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THE EXPECTATIONS HYPOTHESIS OF THE TERM STRUCTURE: EVIDENCE FOR GERMANY

Abstract: In this paper we examine the expectations hypothesis of the term structure (EHT) using a newly constructed monthly database of zero coupon bond yields from the German Government bond market. We use data at the short end of the maturity spectrum (maturities less than two years) and employ two approaches to predict future movements in shorter-term interest rates: one based on the yield spread, the other based on the forward-spot rate spread. We find that for the period considered, 1985:2-1994:12, both spreads contain substantial information for predicting future interest rate movements. Moreover, the results are, in general, consistent with the implications of the EHT, as far as the value of the coefficient of the spread is concerned. This means that in Germany the spread can be used as an important indicator for the conduct of monetary policy.

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1. Introduction

The Expectations Hypothesis of the Term Structure (EHT) and the implications for the information content have been extensively tested by using U.S. data, while only little evidence exists for other countries.[1] The empirical evidence for the U.S. is, in general, counter to the EHT (see Rudebush(1995) for a summary of different U.S. studies), whereas results outside the U.S. are mixed, depending on the country and the period considered. This paper presents some evidence for Germany based on data newly derived from estimated term structures. The procedure adopted to estimate the term structure is described in Boero, Madjlessi and Torricelli (1995), and is based on German Government bond data provided by the Karlsruher Kapitalmarkt Datenbank (KKMDB). Recent studies for Germany using different data have found some support for the information content of the term structure, whereas the results are not always consistent with the EHT, in terms of the coefficient value of the spread (see, for instance, Jondeau and Ricart (1996) and Gerlach and Smets (1997) which use Euro-rates). The data used in this paper seem to give stronger results than those obtained in previous studies, and generally support the EHT.

In this paper, the EHT is tested by employing two approaches: one uses the spread between the long rate and the short rate to predict future movements in shorter-term interest rates; the other uses the spread between the forward rate and the spot rate to predict changes in the spot rate. The analysis is conducted by means of standard regressions with monthly data over the period 1985(2)-1994(12). The monetary policy followed by the Bundesbank has been, at least officially, monetary targeting during the whole period under investigation (see Schächter and Stokman, and Deutsche Bundesbank, 1995). Moreover, as described in the Appendix, the beginning of our sample period is a turning point in the conduct of monetary policy: since that point, the Bundesbank has relied more heavily on repurchase agreements (Pensiogeschäfte), which fall within its open market operations.

With only few exceptions, our data suggest that both the long-short rate and the forward-spot rate spreads are very powerful predictors of future interest rate changes, in accordance with the EHT. This is in strong contrast with previous evidence for the U.S., where, unlike in Germany, interest rate targeting has been the primary target of monetary policy. Our results support the argument put forward by Mankiw and Miron (1986), and later confirmed by empirical evidence for other countries (see among others, Kugler, 1988, Engsted and Tanggaard, 1995, and Engsted, 1996), that the predictive power of the spread is stronger under monetary targeting than under interest rate targeting. The above argument is further reinforced by the few exceptions

[1] Recently empirical evidence for some European countries has been proposed. Hurn et al. (1995) and Rossi (1996) test the EHT for the UK using interbank interest rates. Engsted and Tangaard (1995) and Engsted (1996) investigate the predictive power of the Danish term structure using zero-coupon bond yields and money market rates respectively. Dahlquist and Jonsson (1995) focus on the information content of the Swedish short forward rates.

emerging in our study, in which the EHT is rejected. For example, a clear rejection of the EH is found in connection with the 3-months interest rate, reflecting an indirect influence of the German monetary policy on that particular maturity.

The rest of the paper is organised as follows. Section 2 describes the theory and introduces the regressions used in the empirical analysis. Section 3 presents the data and briefly discusses the time series properties of the variables. Section 4 reports the results from the regression equations used to test the EHT and the information content of the spread. Section 5 summarises the main findings and offers further remarks.

2. The expectations theory of the term structure

The EHT can be expressed in many alternative ways.[2] In the present paper we take two main approaches: the yield spread approach and the forward-spot spread approach.

The yield spread approach is based on the EHT contention that current long-term interest rates should equal the market expectation of the average level of current and future short-term interest rates plus a constant term premium, which is zero in the so called pure EHT. As a consequence, the yield spread, i.e. the spread between a long and a short interest rate, should predict future changes in the short rate. To test this implication, we follow Rudebusch (1995) in limiting ourselves to two types of evidence: evidence from spreads between one-period and two-period yields and evidence from spreads between an arbitrary h-period rate and a one-period rate.[3] We now describe the yield spread approach more formally.

Let $r(h/2)_t$ be the yield on h/2-period zero coupon bond, $r(h)$ the yield on a zero-coupon with double time to maturity and $p(h)$ a constant term premium on the latter, then the EHT asserts that:

$$r(h)_t = 1/2\left[r(h/2)_t + E_t r(h/2)_{t+h/2}\right] + p(h) \quad (1)$$

The assumption of Rational Expectations implies:

$$r(h/2)_{t+h/2} = E_t r(h/2)_{t+h/2} + e_{t+h/2} \quad (2)$$

where $e_{t+h/2}$ is the expectational error which is orthogonal to the information available at time t.

After rearrangements, (1) and (2) provide the following regression equation:

$$1/2\left[r(h/2)_{t+h/2} - r(h/2)_t\right] = a + b\left(r(h)_t - r(h/2)_t\right) + u_{t+h/2} \quad (3)$$

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[2] See Cox *et al.*(1981) for a discussion of inconsistencies among various versions of the EHT.

[3] Most of the above cited papers follow Campbell and Shiller (1991) in discussing a linearised version of the EHT, that allows to derive regression equations which are more general but also more cumbersome than those two presented in Rudebusch(1995). We think that this choice eases the exposition and yet allows a proper discussion of the EHT.

where $u_t = e_t / 2$ and the EHT implies that $b = 1$ and $a = -p(h)$.

The EHT can also be stated more generally as follows:

$$r(h)_t = 1/h\left[r_t + \sum_{i=1}^{h-1} E_t r_{t+i}\right] + p(h) \qquad (4)$$

where $r(h)_t$ and r_t are the h- and one-period rates respectively and $p(h)$ is a constant term premium on the longer rate.

Equation (4) can be rewritten, after some rearrangements, in the form of the following regression equation:

$$\frac{1}{h}\sum_{i=0}^{h-1} r_{t+i} - r_t = a + b\left(r(h)_t - r_t\right) + u_{t+h-1} \qquad (5)$$

where here $u_t \equiv e_t$ and $e_{t+h-1} = \frac{1}{h}\sum_{i=0}^{h-1} r_{t+i} - \frac{1}{h}\sum_{i=0}^{h-1} E_t r_{t+i}$ is the expectational error.

As for equation (3), the EHT implies that $b = 1$ and $a = -p(h)$.

The forward-spot yield spread approach is based on that version of the EHT stating that forward rates are (unbiased) predictors of future short rates. More specifically:

$$E_t r_{t+h-1} = f_t(h-1,h) + f \qquad (6)$$

where r_t is the one-period rate, $f_t(n-1,n)$ denotes the one-period forward rate, i.e. the rate at trade date t for a loan from settlement date $t+n-1$ to maturity date $t+n$ and f is a constant forward term premium, which is zero in the unbiased version of EHT.

It follows that the corresponding regression tests take the following form:

$$r_{t+h-1} - r_t = a + b\,[f_t(h-1,h) - r_t] + e_{t+h-1} \qquad (7)$$

where ε_{t+h-1} is the usual expectational error orthogonal to the information available at time t.

Testing the EHT implies testing the following restrictions: $a = f$ and $b = 1$.

In Section 4, we empirically perform the yield spread analysis by testing the restriction on b in equations (3) and (5) and the forward-spot spread analysis by testing the restriction on b in equation (7). It is to be noticed that tests on $a = 0$ and $a = 0$ correspond to testing the pure form and the unbiased form of the EHT respectively.

3. The data and tests for stationarity

The empirical study carried out in the next section uses monthly observations of interest rates derived from the estimation of the German term structure[4], covering the time period 1985(2)-1994(12). The estimation of the term structure is based on the non-linear regression approach suggested by Chambers, Carleton and Waldman (CCW) (1984), and is described in detail in Boero, Madjlessi and Torricelli (1995). For our analysis we select maturities from 1 to 15 months. In Figure 1 we show the evolution of the 1, 3, 6 and 12-months interest rates. These rates move mostly in the same direction, as do those at intermediate maturities not shown in the graph. All interest rates have approximately the same minimum, around 1988, ranging from 3.4% for the 1-month rate to 3.6% for the 15-months rate, while the maximum, exhibited in connection with the ERM crises in 1992, decreases with maturity (9.98% for the 1-month rate, 8.86% for the 15-months rate). The term structure is upward sloping for most of the period up to 1990, and is inverted for most of the period from 1990 onwards.

The series used in the empirical analysis to test the EHT of the term structure, with regressions of the type described in Section 2 (regressions (3), (5) and (7)), are changes in interest rates for different maturities and at different horizons, spreads between longer and shorter rates, and spreads between forward and spot rates. These regressions require stationarity of the variables, so unit root tests have been carried out to establish the order of integration of each series. The tests used for this analysis are the Augmented Dickey-Fuller (Dickey and Fuller, 1979) (ADF) and Phillips-Perron (Phillips, 1987, and Phillips and Perron, 1988) (PP) tests. The tests suggest that, in general, the levels of interest rates are non stationary I(1) series, while changes in interest rates and spreads are stationary. Changes in interest rates at longer horizons than those reported in this study and spreads involving maturities at the longer end of the term structure are not all unambiguously stationary. Some of these series exhibit a break around 1992, in connection with the monetary tensions due to the ERM crisis. So we have also applied the procedure suggested by Perron (1989) to test for unit roots in the presence of a structural change.[5] The empirical analysis below has been conducted with series for which stationarity was unambiguously detected.

4. Testing the expectations hypothesis

Forecasting the change in the short term rate with the yield spread

In this section we test the Expectations Hypothesis of the term structure by running the three regression equations derived in section 2. We start with regressions (3) and (5) which forecast the change in the shorter interest rates with the yield spread, reported here for convenience:

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[4] To our knowledge, the EHT has not been previously tested for Germany on pure discount bond yields. Other studies use either Euro-rates (Jondeau and Ricart(1996), Gerlach and Smets, 1997) or Bundesbank bond yield data (Gerlach, 1995). Yet, the Bundesbank essentially provides the term structure of internal rate of returns of default-free bonds, which is flawed with the coupon bias.

[5] Details on the numerical results of the individual tests are available upon request.

$$1/2\left[r(h/2)_{t+h/2} - r(h/2)_t\right] = a + b\left(r(h)_t - r(h/2)_t\right) + u_{t+h/2} \qquad (3)$$

$$\frac{1}{h}\sum_{i=0}^{h-1} r_{t+i} - r_t = a + b\left(r(h)_t - r_t\right) + u_{t+h-1} \qquad (5)$$

These two regressions are alternative characterisations derived from the Expectations Hypothesis which asserts that the long term interest rate (the h-period rate) should equal the average of current and future shorter term interest rates plus a constant term premium (see equations (1) and (4) in Section 2). An implication of the EHT is that spreads between long and short rates should predict future movements in interest rates. In this paper, we limit our discussion to the ability of spreads to predict changes in short term interest rates[6]. In equation (1) the maturity of the short-term rate is exactly one-half that of the longer-term rate; whereas, in equation (4), the short rate is the 1-period rate. Consequently, regression (3) predicts one-half of the change in the $h/2$-period interest rate $h/2$-periods ahead, by using as predictor the spread between the h-period rate and the $h/2$-period rate. For example, the spread between the 6-month rate and the 3-month rate today should predict one-half of the change in the 3-month rate 3 months ahead. Regression (5) uses the 1-period interest rate r_t as the basic short rate and predicts the deviation of today's short rate from its average level over the forecast horizon h with the spread between the h-period rate and the 1-period rate. For instance, the spread between the 6-month rate and the 1-month rate today should predict the deviation of today's 1-month rate from its expected average level over the next 6 months. From a practical point of view, regression (3) is more useful as it offers a framework to test the predictability of shorter rates with different maturities, while regression (5) is limited to the predictability of the 1-period rate. Moreover, the intuition behind the dependent variable in regression (3) is more direct than that in regression (5). In both formulations we look at the short end of the term structure only, with forecast horizons from 1 to 9 months in regression (3), and up to 15 months in regression (5).[7] The coefficient a in the regressions is the constant term premium. The coefficient b tells by how much future shorter-term rates change for a given value of the current spread.

Tables 1 and 2 present the estimated regressions, for which we test two hypotheses: H_0:β=0, i.e. there is no information content in the spread for future changes in the short rates, and H_0: β=1, which predicts a one-to-one relationship between the spread and future interest rate changes, as implied by the EH. Due to overlapping data, the equations are estimated by OLS with corrections based on Newey-West (1987) for a moving average of order *h-1*,

[6] An analysis of the information content of spreads for long term interest rates, based on the same data set used in this paper, can be found in Boero, Madjlessi and Torricelli (1995).

[7] Results from regressions with h=9, spread R18-R9, and h=15, spread R15-R1, are reported in this study for completeness, but they have to be interpreted with caution, as the break in 1992 generates some instability in their coefficients estimates.

where *h* is the forecasting horizon (in months), and for conditional heteroscedasticity.[8]

Note that, according to the EHT, there is a strict correspondence (in terms of the spread coefficient, and minus a constant term premium) between the regressions in Table 1 and those in Table 2 with spreads involving the same longer term rates. For example, the second regression in Table 1 with spread r(6)-r(3) corresponds to the third regression in Table 2 with spread r(6)-r(1). In fact, the second can be obtained from the first by rewriting r(3) in terms of the average of current and expected future 1-period rates, as asserted by the EHT. Similarly, the third regression in Table 1 with spread r(12)-r(6) corresponds to the fifth regression in Table 2 with spread r(12)-r(1).[9] Thus, results from tests of hypotheses on the spread coefficient β in Table 1 are expected to hold also in the analog regressions in Table 2.

Table 1

Estimated regression: $\mathbf{1/2}[r(h)_{t+h} - r(h)_t] = a + \beta[r(2h)_t - r(h)_t] + u_{t+h}$

r(h)= shorter term interest rate; r(2h)= longer term interest rate

h=forecast horizon and short rate term

estimation period: 85(2)-94(12); number of observations: 119

steps ahead h months	$1/2[r(h)_{t+h} - r(h)_t]$ dependent var.	$r(2h)_t - r(h)_t$ spread	β	R^2	Wald test β=1
1	$1/2[r(1)_{t+1} - r(1)_t]$	$r(2)_t - r(1)_t$	0.98 [a]	0.17	F=0.01
3	$1/2[r(3)_{t+3} - r(3)_t]$	$r(6)_t - r(3)_t$	0.63 [a]	0.18	F=6.75 [a]
6	$1/2[r(6)_{t+6} - r(6)_t]$	$r(12)_t - r(6)_t$	0.99 [a]	0.26	F=0.03
9	$1/2[r(9)_{t+9} - r(9)_t]$	$r(18)_t - r(9)_t$	1.08 [a]	0.20	F=0.05

[a] indicates statistical significance at the 1% level, [b] at the 5% and [c] at the 10%

[8] Regressions with longer forecast horizons and spreads were performed, but the results are not reported here as in those cases the variables showed non-stationarity and the coefficient estimates were found to be unstable. Also, the Newey-West correction becomes less reliable when the degree of overlap is large. The regressions are estimated and tested with the econometric package EViews.

[9] A specific case is represented by the regressions in the first rows of the two tables which coincide, as they use the same spread r(2)-r(1) and the same dependent variable, although the latter is formulated in a different way:

$1/2[r(1)_{t+1} - r(1)_t]$ in table 1, and $1/2[r(1)_t + r(1)_{t+1}] - r(1)_t$ in Table 2.

Table 2

Estimated regression: $\frac{1}{h}\sum_{i=0}^{h-1} r_{t+i} - r_t = a + b\left(r(h)_t - r_t\right) + u_{t+h-1}$

r = one-month interest rate; r(h)= h-month interest rate

h-1=forecast horizon

estimation period: 1985(2) 1994(12); number of observations: 119

steps ahead h-1 months	dep. var.	$r(h)_t - r_t$ spread	β	R^2	Wald test β=1
2-1	$\frac{1}{2}\sum_{i=0}^{2-1} r_{t+i} - r_t$	$r(2)_t - r_t$	0.98 [a]	0.17	F=0.01
3-1	$\frac{1}{3}\sum_{i=0}^{3-1} r_{t+i} - r_t$	$r(3)_t - r_t$	0.75 [a]	0.22	F=2.44
6-1	$\frac{1}{6}\sum_{i=0}^{6-1} r_{t+i} - r_t$	$r(6)_t - r_t$	0.71 [a]	0.35	F=6.82 [a]
9-1	$\frac{1}{9}\sum_{i=0}^{9-1} r_{t+i} - r_t$	$r(9)_t - r_t$	0.80 [a]	0.47	F=3.79 [c]
12-1	$\frac{1}{12}\sum_{i=0}^{12-1} r_{t+i} - r_t$	$r(12)_t - r_t$	0.88 [a]	0.51	F=1.44
15-1	$\frac{1}{15}\sum_{i=0}^{15-1} r_{t+i} - r_t$	$r(15)_t - r_t$	1.00 [a]	0.53	F=0.002

[a] indicates statistical significance at the 1% level, [b] at the 5% and [c] at the 10%

With this premise, our results show some interesting aspects of the German term structure and its ability to predict future interest rates. Unlike similar regressions for the U.S. (see Rudebusch, 1995, for a summary), the results given in Table 1 and 2 indicate that the coefficient of the spread is significantly different from zero at the 1% level in all cases. Moreover, the R^2 values range between 0.17 and 0.53: these are much higher values than those reported in earlier studies for the U.S.. Thus, the spreads contain useful information about future interest rates, which can be important for the conduct of monetary policy. These results on the information content of the spreads confirm those obtained in an earlier study for Germany (see Boero, Madjlessi and Torricelli, 1995).

Tables 1 and 2 also report, in the last column, the Wald test for the EHT that the spread coefficient is equal to one. The results of this test show that estimates of b are close to the theoretical value of 1 in most of the cases considered. The only exceptions concern the regression with spread r(6)-r(3) in Table 1, and the corresponding regression in Table 2 with spread $r(6)-r_t$, for which the hypothesis is rejected at the 1% level. The hypothesis is also rejected, but only marginally (at the 10% level), in the regression with spread $r(9)-r_t$ in Table 2. A possible explanation for these anomalies is offered below.

An informal check of the robustness of the results from the Wald test, we examine the stability of the spread coefficients by computing recursive estimates over the whole sample period. In Figure 2 we plot the recursive estimates from selected regressions for which the EHT is accepted, and in Figure 3 we report the recursive estimates from the two regressions where the hypothesis is strongly rejected. The plots show fairly stable coefficients throughout the sample period: in Figure 2 they are close to one, and in Figure 3 they clearly deviate from one. These plots provide further support for the results of the Wald test.

Furthermore, it is of interest to note that in both Tables 1 and 2 the values of the beta coefficients display an evident U-shaped pattern with, in each case, a minimum corresponding to the regression for which the EHT is not supported. This result is in line with other empirical findings where a U-shaped relationship between the value of β and the width of the maturity spread is found (see Campbell and Shiller, 1991, Rudebusch, 1995, and Campbell, Lo and MacKinley, 1997). Rudebusch (1995) suggests that the interest rate targeting behaviour of the Federal Reserve is responsible for such a U-shaped pattern in the predictive ability of the yield curve. Although the monetary policy of the Bundesbank is officially monetary targeting, a plausible explanation for the isolated failure of the EHT for the regression in Table 1 (and its corresponding regression in Table 2), can be based on the existence of an indirect influence of the German monetary policy on the predictability of the 3-month rate.[10] The fact that the monetary policy may weaken the implication of the EHT at the 3-month maturity may be attributed to the maturity range of the two instrumental rates used by the Bundesbank, i.e. the discount and the Lombard rate which, respectively, represent a lower and an upper bound for the three-month fund rate. A brief description of the main features of the monetary policy of the Bundesbank during the period under investigation and the implications for our analysis can be found in the Appendix.

In summary, apart from the isolated cases just described, our results support the EHT. Moreover, the constant, not reported in the Tables, is never significantly different form zero at the 1% level, and this reinforces the validity of the EHT in its pure form.

The forward-spot spread analysis

To reinforce our findings we conduct a third analysis based on regression equation (7):

$$r_{t+h-1} - r_t = a + b\left(f_t(h-1,h) - r_t\right) + e_{t+h-1}$$

where r_{t+h-1} and r_t are the one-month rate at date $t+h-1$ and t respectively, and $f_t(h-1,h)$ is the one-month forward rate at date t for time $h-1$. In these regressions we use the spread between the 1-month forward rate and the 1-month spot rate to predict changes in the spot rate over $h-1$ periods, with h = 3, 6, 9, 12 and 15 months. The results are similar to those reported in Tables 1 and 2.

[10] This explanation has already been proposed to justify similar anomalies in other studies (Hurn et al., 1995) based on interbank rates, which are more directly related to monetary policy instrumental rates. Even if we are dealing with Government bond market rates, it should be stressed that, given the structure of the German financial system, the money market has a close correlation with the bond market especially at the short end where there is a closer substitutional relationship (see Deutsche Bundesbank(1991), page 38, Deutsche Bundesbank(1995) page 1995, Deutsche Bundesbank(1996) page 32).

The slope coefficient is always significantly different from zero at the 1% level, so there is significant predictive power of the forward-spot spread, which also emerges from the relatively high values of the R^2s, and tests on the restriction $\beta=1$ implied by the EHT are unable to reject the hypothesis at the 1% level in all cases. The hypothesis can be rejected in only two cases: *h*=3 and spread f(2,3)-r_t (at the 5% level), and *h*=15 and spread f(14,15)-r_t (at the 10% level). As in the previous regressions, the constant, which is not tabulated, is never significantly different from zero at the 1% level, in accordance with the unbiased version of the EHT.

Table 3

Estimated regression: $r_{t+h-1} - r_t = a + b\,[f_t(h-1,h) - r_t] + e_{t+h-1}$
r = one-month interest rate; f= one-month forward interest rate
h-1=forecast horizon
estimation period: 1985(3)-1994(12); number of observations: 118

h months	$f_t(h-1,h) - r_t$ spread	β	R^2	Wald test $\beta=1$
3	$f(2,3)_t - r_t$	0.68[a]	0.26	F=6. 21[b]
6	$f(5,6)_t - r_t$	0.83[a]	0.42	F=2.38
9	$f(8,9)_t - r_t$	0.97[a]	0.47	F=0.04
12	$f(11,12)_t - r_t$	1.30[a]	0.41	F=0.70
15	$f(14,15)_t - r_t$	1.35[a]	0.42	F=3.23[c]

[a] indicates statistical significance at the 1% level, [b] at the 5% and [c] at the 10%

In sum, compared with similar studies for Germany using different data, our results provide stronger support for the validity of the EHT. For example, Jondeau and Ricart (1996), using Euro-rates for three countries, France, Germany and the U.S., are able to accept the hypothesis that $\beta=1$ only rarely for Germany, while the study by Gerlach and Smets (1997), which also uses Euro-rates for different countries, produces more favourable results for Germany, although these are based on limited evidence.

5. Conclusions

Most of the empirical literature on the EHT of the term structure is based on data for the U.S.. In the present paper we have tested the EHT for the case of Germany. The database used in this analysis, obtained from estimates of the term structure, provide very clear results which are stronger than those obtained with other available interest rate data. We have employed two approaches to predict future movements in short term rate: one based on the yield spread, the other based on the forward-spot spread. The major findings are as follows: the hypothesis that the slope of the German term structure does not contain information for future changes in interest rates is rejected in all cases considered; moreover, the term structure is in general consistent with the EHT as far as the value of the spread coefficient is concerned. The only exceptions to this last result regard regressions with maturities which are indirectly influenced by the German monetary policy, and we have seen that this is particularly true for the 3-months rate.

There are a number of studies on tests of the EHT for countries outside the U.S. which have found results in support of the EHT (see, inter alia, Kugler, 1988, for Sweden, and Engsted and Tanggaard, 1995, for Denmark). By contrast, earlier studies with U.S. data report, in general, findings against the EHT. An interesting interpretation for this difference can be found in the argument suggested by Mankiw and Miron (1986) that the ability of the spread to predict future interest rate movements is enhanced in the presence of a money supply target policy and is diminished under interest rate stabilisation. According to the analysis of Mankiw and Miron (1986), the data should be more supportive of the EHT in Germany than in the United States, as monetary targeting has been the primary instrument of monetary policy in Germany, while the U.S. have followed a policy of interest rates targeting.

Further support to the Mankiw and Miron argument is given in our study by those isolated cases in which the EHT is rejected, concerning regressions with maturities which are indirectly influenced by the German monetary policy.

The issue needs further investigation. Recent studies for the U.S (e.g. Dotsey and Otrok, 1995, Rudebusch, 1995) have empirically formalised the Mankiw and Miron argument, by generating synthetic interest rate data from a Fed's interest rate targeting model which are then used to test the EHT. Yet, the same type of empirical analysis cannot be replicated for the case of Germany where monetary policy is officially monetary targeting and public interest rate targets are not available. An alternative line of research is represented by a theoretical model of the type proposed in McCallum (1994) which links, within a Rational Expectation framework, a Fed's policy reaction to changes in the spread to the regression estimates of the EHT. The estimation of a McCallum's policy reaction model, already performed by Hsu and Kugler (1997) using Euro dollar rates, could be usefully replicated for the case of Germany in order to assess the responsibility of monetary policy in the few deviations of the German term structure from the EHT.

Appendix - The monetary policy of the Bundesbank

This Appendix briefly describes the type of monetary policy performed by the Bundesbank and the policy instruments used to this end, during the time period under investigation in the present paper. The material mainly draws from Deutsche Bundesbank (1995, 1996).

Due to its past history, the ultimate objective of monetary policy in Germany is price stability and the defence of the exchange rate. In order to assess the effects of monetary policy at earlier dates, the Bundesbank relies on intermediate target variables, such as interest rates, credit aggregates and monetary aggregates. Since the term structure of interest rates is considered to be the weakest among possible intermediate indicators, the German central bank officially adopts an intermediate monetary policy target (see Deutsche Bundesbank, 1995, page 80). The Bundesbank is entitled by the Bundesbank Act to use a wide range of interest rates and liquidity policy instruments, which can be classified as:

- refinancing policy
- open market policy
- minimum reserve policy.

Since the latter is not directly related to our empirical investigation, we will describe the main characteristics only of the former two.

The refinancing policy of the Bundesbank is based on the use of two rates which are publicly announced, i.e. the Lombard and the discount rate. The former is the rate at which credit institutions can obtain liquidity at short notice by pledging Government papers and bills of exchange falling within three months from the date of purchase and satisfying certain conditions (Bundesbank Act, Section 19). Typically, the Lombard facility is used at the end of the month to make up shortfalls in required reserves. The discount rate is the rate at which credit institutions can rediscount certain securities (see Bundesbank Act, Section 19) for three months. It is traditionally the lowest refinancing rate and therefore the total amount of rediscount credit must be limited. The Lombard and discount rates are meant as, respectively, an upper and a lower bound on the very short term money market rates. The three-month fund rate, for instance, has moved since 1985 most of the time within the discount-Lombard tunnel (see Deutsche Bundesbank(1996), page 9). These two official rates are determined by the Bundesbank Council. Changes have been rare and long periods of no change have been interspersed by small unidirectional changes.

The year 1985 is a turning point in the conduct of monetary policy in Germany, which, since then, has relied more heavily on repurchase agreements (Pensiogeschäfte). Repurchase agreements (Repo) fall within the open market operations of the Bundesbank (which to a minor extent has been operating also in money market papers and long-term securities) and are offered to credit institutions in the form of fixed-rate or variable-rate tenders. Since 1985 repurchase agreements have been offered with a different frequency, ranging from three to four time per month, and different maturities, ranging from two weeks to two months. In October 1992, after the EMS crisis, the long tranches were suspended reducing maturity to fourteen days and since December 1993 the frequency is weekly (for more details, see Bundesbank, 1995, page 113).

In summary, two main features related to our analysis emerge. First, changes in the discount and Lombard rates, which represent respectively a floor and a ceiling for the three-month fund rate, have been on the whole rare. Secondly, although a monetary targeting policy is officially declared, there are presumptions of interest rate targeting (see fixed rate tenders Repo) which may be further supported by the particular importance of the discount rate as a monetary indicator at least in public statements.

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Fig. 1 Interest rates

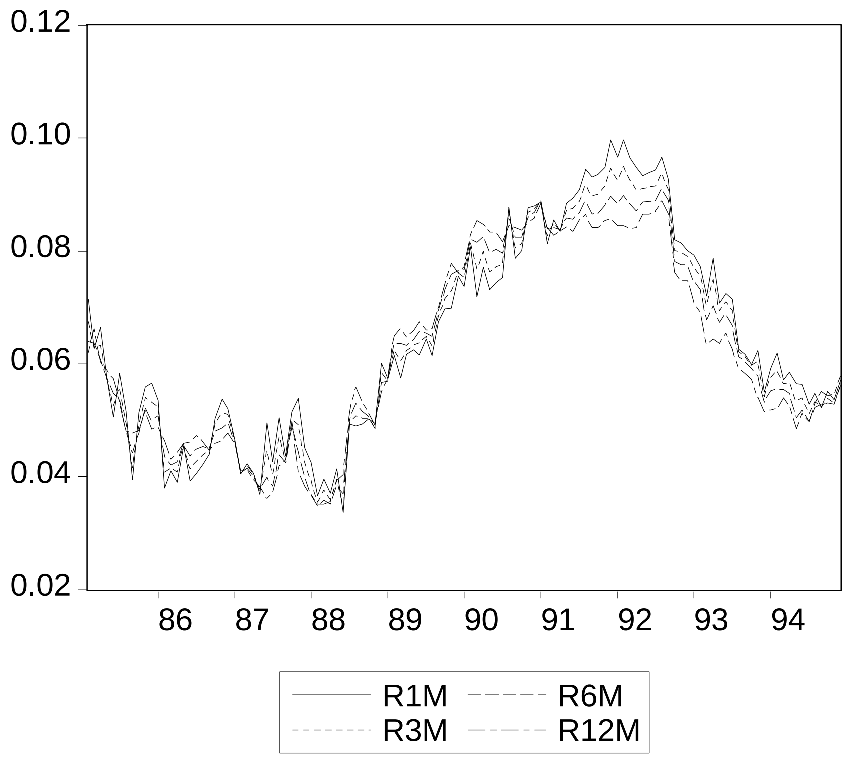

Fig.2 Recursive estimates of the spread coefficients

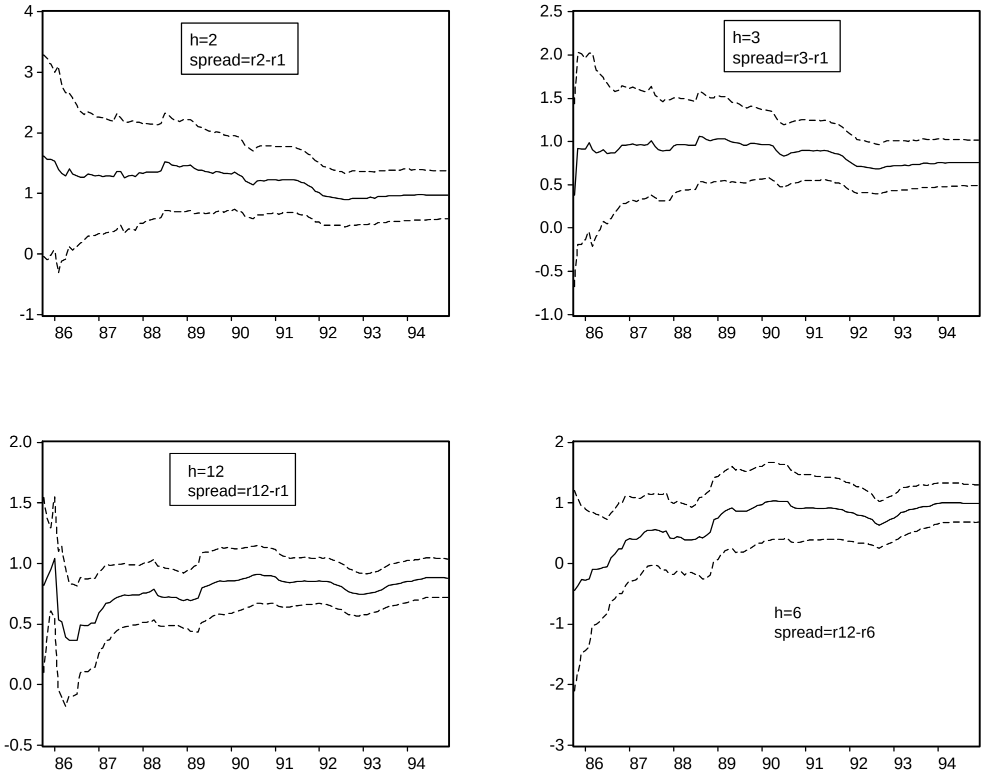

Fig. 3 Recursive estimates of the spread coeffcients