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THE TERM STRUCTURE OF EURO-RATES: some evidence in support of the expectations hypothesis

by

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Abstract

This paper studies 1, 3, 6 and 12-month Euro-rates for 17 countries using between 10 and 30 years of data. Term spreads contain information about future short-term rates in all 51 regressions that we estimate. Furthermore, in 35 cases we accept the expectations hypothesis. Using cross-sectional regressions, we estimate the variance of the term premium and the correlation of the term premium and the expected change in short rates. The estimates are compatible with existing informal estimates. We conclude that, despite the presence of a time-varying term premium, for many countries the expectations hypothesis is broadly compatible with the data.

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1. Introduction

It is commonly believed that, while central banks closely control short-term interest rates, long-term interest rates, which are heavily influenced by expectations, play a more important role in affecting aggregate demand. Central banks thus face the problem of setting short-term interest rates in such a way as to move, longer-term interest rates in the desired direction. An understanding of the relationship between short and long-term interest rates, the *term structure of interest rates*, is thus of central importance for the conduct of monetary policy. Unfortunately, the standard conclusion in the extensive empirical literature on the term structure is that existing models explain movements in short and long interest rates very poorly. Shiller (1990, p. 670), for instance, in his survey on the term structure concludes that: "Empirical work on the term structure has produced consensus on little more than that the rational expectations model ... can be rejected."

Recently, however, a considerable amount of empirical evidence has been presented suggesting that the explanatory power of the expectations hypothesis -- which states that longer interest rates are averages of expected future short interest rates plus, perhaps, a constant term premium -- may be greater than previously thought. Fama (1984) studies the behaviour of interest rates with maturities of 1 to 6 months and shows that forward interest rates do contain information about future 1-month rates. In addition, Mankiw and Miron (1986) study the behaviour of 3 and 6-month interest rates over the period 1890-1979 and show that the expectations hypothesis receives considerable support in data from the period before the founding of the Federal Reserve System in 1913, but not thereafter. Furthermore, they show that changes in short-term rates were more predictable before the founding of the Fed and argue that, for econometric reasons, regression tests of the expectations hypothesis are likely to be the more informative, the more predictable short rates are. If changes in interest rates are more predictable, spreads between long and short interest rates contain more information about future short rates, and the econometric power of term structure regressions increases. This argument suggests that the poor performance of the expectations hypothesis is an econometric problem: with short rates difficult to predict, tests of the expectations hypothesis are always likely to yield poor results.[1]

A second line of inquiry is followed by Campbell and Shiller (1987, 1991), who study the behaviour of short and long rates and find that, although the expectations hypothesis is rejected on *statistical* grounds, on *economic* grounds the rejection is less obvious. Estimating bivariate VARs for short rates and term spreads, Campbell and Shiller show that, although statistically rejected, long rates behave in a way strikingly similar to that implied by the expectations hypothesis. The expectations hypothesis thus remains a useful benchmark.

Finally, the expectations hypothesis receives considerable support in Hardouvelis (1994), who studies the behaviour of 3-month and 10-year rates in the G-7 countries using between 20 and 40 years of data depending on the country. One finding of particular interest is that the expectations hypothesis appears to do a much better job of accounting for the behaviour of interest

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1 Hardouvelis (1988) finds similar evidence using weekly data for US Treasury bills for the period 1972-85.

rates outside the United States. Furthermore, Hardouvelis shows that multiperiod regressions -- in which cumulative future returns on 3-month investments are regressed on the current spread between long and short rates -- are supportive of the expectations hypothesis when longer investment horizons are considered. To the extent that it is easier to predict changes in short rates over longer forecast horizons, this evidence is also compatible with the Mankiw-Miron hypothesis that the expectations hypothesis may fare badly in empirical work because short rates are difficult to predict, and not because the theory is fundamentally flawed.

Since the predictability of short rates is likely to vary between currencies, one would expect that using data for several currencies with potentially substantial differences in the time series behaviour (and predictability) of short rates would shed further light on the expectations hypothesis. In this paper we pursue this line of reasoning and use Euro-rates to study the behaviour of 1, 3, 6 and 12-month rates for a sample of 17 currencies. We show that, in general, the data provide considerable support for the expectations hypothesis. Furthermore, the results reinforce the conclusion in Mankiw and Miron (1986) that the easier it is to forecast future short rates, the better the data conform to the implications of the expectations hypothesis.

The remainder of this paper is organised as follows. In Section 2 we use the expectations theory to derive an estimable equation. The theory implies that the realised future excess return on rolling over a 1-period investment over j periods should be related on a one-to-one basis to the current spread between j-period and 1-period interest rates. Section 3 reports the estimates of the equation. The results provide strong support for the expectations hypothesis. We follow Mankiw and Miron (1986) and provide estimates of the predictability of short-term rates, and show that tests of the term structure hypothesis are indeed the less likely to reject, the more forecastable short rates are. Furthermore, since we have results for 17 currencies, in contrast to other authors, we use cross-sectional regressions to provide estimates of the volatility of the term premium and the correlation between the term premium and the expected change in the short-term rate (conditional on the assumption that these are the same across currencies). One interesting finding is that our estimates are quite similar to the conjectures previously presented in the literature. The paper ends with some conclusions and issues for further research in Section 4.

2. Theory

In order to test the expectations hypothesis we follow Hardouvelis (1994) and perform multiperiod regressions. The theoretical underpinning for these regressions is straightforward. Let R_t^j denote the j-period interest rate at time t, θ_t^j a possible non-zero j-period term premium and $E_t r_{t+i}$ the expected value of the 1-period interest rate at time t+i, formed on the basis of information available at time t. All interest rates are expressed at annualised rates. In what follows, we use 1, 3, 6 and 12-month rates, so that j = 1, 3, 6 and 12. The expectations theory then posits that the return on the j-period investment should equal the return on a 1-period investment, rolled over j times, plus the term premium

(1) $$(1+R_t)^j = \theta_t^j + \prod_{i=0}^{j-1}(1+E_t r_{t+i}/j)$$

Linearising, we have that (approximately)

(2) $$R_t^j \approx \theta_t^j + \sum_{i=0}^{j-1}(E_t r_{t+i}/j)$$

or that

(3) $$(E_t r_{t+i-1} + E_t r_{t+i-2} + \ldots + r_t)/j \approx -\theta_t^j + R_t^j$$

Equation (3) spells out the fundamental implication of the expectations hypothesis: the expected return on rolling over the 1-period position (on the LHS) should equal the return on holding the j-period investment until maturity, adjusted for the term premium (on the RHS). The expectations hypothesis can be tested by estimating

(4) $$\sum_{i=1}^{j}(r_{t+i-1} - r_t)/j = \alpha + \beta(R_t^j - r_t) + v_t$$

where $\alpha = -\theta_t^j$, $v_t \equiv \sum_{i=0}^{j-1}(r_{t+i} - E_t r_{t+i})/j + \varepsilon_t$, and where $\beta = 1$ under the expectations hypothesis. Thus, the expectations theory of the term structure implies that the term spread should predict the average future change in 1-period interest rates during the holding period. In what follows we refer to the LHS of equation (4) as the roll-over spread. Note that although we, as others, assume that expectation errors, $r_{t+i} - E_t r_{t+i}$, are uncorrelated over time, v_t, is not white noise, but rather follows an MA(j-1) process.[2] Note also that equation (4) differs somewhat from equation (17) in Hardouvelis (1994) in that the future 1-period rates on the LHS are all equally weighted. This is a consequence of the fact that interest rates in the Euro-market are paid at maturity, so that maturity and duration are equal.[3]

3. Econometric results

Next we estimate equation (4) using Euro-market data for all 17 currencies for which we could obtain at least about ten years of data on 1, 3, 6 and 12-month maturities. We use Euro-rates for three reasons. First, Euro-market data are available for many more currencies and maturities than domestic market data, and it is therefore easy to study a relatively large number of

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2 In the empirical work we therefore follow Newey and West (1987) and compute standard errors that are heteroscedasticity-consistent and robust to MA errors of order j-1.

3 See also the discussion in Shiller, Campbell and Schoenholtz (1983) on this point.

currencies. This is likely to be helpful since the predictability of changes in short-term rates will probably vary across currencies. Second, the Euro-rates are not affected by capital controls, tax treatments or legal regulations which could drive observed rates away from equilibrium levels. Finally, the rates for different currencies are directly comparable and do not depend on factors such as default risk, differences in duration, the calculation of yields, etc.

3.1 Empirical regularities

Before turning to the econometric results, it is helpful to consider Figures 1-17, which contain plots of the raw data. The three plots in the left column contain scatter plots of the roll-over spread $(\sum_{i=1}^{j}(r_{t+i-1} - r_t)/j)$ against the term spread $(R_t^j - r_t)$ for $j = 3$, 6 and 12. For completeness, the column on the right contains time series plots for the same data; these are much less informative and we do not discuss them further below.

To see what the expectations hypothesis implies for the scatter plots, assume first that there are no expectation errors and the term premium is constant. If that is the case, the data points should lie on a line that has a slope of unity and cuts the vertical axis at $-\theta^j$. Expectation errors would cause the data points to scatter around this line, but should not lead us to reject the hypothesis of a unity slope. However, as will be discussed below, a time-varying term premium could distort the picture by reducing the slope of the regression line.

The behaviour of asset prices over time is typically dominated by the news component and the scatter plots indicate that this is also the case for the Euro-rates considered here. Thus, it is clear that term spreads will not explain a large fraction of future cumulative returns on the 1-month asset. However, there is some evidence of a positive relationship between the two variables and that the relationship may be proportional. This is most apparent in the cases of Belgium, Denmark, France, Ireland, Italy, Spain and Sweden. As we argue further below, this list of countries suggests that it is easier to find evidence supportive of the expectations hypothesis with respect to the currencies for which devaluation expectations have caused large and predictable movements in short-term rates.

3.2 Regression tests

Next we turn to the regressions. Table 1 provides estimates of the parameters in equation (4), together with p-values for the hypotheses that $\alpha = 0$; $\beta = 0$; $\beta = 1$; and the joint hypothesis that $\alpha = 0$, $\beta = 1$. Since a total of 51 regressions are reported in the table, for reasons of space we do not discuss the results for individual currencies. Instead we summarise the main findings of the empirical analysis.

Note, first, that in *all* cases β is estimated to be positive and significantly different from zero. The smallest estimates are obtained for Austria (0.39, 0.40 and 0.52 for $j = 3$, 6 and 12) and the United States (0.40, 0.40, 0.53); the largest estimates are obtained for Sweden (1.24, 1.19, 1.13) and Italy (0.75, 1.12, 1.15). Thus, there is considerable evidence that the term spread contains information about the future course of 1-month interest rates. Furthermore, in 35 of 51 cases (or 69% of the regressions) we are unable to reject the hypothesis that $\beta = 1$; in 26 cases (or 51% of the regressions) we are unable to reject the joint hypothesis that $\alpha = 0$ and $\beta = 1$.

Given the existing literature on the term structure hypothesis, these results are quite striking. One reason why there is a widely held perception that, at least in the short run, the term structure does not contain much information might be that most of the empirical literature on the expectations theory of the term structure is based on data for the United States.[4] Table 1 shows, however, that the United States is the only country for which we can reject the hypothesis that $\beta = 1$ for each of the maturities. The fact that the results for the United States differ from those for the other countries is of considerable interest, and has also been observed by Hardouvelis (1994) in his study of the expectations theory and long-term interest rates in the G-7 countries.

3.3 Interpretation

To interpret the cross-country variation in regression results, we follow Fama (1984), Mankiw and Miron (1986) and many others in noting that variations in the term premium can bias downwards the coefficient on the spread in equation (4). For ease of notation we consider the two-period case of equation (4).[5]

(5) $$\Delta r_{t+1}/2 = \alpha + \beta(R_t^2 - r_t) + v_t$$

where, under the expectations hypothesis, we have that $R_t^2 - r_t = E_t \Delta r_{t+1}/2 + \theta_t^2$. If the correlation between the term premium θ_t and the expected change in the short-term interest rate is denoted by ρ, the estimate of β is given by

(6) $$\hat{\beta} = \frac{\sigma^2(E_t \Delta r_{t+1}/2) + 2\rho\sigma(E_t \Delta r_{t+1}/2)\sigma(\theta_t)}{\sigma^2(E_t \Delta r_{t+1}/2) + \sigma^2(\theta_t) + 2\rho\sigma(E_t \Delta r_{t+1}/2)\sigma(\theta_t)}$$

where $\sigma^2(E_t \Delta r_{t+1}/2)$ denotes the variance of the expected change in the short rate. From equation (6) it is clear that, when the variance of the term premium is zero (the pure expectations hypothesis), the estimate of β converges to unity. However, when there is a time-varying term premium, the estimate will be biased downwards and the size of the bias will depend, inter alia, on the variance of the expected future change in the short rate. As this variance goes to zero, the coefficient in (6) converges to zero. The intuition for these results is clear: the presence of a risk premium can be considered as implying that the spread measures the expected change in the short-term rate with an error. Thus, standard errors-in-variables results can be used to assess how the slope parameter is biased away from unity: if the term premium is time-varying, the slope

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[4] See e.g. Mankiw and Miron (1986, pp. 211-12), who note that: "Perhaps the most striking rejections use data at only the short end of the maturity spectrum. Recently Fama (1984); Jones and Roley (1983); Mankiw and Summers (1984); and Shiller, Campbell and Schoenholtz (1983) all conclude that yields on Treasury bills of less than one year do not obey the expectations theory."

[5] See Mankiw and Miron (1986, p. 219).

parameter depends on the relative variance of the expected changes in the short rate and the variation in the forward premium which obscures the information in the term structure about expected interest rates and their correlation.[6]

To test the proposition that differences in the variance of expected changes in the short-term interest rate account for the cross-country differences in the estimates of β, we follow Mankiw and Miron (1986) and estimate it using using a simple univariate forecasting equation comprising the current and lagged short and longer-term rates as explanatory variables.[7] Table 2 shows the total variance of the future change in short-term interest rates and the expected and unexpected part. It is noteworthy that the variance of the expected change in the short-term rate is smallest in the United States and Austria, which are the two countries with the lowest β estimates. Furthermore, the variance is very large in France, Italy and Norway, countries for which the expectations hypothesis does seem to capture the behaviour of interest rates quite well.[8]

It is difficult to summarise briefly the variance estimates in Table 2. However, under the hypothesis that the variance of the forward premium and its correlation with the expected changes in the short rate are identical across currencies, equation (6) should capture the cross-country relationship between the estimates of β and the predictability of the short rate. We therefore added an error term to equation (6) and estimated it using non-linear least squares.[9,10] The estimation results are provided in Table 3, and Figure 18 contains scatter plots of the estimates of β against the estimated variance of the predictable part of the change in the short rate together with our estimates of the non-linear relationship. One finding of interest is that for the 6 and 12-month horizon almost 70% of the cross-country variation in the estimated β estimates is explained by differences in the predictability of the short rate. Moreover, the regressions give precise estimates of the variance of the forward premium and its correlation with the expected changes in

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6 The ratio of the variance of the expected change in the short rate and the premium can be thought of as akin to a signal-to-noise ratio. See Jorion and Mishkin (1991).

7 To calculate the variance of the expected change in the short-term interest rate, we regressed the right-hand side of equation (4) for each of the maturities on current and three lags of the short-term interest rate and the relevant term spread. The results are reported in Table 2.

8 The variance of expected changes in the short-term interest rate can be decomposed into two factors: the total variability of the short-term interest rate (as captured by its variance) and its predictability (as indicated by the R^2). In what follows we interpret differences in the variance of expected changes as differences in predictability. This is the case, for example, when the United States is compared with Germany: although the total variability of 1-month rates is very similar (second column of Table 2), changes are much more predictable in Germany than in the United States and explain the higher variance of expected changes in Germany. This is, however, not always true. For instance, the factors behind the equally low variance of expected changes in Austria and the United States differ: the short-term interest rate in the United States is more variable but less predictable than in Austria.

9 We recognise that our estimate of the variance of the expected change in the short rate may be subject to error, so that our estimates of equation (6) may be subject to generated regressors bias. It is difficult to see how this problem could be avoided.

10 Alternatively, one could assume that the ratio of the variance of the forward premium and the change in the short-term interest rate is constant across countries and estimate β as a function of the R^2 of the prediction equations. However, this model fits the β estimates less well, suggesting that the variance of the term premium is not proportional to the variance of the changes in interest rates.

the short rate. Furthermore, these estimates are comparable with other estimates presented in the literature. Jorion and Mishkin (1991), for example, find that the typical range of ρ values found in the data lies between -0.5 and -0.9. Mankiw and Miron (1986) report estimates of the variance of θ_t for the United States of between 0.007 and 0.07 depending on the sub-period considered.

It should be noted that, over the 3-month horizon, equation (6) works much less well in explaining cross-country variations in the β estimates. This might, however, simply be due to the fact that the predictability of short term rates is uniformly lower over shorter forecast intervals, increasing the relative importance of cross-country differences in the forward premium and its effect on the β estimates.

In sum, we view Table 3 and Figure 18 as presenting compelling evidence that the lack of predictability of short-term interest rates accounts for the failure of standard tests of the expectations theory in a number of countries, most notably the United States. It remains to be explained, however, why short-term interest rates are more predictable in some countries than in others.[11] The difference in predictability of the German versus the US short-term interest rate is striking. As noted when reviewing the scatter plots, the positive relationship between the spread and the realised cumulative return on the 1-month rate position is most apparent in the cases of Belgium, Denmark, France, Ireland, Italy, Spain and Sweden. One plausible explanatory factor is that all these countries had fixed (or quasi-fixed) exchange rate regimes during a large part of the sample period and experienced episodes of speculative attacks in the foreign exchange market. To see how this is likely to affect the estimates, note that speculative pressures are typically associated with large increases in very short-term interest rates, and smaller increases for longer-term interest rates. Term spreads as measured by $(R_t^j - r_t)$ thus tend to become large and negative, particularly for larger j values. Following the speculative attacks, however, short interest rates tend to fall. In brief, the speculative attack generates periods of predictable movements in 1-month rates, which increases the power of the tests. This appears quite clearly in the plots for the countries in question, in which a large number of data points fall in the lower left-hand corner of the scatter plots. Further research on the extent to which our results are sensitive to the inclusion of periods of speculative attacks is warranted.

[11] It should be noted once again that the variability of short-term interest rates also matters. See footnote 8.

4. Conclusions

In this paper we have provided evidence in support of the expectations hypothesis of the term structure at the short end (less than one year) of the maturity spectrum. We find that for all 17 currencies in our data set the term spread does predict future movements in the short rate. Moreover, in a majority of cases we cannot reject the hypothesis that the estimated slope coefficient is different from unity as implied by the pure expectations theory. Furthermore, we show that the failure of the expectations theory to hold in a number of countries, most notably the United States, is due to a lack of predictability of the short-term rate which introduces a downward bias in the estimates in the presence of a time-varying term premium.

Recently central banks have increasingly turned to financial market indicators and, in particular, longer-term interest rates to gauge private sector expectations of future interest rates, inflation and economic activity. The evidence in this paper suggests that 6 and 12-month Euro-market rates might be valid candidates for obtaining information about the private sector's expectations of future changes in the very short-term interest rates through which central banks implement monetary policy. While expectation errors can be large and even serially correlated, especially in small samples, in many countries term spreads on average correctly predict the direction and even the degree of future changes in 1-month interest rates.

Table 1

Country and estimation period	Parameter estimates			p-values for hypothesis tests				
	j	α	β	α = 0	β = 0	β = 1	α = 0, β = 1	R^2
Austria 1978:1-93:12	3	–0.08	0.40	2.3	2.6	0.0	0.0	9.8
	6	–0.14	0.39	6.6	2.2	0.0	0.0	7.8
	12	–0.22	0.52	24.3	5.6	7.7	13.5	8.4
Belgium 1977:9-93:12	3	–0.12	1.09	4.7	0.0	74.8	8.1	21.6
	6	–0.11	1.07	36.0	0.0	67.3	64.5	31.6
	12	–0.07	0.97	76.3	0.0	84.3	92.8	29.5
Canada 1977:9-93:12	3	–0.13	0.88	4.0	0.0	47.4	2.0	19.1
	6	–0.19	0.70	25.9	0.2	19.1	5.6	12.7
	12	–0.21	0.64	51.3	0.0	4.6	2.0	11.0
Denmark 1977:9-93:12	3	–0.22	0.80	2.0	0.0	17.4	1.2	22.9
	6	–0.34	0.94	4.0	0.0	62.3	10.2	43.0
	12	–0.34	0.99	17.7	0.0	85.3	38.0	50.3
France 1977:9-93:12	3	–0.24	0.99	13.9	0.0	97.3	21.4	27.7
	6	–0.42	1.01	9.6	0.0	95.4	25.0	40.2
	12	–0.40	0.90	29.0	0.0	40.7	54.7	47.8
Germany 1972:1-93:12	3	–0.07	0.73	10.4	0.0	4.4	2.1	15.5
	6	–0.18	0.83	4.7	0.0	23.3	9.2	24.6
	12	–0.25	0.86	22.4	0.0	55.1	40.1	27.1
Ireland 1981:11-93:12	3	0.00	0.59	98.8	0.8	6.8	9.3	31.6
	6	0.00	0.94	99.5	0.0	59.9	84.7	51.2
	12	–0.17	1.11	62.3	0.0	1.7	4.9	67.5
Italy 1977:9-93:12	3	–0.21	0.75	14.8	0.0	24.4	8.6	11.6
	6	–0.49	1.12	2.7	0.0	52.7	8.5	31.6
	12	–0.53	1.15	8.6	0.0	21.1	3.6	49.6
Japan 1977:9-93:12	3	–0.07	0.43	3.2	1.9	0.2	0.0	11.6
	6	–0.13	0.68	9.6	0.0	10.5	14.6	28.1
	12	–0.15	0.98	39.1	0.0	92.4	63.3	39.4
Greece 1984:9-93:12	3	–0.44	0.60	7.4	0.0	1.4	0.0	11.3
	6	–0.82	0.86	2.8	0.0	42.0	4.6	27.8
	12	–0.95	0.84	11.7	0.0	24.5	12.0	34.2
Netherlands 1972:5-93:12	3	–0.12	0.89	6.2	0.0	53.7	12.0	18.9
	6	–0.25	1.10	3.6	0.0	52.7	5.3	35.6
	12	–0.31	1.12	14.5	0.0	49.1	21.3	44.1

Table 1 (continued)

Country and estimation period	Parameter estimates			p-values for hypothesis tests				
	j	α	β	α = 0	β = 0	β = 1	α = 0, β = 1	R^2
Norway 1977:9-93:12	3	–0.04	0.87	73.5	0.0	27.0	54.3	31.0
	6	–0.08	0.89	62.3	0.0	13.6	32.6	50.0
	12	–0.09	0.99	66.7	0.0	92.4	90.9	67.6
Spain 1985:4-93:12	3	–0.12	0.87	24.6	0.0	46.5	23.7	33.7
	6	–0.07	0.94	69.2	0.0	33.5	39.9	52.7
	12	–0.17	1.02	59.0	0.0	84.6	86.1	51.1
Switzerland 1972:5-93:12	3	–0.16	0.61	0.2	0.0	0.1	0.0	12.7
	6	–0.24	0.53	0.3	0.1	0.3	0.0	10.5
	12	–0.31	0.64	19.7	1.1	15.4	12.2	12.7
Sweden 1977:9-93:12	3	–0.06	1.24	45.0	0.0	36.1	51.1	29.0
	6	0.07	1.19	61.2	0.0	16.7	38.3	48.8
	12	0.23	1.13	32.2	0.0	24.9	35.3	52.9
United Kingdom 1968:4-93:12	3	–0.15	0.77	2.3	0.0	1.8	0.9	24.2
	6	–0.18	0.75	18.6	0.0	0.9	1.9	28.5
	12	–0.18	0.86	51.1	0.0	10.8	24.8	26.5
United States 1964:6-93:12	3	–0.09	0.40	4.1	3.7	0.2	0.0	2.9
	6	–0.16	0.40	9.7	1.4	0.0	0.0	3.7
	12	–0.26	0.53	20.4	0.1	0.5	0.1	7.2

Table 2
Variance of expected and unexpected changes in interest rates

Country and estimation period	j	Variance of changes in the s-t rate	of which		R^2	Variance of the term spread
			unexpected	expected		
Austria 1978:1-93:12	3	0.21	0.15	0.05	0.24	0.12
	6	0.52	0.37	0.15	0.29	0.26
	12	1.28	0.85	0.42	0.33	0.39
Belgium 1977:9-93:12	3	0.41	0.26	0.14	0.34	0.07
	6	1.15	0.70	0.45	0.39	0.31
	12	2.20	1.36	0.83	0.38	0.68
Canada 1977:9-93:12	3	0.44	0.33	0.11	0.25	0.11
	6	1.44	1.18	0.25	0.17	0.37
	12	3.05	2.51	0.53	0.17	0.81
Denmark 1977:9-93:12	3	1.68	0.91	0.76	0.45	0.60
	6	3.18	1.32	1.85	0.58	1.53
	12	4.82	1.90	2.91	0.60	2.49
France 1977:9-93:12	3	3.51	2.23	1.27	0.36	0.99
	6	6.91	3.62	3.28	0.47	2.71
	12	8.58	3.92	4.65	0.54	5.07
Germany 1972:1-93:12	3	0.46	0.37	0.09	0.20	0.13
	6	1.00	0.71	0.29	0.29	0.36
	12	2.31	1.46	0.85	0.37	0.84
Greece 1984:9-93:12	3	4.53	3.51	1.01	0.22	1.39
	6	8.86	5.13	3.73	0.42	3.34
	12	11.47	5.98	5.49	0.48	5.61
Ireland 1981:11-93:12	3	2.49	1.31	1.18	0.47	2.26
	6	6.83	2.88	3.95	0.58	3.93
	12	9.77	2.55	7.21	0.74	5.34
Italy 1977:9-93:12	3	2.86	2.02	0.84	0.29	0.58
	6	6.13	3.13	2.99	0.49	1.55
	12	7.42	3.28	4.13	0.56	2.76
Japan 1977:9-93:12	3	0.30	0.21	0.08	0.27	0.19
	6	0.79	0.46	0.32	0.41	0.47
	12	2.02	0.98	1.03	0.51	0.83
Netherlands 1972:5-93:12	3	0.83	0.57	0.25	0.30	0.19
	6	2.21	1.24	0.96	0.43	0.64
	12	3.96	1.76	2.20	0.56	1.37

Table 2 (continued)

Variance of expected and unexpected changes in interest rates

Country and estimation period	j	Variance of changes in the s-t rate	of which		R^2	Variance of the term spread
			unexpected	expected		
Norway 1977:9-93:12	3	2.81	0.95	1.85	0.66	1.16
	6	3.93	1.26	2.66	0.68	2.46
	12	5.38	1.31	4.06	0.75	3.68
Spain 1985:4-93:12	3	1.40	0.66	0.73	0.52	0.61
	6	2.21	0.89	1.32	0.60	1.33
	12	4.02	1.21	2.81	0.70	1.95
Sweden 1977:9-93:12	3	1.42	0.84	0.57	0.40	0.27
	6	2.53	1.20	1.32	0.52	0.87
	12	4.00	1.77	2.22	0.56	1.64
Switzerland 1972:5-93:12	3	0.54	0.41	0.12	0.22	0.18
	6	1.27	0.98	0.29	0.23	0.47
	12	2.73	1.92	0.81	0.30	0.84
United Kingdom 1968:4-93:12	3	1.34	0.91	0.43	0.32	0.55
	6	2.63	1.68	0.95	0.36	1.31
	12	5.11	3.27	1.83	0.36	1.83
United States 1964:6-93:12	3	0.47	0.44	0.03	0.06	0.08
	6	1.25	1.11	0.13	0.10	0.25
	12	2.31	1.95	0.35	0.15	0.58

Table 3
Estimates of

$$\hat{\beta}_i = \frac{\sigma^2 + \alpha_1\sigma}{\sigma^2 + \alpha_1\sigma + \alpha_2} + \xi_i$$

where

$$\sigma^2 = \text{var}(E_t\Delta r_{t+1}/2); \;\; \alpha_1 = 2\rho\sigma(\theta_t) \text{ and } \alpha_2 = \sigma^2(\theta_t)$$

Forecast horizon j	α_1	α_2 Variance of term premium, $\sigma^2(\theta_t)$	Correlation between term premium and expected change in s-t rate ρ	Adjusted R^2
3 months	–0.009 (0.030)	0.051 (0.924)	–0.01	0.179
6 months	–0.305 (5.643)	0.044 (2.073)	–0.72	0.684
12 months	–0.501 (6.033)	0.069 (1.857)	–0.95	0.646

Figure 1
Austria

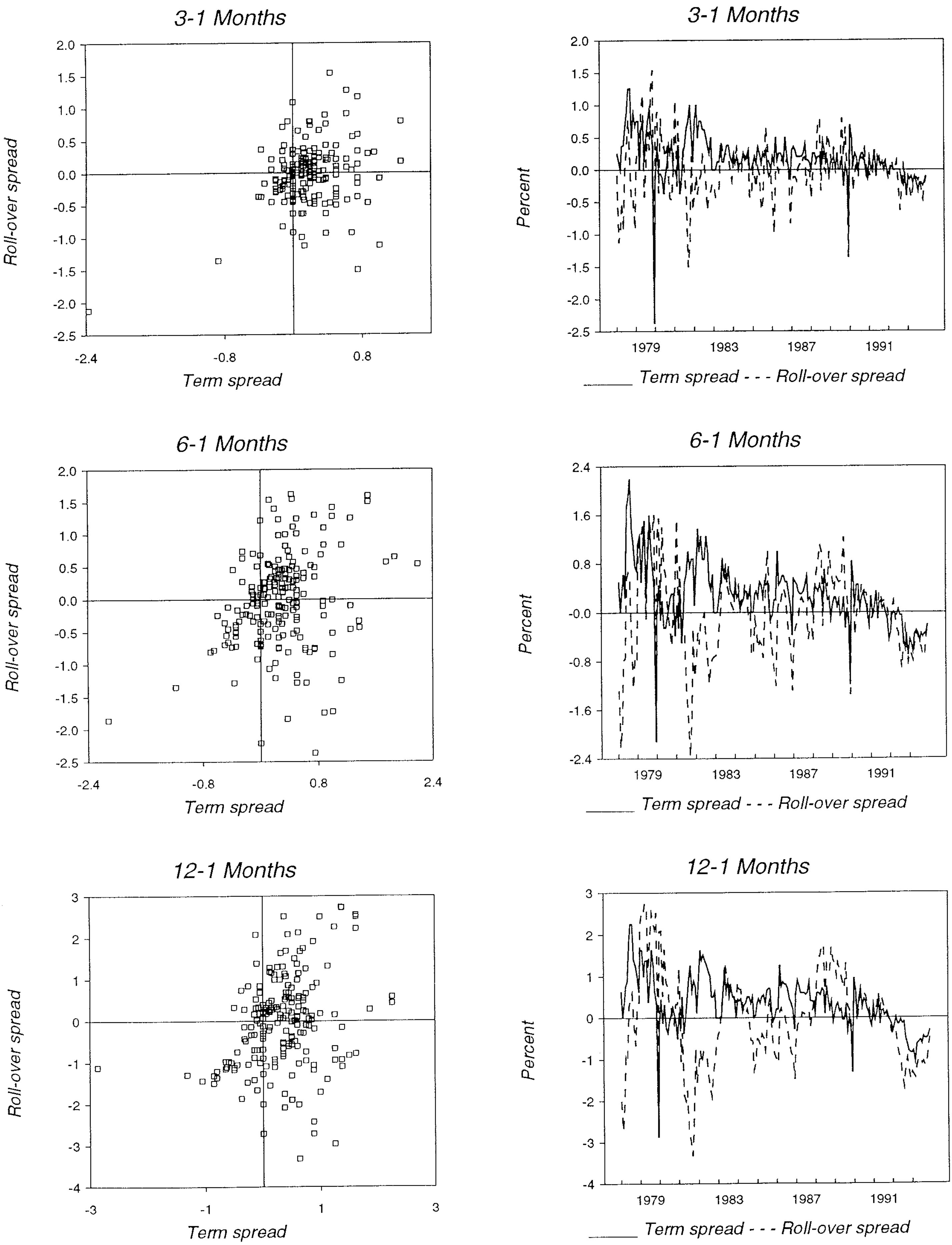


Figure 2
Belgium

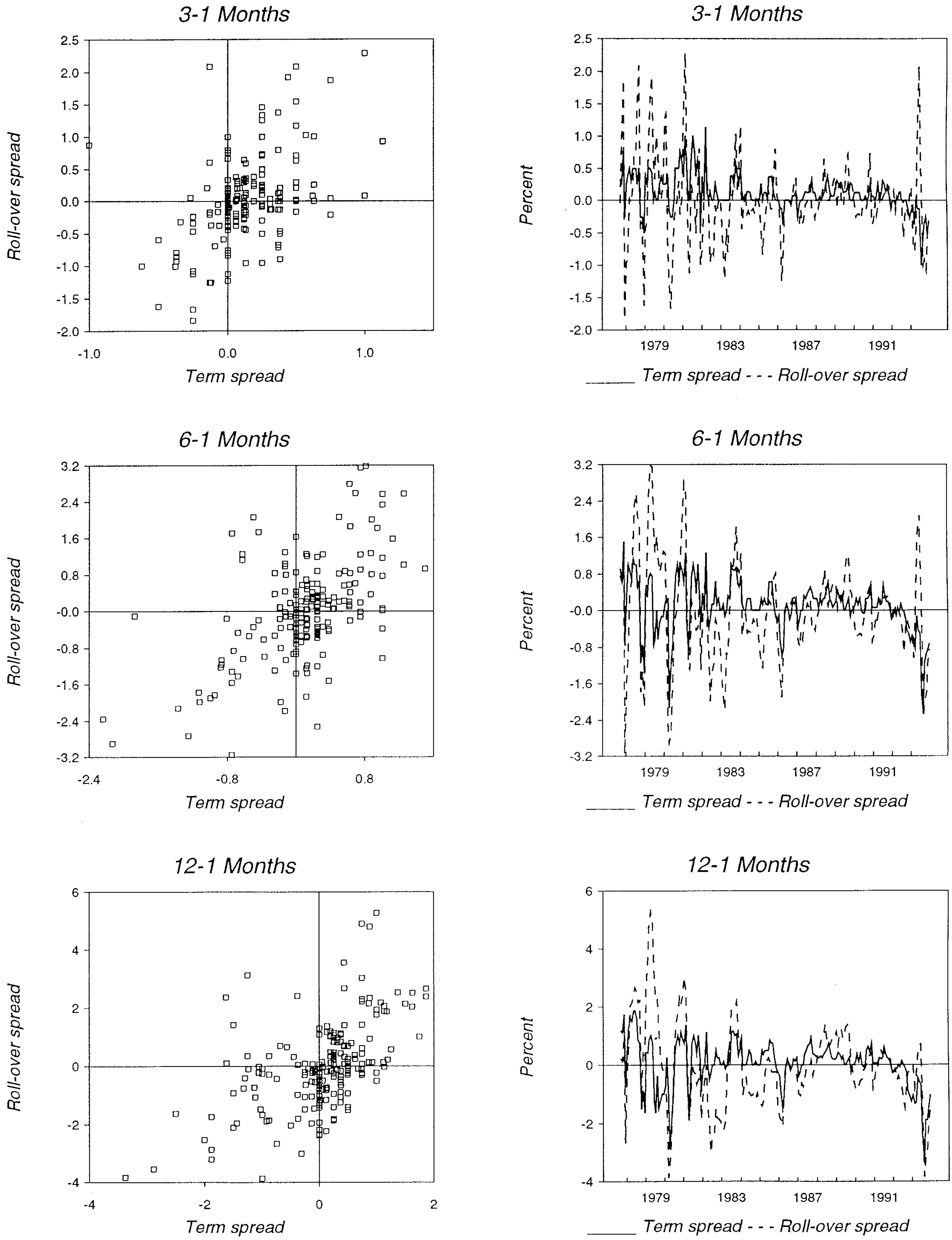


Figure 3
Canada

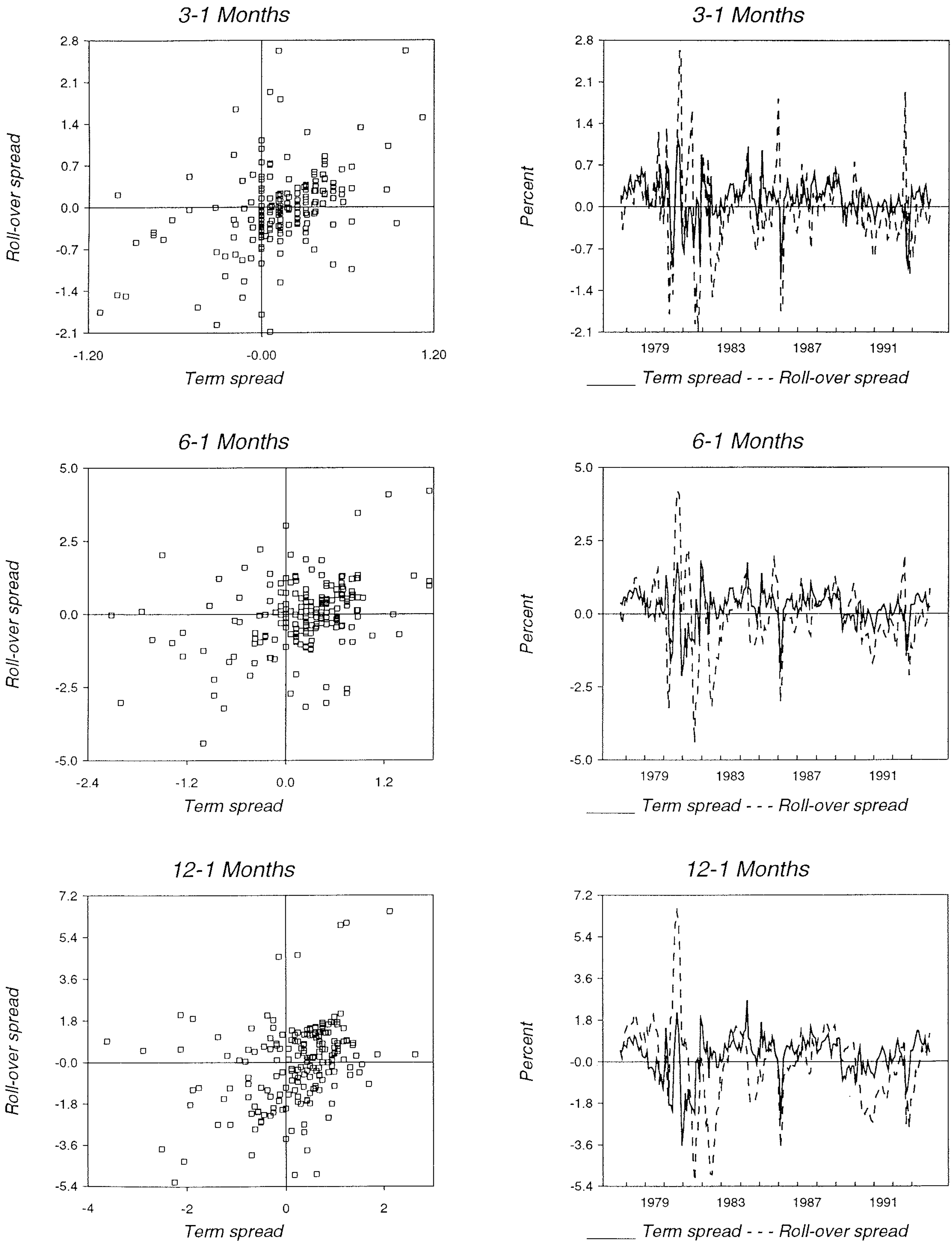


Figure 4
Denmark

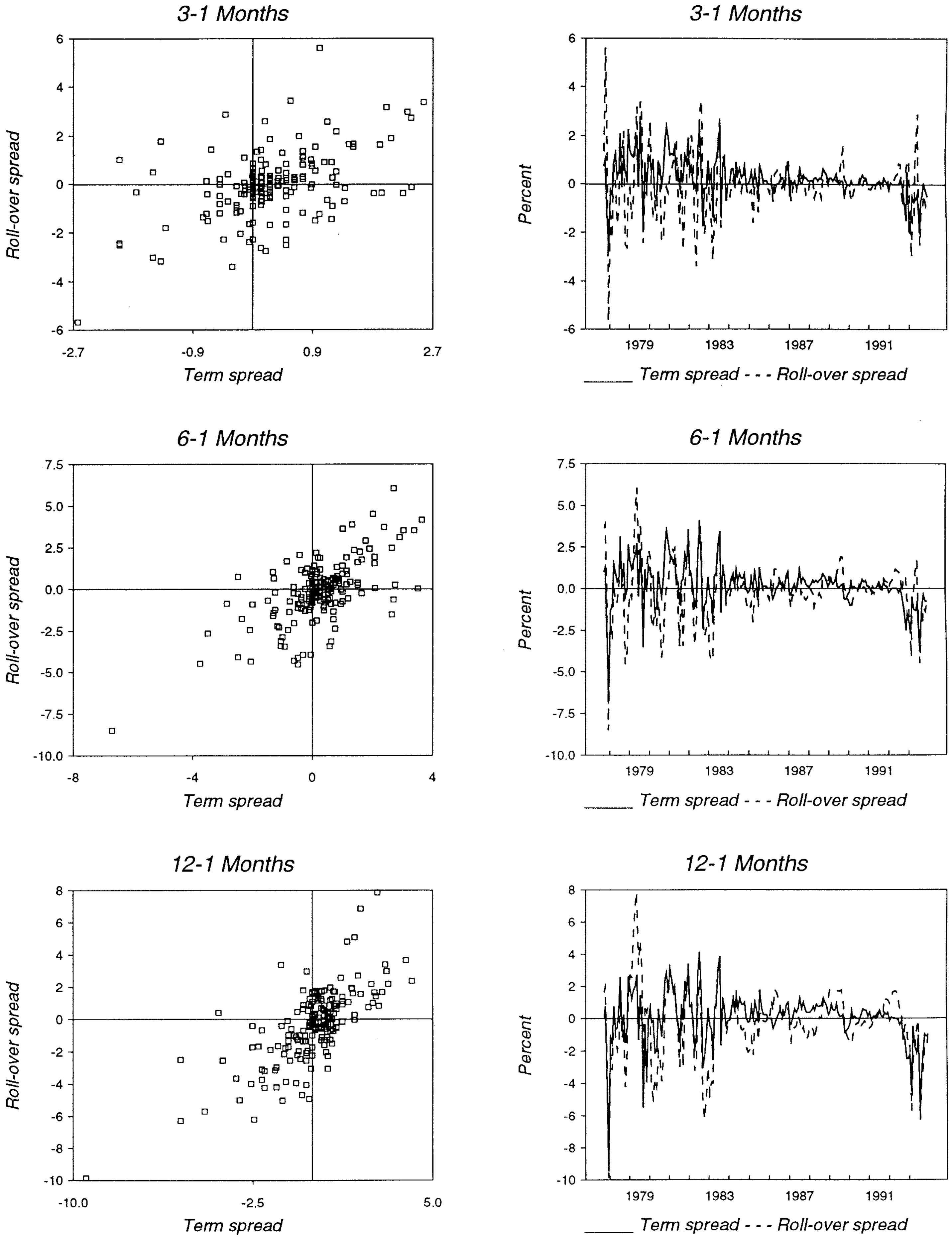


Figure 5
France

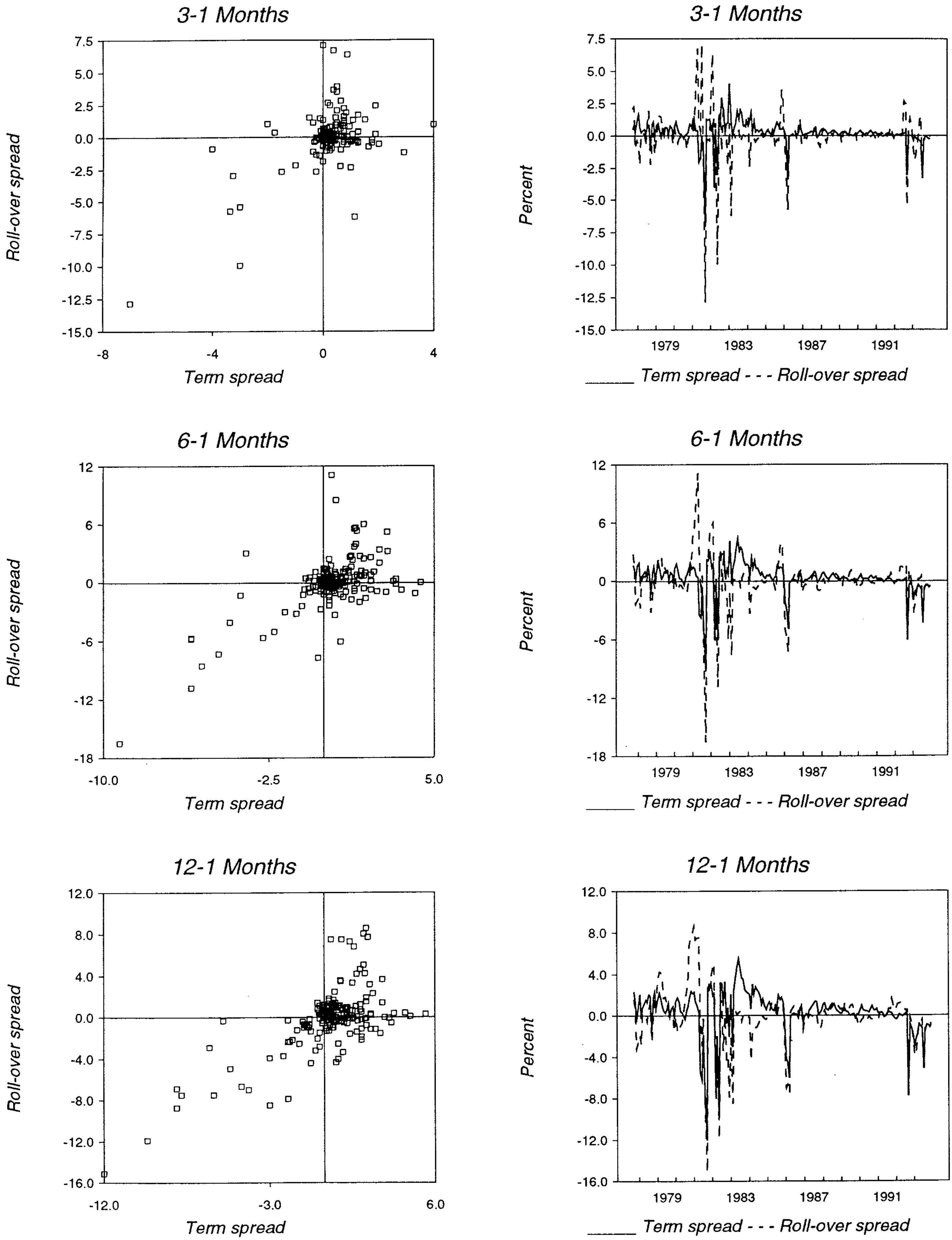


Figure 6
Germany

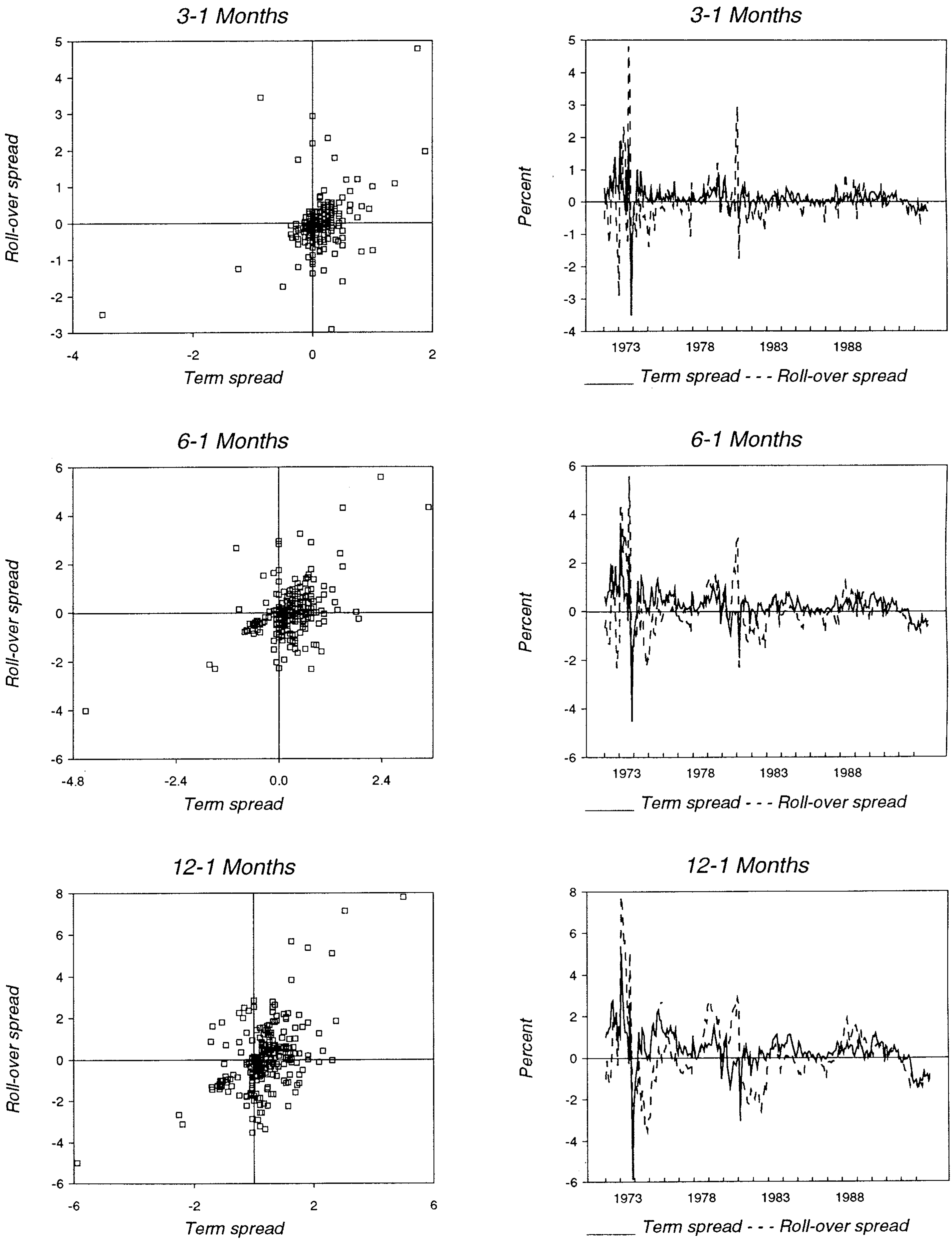


Figure 7
Greece

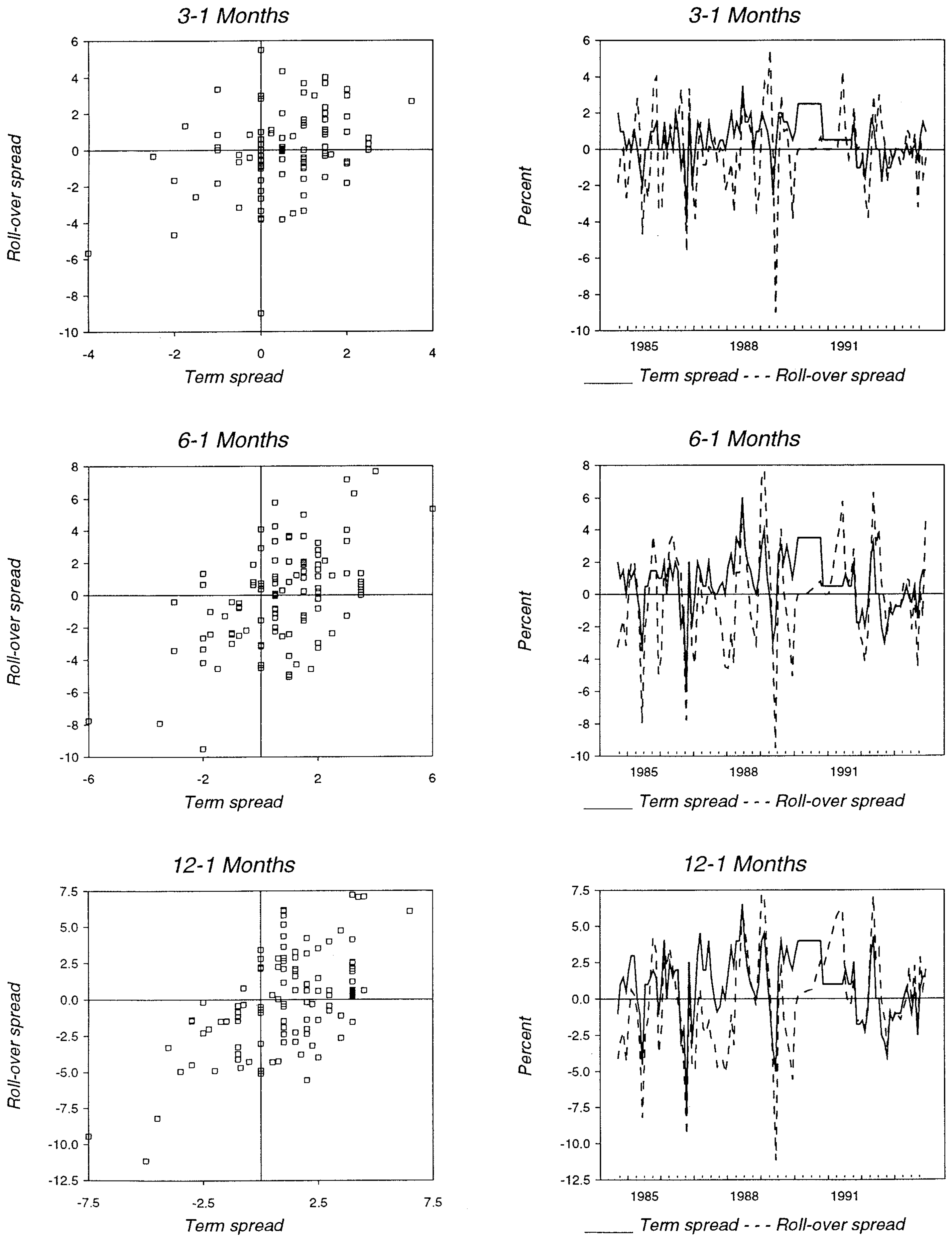


Figure 8
Ireland

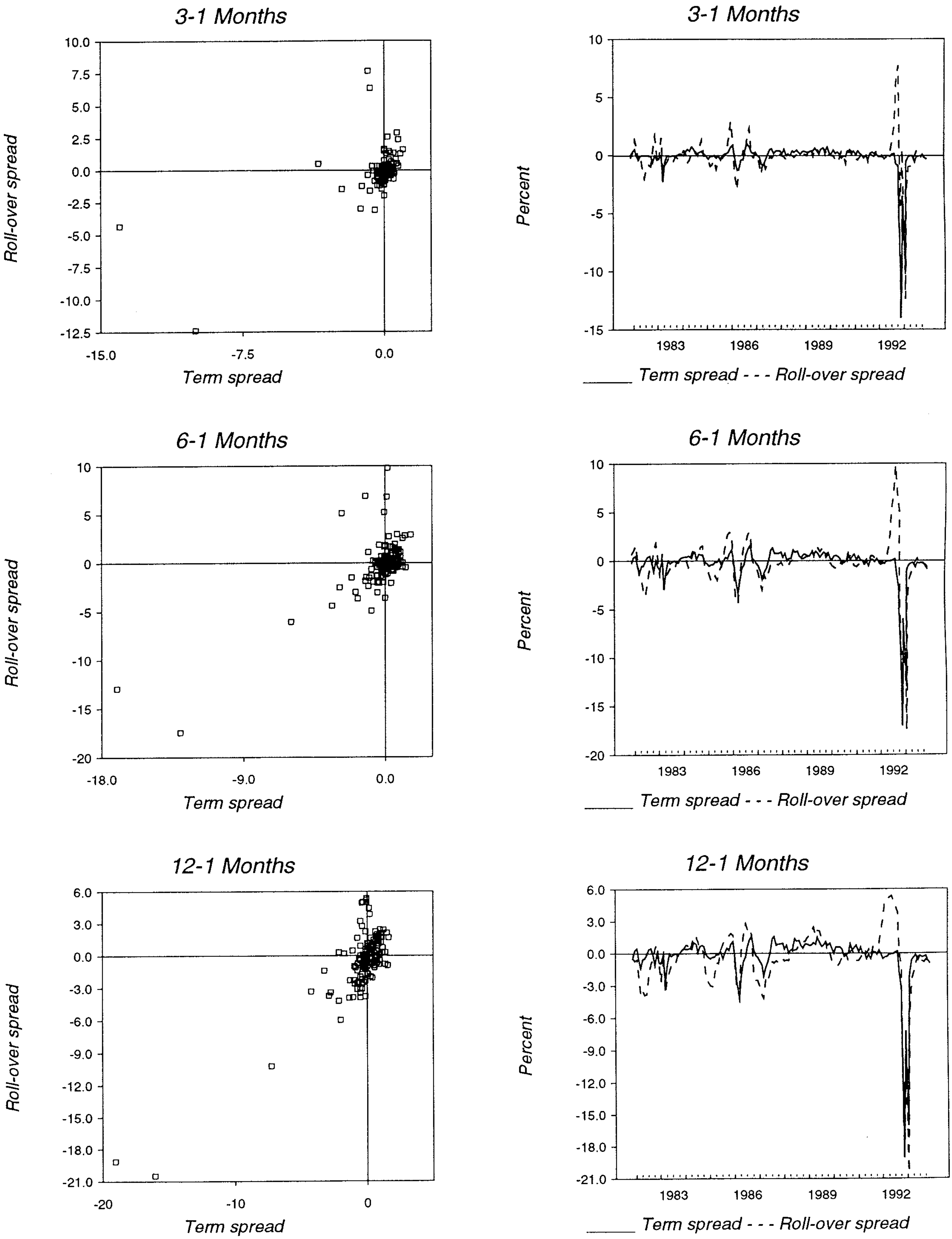


Figure 9
Italy

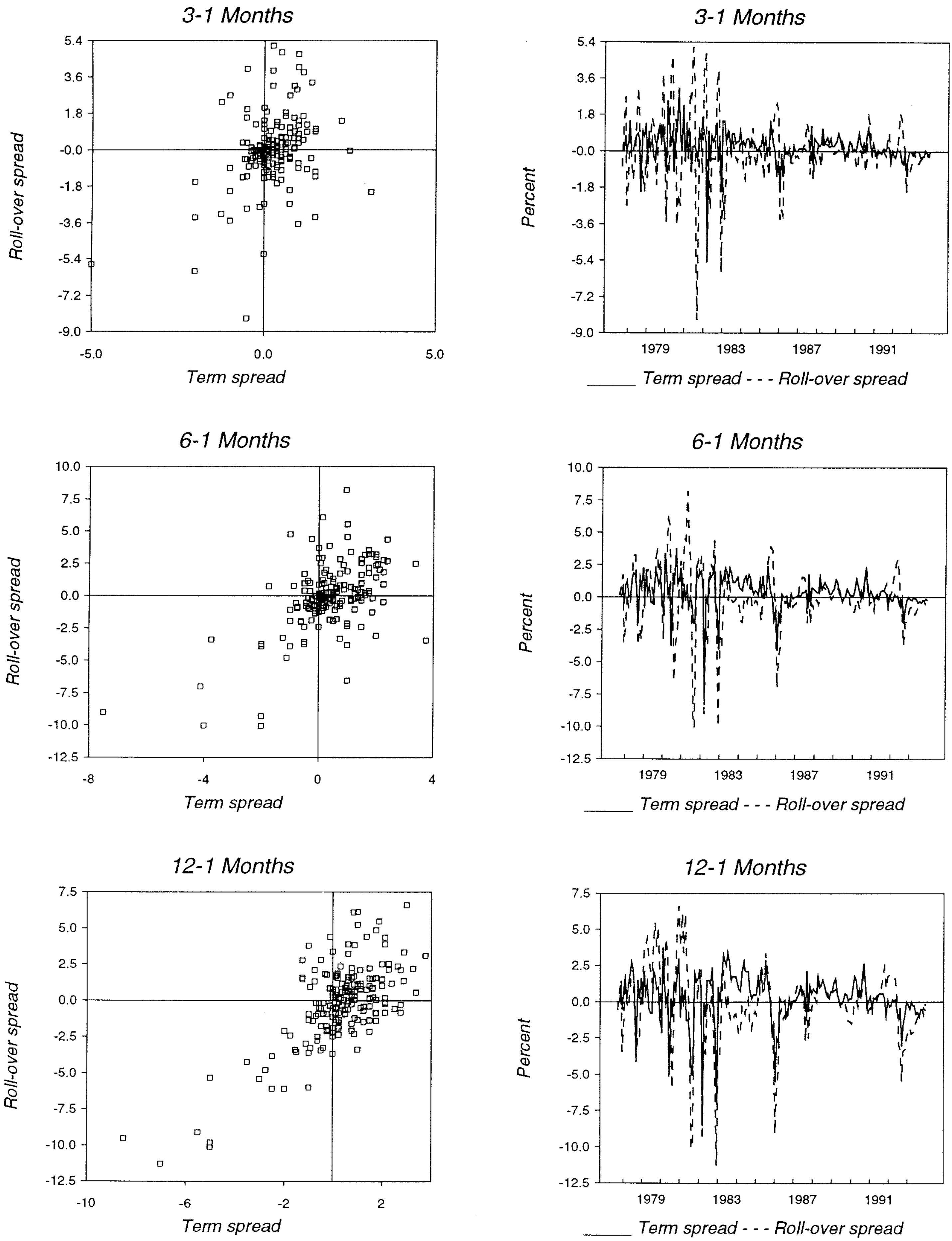


Figure 10
Japan

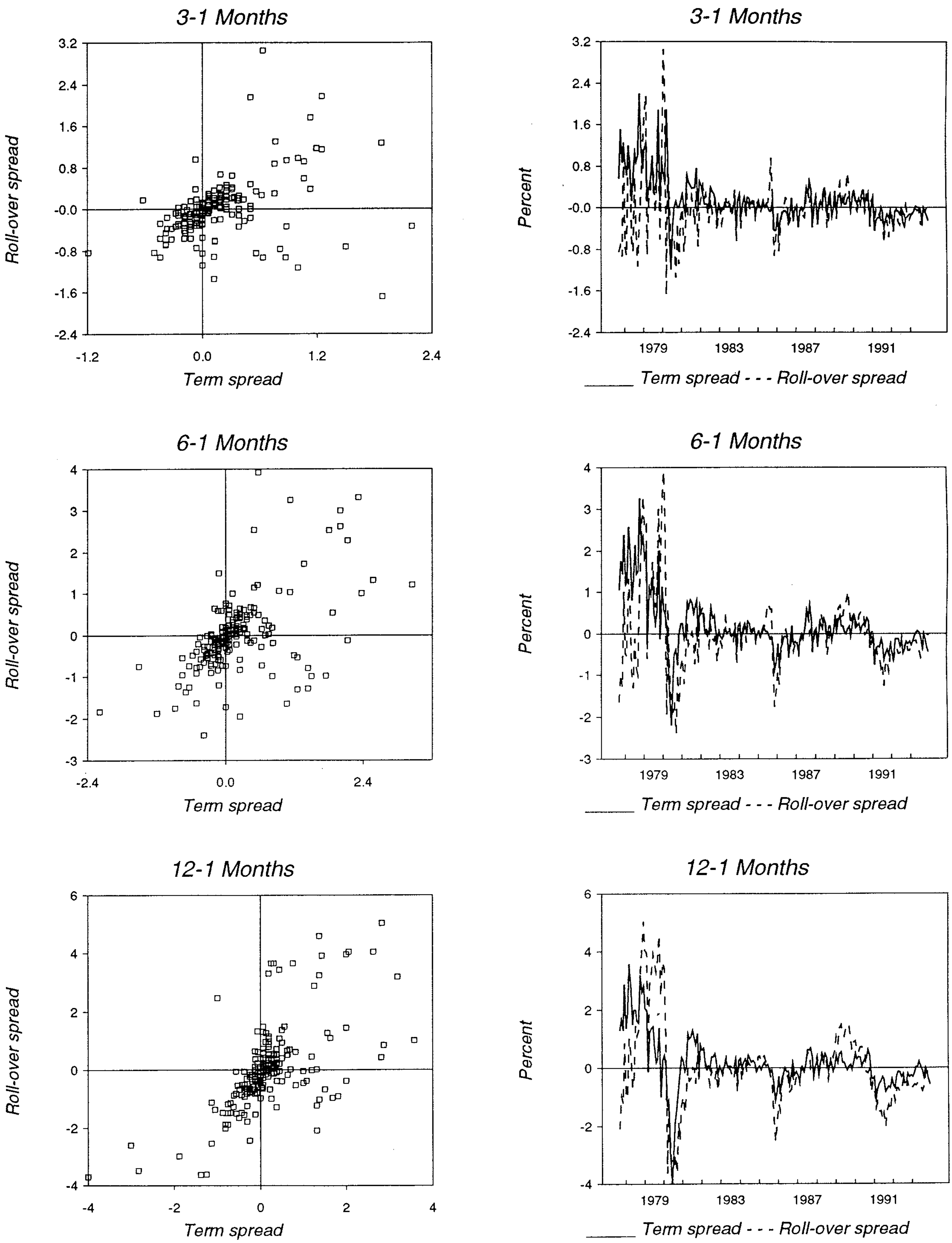


Figure 11
Netherlands

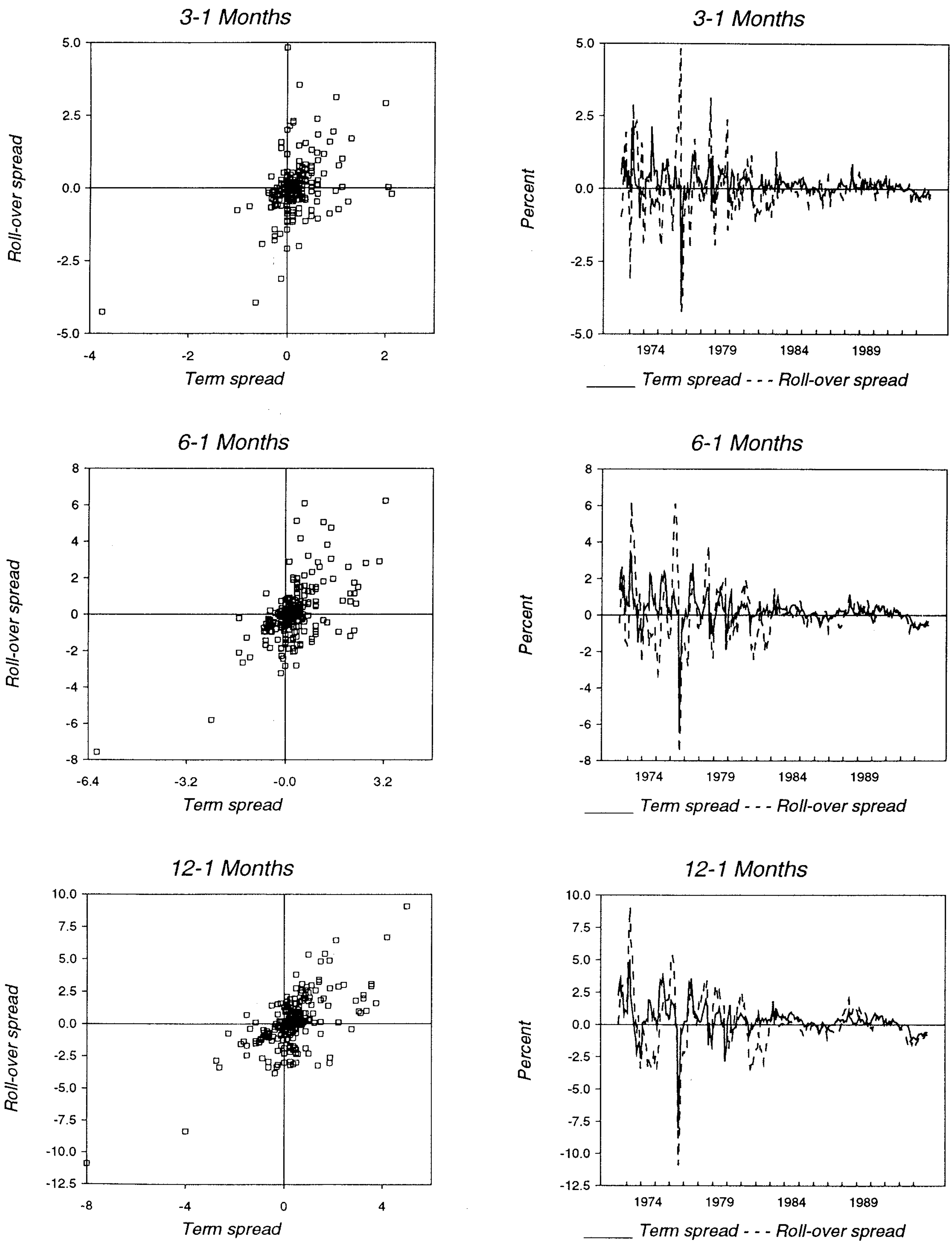


Figure 12
Norway

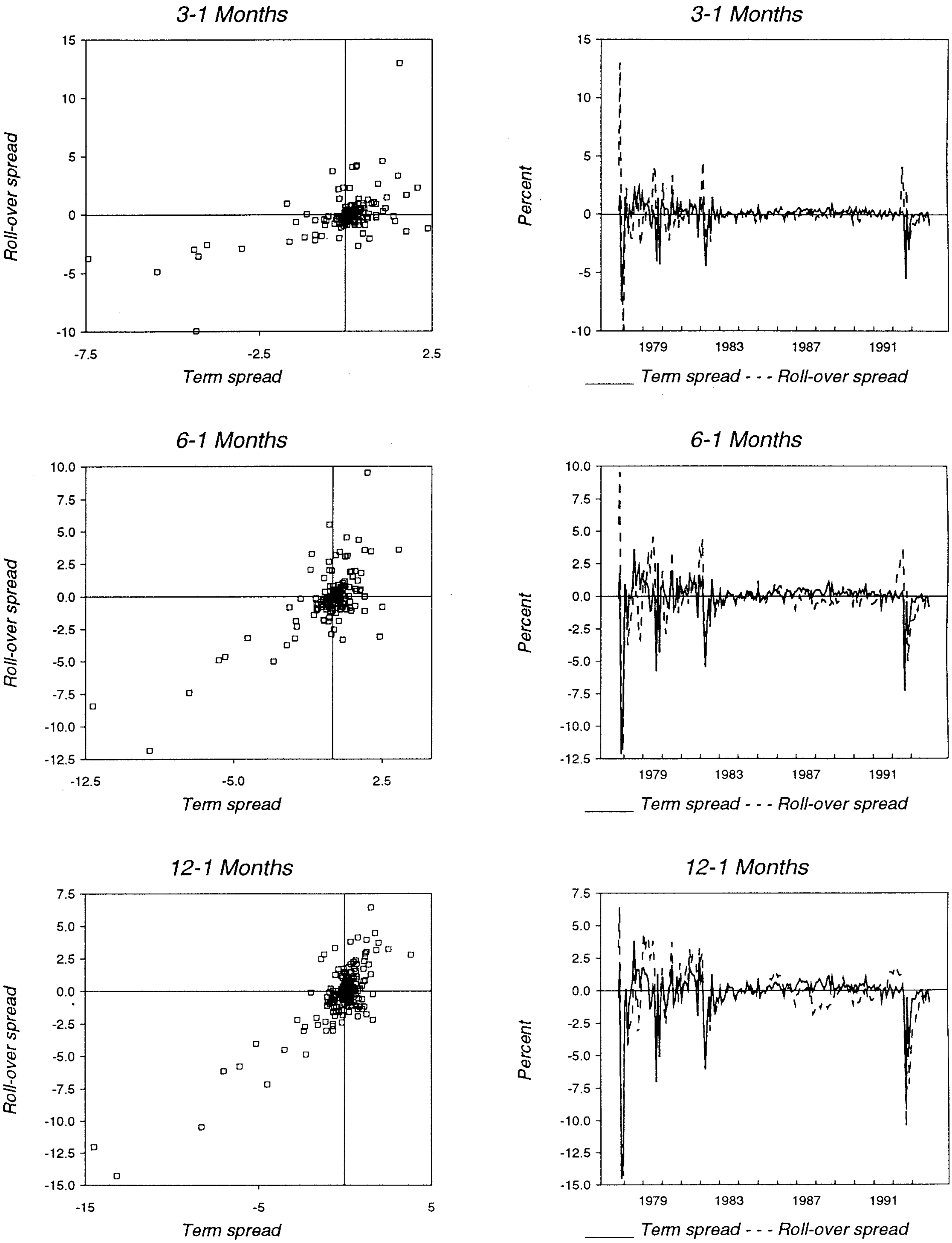


Figure 13
Spain

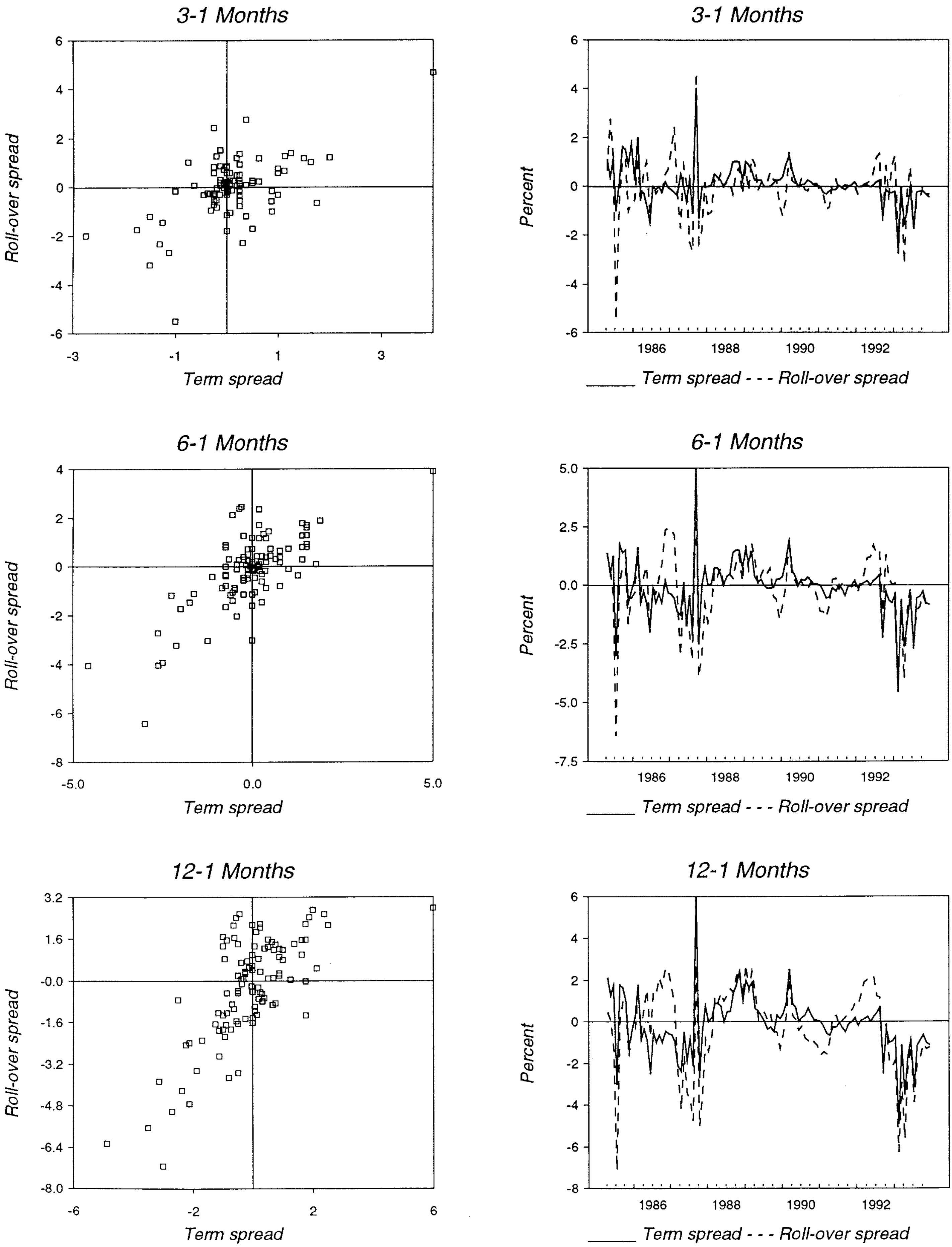
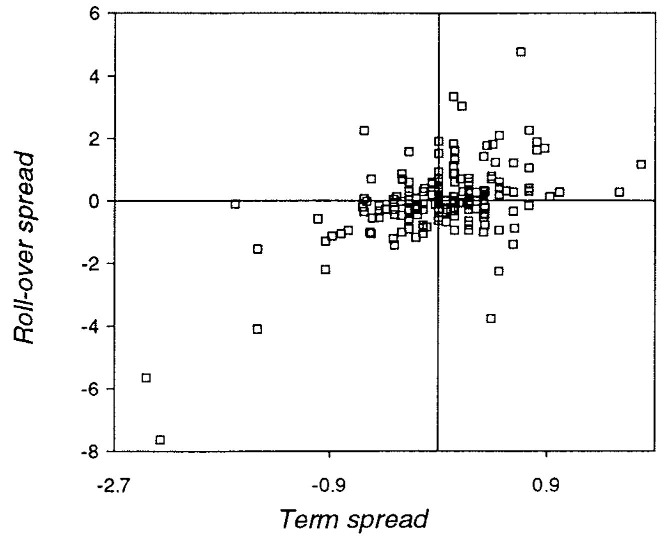


Figure 14
Sweden

3-1 Months



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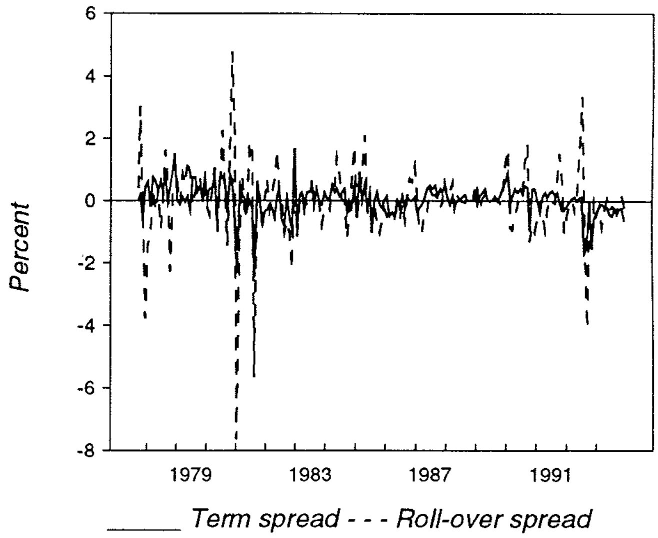
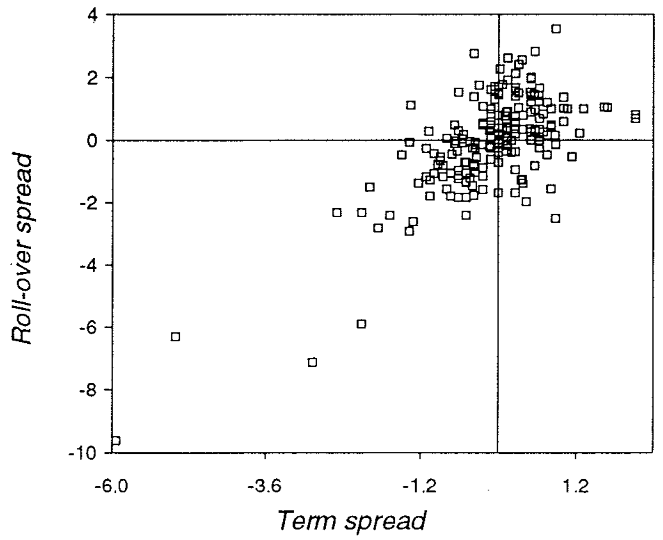
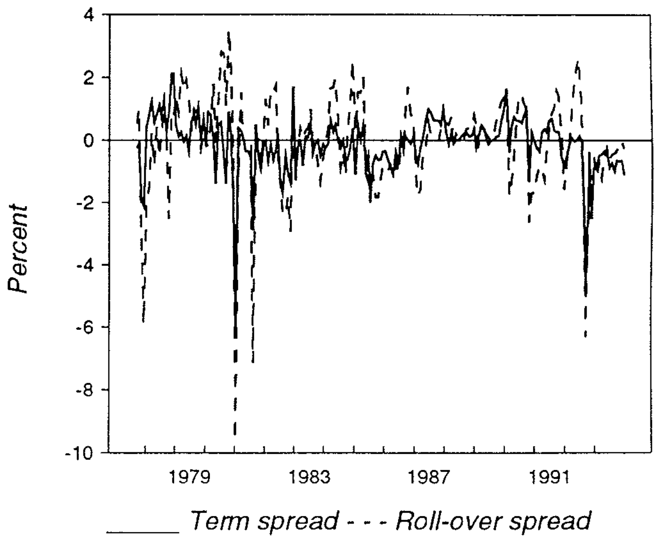


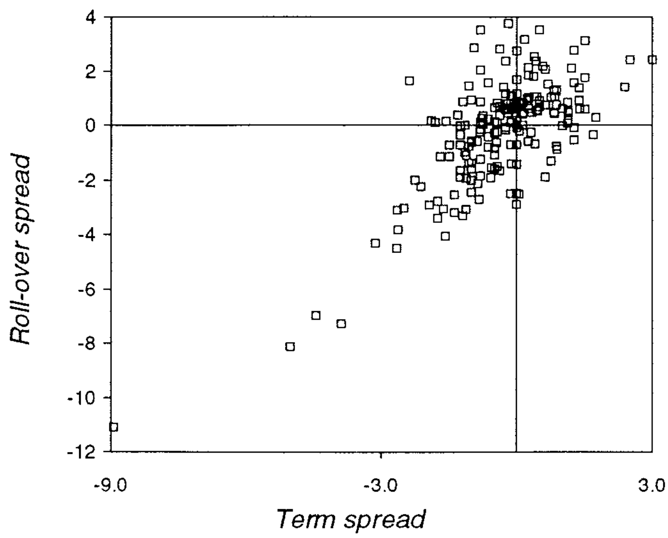
6-1 Months



6-1 Months



12-1 Months



12-1 Months

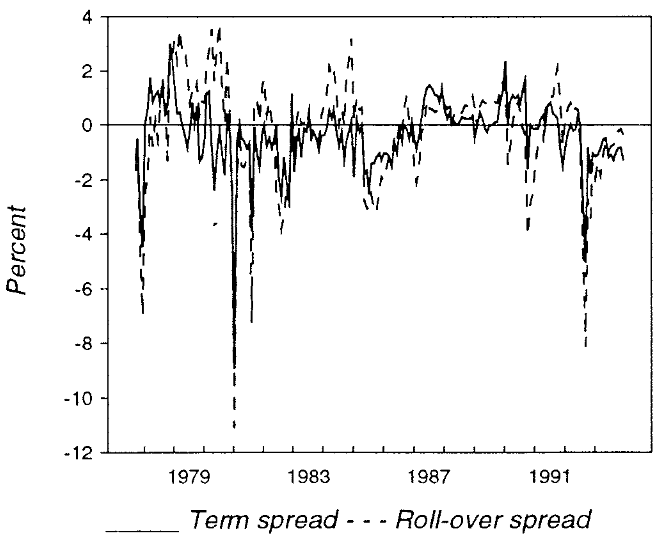
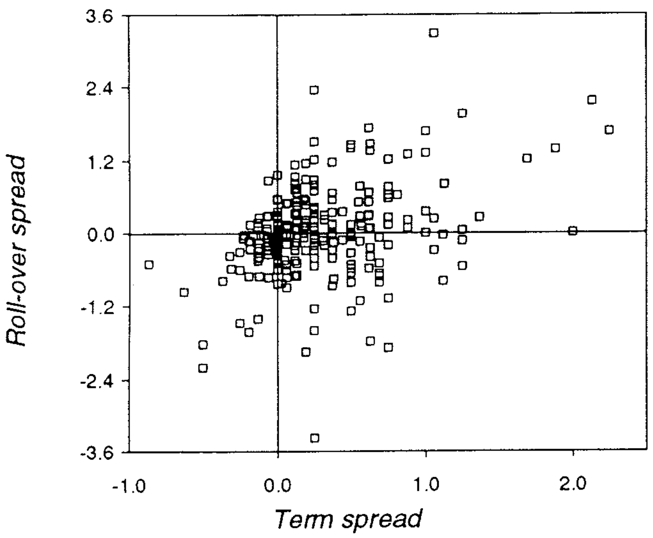
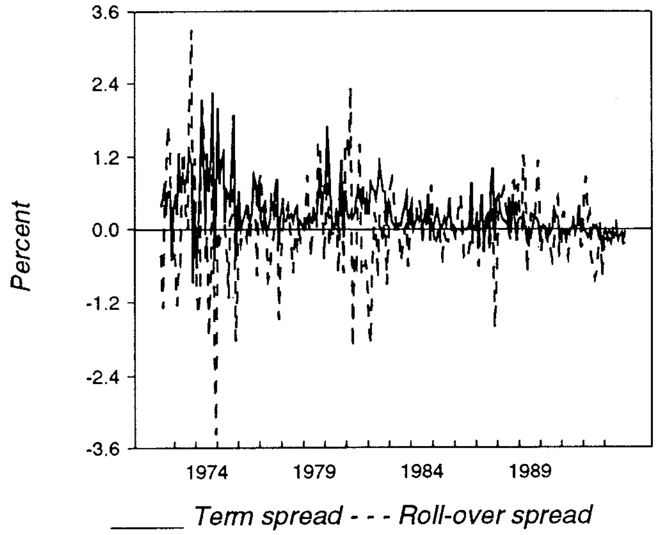


Figure 15
Switzerland

3-1 Months



3-1 Months



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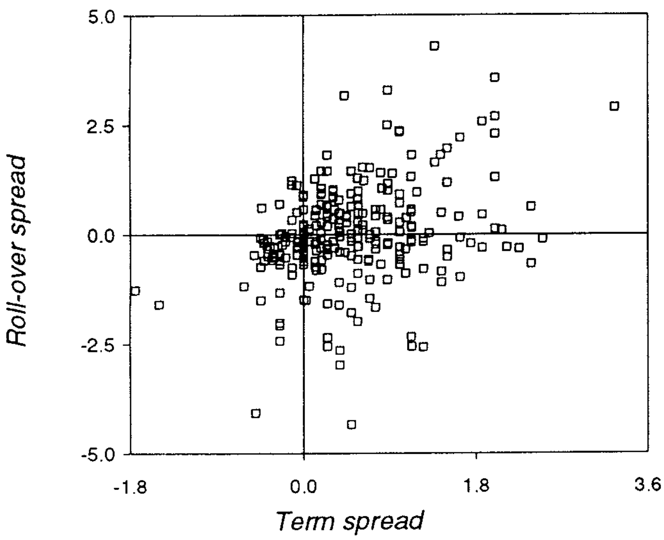
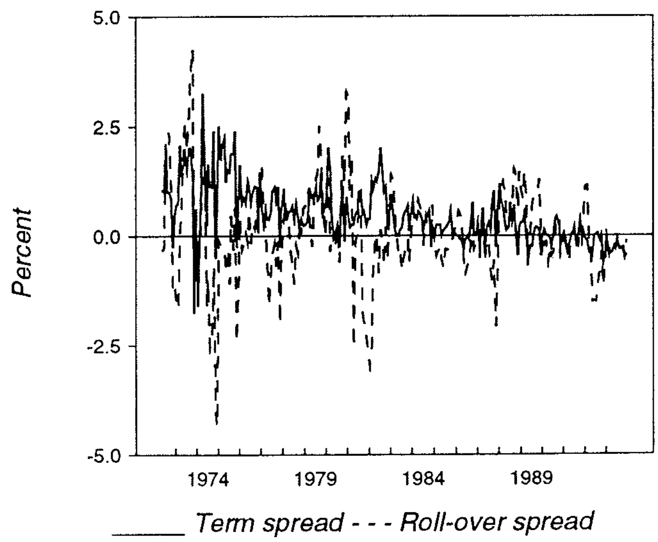


6-1 Months



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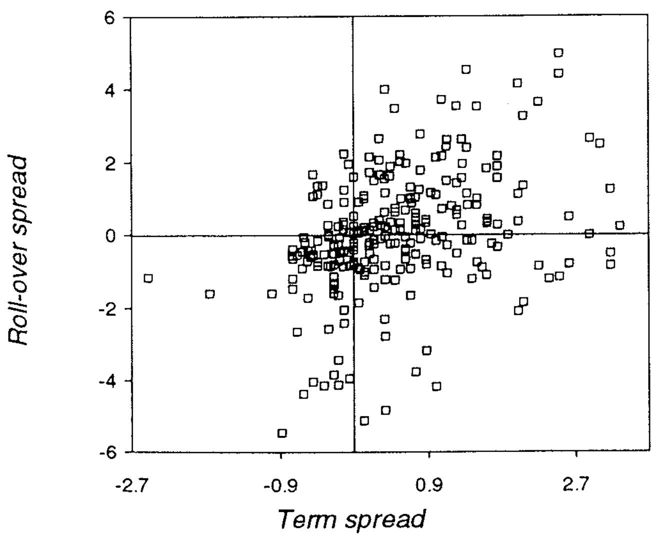

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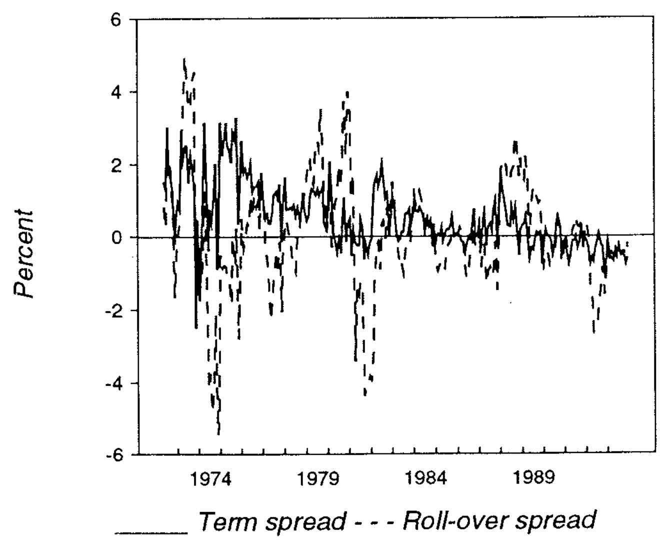


Figure 16
United Kingdom

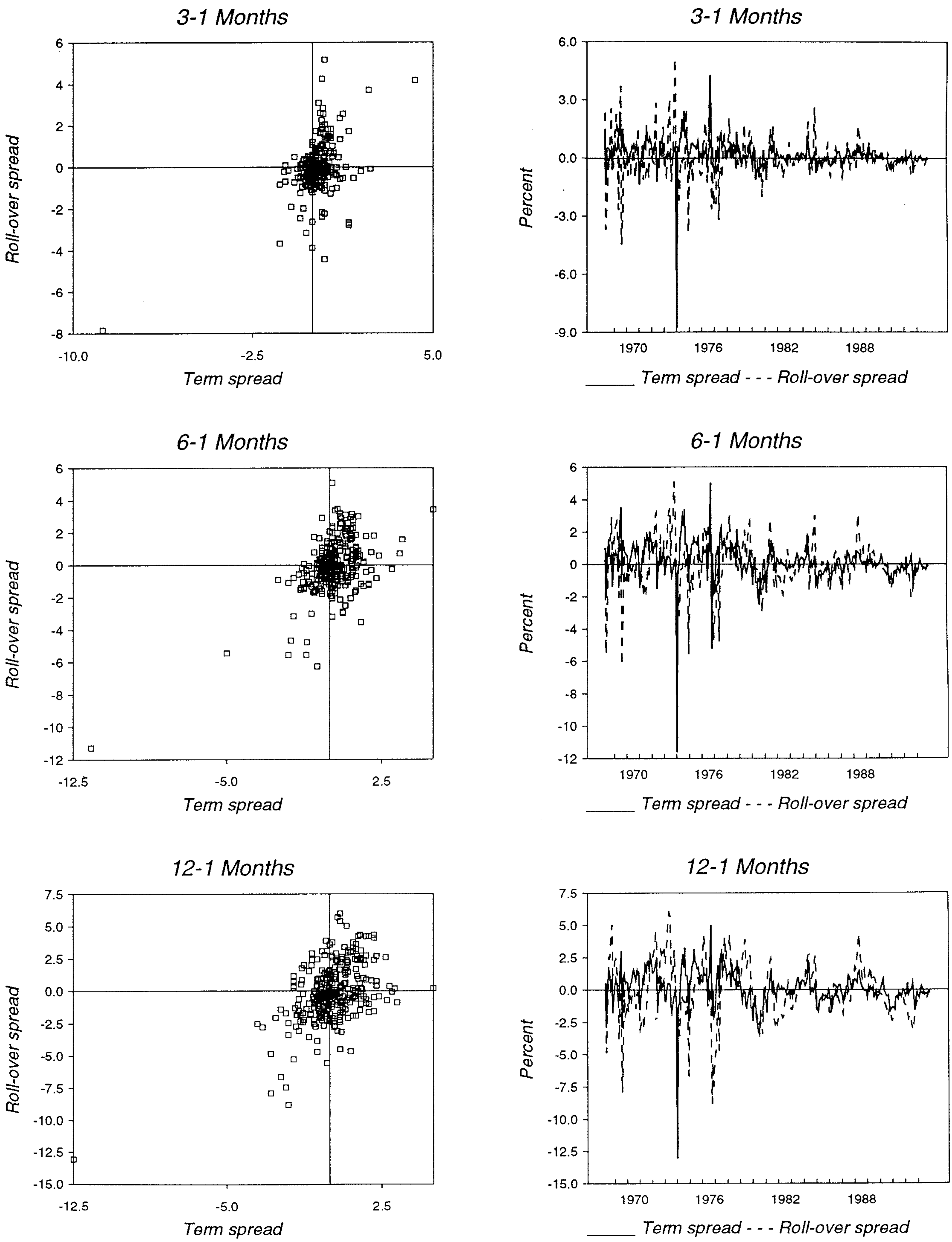


Figure 17
United States

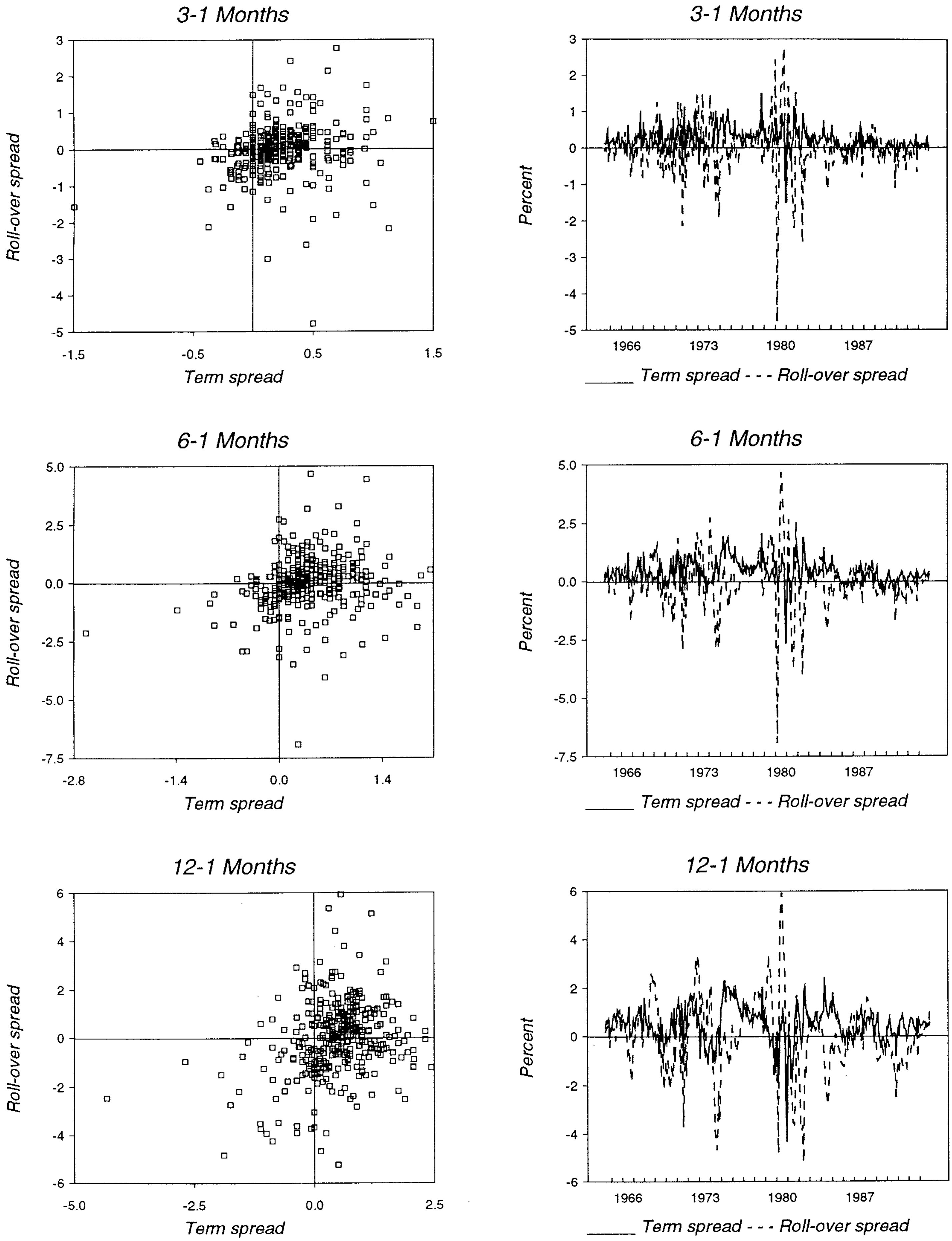
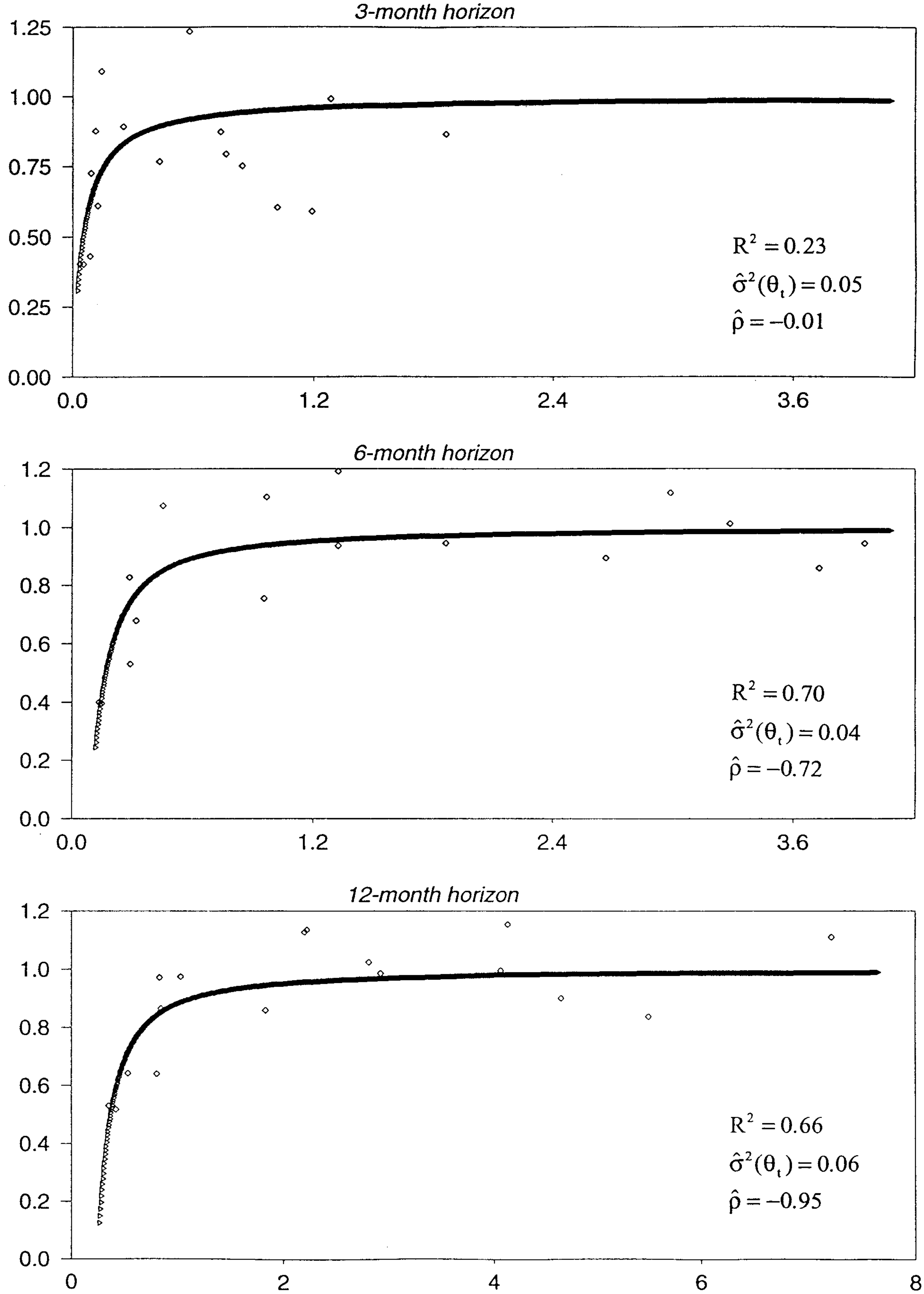


Figure 18
Cross-country variation in β -estimates



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