-term interest rates: error correction equations [1]

Countries	η	α	β	φ	φ(ν)	δ	γ(θ)	λ	R^2	DW/h	St.e.	F	r*	Period
United States[2]	0.141**	- 0.048 ^{c}	0.017**	0.031_{120}**	--	--	--	0.192**	0.19	1.93	0.27	0.60	2.95	1960-99
Japan	0.012	- 0.027 ^{c}	0.004*	0.023_{150}**	--	--	0.143_{us}**	0.072*	0.04	0.54	0.32	2.80	0.45	1965-99
Germany	0.090**	- 0.022 ^{c}	0.012**	0.010_{120}*	--	--	0.163_{us}**	0.348**	0.25	0.91	0.18	0.80	3.90	1960-99
France	0.102**	- 0.035 ^{c}	0.021**	0.013_{180}*	--	0.139**	0.471_{de}**	--	0.18	2.06	0.29	0.65	2.90	1960-99
Italy	0.059*	- 0.024 ^{c}	0.013**	0.011_{180}*	--	0.066**	0.189_{de}**	0.344**	0.23	- 0.15	0.31	0.06	2.45	1960-99
United Kingdom[3]	0.091*	- 0.061 ^{c}	0.015*	0.045_{180}**	0.384_{de}**	--	0.303_{us}**	--	0.13	1.91	0.47	0.60	1.50	1960-99
Canada	0.289**	- 0.122 ^{c}	0.022**	0.040_{120}**	0.060_{us}**	0.081**	--	0.148**	0.06	0.27	0.36	0.01	3.65	1960-99
Australia	0.127**	- 0.052 ^{c}	0.007*	0.017_{120}**	0.028_{us}**	--	0.137_{us}**	--	0.07	1.89	0.36	1.30	3.10	1969-99
Belgium[4]	0.073**	- 0.020 ^{c}	--	0.020_{120}**	0.132_{de}**	0.063**	0.110_{us}**	--	0.07	1.83	0.21	0.05	3.70	1960-99
Denmark[2 5]	0.330**	- 0.044 ^{c}	--	0.044_{90}**	--	0.063**	0.207_{de}**	0.206**	0.09	- 1.11	0.42	0.55	3.30	1960-99
Finland	0.070**	- 0.031 ^{c}	0.005	0.026_{120}**	--	--	0.256_{de}**	--	0.05	1.97	0.37	0.30	2.25	1972-99
Ireland[6]	0.267**	- 0.091 ^{c}	0.026**	0.030_{120}**	0.035_{de}**	- 0.070**	0.171_{uk}**	--	0.09	1.91	0.47	0.90	2.60	1971-99
Netherlands	0.033*	- 0.050 ^{c}	--	0.013_{120}*	0.037_{de}**	--	0.218_{us}**	0.165**	0.17	0.26	0.23	0.91	3.05	1960-99
Norway	0.066**	- 0.028 ^{c}	0.004	0.024_{120}*	--	--	0.139_{de}**	0.087*	0.04	- 1.10	0.26	3.90	2.35	1961-99
Spain[4]	0.087*	- 0.050 ^{c}	0.022**	0.028_{180}**	0.349_{de}**	0.090*	0.172_{us}**	--	0.06	1.92	0.51	1.70	1.75	1978-99
Sweden[2 4]	0.177**	- 0.060 ^{c}	0.010*	0.050_{150}**	0.167_{de}**	--	0.132_{us}**	0.315**	0.12	- 0.49	0.30	0.25	3.00	1960-99
Switzerland[7]	0.011*	- 0.011 ^{c}	0.011**	--	0.072_{de}**	--	0.091_{us}**	0.135**	0.08	- 0.04	0.15	7.42	1.05	1960-99

[1] The coefficients are obtained from estimating the following error correction equation for each country: $\Delta i = \eta + \alpha i_{-1} + \beta\pi_{-1} + \phi\pi_{movavg} + \varphi i^*_{us,-1} + \nu i^*_{de,-1} + \delta\Delta\pi_{-1} + \gamma\Delta i^*_{us,-1} + \theta\Delta i^*_{de,-1} + \lambda\Delta i_{-1} + \varepsilon$

with *i* = nominal bond rate; *i** = foreign nominal bond rate (United States and/or Germany); π = 12-month rate of inflation (CPI); π_{movavg} = moving average of π; ε = random error; Δ = first difference operator. The coefficients shown are those obtained after imposing the homogeneity constraint β + φ + φ + ν= - α. [2] The coefficient shown for λ is the sum of the coefficients on the one- and two-month lagged change in *i*;both coefficients are significant. [3] Contemporaneous changes in German (in column φ(ν)) and US interest rates. [4] Two-month lagged change in German interest rate in column φ(ν). [5] Also includes an intercept dummy with a value of 0 until 1981 and 1 thereafter; the coefficient on the intercept dummy is - 0.170**, with r* prior to 1982 = 7.5. [6] Also includes a lagged change in German interest rates (0.304**). [7] Three-month lagged change in German interest rate in column φ(ν).

Note: ^{c} = Constrained coefficient. F-values test the homogeneity condition; critical values are 3.85 and 6.65 for 5% and 1% significance intervals respectively. r* is the steady-state real interest rate, derived as η/(-α) (see equation (4)); for the four countries with significant level effects of foreign rates, we used equation (7)). * and ** indicate 95% and 99% levels of significance respectively.

Table 3

Weights and average lags

Countries	Weights			Average lag in months
	π_{-1}	π_{movavg}	i^*	
United States	0.35	0.65	--	39
Japan	0.15	0.85	--	79
Germany	0.55	0.45	--	27
France	0.60	0.40	--	37
Italy	0.54	0.46	--	42
United Kingdom	0.25	0.75	--	67
Canada[1]	0.18	0.33	0.49	42
Australia[1]	0.13	0.33	0.54	44
Belgium	0.00	1.00	--	60
Denmark	0.00	1.00	--	45
Finland	0.16	0.84	--	51
Ireland[1]	0.28	0.32	0.39	44
Netherlands[1]	0.00	0.26	0.74	36
Norway	0.14	0.86	--	52
Spain	0.44	0.56	--	51
Sweden	0.16	0.84	--	63
Switzerland	1.00	0.00	--	1
Average	*0.27*	*0.55*	*0.18*	*46*

[1] Average lag for the United States or Germany assigned to the weight on i^*

Table 4

Real and nominal bond rates: averages, standard deviations, covariances and end-1998 values*

	Nominal rate		Real rate 1		Inflation (π)				Real rate 2		End-1998 values			
	μ	σ	μ	σ	μ	σ	$cov_{\pi,i}$	$cov_{\pi,r}$	μ	σ	Nominal	Real 1	Real 2	Consens
United States[1]	7.4	2.6	2.8	2.5	4.0	3.1	4.8	- 4.7	2.9	1.1	4.6	3.0	2.0	2.2
Japan	6.2	2.0	1.8	4.0	4.6	4.7	5.4	- 16.9	1.1	1.6	2.1	1.5	1.0	- 0.2
Germany	7.2	1.4	4.0	1.2	3.0	1.9	1.9	- 1.6	4.0	0.9	3.9	3.5	2.4	2.3
France	9.0	2.7	3.1	2.6	5.5	3.8	7.8	- 6.8	2.9	1.2	3.9	3.6	2.4	2.6
Italy	10.9	4.2	2.4	4.7	7.2	6.1	17.8	- 19.1	2.4	2.2	4.0	2.5	0.8	2.6
United Kingdom[1]	10.5	2.6	2.7	4.4	7.1	5.3	11.6	- 17.1	1.9	1.3	4.4	1.6	0.4	2.9
Canada[1]	8.4	2.6	3.7	2.4	4.3	3.3	6.0	- 5.2	3.7	1.1	4.9	3.9	2.9	3.3
Australia[1]	10.1	2.9	3.1	4.0	5.6	4.3	5.2	- 13.0	3.1	1.6	5.0	3.5	2.3	2.9
Belgium	8.8	2.2	4.0	2.9	4.4	3.1	3.8	- 5.6	3.7	1.3	4.1	3.5	1.7	na
Denmark	12.0	3.9	5.9	2.5	6.1	3.7	10.4	- 3.6	5.4	1.9	5.4	3.7	3.4	na
Finland	10.0	2.6	3.1	4.8	5.9	4.7	4.1	- 20.3	2.6	2.1	3.6	2.8	1.2	na
Ireland	11.3	3.3	3.0	4.2	5.0	6.6	18.3	- 24.8	2.6	1.9	4.4	2.2	2.2	na
Netherlands	7.5	1.4	3.3	2.5	4.2	2.7	1.9	- 5.6	2.9	1.8	4.0	2.2	1.8	2.1
Norway	9.1	2.7	2.6	3.7	5.9	3.3	4.0	- 7.0	2.4	1.6	5.3	3.0	2.7	3.1
Spain	12.1	3.5	3.9	3.6	8.9	4.9	12.1	- 12.5	2.2	1.9	3.7	2.3	0.1	2.3
Sweden[1]	9.6	2.4	3.2	3.2	5.7	3.6	5.5	- 7.8	3.0	1.0	4.2	5.3	1.0	2.7
Switzerland	4.6	1.1	1.1	1.9	3.5	2.4	1.7	- 4.0	--	--	2.4	2.6	--	1.1
Average	*9.1*	*2.6*	*3.2*	*3.2*	*5.3*	*4.0*	*7.2*	*- 10.3*	*2.8*	*1.5*	*4.1*	*3.0*	*1.8*	*2.3*
"Global rate"	*8.2*	*2.0*	*2.8*	*2.6*	*4.3*	*3.2*	*6.5*	*- 9.3*	*3.0*	*1.1*	*4.0*	*2.8*	*1.7*	*na*

Notation: μ = average rate; σ = standard deviation; real rate 1 = current nominal rate less rate of inflation over the last 12 months; π = rate of inflation; $cov_{\pi,i}$ = covariance between rate of inflation and nominal rate of interest; $cov_{\pi,r}$ = covariance between rate of inflation and real rate 1; real rate 2 = real rate derived from Table 2; and consensus = nominal rate less expected rate of inflation for the next 10 years (Consensus Economics *Consensus Forecasts*, November 1998). For each country, the period of calculation is determined by the interest rate series with the shortest time horizon. "Global" rate refers to the weighted average rate shown in Graph 1.

[1] Implied real rates for index-linked government bonds are: United States, 3.7%; United Kingdom, 2.1%; Canada, 4.1%; Australia, 3.4%; and Sweden, 3.1%.

Table 5

Inflation and real interest rates[1]

Countries	Levels		Changes	
	rate 1	rate 2	rate 1	rate 2
United States	- 0.40**	- 0.03*	- 0.86**	- 0.11**
Japan	- 0.76**	- 0.22**	- 0.96**	- 0.23**
Germany	- 0.45**	- 0.22**	- 0.96**	- 0.23**
France	- 0.56**	- 0.10**	- 0.93**	- 0.33**
Italy	- 0.50**	- 0.16**	- 0.96**	- 0.48**
United Kingdom	- 0.60**	0.04**	- 1.00**	- 0.08**
Canada	- 0.47**	0.02*	- 0.99**	- 0.25**
Australia	- 0.70**	- 0.12**	- 0.31**	- 0.08**
Belgium	- 0.59**	0.05	- 0.92**	0.10**
Denmark	- 0.25**	0.29	- 0.96**	0.04
Finland	- 0.83**	- 0.27**	- 0.93**	- 0.12**
Ireland	- 0.57**	- 0.22**	- 0.95**	- 0.42**
Netherlands	- 0.75**	- 0.19**	- 0.97**	0.05
Norway	- 0.64**	- 0.14**	- 0.99**	- 0.13**
Spain	- 0.51**	- 0.11**	- 1.05**	- 0.52**
Sweden	- 0.59**	0.02*	- 0.97**	0.02
Switzerland	- 0.70**	--	- 0.96**	--
Average	*- 0.58*	*- 0.08*	*- 0.92*	*- 0.17*

[1] The figures show regression coefficients obtained by estimating the following equation for each country in levels and first differences: $r_i = \alpha + \beta\pi$ for i = 1,2, r = real rate of interest and π = rate of inflation. * and ** indicate 95% and 99% levels of significance respectively.

Table 6

Bilateral correlation of nominal and real interest rates (rate 1)

	US	JP	DE	FR	IT	GB	CA	AU	BE	DK	FI	IR	NL	NO	ES	SE	CH	*Mean*
US	**.30**	*.68*	*.44*	*.62*	*.64*	*,67*	*.77*	*.73*	*.55*	*.39*	*.71*	*.55*	*.51*	*.59*	*.44*	*.58*	*.34*	*.54*
JP	.50	**- .19**	*.40*	*.67*	*.69*	*.51*	*.66*	*,71*	*.78*	*.57*	*.77*	*.53*	*.62*	*.59*	*.18*	*.54*	*.41*	*.50*
DE	.56	.71	**- .01**	*.56*	*.51*	*.51*	*.47*	*.50*	*.49*	*.23*	*.56*	*.58*	*.59*	*.46*	*.44*	*.49*	*.44*	*.45*
FR	.91	.68	.68	**.00**	*.72*	*.68*	*.63*	*.86*	*.72*	*.41*	*.90*	*.79*	*.69*	*.75*	*.81*	*.71*	*.45*	*.60*
IT	.87	.40	.48	.89	**.04**	*.72*	*.67*	*.88*	*.74*	*.41*	*.90*	*.82*	*.65*	*.73*	*.71*	*.73*	*.46*	*.65*
GB	.78	.74	.67	.83	.75	**- .33**	*.64*	*.74*	*.64*	*.24*	*.79*	*.76*	*.56*	*.63*	*.32*	*.67*	*.30*	*.55*
CA	.98	.54	.61	.92	.88	.82	**.28**	*.87*	*.71*	*.38*	*.85*	*.69*	*.62*	*.71*	*.69*	*.69*	*.49*	*.55*
AU	.79	.38	.31	.57	.82	.55	.83	**.28**	*.83*	*.56*	*.88*	*.76*	*.77*	*.78*	*.62*	*.72*	*.45*	*.68*
BE	.93	.67	.68	.97	.90	.82	.95	.77	**.22**	*.50*	*.85*	*.68*	*.78*	*.68*	*.37*	*.58*	*.40*	*.60*
DK	.80	.77	.63	.89	.76	.88	.82	.49	.85	**.43**	*.54*	*.38*	*.56*	*.41*	*.04*	*.32*	*.32*	*.37*
FI	.69	.62	.51	.75	.78	.57	.75	.85	.79	.54	**.22**	*.86*	*.84*	*.91*	*.63*	*.79*	*.49*	*.72*
IR	.77	.85	.60	.87	.70	.91	.79	.59	.83	.92	.58	**- .48**	*.76*	*.85*	*.44*	*.70*	*.51*	*.63*
NL	.81	.72	.81	.85	.78	.88	.85	.51	.87	.81	.63	.77	**.25**	*.73*	*.59*	*.58*	*.45*	*.60*
NO	.81	.19	.32	.76	.81	.58	.82	.92	.76	.54	.82	.46	.57	**.47**	*.64*	*.73*	*.41*	*.62*
ES	.82	.89	.80	.89	.91	.83	.87	.83	.91	.78	.89	.81	.81	.77	**.03**	*.48*	*.25*	*.45*
SE	.87	.36	.48	.83	.90	.71	.89	.89	.87	.65	.88	.56	.75	.90	.92	**.17**	*.55*	*.57*
CH	.35	.46	.79	.43	.34	.53	.41	.10	.43	.37	.41	.22	.70	.20	.50	.38	**- .25**	*.40*
Mean	.72	.56	.57	.75	.70	.70	.75	.60	.76	.64	.62	.66	.71	.60	.78	.70	.39	***.08***

Note: Figures (in italics) above the diagonal show bilateral correlations between real interest rates (rate 1) and those below the diagonal bilateral correlations for nominal rates. Figures on the diagonal (in bold) are correlations between nominal and real rates for each country.

Table 7

Bilateral correlation of real interest rates (rate 2)

	US	JP	DE	FR	IT	GB	CA	AU	BE	DK	FI	IR	NL	NO	ES	SE	CH	*Mean*
US	**.55/.95**	*.45*	*.46*	*.72*	*.63*	*.04*	*.79*	*.66*	*.61*	*.40*	*.32*	*.10*	*.33*	*.52*	*.46*	*.48*	*.04*	*.42*
JP	.32	**-.25/.83**	*.45*	*.65*	*.72*	*.02*	*.64*	*.63*	*.44*	*.70*	*.73*	*.46*	*.69*	*.55*	*.64*	*.40*	*.32*	*.50*
DE	.24	.24	**.44/.71**	*.049*	*.32*	*.02*	*.55*	*.63*	*.52*	*.39*	*.61*	*.36*	*.63*	*.56*	*.61*	*.53*	*.03*	*.43*
FR	.20	.26	.22	**.30/.85**	*.76*	*.02*	*.66*	*.76*	*.59*	*.50*	*.56*	*.29*	*.54*	*.73*	*.64*	*.51*	*.17*	*.47*
IT	.06	.03	.13	.10	**.26/.57**	*.20*	*.64*	*.67*	*.44*	*.43*	*.61*	*.45*	*.52*	*.56*	*.53*	*.40*	*.30*	*.48*
GB	.33	.22	.22	.17	.11	**.33/.94**	*.26*	*-.22*	*.29*	*.49*	*-.17*	*.18*	*.15*	*-.36*	*-.05*	*.23*	*.04*	*.07*
CA	.61	.36	.17	.18	.13	.30	**.26/.92**	*.68*	*.71*	*.33*	*.51*	*.38*	*.62*	*.48*	*.59*	*.59*	*.19*	*.55*
AU	.24	.13	.17	.10	.26	.11	.26	**.41/.94**	*.41*	*.49*	*.73*	*.44*	*.59*	*.82*	*.50*	*.44*	*.31*	*.52*
BE	.30	.13	.24	.38	.08	.22	.28	.17	**.53/.98**	*.72*	*.30*	*.11*	*.66*	*.24*	*.65*	*.57*	*-.28*	*.42*
DK	.19	.08	.19	.26	.11	.21	.20	.17	.29	**.72/.99**	*.56*	*-.19*	*.67*	*.53*	*.74*	*.43*	*-.45*	*.41*
FI	.09	.15	.16	.20	.04	.10	.16	.11	.15	.09	**.28/.95**	*.64*	*.75*	*.66*	*.53*	*.30*	*.35*	*.48*
IR	.17	.11	.22	.20	.20	.42	.24	.19	.21	.20	.05	**-.57/.70**	*.58*	*.39*	*.11*	*.16*	*.29*	*.28*
NL	.41	.24	.52	.37	.16	.14	.30	.23	.41	.25	.18	.15	**.15/.99**	*.47*	*.60*	*.36*	*.15*	*.49*
NO	.07	-.4	.24	.26	.09	.19	.02	.07	.23	.13	.27	.03	.14	**.67/.95**	*.37*	*.35*	*.36*	*.44*
ES	-.01	.10	.15	.13	.20	.01	.11	-.04	.09	-.12	.23	-.02	.09	.20	**.41/.66**	*.56*	*-.05*	*.44*
SE	.11	.16	.22	.22	.14	.09	.18	.10	.26	.16	.26	.06	.29	.19	.22	**.55/.93**	*.10*	*.38*
CH	.13	-.03	.22	.09	.09	.18	.13	.03	.08	.13	.06	.11	.10	.10	.06	.05	**-.26/.25**	*.11*
Mean	.21	.14	.21	.15	.11	.20	.21	.14	.21	.15	.13	.15	.23	.11	.08	.16	.09	**.28/.83**

Note: Figures (in italics) above the diagonal show bilateral correlations between *levels* of real interest rates (rate 2; for Switzerland, rate 1) and those below the diagonal bilateral correlations for *changes* in real rates. Figures on the diagonal (in bold) are correlations, by country, for levels and changes in nominal and real interest rates respectively.

Table 8

Bilateral correlation of changes in nominal in real interest rates (rate 1)

	US	JP	DE	FR	IT	GB	CA	AU	BE	DK	FI	IR	NL	NO	ES	SE	CH	*Mean*
US	**.57**	*.15*	*.13*	*.15*	*.09*	*.14*	*.35*	*.20*	*.15*	*.05*	*.10*	*.17*	*.08*	*.09*	*-.07*	*.09*	*.17*	*.12*
JP	.35	**.27**	*.09*	*.22*	*.12*	*.00*	*.11*	*.13*	*.06*	*.01*	*.18*	*.02*	*-.03*	*.10*	*.08*	*.03*	*-.07*	*.07*
DE	.43	.46	**.45**	*.16*	*.14*	*.19*	*.06*	*.09*	*.19*	*.09*	*.12*	*.22*	*.17*	*.10*	*.16*	*.07*	*.24*	*.13*
FR	.30	.29	.35	**.39**	*.17*	*.13*	*.52*	*.11*	*.42*	*-.15*	*.12*	*.30*	*.31*	*-.02*	*-.35*	*-.10*	*.25*	*.13*
IT	.10	.05	.26	.27	**.18**	*.10*	*.17*	*.12*	*-.08*	*-.26*	*.56*	*.28*	*.13*	*.13*	*.19*	*-.53*	*-.14*	*.09*
GB	.25	.22	.24	.28	.18	**.56**	*.11*	*.11*	*.14*	*.04*	*.20*	*.36*	*.11*	*.03*	*.04*	*.07*	*.13*	*.11*
CA	.67	.37	.32	.26	.19	.30	**.55**	*.65*	*.17*	*.11*	*.32*	*.00*	*.25*	*.04*	*.03*	*.22*	*.14*	*.19*
AU	.22	.13	.27	.16	.27	.16	.24	**.68**	*.25*	*.21*	*.09*	*.49*	*.21*	*.04*	*.39*	*.47*	*.26*	*.23*
BE	.35	.22	.39	.47	.19	.25	.29	.15	**.35**	*.30*	*.15*	*.17*	*.47*	*.13*	*-.13*	*.36*	*.17*	*.17*
DK	.20	.10	.24	.33	.16	.21	.22	.15	.28	**.37**	*-.05*	*-.53*	*.24*	*.49*	*.07*	*.46*	*.33*	*.08*
FI	.12	.09	.22	.19	.18	.01	.15	.14	.21	.09	**.49**	*.08*	*.35*	*.35*	*.19*	*-.23*	*.02*	*.17*
IR	.23	.15	.31	.35	.23	.68	.27	.26	.31	.27	.08	**.65**	*.00*	*.01*	*-.32*	*-.46*	*-.18*	*.03*
NL	.47	.33	.68	.42	.22	.13	.34	.22	.38	.24	.21	.16	**.26**	*.44*	*.21*	*.43*	*.00*	*.20*
NO	.09	-.04	.17	.26	.16	.14	.08	.10	.25	.13	.33	.11	.15	**.33**	*.32*	*.06*	*-.24*	*.12*
ES	.14	.04	.18	.20	.40	.03	.15	.23	.20	.10	.29	.05	.19	.21	**.52**	*.30*	*-.22*	*.05*
SE	.18	.15	.29	.26	.28	.10	.20	-.03	.31	.17	.33	.15	.29	.21	.35	**.33**	*.30*	*.09*
CH	.33	.23	.45	.30	.12	.32	.26	.22	.34	.20	.16	.31	.46	.18	.21	.18	**.26**	*.06*
Mean	.26	.18	.30	.27	.19	.20	.25	.18	.27	.18	.16	.23	.29	.15	.17	.20	.27	***.40***

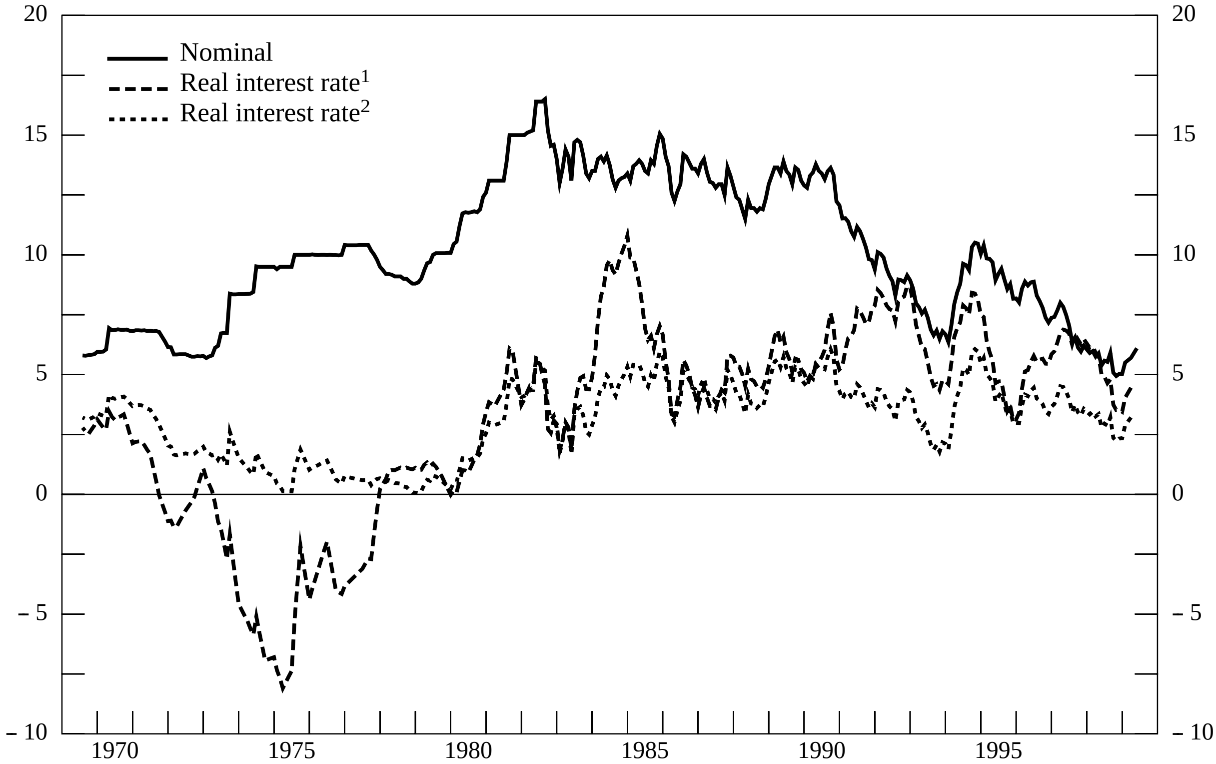
Note: Figures (in italics) above the diagonal show bilateral correlations between changes in real interest rates (rate 1) and those below the diagonal correlations for changes in nominal rates. Figures on the diagonal (in bold) are correlations between changes in nominal and real rates.

Graph 2

Australia

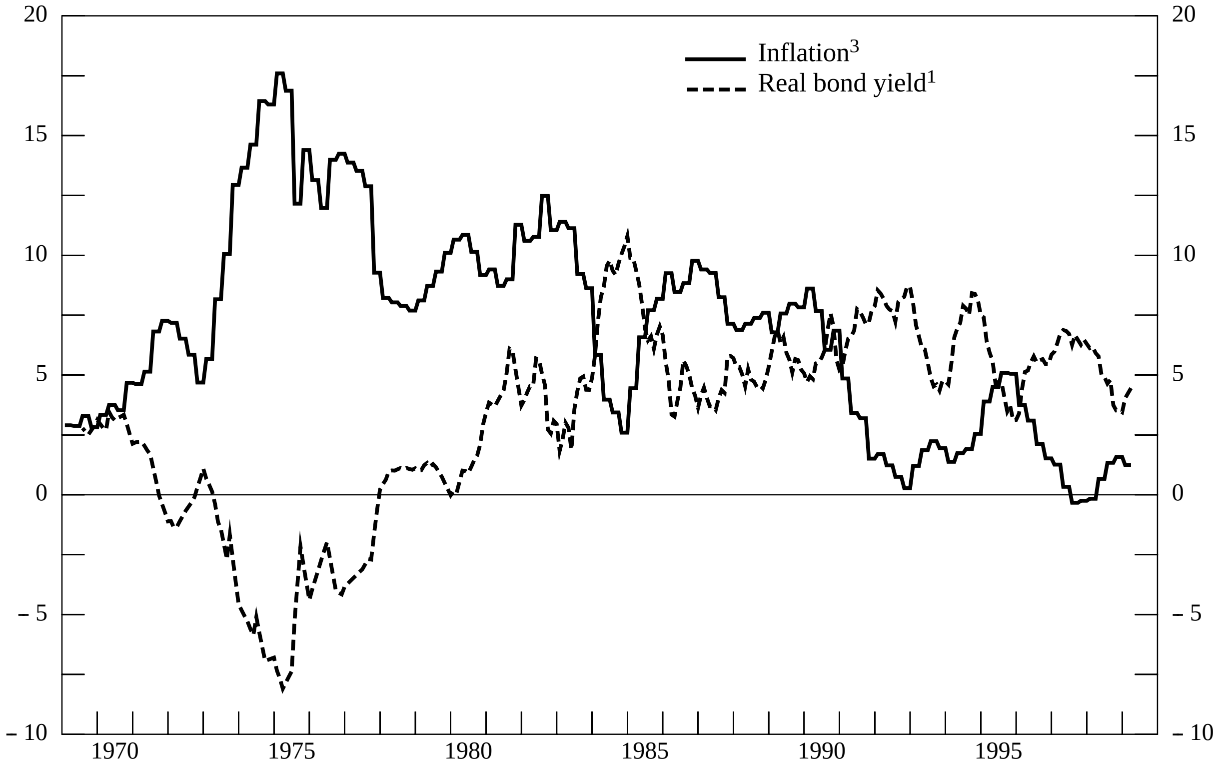
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



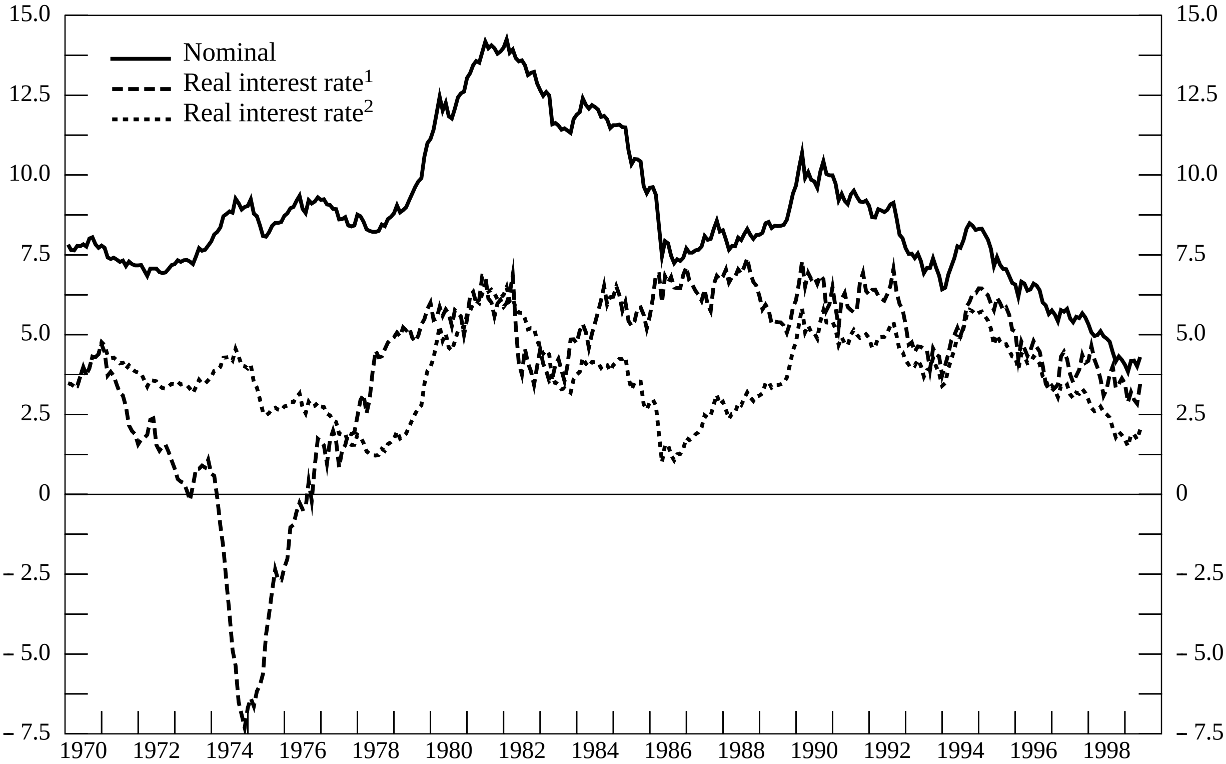
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Belgium

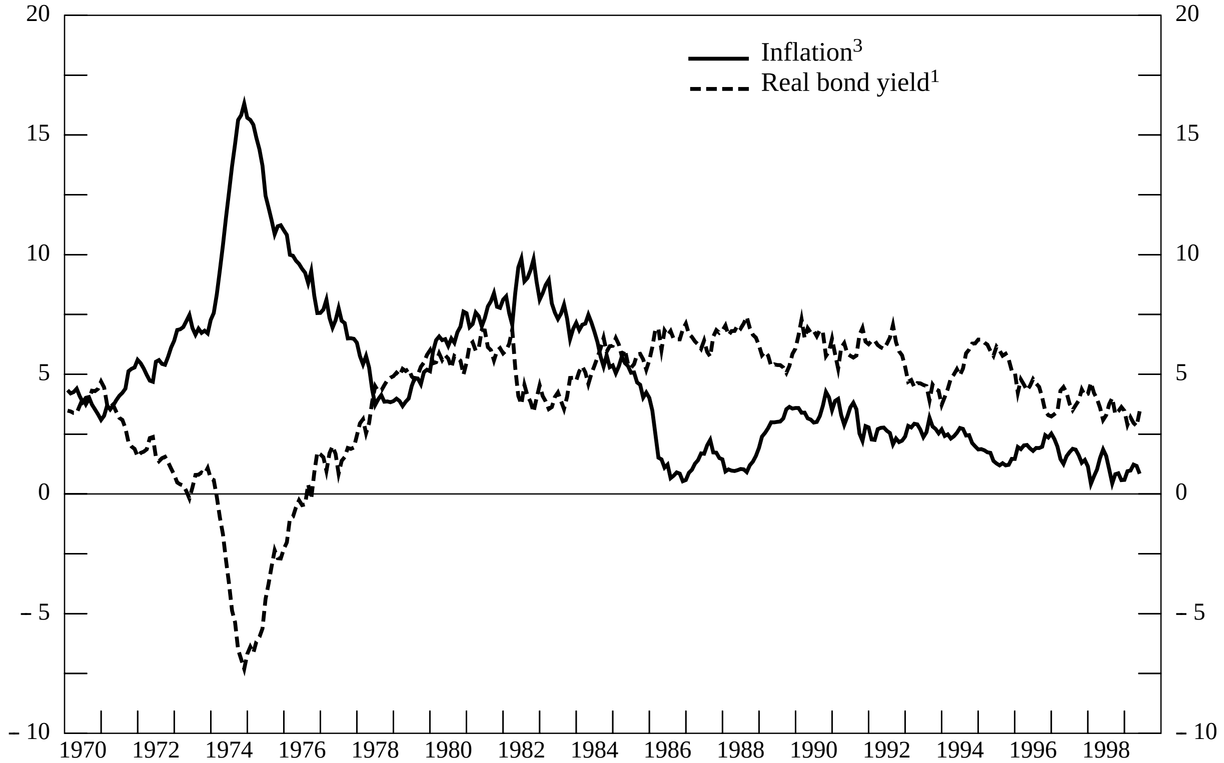
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



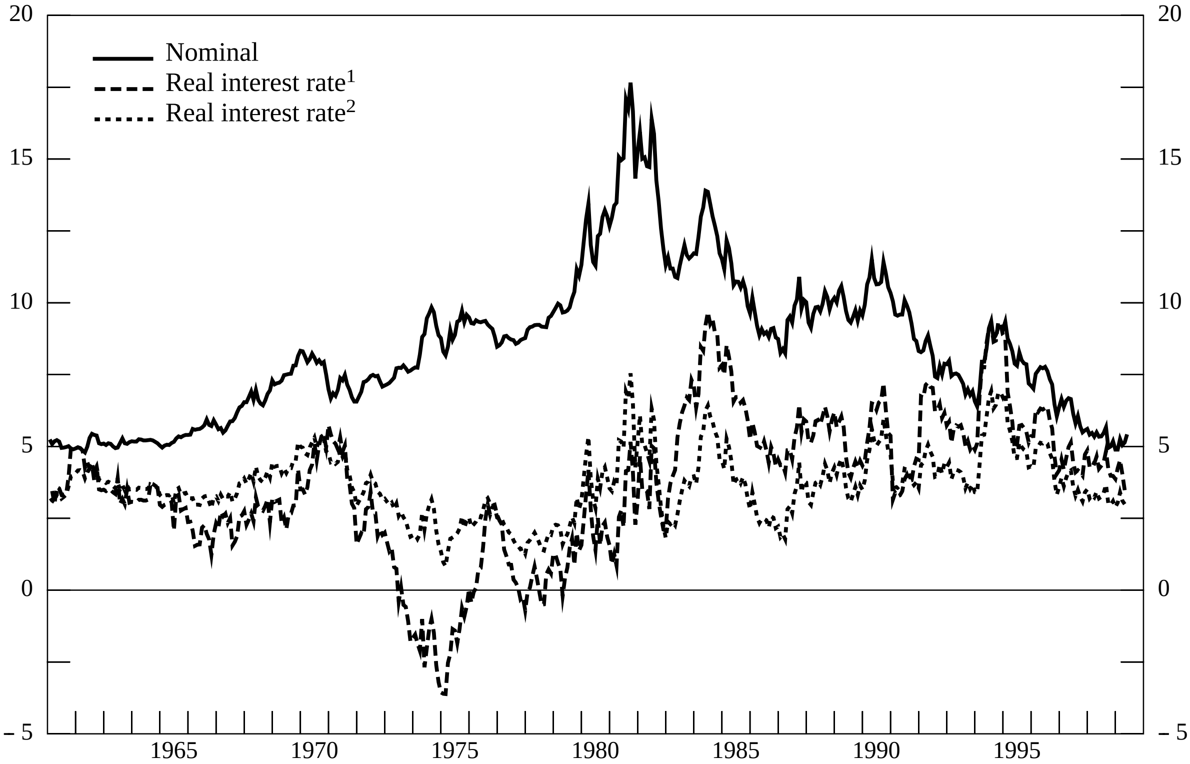
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Canada

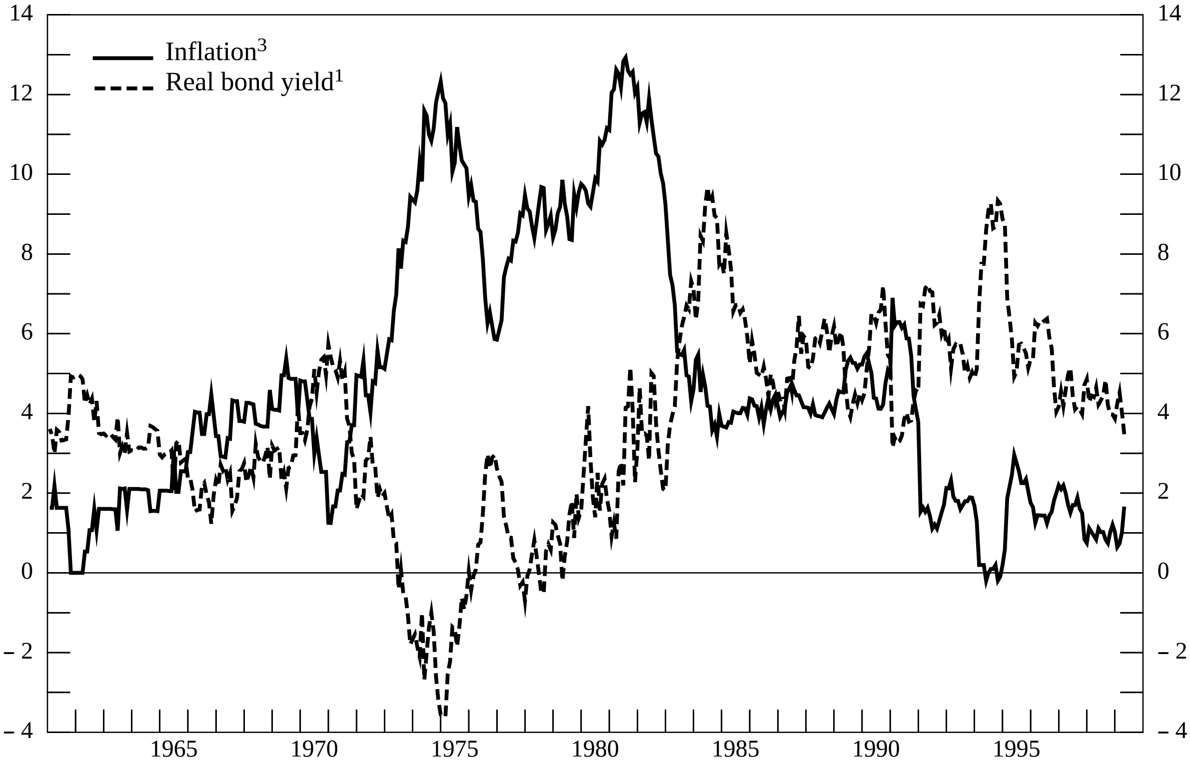
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



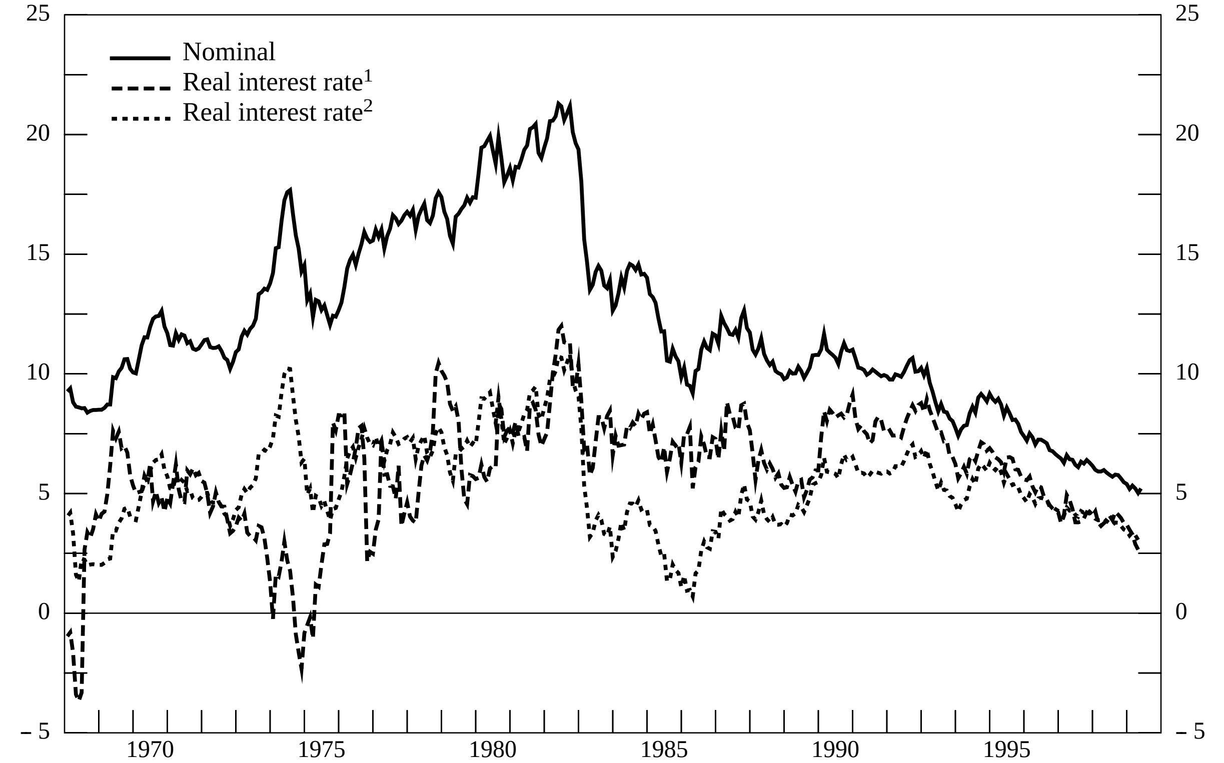
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Denmark

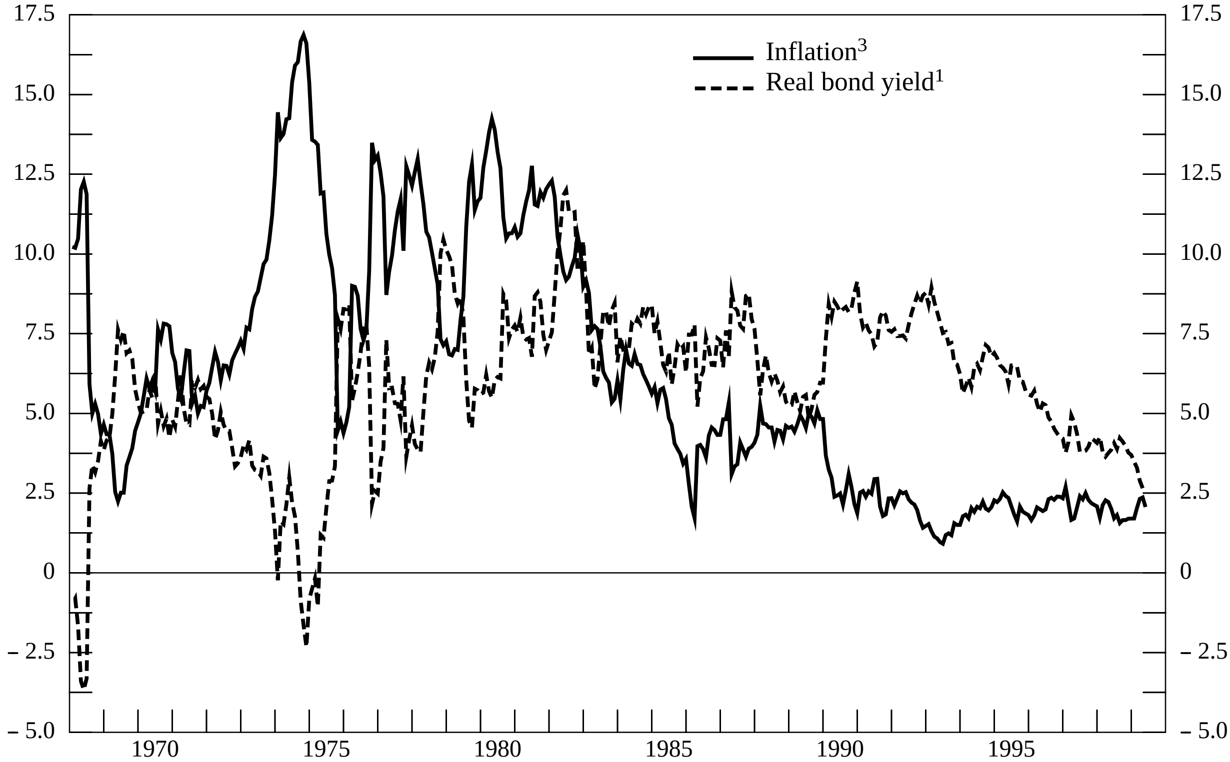
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



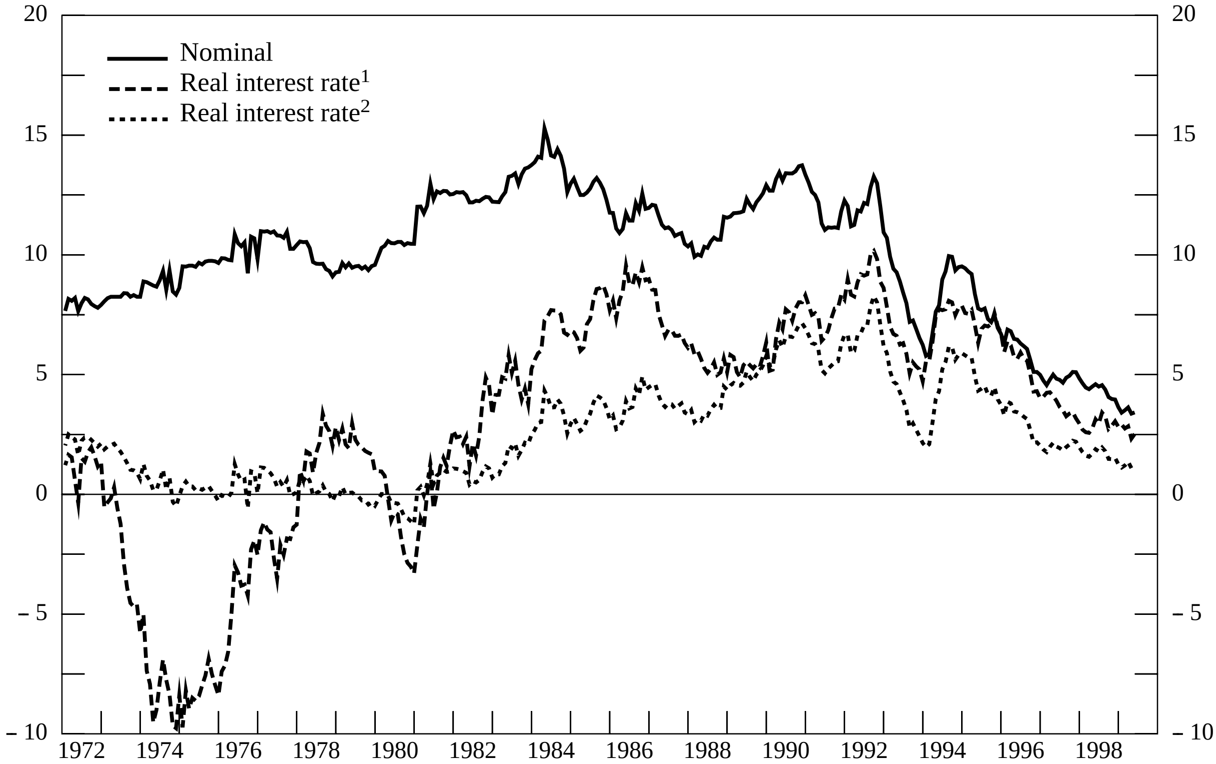
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Finland

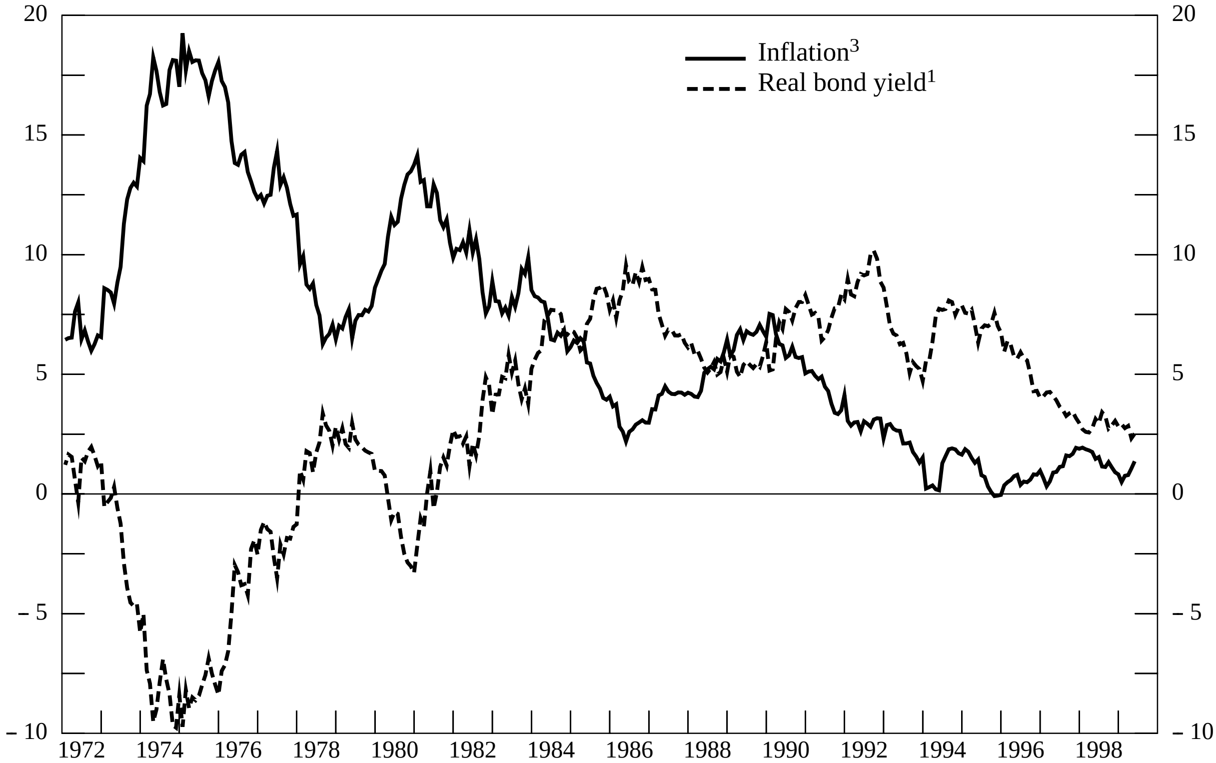
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



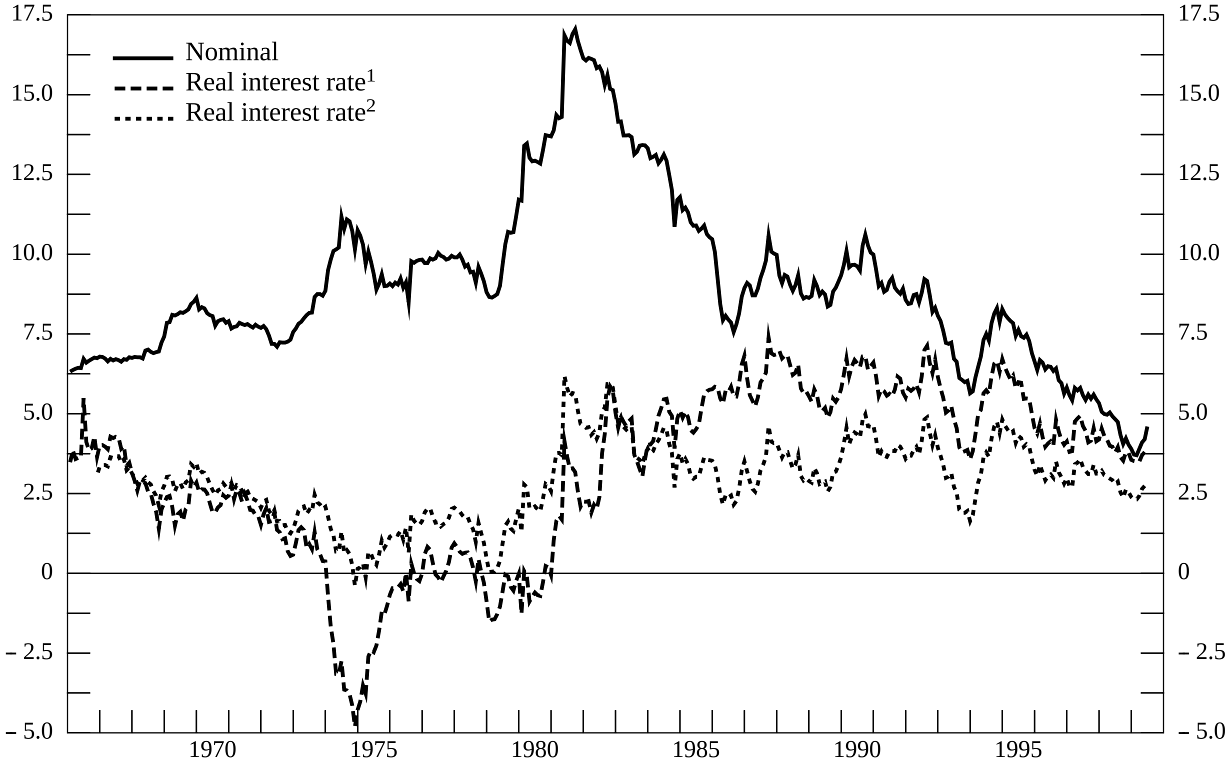
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

France

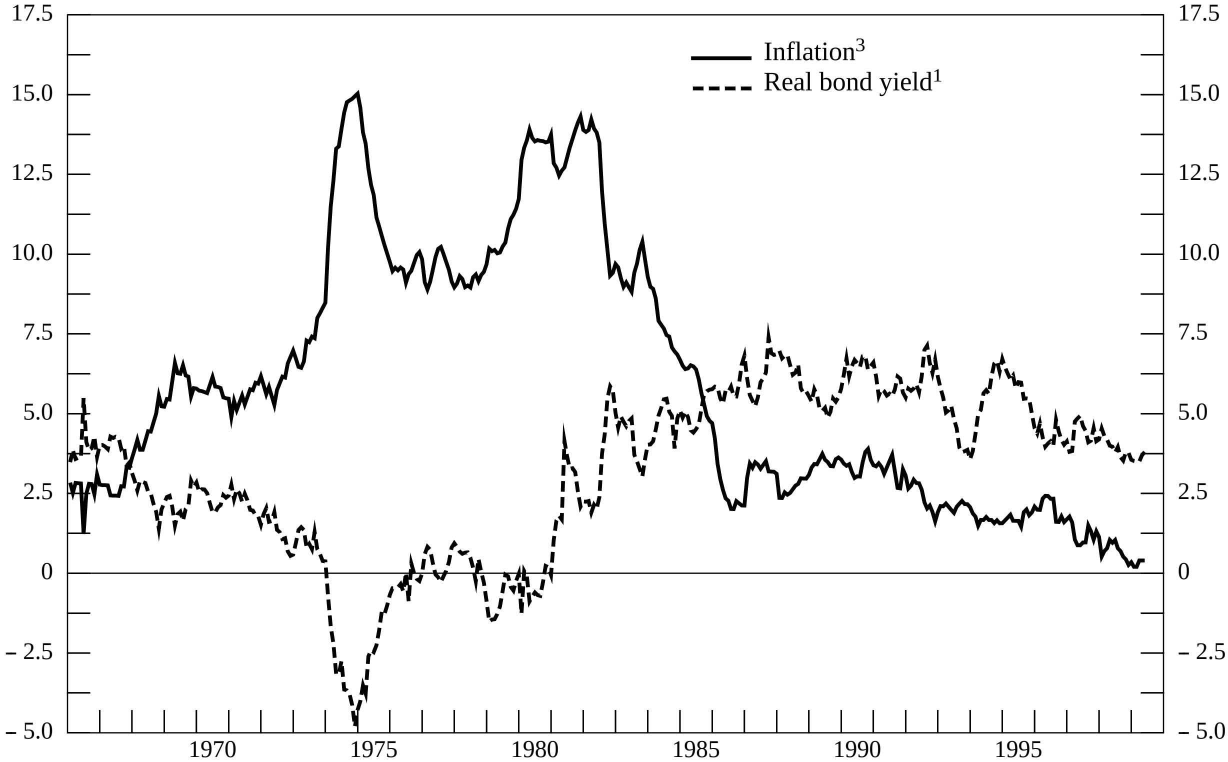
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



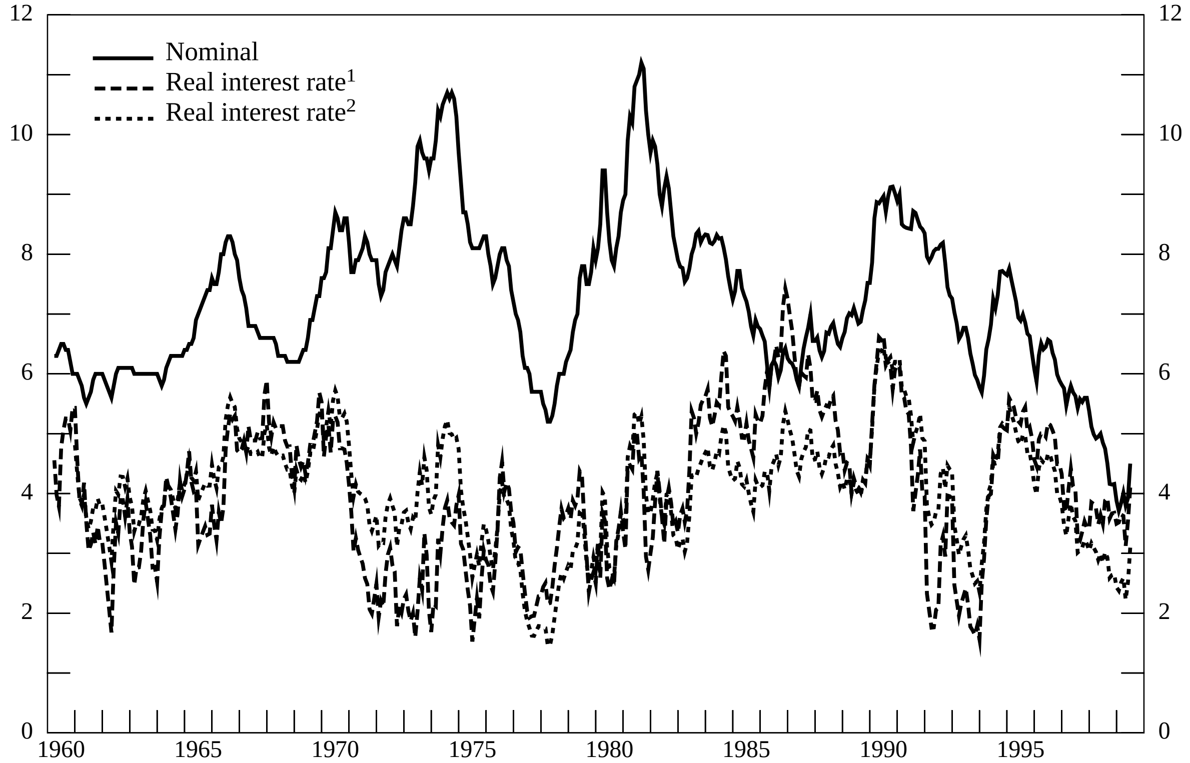
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Germany

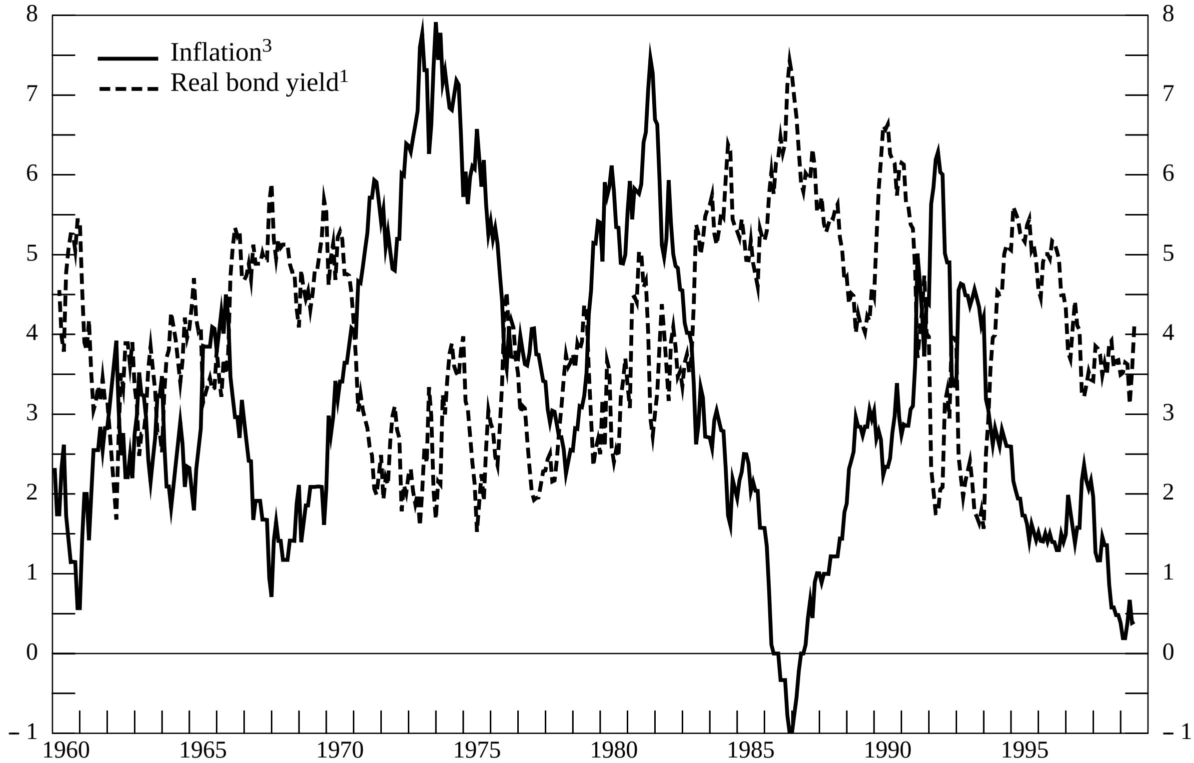
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



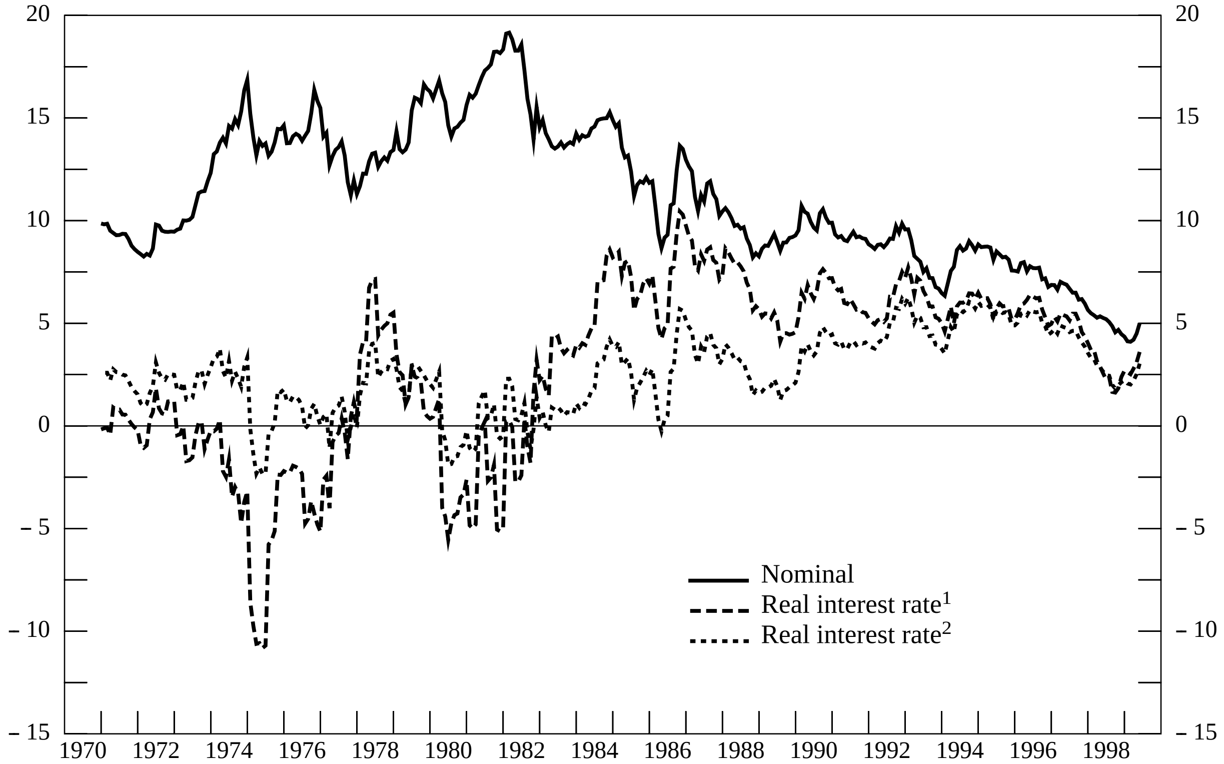
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Ireland

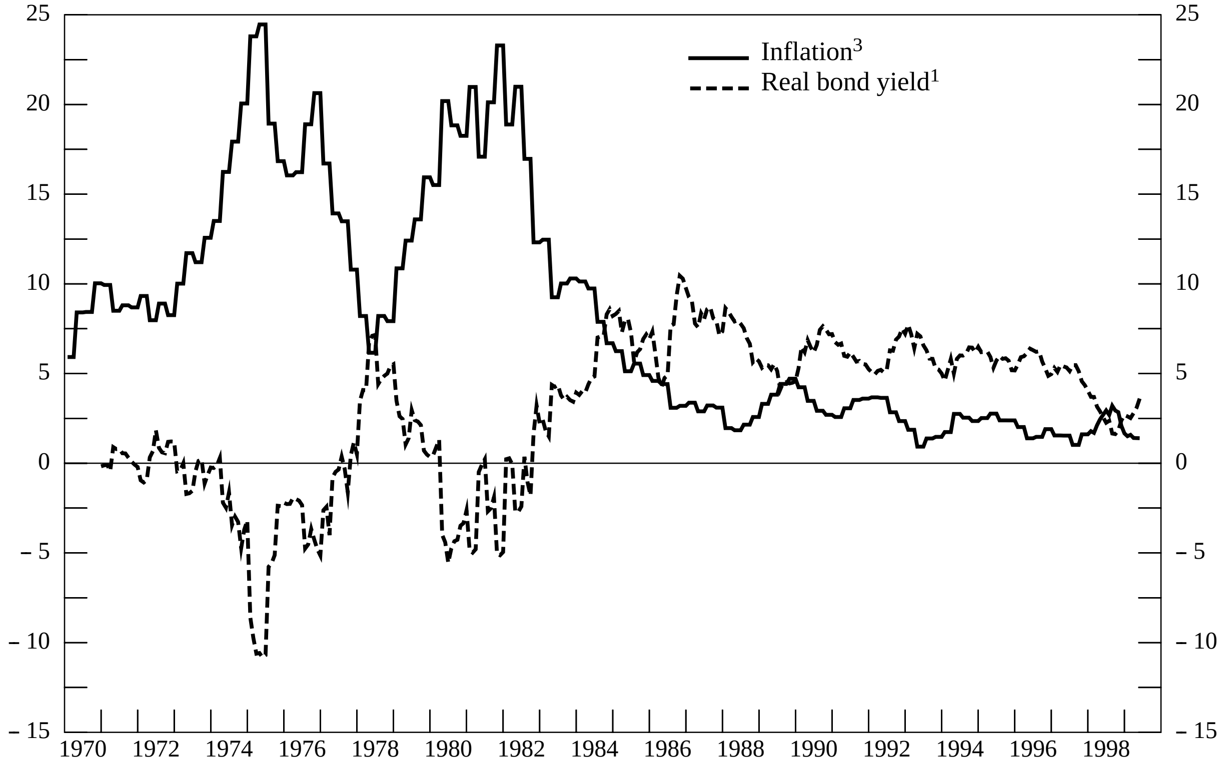
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



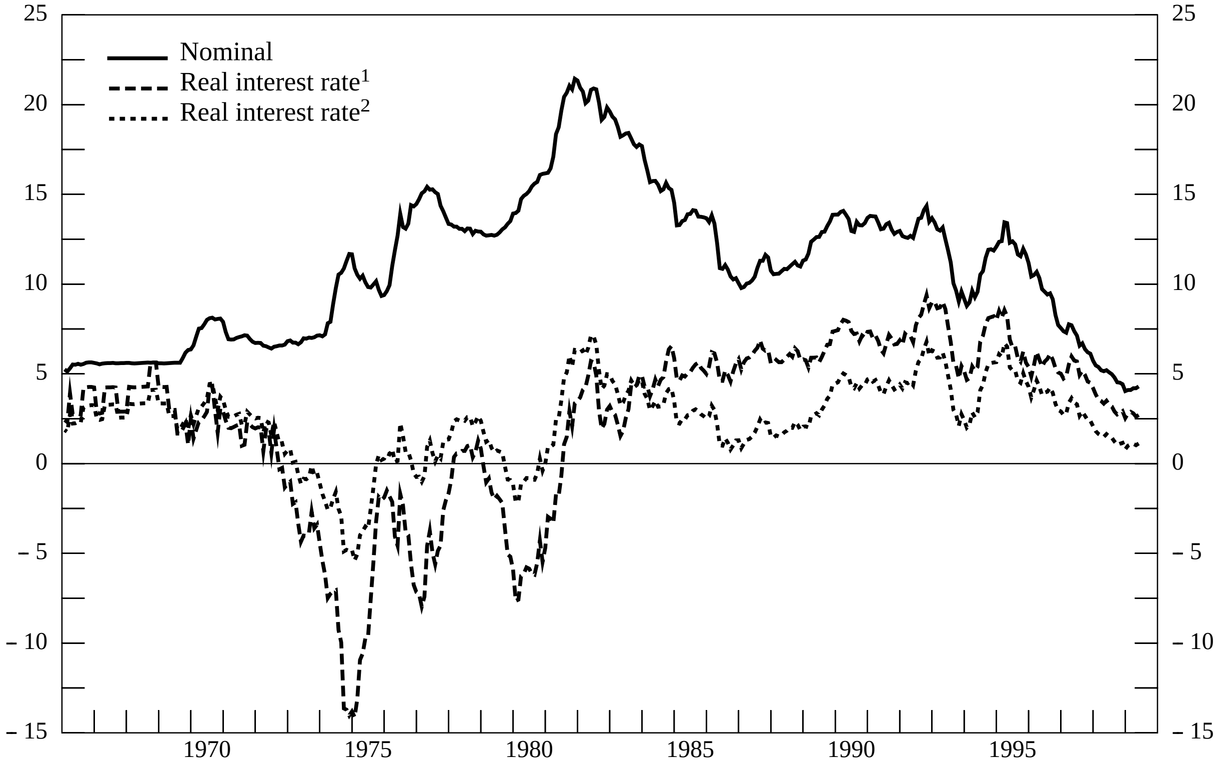
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Italy

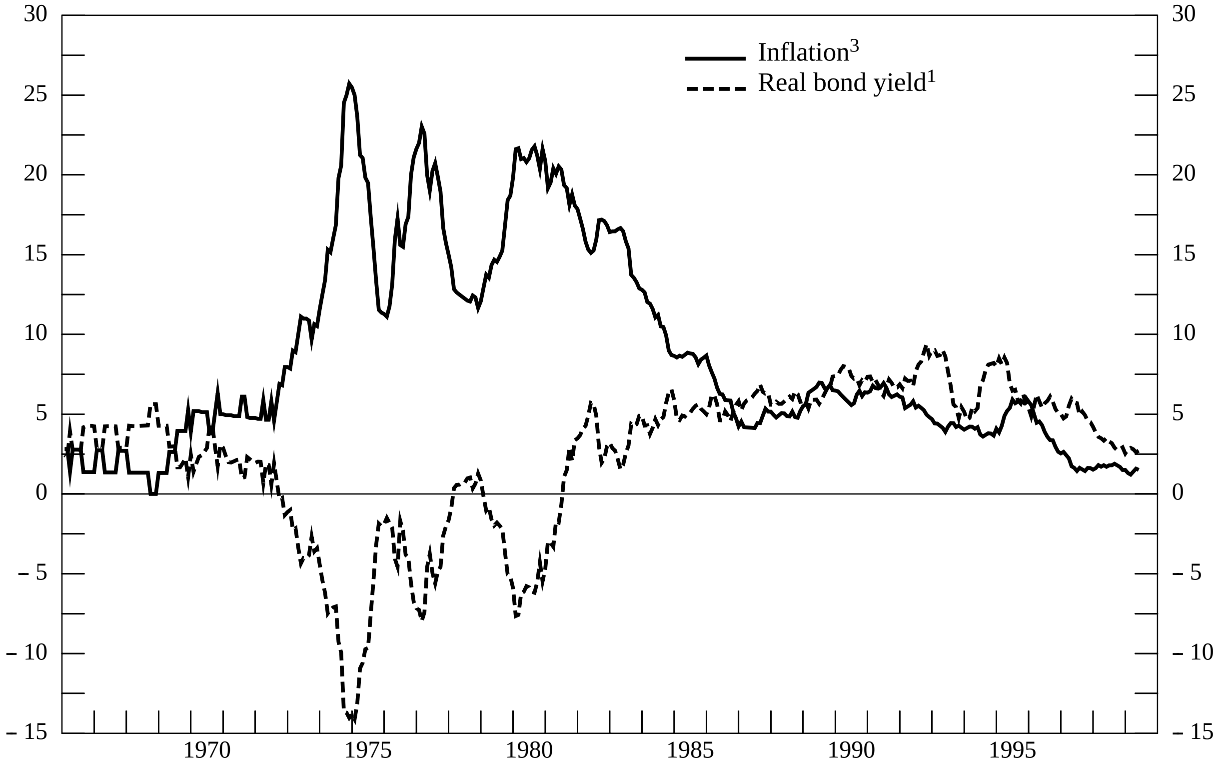
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



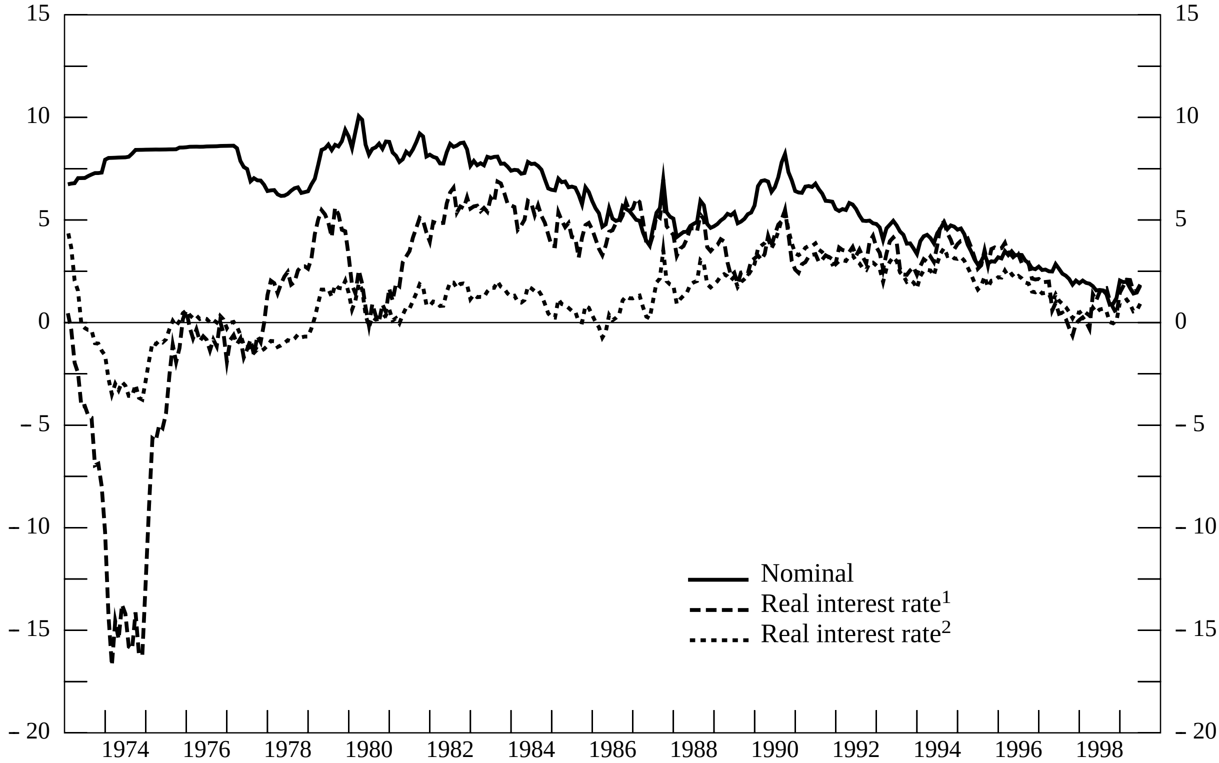
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Japan

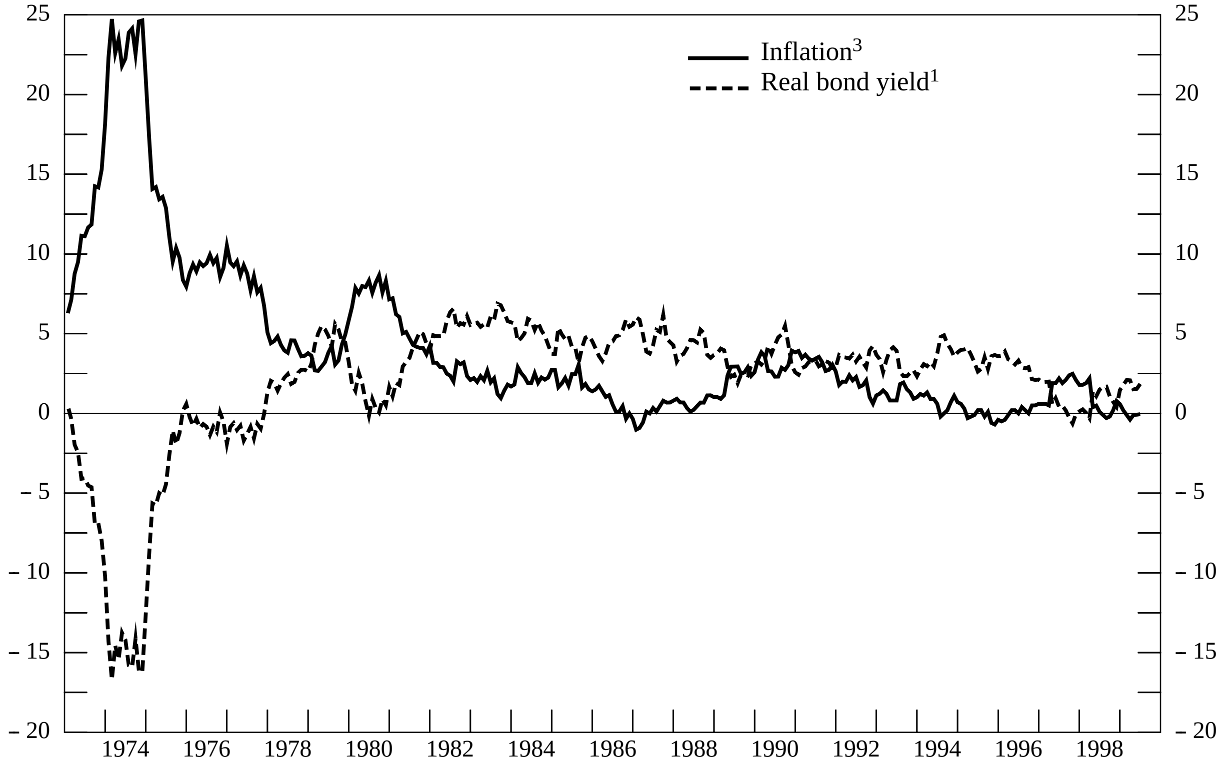
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



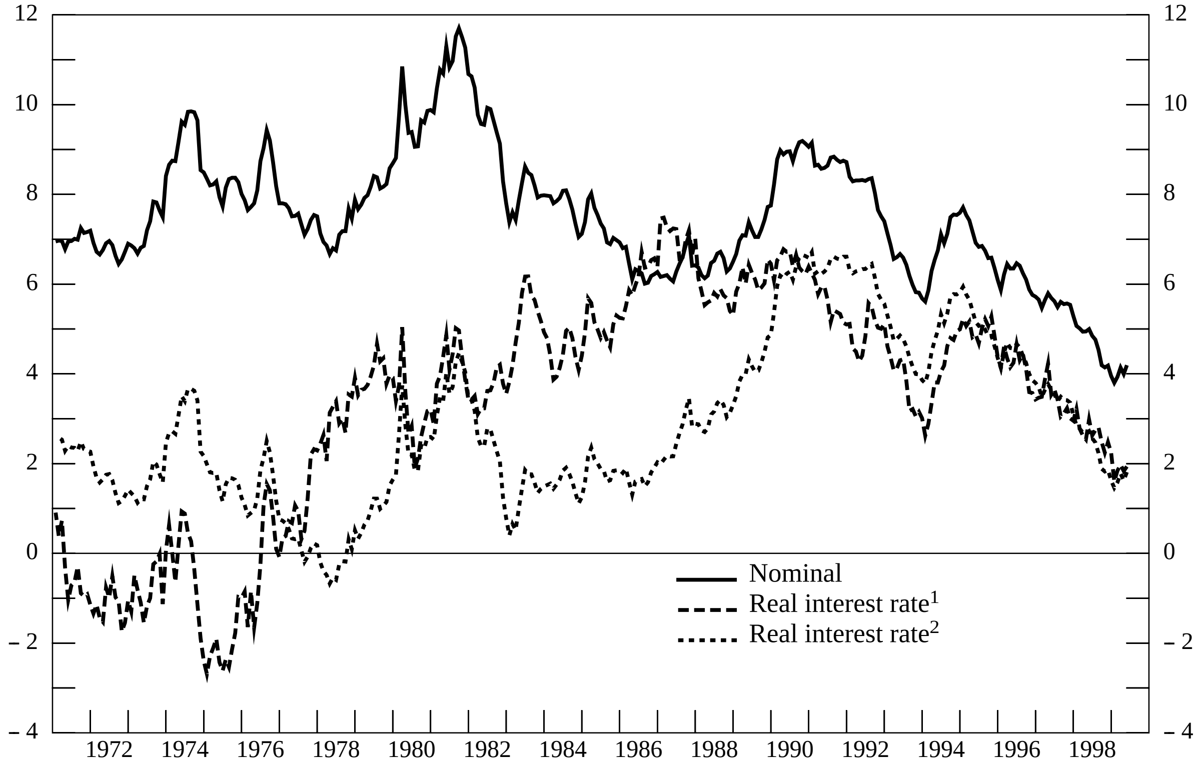
[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

Graph 2 (cont.)

Netherlands

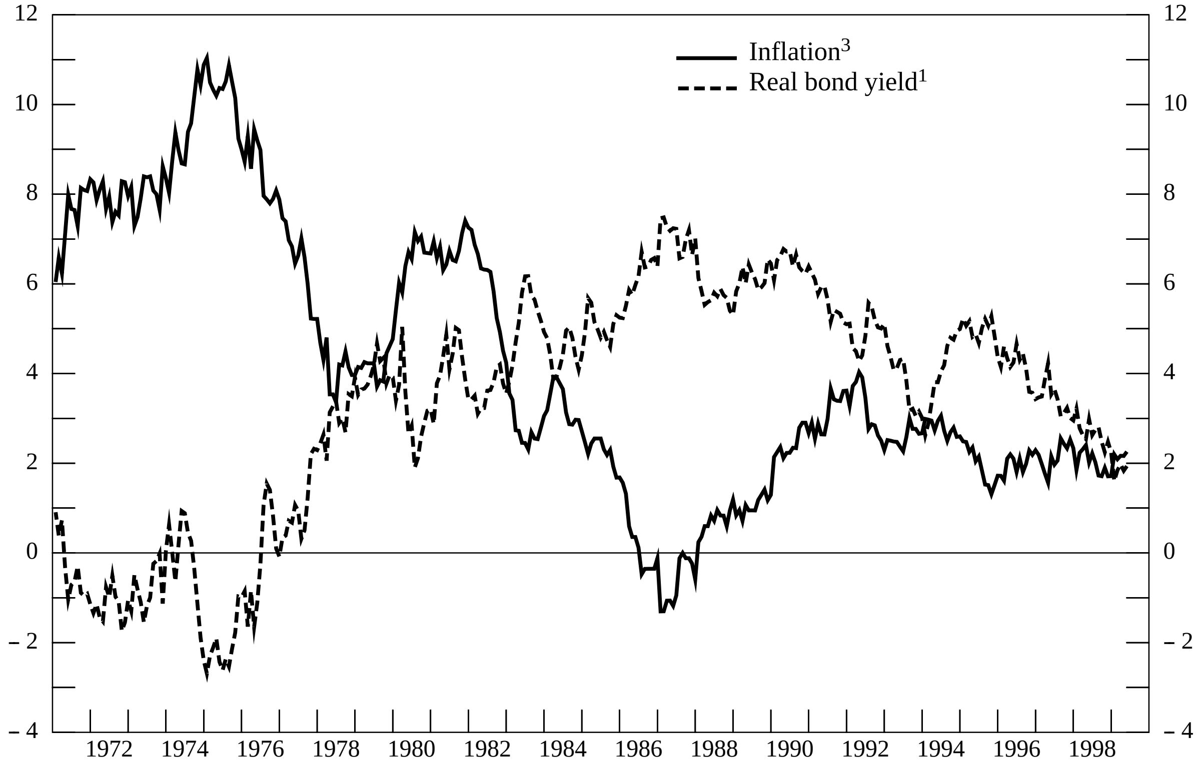
Nominal and real 10-year bond yields

In percentages and percentage points



Consumer price inflation and real 10-year bond yield

In percentages and percentage points



[1] Nominal yield less annual rate of inflation. [2] Nominal yield less weighted average of current and 10-year moving average rates of inflation. [3] Change in consumer prices over 12 months.

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