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EXPECTATION ERRORS AND RISK PREMIA IN THE TERM STRUCTURE OF INTEREST RATES

by

Ulf Luthman

http://www.oru.se/esi/wps

SE-701 82 Örebro
SWEDEN

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I INTRODUCTION

A considerable amount of empirical evidence has been presented in understanding the relationship between short- and long term rates. It is concerned with the information content in the term structure of interest rates, in particular, the extent to which the forward interest rates that are implicit in the term structure are predictors of future spot interest rates. Gerlach and Smets (1995) tested the expectations hypothesis (EH) under the assumtion of rational expectations (RE) on Euro-rates from 17 currencies. In the majority of cases they could not reject the EH+RE. One of these countries is Sweden[1]. The U.S. is one of the countries where the EH+RE is rejected. A common feature of other tests of the EH+RE is that the hypothesis is rejected when tested on U.S. data. In Sweden the EH+RE has been tested by Hörngren (1986), Ekdahl and Warne (1990), Dahlquist and Jonsson (1994) and Hördahl (1994). With the exception of Hörngren's study the EH+RE cannot be rejected on Swedish data[2].

In line with other authors who have tested the EH+RE, Froot (1989) performs the standard test[3] of the EH+RE whether the forward premium is an unbiased predictor of future interest rate changes. He deepens previous work by decomposing the forward premium's bias into one component attributable to a risk premium and one component attributable to a systematic expectation error. This makes it possible to measure to what extent a time-varying risk premium and an expectation error contribute to the rejection of the EH+RE. The decomposition of the forward premium's bias into one component attributable to risk premia and one component attributable to systematic expectation errors requires a time series of expected interest rates. In this respect Froot used a survey data set of expected interest rates. In his study the EH+RE is rejected. The reason is a risk premium which is significantly different from zero. The expectation errors are of the same sign as the risk premia making the EH+RE to be rejected.

This study tests the EH during the period January 1986 to December 1997. To avoid the extreme circumstances prevailing in the money market in autumn 1992 we also study the subperiod January 1986 to May 1992. This subperiod covers the time when Sweden applied a fixed exchange rate regime. It might be a good complement to the author's study (Luthman 1998) during the period December 1992 to January 1996 when Sweden applied a flexible exchange rate regime. The way monetary policy is applied differs enormously between fixed- and flexible exchange rate regimes. Without maintaining that the EH is dependent on exchange rate regime it might be an interesting comparison[4]. For the two studied periods we perform the standard test of the EH+RE and decompose the forward premium's bias into one component attributable to the risk premium and one component attributable to the systematic expectation error. Using the standard test makes it possible, directly, to compare the results in this study with the results of tests made by other authors, in the first

[1] The time period is September 1979 to December 1993.
[2] For a more detailed presentation of both foreign and Swedish tests of the EH see Luthman (1998).
[3] By the standard test we mean the test where the forward premium (i.e. the implicit forward rate minus the spot interest rate) plus a constant is regressed on the interest rate differential.
[4] Gerlach and Smets (1997) have tested if there is evidence wheather the EH is rejected less frequently in countries in which monetary policy is conducted using flexible exchange rate targets than in countries using fixed exchange rate targets. Weekly data is used to test the 3, 6 and 12-month eurorates in ten countries. They find it more difficult to reject the EH under fixed exchange rate regimes. Sweden is one of the chosen countries using fixed exchange rate, 1979-1992, where the EH is not rejected.

place Froot, Hörngren and Dahlquist and Jonsson but also tests using data from other countries. However, one problem arises. To decompose the forward premium's bias into the two components we need a time series of interest rate expectations. As this study covers the time when there was no survey data available in Sweden the survey data set must be replaced, in one way or other, by an estimation of future interest rates. There are several ways to produce expectations. With the exceptions of surveying market participants or the general public one possibility is to estimate the future interest rate. This study uses the latter method. Data on interest rates some years backwards are used to estimate the expected interest rate. Particularly, a forecasting equation is used to estimate future expected interest rates. The parameters of this equation are estimated from data preceding the actual studied period, particularly, from January 1983 to December 1985. The parameter estimates from this regression are then applied to estimate future interest rates during the subsequent period, January 1986 to December 1997. Hence, we use an out-of-sample estimation of future interest rates. Out-of-sample forecasts are theoretically more satisfactory than within-sample estimation. It is difficult to judge how exact the estimations of future interest rates measure the "actual" expected interest rates compared to survey data. It is unusual to use survey data. Most economists distrust survey data. They argue that it is hard to accept that a collection of relatively careless verbal responses, can be identified directly with the market expectations.[5] Even if Froot is skeptical to survey data he uses them. He argues that used correctly they can potentially add to the understanding of the behavior of expectations. With this knowledge, the estimation of a future interest rate may be a good proxy for survey data. Moreover, on Swedish data during the relevant period it is the best there is.

The emphasis in this study is an exploratory empirical study of the properties of the term structure of interest rates in the Swedish money market. According to the EH+RE it tests statistically to what extent the forward interest rates that are implicit in the term structure can be used to forecast future interest rates. By using Froot's method and decomposing the bias into the two components we can learn something about their relative importance. For a given forward premium - the smaller the expectation error the greater the role of the risk premium component. The information in the empirical roles of expectation errors and risk premia is important for understanding the composition of the term structure of interest rates. This decomposition of the forward premium into a component attributable to expectation error and a component attributable to risk premium has never been studied on Swedish data before[6]. The decomposition is the extra contribution this paper gives the literature in this field. Hörngren and Dahlquist and Jonsson have both used the standard test to test the EH+RE. However, they do not decompose the forward premium into its two components. In this respect this study goes one step deeper than both Hörngren's and Dahlquist and Jonsson's studies. In other words this paper does not only test the EH+RE it also explains the forward premium according to expectation error and risk premium.

This study has great similarities with Luthman (1998) why we use the same disposition, in applied parts, in the two studies. The paper is organized as follows. The forecasting equation is presented in section II. Section II:1 presents the data set. The regression results from the estimated expected interest rates are performed in section II:2. We present the forecast errors of the estimated future interest rates in section II:3. In section II:4 we answer the question if the estimated future interest rates behave rational. Section III gives the theoretical background material to this study. It contains

[5] In Luthman (1998) further critical arguments about survey data are discussed.
[6] Except in Luthman (1998).

the presentation of the expectations hypothesis including the standard test of the EH+RE. In section III:1 we present the results of testing the EH+RE and make comparisons with results from other studies. Section IV performs the test of the expectations hypothesis with estimated future interest rates. Particulary, section IV:1 performs the decompositon of the forward premium and we also answer the question if the forward premium contains a risk premium and/or an expectation error. In section IV:2 we decompose the β-coefficient and show the empirical results of the decomposition. We also obtain confidence intervals for these point estimates. In section IV:3 we compare the results in this study with the results in other studies where the β-coefficient has been decomposed into an expectation error and a risk premium. The final section, V, gives some concluding comments.

II THE FORECASTING EQUATION

We begin with presenting the forecasting eqaution to estimate future interest rates. These forecasted interest rates are than used to decompose the β-coefficiant into its two components. Froot (1989) himself uses statistical survey data for this estimation. Participants in the financial markets have been asked by a survey institute for his or her expectations on levels of interest rates three- and six months into the future. The survey institute publishes the median of these responses.[7]

In Sweden the first survey data of expected interest rates were published in September 1992. The news agency Direkt asked market participants about their expectations of the six-month T-bill rate three- and six months ahead, and the five-year bond rate three- and six months ahead. Hence, during the time for the data used in this study no survey data are available. To replace survey data we must, in some way or other, estimate the future interest rates. This is something rather unusual. There are many problems in making forecasting equations, but still it is better than doing nothing. In a study of exchange rate expectations Nessén (1994) used an ad hoc model to forecast the future exchange rate. The current value of the exchange rate was regressed not only on its first lag, but also on higher lags, the square and cube of forward premium (and even regime dummies). With all the difficulties in mind we now try to make an equation to forecast future interest rates.

One common feature of forecasting models is that their explanatory powers are impressive in within-sample estimation. However, used out-of-sample their explanatory powers are greatly weakened. The prediction errors are much greater compared to within-sample estimation. In within-sample estimation the relevant model is used to adopt a time-series from the same time period as the estimated future interest rates. We use information about the future to perform our estimated model. Within-sample estimation is often used if one afterwards wants to describe the data. One objection to within-sample estimation is that the standard errors become low making the t-ratios too high. One ought to adjust for the variance. One further objection to using within-sample estimation, in this particular case, has to do with the choice of explanatory variables. If the forward premium, $fp_t^{k,t-k}$[8], is used as one of the regressors (as it is, see below) the method collapses. OLS assumes that the $\varepsilon'_{t+k'}$ - and the $fp_t^{k,t-k}$ components in equation (9) in Luthman (1998) are uncorrelated. If they are uncorrelated the $Cov(u_t^{k,t-k}, fp_t^{k,t-k})$ is zero and b_{ee}=0 in equation (18) in Luthman (1998). This means that only the risk premium can explain the (possible) rejection of the EH+RE. Equation (18) becomes 1-b_{rp}. In out-of-sample forecasts we use the parameter estimates from the model estimated

[7] For a discussion of the doubtfulness about using survey data, see Luthman (1998).
[8] For definition of forward premium see Luthman (1998).

using data from a certain time period. These parameter estimates are then implanted to be used during the subsequent time period. We use the parameter estimates from a model estimated from data during the preceding time period as valid during the subsequent time period. Out-of-sample forecasts are based on available information for the participants. In this respect it is to a greater extent like a real forecasting situation than within-sample estimation. Out-of-sample forecasts are strictly theoretically more attractive than within-sample estimation.

One approach has forecasting models which try to map the stochastic process governing the term structure. With a one-factor model, only one point along the term structure is focused on. This point is either the long-term rate or the short rate. From changes in this rate, estimates are made of changes in rates for other maturities. Multi-factor models often permit a tighter mapping of interest rate behaviour than do single-factor models. With multiple factors, rates along the term structure are related to two or more exogenous forces. If these factors were the long- and short term rates, changes in all rates would be functions of changes in these two rates. One of the better known models of this type is Brennan and Schwartz's two-factor model. In another approach of modeling the term structure, researchers have used branching processes to quantify how a bond's price changes from one period to the next. Among the first to use this method were Ho and Lee. At the outset we know the price of the bond. At maturity, of course, it is worth the known face value. The evolution of bond prices between the start and finish is what is uncertain. We also know the prices with shorter maturities. Prices are depicted for various states in each of the periods. The branching process fans out each period, and any individual path is a series of ups and downs. Depending on the state path taken the model will describe a term structure of interest rates.

In order to meaningfully compare alternative models it would be necessary to reestimate them using a standard data source. This is not practically possible. We do not know which model is "best" on our data. When there is no "best" solution - a piece of good advice is to give priority to simplicity. We use the forward premium ($fp_t^{k,t-k}$) which is implicit in the term structure of interest rates, as an estimate of future interest rates differences. Among the interest rate forecasting models mentioned above we find $fp_t^{k,t-k}$ among the two-factor models, i.e. Brennan and Schwartz's model- where two points on the term structure are focused on. It is often used by the Swedish central bank to judge the market's expected interest rates. Dahlquist and Jonsson (1994) have shown that the EH+RE cannot be rejected. This strengthens the argument that the forward premium is a good forecast of future interest rates. This motivates the use of the forward premium, $fp_t^{k,t-k}$, as our first explanatory variable.

The relevant time period in this study is January 1986 to December 1997. During this period Sweden first applied a fixed- then a flexible exchange rate regime. When Sweden applied the fixed exchange rate the interest rate staircase was the central bank's means to guide the overnight rate, which was the the very shortest interest rate in the market, from one day to the next. The interest rate staircase implied that the bank's costs for borrowing in the central bank increased with increased borrowing at the same time as the bank received lower interest rates with increased lending to the central bank. The object - from the central bank's point of view - was to place the banks on the staircase that smoothed the currency rate flow. The overnight rate then deteremined interest rates with longer maturities - 30, 60 etc days to maturity. In January 1993 when the Swedish central bank recently had left the fixed exchange rate regime in favour of a flexible exchange rate the board of the central bank announced that the target for the monetary policy was a fixed inflation rate. The means to keep the inflation stable is the overnight rate which influences the short money market interest rates. Of course, during periods when the currency flow and expected inflation rate, respectively, were volatile the market expected changed interest rates. During periods when the currency flow (expected inflation rate) was rather stable the market did not expect any change in the interest rate. This means that the bench-mark in forecasting the future interest rate is the interest rate just then prevailing.

The literature in finance provides many examples of models that purport to explain the formation of expectations. There are a great number of hypotheses that appear to be most relevant to the study of interest rates. One of the better known is Cox, Ingersoll and Ross's (CIR) model[9]. They have proposed the following model to estimate the interest rate change

$$dr = a*(b-r)*dt + \sigma*\sqrt{r}*dz$$

where m(r)= a*(b-r) and s(r) = σ, and a, b and σ are constants. The first term on the right hand side is a mean-reverting drift term and the second term is stochastic. The short rate is pulled to a level b at rate a. Superimposed upon this "pull" is a normally distributed stochastic term $\sigma*\sqrt{r}*dz$. In discrete time we rewrite the equation as

$$\Delta r = a*(b-r)*\Delta t + \sigma*\sqrt{r}*\Delta z$$

By definition

$\Delta_{t,1}r^{t-k} = r_{t+1}^{t-k} - r_t^{t-k}$, where r_{t+1}^{t-k} is the interest rate at time t+1 for a τ-k period investment one period in the future. Substituting $\Delta_{t,1}r^{t-k}$ into the first equation we get

$$r_{t+1}^{t-k} - r_t^{t-k} = a*(b- r_t^{t-k}) + \sigma*\sqrt{r_t^{t-k}}*\Delta z$$

If the expected interest rate in the next period is $E_t(r_{t+1}^{t-k})$ and the mean of the stochastic term is zero the equation becomes

$$E_t(r_{t+1}^{t-k}) - r_t^{t-k} = a*(b- r_t^{t-k})$$

or

$$E_t(r_{t+1}^{t-k}) = a*b + (1-a)* r_t^{t-k}$$

Thus the expected interest rate is a function of the interest rate just then prevailing. The literature provides a great number of models that purport to explain the interest rate expectation in terms of the interest rate just then prevailing i.e. variants of the CIR model. Some authors suggest that the expectations are formed by a weighted average of recent past rates, where the weights should decline quite rapidly to give the most influence to the recent observations. Others suggest that the weights represent the difference between two exponentially declining terms. Some other authors suggest an adaptive model, that the error made in forecasting the current period will be used to adjust the old forecast to obtain the current expectation for the next period. Finally, some

[9] This model is an alternative to Visicek's model.

others suggest that the expecations be approximated by a weighted average of several exponentially weighted averages. The common feature of all these expectations models is that they all, like the CIR-model, in one way or other, use the interest rate just then prevailing as one factor explaining the future interest rate.

Hörngren (1986) compares the forecasts of the implicit forward rates and the martingale method, i.e. the interest rate in the next period is equal to the current one-period interest rate. He finds that the implicit forward rate differs very little from the prevailing spot rate.[10] Hörngren concludes that one possible interpretation of this is that agents form their expectations using a martingale method, i.e. normally predict that the spot rate will remain unchanged. In periods when the currency rate flow and expected inflation rate showed little volatility and the overnight rate was stable for quite a long time this might well have been a rational forecast.

The data set from this study applied to a polynomial distributed-lag model reduces to the interest rate with one lag and polynomial one[11]. The results from this forecast are shown in Table 1. The simple regression fits data quite well which is indicated by rather high $\overline{R}^2$ - values. They are 72-, 74-, 48-, and 24- percent for the one-month rate one month ahead (1m1m), two-month rate one month ahead (2m1m), one-month rate two months ahead (1m2m) and three-month rate three months ahead (3m3m), respectively.

These theoretical and empirical studies motivate the interest rate just then prevailing as our second explanatory variable.

As our third explanatory variable we use the currency rate flow (CF). The very shortest interest rate - the overnight rate - was adjusted according to the currency rate flow during the time Sweden applied a fixed exchange rate. When the Swedish central bank observed currency rate inflow (outflow) prevailing for some time they decreased (increased) the overnight rate to balance the currency rate flow. The currency rate flow is announced four times a month. The observation interval of the interest rates in this study is one per month. The currency flow rate is measured as the sum of the four announcements just preceding the interest rate observation. The currency rate flow variable was dropped when Sweden left the fixed exchange rate regime.

There are of course other methods to estimate the future interest rate than those mentioned above. One alternative is an ARIMA model. Models using macro data are of course also possible. Many of those variables are however, measured only quarterly. That would make it difficult to compare the results in this study with the results of Hörngren and Dahlquist and Jonsson, who, as in this study use one observation per month.

The results of the tests of the models depend, naturally, upon the choice of data. This means that those models that are originally estimated and perfected on data from one country under a certain time period do not at all guarantee the same results applied to data from other countries and other time periods.

With these motivations the forecasting model turns out to be

[10] In Luthman (1998) the martingale method for the six-month rate three months ahead (6m3m) also differs very little compared to the forward rate.

[11] This means that the forecasting equation reduces to $r_{t+k}^{t-k} = \alpha_1 + \beta_2 r_t^{t-k} + e_{t+k}$.

(1) $r_{t+k}^{t-k} = \alpha_3 + \beta_3\, r_t^{t-k} + \beta_4\, fp_t^{k,t-k} + \beta_5\, \mathrm{CF}_{t-1} + e'_{t+k}$.

Before we show the regression results of the estimated future interest rates we present our data.

1 The data

The dataset consists of monthly observations of interest rates for the Swedish T-bill market with 1, 2, 3, and 6 months to maturity. The sample period covers the period from January 1986 to December 1997 providing 144 observations in total. We have had access to daily observations. Quotations on the 15th of every month were chosen. When an observation was unavailable because of a holiday, an observation on the previous banking day was chosen. By this way of selecting the sample we try to match the observations with the actual yield to maturity.

To estimate the expected interest rate we use monthly observations of interest rates for Swedish T-bills with 1, 2, 3 and 6 months to maturity. This sample covers the period January 1983 to December 1985 providing 36 observations. The daily observations were chosen in the same way as the observations in the subsequent period.

The interest rates are quoted as annualized simple interest rates. From there we compute continuously compounded interest rates and forward rates[12]. The term structure of interest rates is plotted against time and time to maturity in Figure 1. The yield curve showed a positive (negative) slope during the following time: April 1987-April 1988, Summer 1991, July 1994-August 1995 and the whole 1997 (January 1986-August 1986, spring and summer 1988, summer and autumn 1989, December 1991-May 1992, September 1992-May 1994 and September 1995-December 1996). During periods not mentioned the slope of the yield curve did not show an umambiguous slope during a longer time period. The increased interest rates during 1990 were due to a real interest rate shock. The reunification of Germany implied an increased demand which forced the German interest rates to increase. The high German interest rate position spread over Europe because of the fixed exchange rates in EMS. For Sweden this development implied an extra great strain. The turbulence in the financial markets caused high interest rates during autumn 1992.

The decomposition of the forward premium into an expectation error and a risk premium demands a forecast of the future interest rate. Hence, we turn to the possibilities for how to estimate the future interest rate.

2 Estimating the expected interest rate - regression results

To be able to decompose the forward premium into one component attributable to expectation error and one component attributable to risk premium we need a time series for the expected future interest rate. In our case we estimate the future interest rate with the help of equation (1). Table 2 displays the results of fitting the equation to data from Swedish T-bills during January 1983 to

[12] In the Appendix in Luthman (1998) we show how the continuously compounded interest rates and forward rates are calculated.

December 1985 providing 36 observations. These are the results of the first "window" out of the 144 forecast estimates. The equations turn out to be: (standard errors in parentheses).

(1m1m) $\hat{r}_{t+k}^{t-k} = 0.0108 + 0.941 r_t^{t-k} + 0.896\, fp_t^{k,t-k} - 6*10^{-7}\, CF_{t-1}$ $\bar{R}^2 = 0.73$
(0.0081) (0.0687) (0.3289) ($7*10^{-7}$)

(2m1m) $\hat{r}_{t+k}^{t-k} = 0.0015 + 1.001 r_t^{t-k} + 1.473\, fp_t^{k,t-k} - 7*10^{-7}\, CF_{t-1}$ $\bar{R}^2 = 0.77$
(0.0086) (0.0786) (0.7913) ($7*10^{-7}$)

(1m2m) $\hat{r}_{t+k}^{t-k} = 0.0030 + 1.000 r_t^{t-k} + 1.415\, fp_t^{k,t-k} - 2*10^{-6}\, CF_{t-1}$ $\bar{R}^2 = 0.61$
(0.0129) (0.1139) (0.4784) ($1*10^{-6}$)

(3m3m) $\hat{r}_{t+k}^{t-k} = 0.0308 + 0.771 r_t^{t-k} + 0.955\, fp_t^{k,t-k} - 2*10^{-6}\, CF_{t-1}$ $\bar{R}^2 = 0.33$
(0.0320) (0.2859) (1.1626) ($1*10^{-6}$)

The r_t^{t-k} - variables show strongly significantly values in all four equations. The forward premia, $fp_t^{k,t-k}$, show significant values on the eight percent level except for the three-month rate three months ahead (3m3m). The currency flow variables, CF_{t-1}, are all not significantly different from zero. The coefficients for the interest rates in the previous period and the forward premia both show positive values for all four equations while all four equations show negative coefficients for the currency flow rate. When the currency inflow increases the interest rate decreases. The coefficients for the constant terms are all not significantly different from zero. The $\bar{R}^2$ - values are quite high, 73 percent for the one-month rate one month ahead (1m1m) and decrease with the horizon (1m1m compared to 1m2m). An interest rate in the near future is easier to forecast than an interest rate in the more distant future. The highest $\bar{R}^2$-value shows the two-month rate one month ahead (2m1m), 77 percent. The sample regression fits data well. We test the forecasting equation for serial correlation and heteroscedasticity. The General LM test show that we do not reject the null hypothesis of no autocorrelation for the one-month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m) and the one-month rate two months ahead (1m2m). For the three-month rate three months ahead (3m3m) the null hypothesis of no autocorrelation is, however, rejected. The ARCH test suggests that the variance of the forecast errors is not constant but varies from period to period, that is, there is some kind of autocorrelation in the variance of the forecast errors. Table 2 displays p-values greater than 0.05 for all four equations. This means that we reject autocorrelation in the error variances. The normality assumtion is not rejected except for the three-month rate three months ahead (3m3m).

Table 3 shows the correlation among the dependent variables. They all show low correlation coefficients.

Tables 4 and 5 show the results from the regression equation (1) lagged once and twice, respectively. The regression results from the original forecasting equation (1) - Table 2 - compared to the lagged regression results show whether the equations generate different forecasts. Figure 2 shows - for the one-month rate one month ahead (1m1m) - that the lagged regressions seem to generate less accurate forecasts compared to the original regression. The constant terms are all not significantly different from zero in the original regression - Table 2 - but become significantly different from zero lagged once and twice for the one-month rate one month ahead (1m1m) - Tables 4 and 5. The t-ratios for the interest rate variable, r_t^{t-k}, become less significant for the lagged equations. For the forward premia, $fp_t^{k,t-k}$, the t-ratios become first less with one lag but increase with two lags. The CF-coefficient shows higher t-ratios for the one-month rate one month ahead (1m1m) and the two-month rate one month ahead (2m1m) lagged twice and three times. The $\overline{R}^2$-values are higher for all terms for the original equation compared to the equation lagged once and twice.

3 The forecast errors of the estimated future interest rates

We evaluate the performance of the model using out-of-sample forecasts from January 1986 to December 1997. The out-of-sample forecasts are obtained using data from the beginning of January 1983 and then evaluating the ability of the resulting model to predict future interest rates. We use a rolling one-step ahead method, which means that we estimate one forecast observation ahead, from the parameter estimates in the previous period with start January 1983. For each new forecast observation we drop the oldest observation, which means that all forecasted observations are parameter estimates from the 36 observations just preceding the forecasted observation.

Table 6a displays the forecast rolling out-of-sample one-step-ahead errors from January 1986 to December 1997. The first line of the table presents the mean. All forecast errors are negative and quite high. However, the mean allows positive and negative errors to be offsetting. The root mean square error (RMSE) provides a measure of the average error. The RMSE:s increase with the horizon (1m1m compared to 1m2m). Finally, the mean absolute errors (MAE) also increase with the horizon[13]. The correlations between the actual- and expected one-month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m), the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m) are 0.94, 0.96, 0.84 and 0.86, respectively. In addition to the results displayed in Table 6a we found that the mean forecast errors are significantly different from zero for the one-month rate one month ahead (1m1m) but not significantly different from zero for the other three forecasting equations.
Table 6b shows the forecast errors for the subperiod January 1986 to May 1992. The mean errors are close to zero. The RMSE:s increase with the horizon (1m1m compared to 1m2m) and are much less than during the whole sample period, January 1986 to December 1997, Table 6a. The mean average errors (RMSE:s) and the mean absolute errors (MAE:s) are both much less compared to the whole sample period. A possible explanation is the turbulence in the financial markets during autumn 1992. The correlations between the forecasted- and the actual rates are 0.91, 0.93, 0.86 and 0.81 for the one-month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m), the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m), respectively. For the subperiod, all four equations show mean forecast errors not

[13] To compare the forecast power of the forecasting equation in this study with the forecast power of one other forecasting equation we chose the Brennan and Schwartz two-factor model. (Froot does not test the forecast power of the survey per se). Expectations about interest rates were estimated using December 1958 to December 1979 interest rates and bond price data. Prices for the entire period were predicted on the basis of data estimated over the whole period; prices for the second half of the period were predicted on the basis of data estimated over the first half. The price prediction errors were then tested as predictors of subsequent bond returns. The within-sample estimation for the whole period shows an RMSE of 0.59. We have already mentioned the weakness of comparing results from different times and different countries and differet maturities and horizons.

significantly different from zero.

4 Do the estimated future interest rates behave rational?

The autocorrelations in the forecast rolling out-of-sample errors for the whole sample period, January 1986 to December 1997, are displayed in Table 7a. If these errors show no systematic forecast erros the forecasting equation behaves rationally. To test whether a particular value of the autocorrelations is equal to zero we use Barletts' test. In the case of the one-month rate one month ahead (1m1m) and the two-month rate one month ahead (2m1m), all lags except the first, second and ninth lags show values less than the critical value indicating white noise. For the one-month rate two months ahead (1m2m) only the first lag shows autocorrelation greater than the critical value and for the three-month rate three months ahead (3m3m) the first and second lags show values greater than the critical value. To test the joint hypothesis that all of the autocorrelations are simultaneously equal to zero we use the Q-statistic introduced by Box and Pierce. They show that the statistic $Q = N\sum_{k=1}^{K}\hat{p}_k^2$ is (approximately) distributed as chi-square with K degrees of freedom (lag length) and $\hat{p}$ is the autocorrelation coefficient. In our case the Q-values with 13 lags turn out to be 29.32, 23.17, 16.76 and 41.88 for the one-month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m), the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m), respectively. The critical value in our case is 22.36.[14] The autocorrelation for the one-month rate two months ahead (1m2m) shows smaller value. We cannot reject the null hypothesis that all ρ_k are all zero. For the one-month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m) and the three-month rate three months ahead (3m3m) we reject the null hypothesis that all autocorrelations are all zero. Taken together we can summarize that the forecasts one-month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m) and the one-month rate two months ahead (1m2m) are close to behaving rationally on 95 percent significant level while the three-month rate three months ahead (3m3m) is not close to behaving rationally.

We now turn to evaluate the autocorrelations in the forecast rolling out-of sample one-step-ahead equation for the subperiod January 1986 to May 1992. These autocorrelations are displayed in Table 7b. We first test if a particular value of the autocorrelation is equal to zero. The one-month rate one month ahead (1m1m) and the two-month rate one month ahead (2m1m) both show values less than the critical value. For the one-month rate two months ahead (1m2m) lags one, five and six are higher than the critical value. Finally, lag one is higher than the critical value for the three-month rate three months ahead (3m3m). We also test the joint hypothesis that all autocorrelation coefficients simultaneously are equal to zero. With 13 lags the Q-statistic becomes 0.57, 8.86, 21.02 and 26.03 for the one month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m), one-month rate two months ahead (1m2m) and three-month rate three months ahead (3m3m), respectively. The critical chi-square value, on the 95 percent level, is 22.36.[15] Only the

[14] With 20 lags the Q-values are 32.18, 26.88, 20.45 and 49.21 for the one-month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m), the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m), respectively. In this case the critical value is 31.41.

[15] Computed with 19 lags the Q-statistic becomes 12.71, 14.55, 30.72 and 28.41 for the one-month rate one month ahead (1m1m), the two-month rate one month ahead (2m1m), one-month rate two months ahead (1m2m)

autocorrelation forecast errors for the three-month rate three months ahead (3m3m) show a Q-statistic greater than the critical value. In this case one can reject the null hypothesis that all ρ_k are all zero. For the other three equations we cannot reject the null hypothesis that all autocorrelation coefficients are all zero. To summarize, the out-of-sample forecasts behave rationally except the one-month rate two months ahead (1m2m) and three-month rate three months ahead (3m3m) forecasts which are close to behaving rationally.

The time series of the expected future interest rates give us the possibility to decompose the β-coefficient into one component attributable to expectation error and one component attributable to risk premium. Before doing that we first turn to the standard regression which is shown in the next section.

III THE STANDARD REGRESSION OR TESTS OF THE EXPECTATIONS HYPOTHESIS WITHOUT A DIRECT MEASURE OF EXPECTATIONS

In Luthman (1998) we distinguished between different forms of the EH. We also derived how these different forms could be tested by running the following time-series regression:

(2) $$r_{t+k}^{t-k} = \alpha_{12} + \beta_{12} f_t^{k,t-k} + \varepsilon_{t+k}$$

where $f_t^{k,t-k}$ is the implicit forward rate[16] at time t for an investment from the settlement date k to the maturity date τ and r_{t+k}^{t-k} is the actual future interest rate. Rational expectations (RE) and risk neutrality taken together imply that the implicit forward rate is an unbiased predictor of the future spot rate (EH+RE). This means that under the null hypothesis α_{12}= 0 and β_{12}=1, $\varepsilon_{t+k}= r_{t+k}^{t-k} - E_t(r_{t+k}^{t-k})$, i.e. the residual term reflects purely random "news". Note that equation (2) concerns the relation between the levels of the implicit forward rate and the future spot rate. The spot rates often show signs of mean non-stationarity (in our case see Table 8). This is why this version of the test of the EH+RE is not commonly used in the literature (se Shiller 1990). To give regression (2) stationarity Fama (1984), Shiller (1990), Dahlquist and Jonsson (1994) and others therefore rewrite it as

(3) $$r_{t+k}^{t-k} - r_t^{t-k} = \alpha_{13} + \beta_{13}(f_t^{k,t-k} - r_t^{t-k}) + \varepsilon'_{t+k},$$

The subsequent change in the spot rate is regressed on the forward premium, $fp_t^{k,t-k}$, which is defined as

(4) $$fp_t^{k,t-k} \equiv f_t^{k,t-k} - r_t^{t-k}$$

The interest rate differentials used in his study appear to be stationary according to Table 8. It is therefore legitimate to estimate equation (3) using OLS.

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and three-month rate three months ahead (3m3m), respectively. In this case the critical chi-square value, on the 95 percent level, is 30.14.

[16] In Luthman (1998) we show, in the Appendix, how the implicit forward rate is calculated.

The expectations hypothesis is a joint hypothesis of rational expectations and risk neutrality (EH+RE). The hypothesis implies that the intercept term is equal to zero, $\alpha_{13} = 0$, and the coefficient for the forward premium is equal to one, $\beta_{13}=1$. The no risk premium means that the forward premium is equal to the subsequent change in the spot rate. The rational expectations assumption implies that the market's expectations are made rationally. This means that the forecast error is on average zero and uncorrelated with information at time t.

If the coefficient of the forward premium is significantly different from zero it means that the forward premium is correlated with the interest rate. In the case where the coefficient of the forward premium is significantly different from one it depends either on an expectation error or a premium that is correlated with the level of the interest rate. In this case the EH does not hold. If the coefficient of the forward premium is greater than one it means that the forward premium is negative when long forward rates are higher than short ones, but less than one if the convert is valid. In the case where the coefficient of the intercept term is significantly different from zero it depends either on a systematic error or a constant risk premium or both. Finally, if the coefficient of the intercept term is significantly different from zero and the coefficient of the forward premium is equal to one there is a constant risk premium or a systematic error or both. In the two latter cases the EH holds.

In this study we use equation (3) to test the EH+RE. In the literature it is the most frequently used model (see Shiller 1990)[17]. It is used by Froot (1989), Hörngren (1986) and Dahlquist and Jonsson (1994). With this model it is possible to make comparisons with results from other studies, particularly Froot's decomposition of the forward premium and other Swedish tests of the EH+RE.

1 The predictive power of forward premia: regression results

The results from fitting equation (3) to data from the Swedish T-bill market during January 1986 to December 1997 are to be found in Table 9a. The chi-square tests show that we cannot reject the joint hypothesis that $\alpha_{13}=0$ and $\beta_{13}=1$. This means that the EH+RE cannot be rejected. The coefficients for the forward premia are all much greater than one and significantly different from zero on five percent significance level. So, the forward premia contain information about future interest rate movements. The slope coefficients - on the seven percent level - are all significantly different from one except the one-month rate one month ahead (1m1m). The constant terms are all not significantly different from zero. This means that the EH is rejected for the two-month rate one month ahead (2m1m), the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m) but not rejected for the one-month rate one month ahead (1m1m). The $\overline{R}^2$-values decrease with the horizon (1m1m compared to 1m2m). This is in line with what one would expect, that forecasts into the near future would be more accurate than forecasts into the more distant future. Since the t tests require that the error terms follow the normal distribution, we test the four equations with the Kolmogorov-Smirnov test for normality. We do not reject (reject) the normality assumtion for the one-month rate one month ahead (1m1m) and the two-month rate one month ahead (2m1m) (the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m)).

[17] For a more complete set of univariate regression tests of the expectations hypothesis, see Froot (1987).

In Table 9b the results from the estimation of equation (3) during the subperiod January 1986 to May 1992 are displayed. The chi-square tests show high p-values. The joint hypothesis that $\alpha_{13}=0$ and $\beta_{13}=1$ cannot be rejected. So, even during this subperiod the EH+RE cannot be rejected for any of the four regressions. The coefficiants for the forward premia are extremly close to one and significantly different from zero. The constant terms are all not significantly different from zero. This means that the EH cannot be rejected. The $\overline{R}^2$ - value for the one-month rate two months ahead (1m2m) is less than the corresponding value for the one-month rate one month ahead (1m1m). This means that the forecast into the near furture is more accurate than forecasts into the more distant future. As in the case for the whole sample period the normality is not rejected (rejected) for the one-month rate one month ahead (1m1m) and the two-month rate one month ahead (2m1m) (the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m)).

The results from performing the joint test of the EH+RE during the whole sample period, January 1986 to December 1997, and the subperiod, January 1986 to May 1992, in this study, give the same results - no rejection of EH+RE - as in Luthman (1998). It would be tautology to once more make closer foreign- and Swedish comparisons with these results. What is the reason for the no rejection of the EH+RE? To answer that question we need to decompose the β_{13}-coefficient into one component attributable to an expectation error and one component attributable to a risk premium. In the next section we follow the discusson how to derive the decomposition of the forward premium and the β-coefficient.

IV TESTING THE EXPECTATIONS HYPOTHESIS WITH ESTIMATED FUTURE INTEREST RATES

1 Decomposition of the forward premium

Even if we in our case cannot reject the EH+RE it is still interesting to make the decomposition of the forward premium into an expectation error and a risk premium. Theoretically, a possible result could be that both the expectation error and the risk premium are significantly different from zero but with different signs and offset each other making the EH+RE not to be rejected. Figures 3a-d show the expected- and the actual interest rates for the different maturities and horizons. The forecast interest rates move both above and below the actual interest rates. The forecast errors seem to be greatest for the longest horizons - one-month rate two months ahead (1m2m) and three-month rate three months ahead (3m3m).

From Froot's (1989) analysis, the risk premium, $rp_t^{k,t-k}$, is obtained from equation (12), in Luthman (1998), when $fp_t^{k,t-k}$ and $E_t(\Delta_{t,k} r^{t-k})$ are both observable. The time series for the risk premia are shown in Figures 4a-d together with the expected interest rate differential, $E_t(\Delta_{t,k} r^{t-k})$, which is derived from successive out-of-sample forcasts. The reason for the variances[18] of the forward premia become obvious if the variances are decomposed. The decomposition is shown in Luthman (1998).

We begin the analysis of the variances with the whole sample period, January 1986 to December

[18] The idea to discuss the variances comes from Nessén (1994).

1997. The variances of $E_t(\Delta_{t,k} r^{t-k})$ are relatively high compared to the variances of the forward premia, $fp_t^{k,t-k}$. This is confirmed in Figures 4a-d and Tables 10 and 11 which contain the variances and correlations, respectively, of all series involved in the computations. The variances of the risk premia, $rp_t^{k,t-k}$, are higher than the variances of the forward premia, $fp_t^{k,t-k}$, (one exception is the two-month rate one month ahead (2m1m)). This means that there is instability in the forecasts, which are less reliable. In this case the expectations are volatile at the same time $fp_t^{k,t-k}$ is relatively stable and $rp_t^{k,t-k}$ fluctuates in the opposite direction to $E_t(\Delta_{t,k} r^{t-k})$. This indicates that the EH does not hold. The variances of the expected interest differential, $E_t(\Delta_{t,k} r^{t-k})$, seem to be two or three times greater than the variances of the risk premia, $rp_t^{k,t-k}$ and the negative correlation is strong. It is surprising that the covariance between $rp_t^{k,t-k}$ and $E_t(\Delta_{t,k} r^{t-k})$ decreases with the horizon (1m1m compared to 1m2m) which gives smaller forecast errors. Equation (12), in Luthman (1998), reveals that if the variance in the risk premium is higher (lower) than the variance in the forward premium the covariance between $rp_t^{k,t-k}$ and $E_t(\Delta_{t,k} r^{t-k})$ must be negative (positive) since the variance in $E_t(\Delta_{t,k} r^{t-k})$ is greater than the variance in $rp_t^{k,t-k}$ (otherwise the variance in $fp_t^{k,t-k}$ cannot be small). This is confirmed in Table 11 and Figures 4a-d. The variances of the forward premia, $fp_t^{k,t-k}$, are much lower than the variances of the interest rate differentials, $\Delta_{t,k} r^{t-k}$. This is particulary true for the one-month rate one month ahead (1m1m) and the one-month rate two months ahead (1m2m). So the forward premia do not keep up with the interest rate differentials.

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From equation (13), in Luthman (1998), we receive the expectation error, $u_t^{k,t-k}$. It is the difference between the actual interest rate differential, $\Delta_{t,k} r^{t-k}$, and the expected interest rate differential, $E_t(\Delta_{t,k} r^{t-k})$. Figures 5a-d display these variables. The interest rates differentials, $\Delta_{t,k} r^{t-k}$, are smaller than the expectation errors, $u_t^{k,t-k}$, and the expected interest rate differentials, $E_t(\Delta_{t,k} r^{t-k})$, particularly during 1987-1989 and 1993-1994. Table 10 shows that the variances in the $u_t^{k,t-k}$:s are much greater than the variances in the $fp_t^{k,t-k}$:s (an exception is the two-month rate one month ahead (2m1m)). This indicates that RE does not hold.

We now turn to analyse the subperiod, January 1986 to May 1992. A closer look at the variances and covariances, Tables 12 and 13, paint a somewhat a different picture. All variables now show much lower variances than during the whole sample period, January 1986 to December 1997. The reason might be the turbulence in the financial markets during autumn 1992. It is confirmed from Figures 4a-d that the variances of the expected interest rate diffrentials, $E_t(\Delta_{t,k} r^{t-k})$, are relatively high compared to the variances of the forward premia, $fp_t^{k,t-k}$, except for the two-month rate one month ahead (2m1m). This is confirmed in Table 12. The variances of the risk premia, $rp_t^{k,t-k}$, are much smaller (greater) than the variances of the forward premia, $fp_t^{k,t-k}$, for the one-month rate one month ahead (1m1m) and the two-month rate one month ahead (2m1m) (for the one-month rate two months ahead (2m1m) and the three-month rate three months ahead (3m3m)), which gives stability (instability) in the forecasts. This indicates that the EH might hold. In line with the whole sample period the variances of the risk premia, $rp_t^{k,t-k}$, are much smaller than the variances of the expected interest rate differentials, $E_t(\Delta_{t,k}r^{t-k})$. They show high negative correlation according to Table 13. The negative correlation between $rp_t^{k,t-k}$ and $E_t(\Delta_{t,k}r^{t-k})$ are, however, smaller than during the whole sample period, January 1986 to December 1997. Contrary to the results from the whole sample period the correlation between $rp_t^{k,t-k}$ and $E_t(\Delta_{t,k}r^{t-k})$ increases with the horizon (1m1m compare to 1m2m). This gives greater forecast errors. In line with the results from the whole sample period the subperiod shows lower variances in the forward premia, $fp_t^{k,t-k}$, compared to the variances in the interest rate differentials, $\Delta_{t,k}r^{t-k}$. The differential is greatest for the three-month rate three months ahead (3m3m). This means that the $fp_t^{k,t-k}$:s do not keep up with the $\Delta_{t,k}r^{t-k}$:s.

Figures 5a-d show the expectation error, $u_t^{k,t-k}$, the actual interest rate differential, $\Delta_{t,k}r^{t-k}$, and the expected interest rate differential, $E_t(\Delta_{t,k}r^{t-k})$. As indicated in Tables 10 and 12 the variances in the of the $u_t^{k,t-k}$:s and the $fp_t^{k,t-k}$:s are smaller during the subperiod compared to the whole sample period. The correlation between the $u_t^{k,t-k}$:s and the $fp_t^{k,t-k}$:s are about the same between the two periods. This indicates that RE might hold.

To summarize, the above analysis of the of the $rp_t^{k,t-k}$:s and $u_t^{k,t-k}$:s, for the whole sample period January 1986 to December 1997, suggests that neither RE nor EH hold. For the subperiod January 1986 to May 1992 the analysis suggests that both RE and EH might hold. However, Tables 9a,b tell that EH+RE cannot be rejected. To investigate this we decompose the β-coefficient into its two components one measuring the forecast error and one the risk premium.

2 Decomposition of the b-coefficient and empirical results of the decomposition

Given that we may decompose $fp_t^{k,t-k}$ we can also decompose the β-coefficient into an expecation error, b_{ee}, and a risk premium, b_{rp}, according to equation (18) in Luthman (1998). The empirical results of this decomposotion is dispalyed in Table 14a for the whole sample period, January 1986 to December 1997. b_{ee} is positive and b_{rp} is negative for all four equations. The risk premium is the major factor in explaining why the forward premia are not exactly equal to one. This is true for all forward premia. It is also seen in Figures 6a-d. The motivation to do the decomposition of the forward premium into expectation error and risk premium in spite of the fact that we cannot reject the EH+RE seems to be valid.

The results for the subperiod, January 1986 to May 1992, are displayed in Table 14b. As in the case with the whole sample period all b_{ee}:s are positive and all b_{rp}:s are negative. The major factor in explaining why the forward premium are unequal to one is the expectation error for the one-month rate one month ahead (1m1m) and the one-month rate two months ahead (2m1m). The risk premium component is the major factor in explaining why the forward premium is not equal to one for the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m).

We can test wheather b_{rp} in Tables 14a and 14b are significantly different from zero by running the regression

(5) $rp_t^{k,t-k} = \alpha_{14} + \beta_{14}\, fp_t^{k,t-k} + e'_{t'}$

We proceed in the same way to test whether $b_{ee}=0$ by running the regression

(6) $u_t^{k,t-k} = \alpha_{15} + \beta_{15}\, fp_t^{k,t-k} + e''_{t''}$

In Luthman (1998) we showed the decomposition of $\hat{b}_{14}$ and $\hat{b}_{15}$.

Table 15a displays the results from running equations (5) and (6) for the whole sample period, January 1986 to December 1997. They tell us firstly that all time-varying risk premia are negative and significantly different from zero on the twelve percent level. Secondly, the constant risk premia are all positive and significantly different from zero on the nine percent level. So we have both a constant- and a time-varying risk premium. This means that the PEH, the EH and the LHP are all rejected. The conclusion from running regression (6) is that the negative β_{15} is not significantly different from zero for any of the four regressions. This means that the expectational component, b_{ee}, is not significantly different from zero. The not significant expectation error is, however, great enough to make the sum of the risk premium and the expectation error not reject the joint test of EH+RE.

We now turn to analyse the results from running regressions (5) and (6) during the subperiod January 1986 to May 1992. These results are displayed in Table 15b. The regressions tell us that the two-month rate one month ahead (2m1m) contains a positive significant constant and a negative significant time-varying risk premium while the expectation error is negative and not significantly different from zero. This means that the PEH, the EH and the LHP do not hold. The one-month rate one month ahead (1m1m) shows a positive constant term which is significantly different from zero while both the negative time-varying risk premium and the positive expectation error are not significantly different from zero. This means that the EH, but not the PEH holds. For the one-month rate two months ahead (1m2m) and the three month-rate three months ahead (3m3m) the constant terms, the time-varying risk premia as well as the expectation errors are not significantly different from zero. For the later investments the PEH holds. The figures for the one-month rate one month ahead (1m1m) compared to the one-month rate two months ahead (1m2m) tell that the LHP does not hold. The positive expectation errors are, however, great enough to make the sum of the negative risk premium and expectation error in all four eqautions not reject the joint test of EH+RE.

3 Comparison with Froot's results and other studies where the b-coefficient has been decomposed into an expectation error and a risk premium

The results in this study are compared more carefully to four other tests of the EH where survey data[19] is used to decompose the β-coefficient into an expectation error and a risk premium. They are: Luthman (1998), Froot's own study (1989), Bachelor (1990) and MacDonald/Macmillan (1994). The results from these decompositions are displayed in Table 16. The common feature from these studies is that all show positive and significant time-varying risk premia. This means that the EH does not hold. The expectation errors are all positive (an exception is Luthman (1998)) and not

[19] For a more detailed presentation of the different survey data sets, see Luthman (1998).

significantly different from zero. This means that RE holds.

The results in this study, for the whole sample period, January 1986 to December 1997, also shows significant risk premia (an exception is the one-month rate one month ahead (1m1m)). This means that the EH does not hold. In line with the results in Table 16 the expectation errors are all not significantly diffe rent from zero, which means that RE holds. There is one important difference between the results in this study and the results in Table 16. In this study the expectation errors and the risk premia are of different signs making the sum of these variables not reject EH+RE. In Table 16 the expectation errors and the risk permia are both positive (an exception is Luthman (1988) where the expectation errors are negative).

The results in Table 16 compared to the results in this study for the subperiod, January 1986 to May 1992, shows two similarities. First, in this study only the risk premium for the two-month rate one month ahead (2m1m) is significantly different from zero. Second, the expectation errors are all positive and not significantly different from zero. The differences between the results displayed in Table 16 and the results in this study during the subperiod are: First, in this study all risk premia (expectation errors) are negative (positive). Second, the risk premia for the one-month rate one month ahead (1m1m), the one-month rate two months ahead (1m2m) and the three-month rate three months ahead (3m3m) are not significantly different from zero. The results in Luthman (1998) and the results in this study during the subperiod both show expectation errors and risk premia with differnt signs. In this study (Luthman(1998)) the expectation errors are positive (negative) and the risk premia are negative (positive). This makes the joint test of EH+RE not to be rejected.

V SUMMARY AND CONCLUSIONS

Our purpose in this paper is to go beyond standard tests of the expectations hypothesis of the term structure of interest rates in the short end of the Swedish term structure. To be able to compare the results in this study with the results in other studies we perform the standard test of the EH+RE. According to Froot (1989) we decompose the forward premium into one component attributable to the expectation error and one component attributable to the risk premium. Froot's method demands an estimation of the future interest rate. Froot himself uses survey data. Owing to lack of survey data in Sweden of future interest rates during the relevant period we use a forecast model to predict the future interest rates.
Our major findings are summarized.

a) We confirm earlier findings on Swedish data that the expectations hypothesis (EH+RE) cannot be rejected in the short end of the term structure. This is consistent with Dalquist and Jonsson (1994), Ekdahl and Warne (1990) and Hördahl (1994) but in contrast to Hörngren (1986). However, the latter used data from the early eighties when the financial markets in Sweden were undeveloped and highly regulated. The results are even in contrast to almost
all tests of the EH+RE applied to U.S. data, which with a few exceptions all reject it.

b) The decomposition of the β-coefficient into two components one attributable to an expectation error and one attributable to a risk premium, during the whole sample period, January 1986 to December 1997, shows that the component assigned to the expectation error (risk premium) is positive (negative) for all maturities and horizons. In absolute values the risk premia are all greater than the expectation errors. All risk premia are significantly different from zero (1m1m on the twelve percent level). This means that the EH is rejected. The negative risk premia are offset by the positive expectation errors making the joint test of EH+RE not to be rejected.

c) The results from the subperiod, January 1986 to May 1992, paint a somewhat different picture. All expectation errors are negative and not significantly different from zero. The risk premia are positive and not significantly different from zero except for the two-month rate one month ahead (2m1m). The positive expectation errors are not great enought to make the sum of the risk premia and expectation errors reject the joint hypothesis of EH+RE. In the case of the two-month rate one month ahead (2m1m) there is a time-varying risk premium making the EH to be rejected. For the other three interest rates and maturities the EH is not rejected.

d) The author's earlier study, December 1992 to January 1996, used surveyed interest rates as forecasts of future interest rates instead of econometrically estimated interest rates used in this study. In line with the results in this study during the whole sample period, January 1986 to December 1997, the results in the two studies are quite similar with one exception. In this study the expectation errors (risk premia) are positive (negative) while they are negative (positive) in the study with surveyed interest rates. Both studies show significant risk premia (1m1m in this study on the twelve percent level) and not significant expectation errors which makes the EH to be rejected.

e) The results from the survey study compared to the results in this study, using data for the subperiod, January 1986 to January 1992, display somewhat different results. Only the risk premium for the two-month rate one month ahead (2m1m), in this study, is significantly different from zero while both risk premia in the survey study show significant values. The two studies display different signs for the expectation errors and the risk premia which offset each other making the joint test of EH+RE not to be rejected.

f) The results in this study are in contrast to the results in three foreign studies which used survey data to test the EH. Froot (1989), Bachelor (1990) and MacDonald/Macmillan (1994) all reject the joint hypothesis of EH+RE. The positive risk premia significantly explain the deviation from the EH while the positive expectation errors do not show significant values. The EH is rejected.

g) This study has shown that the EH+RE cannot be rejected. It gives the actors in the money market a good method for forecasting future interest rates in the short end of the term structure.

FIGURES AND TABLES

Figure 1: The term structure of interest rates. Interest rates against time and time to maturity.

Table 1: Results from estimating regression: $r_{t+k}^{t-k} = \alpha_1 + \beta_1 r_t^{t-k} + e_{t+k}$. The period is January 1983-December 1985. Newey and West (1989) standard errors are given in parentheses. The standard errors are corrected for overlapping observations.

	1m1m	2m1m	1m2m	3m3m
Constant	0.0196	0.0178	0.0377	0.0598
Standard error	(0.0084)	(0.0080)	(0.0128)	(0.0181)
t: α_1=0	2.3335	2.2555	2.9600	3.3035
r_t^{t-k}	0.8495	0.8593	0.7037	0.5143
Standard error	(0.0707)	(0.0658)	(0.1036)	(0.1528)
t: β_1=0	12.0107	13.0570	6.7916	3.3655

$\overline{R}^2$	0.7198	0.7447	0.4842	0.2423
LM test	0.0615	0.4158	9.6219	23.3718
p-value	0.8041	0.5190	0.0019	$1*10^{-6}$
Q test	14.9912	13.7945	24.8222	42.5169
p-value	0.0912	0.1298	0.0032	$3*10^{-6}$
ARCH test	0.6761	0.3057	3.0184	15.5181
p-value	0.4109	0.5804	0.0823	$8*10^{-5}$
Number of observations	36	36	36	36

Table 2: Regression results from estimating the expected interest rate with equation (1): $r_{t+k}^{t-k} = \alpha_3 + \beta_3\, r_t^{t-k} + \beta_4\, fp_t^{k,t-k} + \beta_5\, CF_{t-1} + e'_{t+k}$. The period is January 1983-December 1985. To construct standard errors, we use the covariance matrix suggested by Newey and West (1989) to handle serial correlation and heteroscedasticity of unknown form. The standard errors are corrected for overlapping observations.

	1m1m	2m1m	1m2m	3m3m
Constant	0.0108	0.0015	0.0030	0.0308
Standard error	0.0081	0.0086	0.0129	0.0320
t: $\alpha_3 = 0$	1.3343	0.1769	0.2329	0.9629
β_3	0.9407	1.0011	0.9995	0.7712

Standard error	0.0687	0.0786	0.1139	0.2859
t: $\beta_3 = 0$	13.6912	12.7442	8.7721	2.6972
β_4	0.8962	1.4725	1.4148	0.9549
Standard error	0.3289	0.7913	0.4784	1.1626
t: $\beta_4 = 0$	2.7245	1.8609	2.9570	0.8214
β_5	$-6*10^{-7}$	$-7*10^{-7}$	$-2*10^{-6}$	$-2*10^{-6}$
Standard error	$7*10^{-7}$	$7*10^{-7}$	$1*10^{-6}$	$1*10^{-6}$
t: $\beta_5 = 0$	0.9397	0.9833	1.6184	1.7166
$\overline{R}^2$	0.7339	0.7698	0.6125	0.3298
LM test	0.4446	0.2760	2.6487	16.1576
p-value	0.5050	0.5993	0.1036	$6*10^{-5}$
Q test	12.4807	10.9929	16.4337	20.9567
p-value	0.1310	0.2021	0.0366	0.0073
ARCH test	0.4549	0.3395	2.2819	1.9020
p-value	0.5000	0.5601	0.1309	0.1679
Kolmogorov-Smirnov test				
Maximum gap[20]	0.1352	0.1466	0.2270	0.4183
Number of observations	35	35	35	35

Table 3: Correlations of series in equation (1). January 1983 to December 1985.

	1m1m	2m1m	1m2m	3m3m
r_t^{t-k} - $fp_t^{k,t-k}$	-0.2247	-0.2297	-0.3330	-0.4696
r_t^{t-k} - CF_{t-1}	0.1505	0.1704	0.1505	0.1951
$fp_t^{k,t-k}$ - CF_{t-1}	0.1092	0.2028	0.2028	-0.2378

Table 4 : Regression results from estimating the expected interest rate with equation (1) lagged once: $r_{t+k}^{t-k} = \alpha_6 + \beta_6\, r_{t-1}^{t-k} + \beta_7\, fp_{t-1}^{k,t-k} + \beta_8 CF_{t-2} + \in_{t+k}$. The period is January 1983-December 1985.

[20] Rejection limits are: 1 percent: 0.3327, 5 percent: 0.2776 and 10 percent: 0.2490.

To construct standard errors, we use the covariance matrix suggested by Newey and West (1989) to handle serial correlation and heteroscedasticity of unknown form. The standard errors are corrected for overlapping observations.

	1m1m	2m1m	1m2m	3m3m
Constant	0.0262	0.0183	0.0116	0.0429
Standard error	0.0112	0.0126	0.0203	0.0331
t: $\alpha_6 = 0$	2.3386	1.4498	0.5733	1.2971
β_6	0.8167	0.8629	0.9361	0.6926
Standard error	0.0942	0.1128	0.1740	0.2959
t: $\beta_6 = 0$	8.6659	7.6488	5.3806	2.3406
β_7	0.8708	1.4325	1.9846	1.5955
Standard error	0.4507	1.0519	0.7540	1.1798
t: $\beta_7 = 0$	1.9322	1.3618	2.6323	1.3523
β_8	$-3*10^{-6}$	$-3*10^{-6}$	$-2*10^{-6}$	$-1*10^{-6}$
Standard error	$1*10^{-6}$	$1*10^{-6}$	$1*10^{-6}$	$1*10^{-6}$
t: $\beta_8 = 0$	2.2524	2.4210	1.2457	0.6349
$\overline{R}^2$	0.5672	0.5906	0.4492	0.1378
Number of observations	34	34	34	34

Table 5 : Regression results from estimating the expected interest rate with equation (1) lagged twice: $r_{t+k}^{t-k} = \alpha_9 + \beta_9 \, r_{t-2}^{t-k} + \beta_{10} \, fp_{t-2}^{k,t-k} + \beta_{11} \, CF_{t-3} + \in_{t+k}^{'}$. The period is January 1983-December 1985. To construct standard errors, we use the covariance matrix suggested by Newey and West (1989) to handle serial correlation and heteroscedasticity of unknown form. The standard errors are corrected for overlapping observations.

	1m1m	2m1m	1m2m	3m3m
Constant	0.0373	0.0164	0.0184	0.0615
Standard error	0.0141	0.0183	0.0211	0.0347
t: $\alpha_9 = 0$	2.6529	0.8982	0.8726	1.7737

β_9	0.7579	0.8987	0.9021	0.5500
Standard error	0.1173	0.1602	0.1805	0.3046
t: $\beta_9 = 0$	6.4630	5.6089	4.9977	1.8059
β_{10}	1.9780	3.9279	3.1664	1.7456
Standard error	0.5723	1.4153	1.0110	1.0378
t: $\beta_{10}= 0$	3.4564	2.7753	3.1350	1.6820
β_{11}	$-3*10^{-6}$	$-1*10^{-6}$	$-5*10^{-8}$	$-2*10^{-7}$
Standard error	$1*10^{-6}$	$1*10^{-6}$	$2*10^{-6}$	$2*10^{-6}$
t: $\beta_{11}= 0$	1.8977	1.0181	0.0301	0.0750
$\overline{R}^2$	0.4969	0.4875	0.3774	0.0168
Number of observations	33	33	33	33

Table 6a: Out-of-sample forecast errors - rolling regressions one-step ahead - from January 1986 to December 1997.

	1m1m	2m1m	1m2m	3m3m
Mean	-0.0020	-0.0013	-0.0017	-0.0020

RMSE[21]	0.0101	0.0079	0.0174	0.0152
MAE[22]	0.0059	0.0048	0.0088	0.0092
Number of observations	143	143	142	141

Table 6b: Out-of-sample forecast errors - rolling regressions one-step ahead - from January 1986 to May 1992.

	1m1m	2m1m	1m2m	3m3m
Mean	-0.0001	$-3*10^{-5}$	0.00026	0.0003
RMSE	0.0070	0.0060	0.0086	0.0095
MAE	0.0047	0.0042	0.0068	0.0077
Number of observations	77	77	77	77

Table 7a: Autocorrelation coefficients in the forecast errors based on out-of-sample forecasts - rolling regressions one-step ahead - from January 1986 to December 1997.

	1m1m	2m1m	1m2m	3m3m
Lag	$\hat{r}_k$	$\hat{r}_k$	$\hat{r}_k$	$\hat{r}_k$

[21] The root mean square error (RMSE) is computed as $RMSE = \sqrt{\frac{1}{N}\sum(\hat{x}_i - x_i)^2}$, where $\hat{x}_i$ is the predicted value, x_i is the actual, and N is the number of periods.

[22] Similarly, the mean absolute error (MAE) is defined as $MAE = \frac{1}{N}\sum|\hat{x}_i - x_i|$.

1	0.191	0.233	0.281	0.459
2	0.168	0.193	0.135	0.220
3	0.074	0.082	0.018	0.143
4	0.080	0.020	0.017	0.035
5	0.159	0.069	-0.037	0.021
6	-0.009	-0.015	0.036	0.006
7	0.141	0.076	0.029	0.069
8	0.088	0.023	0.043	0.032
9	0.255	0.199	0.063	0.043
10	0.064	0.008	-0.019	-0.038
11	-0.066	-0.001	-0.069	-0.062
12	-0.026	-0.104	-0.090	-0.026
13	-0.016	-0.031	0.021	-0.055
14	0.111	0.085	-0.051	-0.072
15	-0.027	-0.015	-0.059	-0.007
16	0.020	0.093	0.048	0.116
17	0.112	0.116	0.126	0.128
18	-0.075	-0.022	0.006	0.081
19	-0.028	-0.011	0.018	0.105
20	-0.085	0.024	0.039	0.069
Number of observations	143	143	142	141

Table 7b: Autocorrelation coefficients in the forecast errors based on out-of-sample forecasts - rolling regressions one-step ahead - from January 1986 to May 1992.

Lag	1m1m $\hat{r}_k$	2m1m $\hat{r}_k$	1m2m $\hat{r}_k$	3m3m $\hat{r}_k$

1	0.082	0.127	0.373	0.502
2	0.016	0.059	-0.033	0.173
3	-0.126	-0.100	0.051	-0.053
4	-0.081	-0.066	-0.001	-0.020
5	0.006	-0.110	-0.231	-0.073
6	-0.166	-0.162	-0.239	0.082
7	-0.007	-0.023	0.011	0.156
8	-0.009	-0.039	-0.008	0.110
9	0.039	0.051	-0.088	0.099
10	0.014	-0.027	0.027	0.071
11	-0.136	-0.006	0.094	0.029
12	-0.002	-0.052	-0.059	-0.043
13	-0.062	-0.016	-0.010	-0.012
14	0.203	0.162	0.167	0.022
15	0.097	0.103	0.073	0.055
16	-0.036	-0.048	0.010	0.053
17	0.124	0.065	0.103	0.047
18	-0.059	-0.046	0.007	-0.056
19	-0.124	-0.171	-0.192	-0.143
Number of observations	77	77	77	77

Tabell 8: Dickey-Fuller (DF) unit-root-rest. The time is January 1986 to December 1997 and the subperiod January 1986 to May 1992. *, **, ***, significant at ten, five and two percent level, respecetively. The Augmented Dickey-Fuller (ADF) test has one lagged dependant variable included in the estimated equatio n. January 1986-December 1997.

		r_t^{t-k}	r_{t+k}^{t-k} - r_t^{t-k}	$f_t^{k,t-k}$	$f_t^{k,t-k}$ - r_t^{t-k}	CF_{t-1}
Jan 86-Dec 97						
	DF					-7.1110***
1m1m	DF	-2.0573	-15.203***	-2.9269*	-13.346***	
	ADF			-16.451***		
2m1m	DF	-1.6106	-14.294***	-2.5540	-8.7143***	
	ADF			-16.005***		
1m2m	DF	-3.7640***	-9.3794***	-2.4110	-1.7143	
	ADF	-17.026***		-16.498***		
3m3m	DF	-2.8898*	-7.8007***	-2.8898*	-7.3587***	
	ADF	-16.161***		-13.779***		
Jan 86-May 92						
	DF					-9.307***
1m1m	DF	-2.491	-10.179***	-1.897	-12.196***	
	ADF					
2m1m	DF	-1.985	-8.329***	-1.547	-8.190***	
	ADF			-6.856***		
1m2m	DF	-2.510	-6.064***	-1.815	-8.190***	
	ADF					
3m3m	DF	-1.667	-4.140***	-1.745	-4.214***	
	ADF	-7.250***	-6.961***			

Table 9a: Results from estimating regression (3), r_{t+k}^{t-k} - r_t^{t-k} = $\alpha_{13} + \beta_{13}(f_t^{k,t-k} - r_t^{t-k}) + \varepsilon'_{t+k}$.
The period is January 1986-December 1997. To construct standard errors, we use the covariance

matrix estimator suggested by Newey and West (1989) to handle serial correlation and heteroscedasticity of unknown form. The standard errors are corrected for overlapping observations.

	1m1m	2m1m	1m2m	3m3m
Constant	0.0008	0.0008	0.0017	0.0008
Standard error	(0.0008)	(0.0007)	(0.0017)	(0.0019)
t: α_{13}=0	0.9893	1.1331	1.0297	0.4171
β_{13}	1.5690	1.9601	1.4353	1.7472
Standard error	(0.5075)	(0.4378)	(0.2334)	(0.3460)
t: β_{13}=0	3.0917	4.4770	6.1489	5.0491
t: β_{13}=1	1.1212	2.1951	1.8650	2.1595
Chi-square test:				
α_{13}=0 and β_{13}=1	1.9954	5.0700	4.1763	4.7816
p-value	0.3687	0.0793	0.1239	0.0916
$\overline{R}^2$	0.4281	0.5448	0.3733	0.4067
DW	2.2580	2.0670	1.5683	1.0359
Q test	33.79	31.29	36.10	92.77
p-value	0.5262	0.6477	0.4170	$4*10^{-7}$
White's test	34.91	13.12	0.9696	1.8807
p-value	$3*10^{-8}$	0.0014	0.6158	0.3905
Kolmogorov-Smirnov test				
Maximum gap[23]	0.1148	0.0927	0.1406	0.3614
Number of observations	143	143	142	141

[23] Rejection limits are: 1 percent: 0.1664, 5 percent: 0.1388 and 10 percent: 0.1245.

Table 9b: Results from estimating regression (3), $r_{t+k}^{t-k} - r_t^{t-k} = \alpha_{13} + \beta_{13}(f_t^{k,t-k} - r_t^{t-k}) + \varepsilon'_{t+k}$.
The period is January 1986-May 1992. To construct standard errors, we use the covariance matrix estimator suggested by Newey and West (1989) to handle serial correlation and heteroscedasticity of unknown form. The standard errors are corrected for overlapping observations.

	1m1m	2m1m	1m2m	3m3m
Constant	0.0011	0.0008	0.0016	0.0011
Standard error	0.0009	0.0008	0.0015	0.0018
t: α_{13}=0	1.2328	1.0213	1.0413	0.6064
β_{13}	0.9908	0.9911	1.0724	1.0030
Standard error	0.1074	0.1883	0.1734	0.3408
t: β_{13}=0	9.2234	5.2628	6.1856	2.9433
t: β_{13}=1	0.0857	0.0473	0.4175	0.0088
Chi-square test:				
α_{13}=0 and β_{13}=1	1.7207	1.2585	1.1955	0.3690
p-value	0.4230	0.5330	0.5500	0.8315
$\bar{R}^2$	0.3837	0.1862	0.3040	0.1289
DW	1.7386	1.5594	0.9587	0.6783
Q test	22.85	26.67	56.74	62.27
p-value	0.2441	0.0899	$1*10^{-5}$	$2*10^{-6}$
White's test	0.7487	1.4849	3.0386	5.3735
p-value	0.6877	0.4760	0.2189	0.0681
Kolmogorov-Smirnov test				
Maximum gap[24]	0.1369	0.1937	0.3753	0.5137
Number of observations	77	77	77	77

[24] Rejection limits are: 1 percent: 0.2253, 5 percent: 0.1963 and 10 percent: 0.1761.

Table 10: Variances of series. January 1986-December 1997.

	1m1m	2m1m	1m2m	3m3m
$fp_t^{k,t-k}$	0.0065	0.0145	0.0145	0.0143
$E_t(\Delta_{t,k} r^{t-k})$	0.0249	0.0181	0.0427	0.0417
$rp_t^{k,t-k}$	0.0111	0.0074	0.0147	0.0180
$u_t^{k,t-k}$	0.0147	0.0090	0.0432	0.0328
$\Delta_{t,k} r^{t-k}$	0.0359	0.0247	0.0764	0.0599

Table 11: Correlation of series one-month rate one month ahead (1m1m), two-month rate one month ahead (2m1m), one-month rate two months ahead (1m2m) and three-month rate three months ahead (3m3m). January 1986-December 1997.

1m1m	$fp_t^{k,t-k}$	$E_t(\Delta_{t,k} r^{t-k})$	$rp_t^{k,t-k}$	$u_t^{k,t-k}$
$E_t(\Delta_{t,k} r^{t-k})$	0.8241	-	-	-
$rp_t^{k,t-k}$	-0.4933	-0.8993	-	-
$u_t^{k,t-k}$	-0.0464	-0.0861	0.0963	-
$\Delta_{t,k} r^{t-k}$	0.6574	0.7790	-0.6886	0.5577
2m1m				
$E_t(\Delta_{t,k} r^{t-k})$	0.9071	-	-	-
$rp_t^{k,t-k}$	-0.7433	-0.9558	-	-
$u_t^{k,t-k}$	-0.0655	-0.0942	0.1039	-
$\Delta_{t,k} r^{t-k}$	0.7403	0.8029	-0.7591	0.5178
1m2m				
$E_t(\Delta_{t,k} r^{t-k})$	0.8783	-	-	-
$rp_t^{k,t-k}$	-0.5388	-0.8760	-	-
$u_t^{k,t-k}$	-0.0564	-0.1078	0.1330	-
$\Delta_{t,k} r^{t-k}$	0.6146	0.6672	-0.5555	0.6686
3m3m				
$E_t(\Delta_{t,k} r^{t-k})$	0.8794	-	-	-
$rp_t^{k,t-k}$	-0.6792	-0.9467	-	-
$u_t^{k,t-k}$	-0.1280	-0.1949	0.2139	-
$\Delta_{t,k} r^{t-k}$	0.6410	0.6926	-0.6341	0.5725

Table 12: Variances of series. January 1986-May 1992.

	1m1m	2m1m	1m2m	3m3m
$fp_t^{k,t-k}$	0.0032	0.0036	0.0036	0.0016
$E_t(\Delta_{t,k} r^{t-k})$	0.0038	0.0018	0.0085	0.0059
$rp_t^{k,t-k}$	0.0007	0.0006	0.0039	0.0037
$u_t^{k,t-k}$	0.0038	0.0027	0.0057	0.0060
$\Delta_{t,k} r^{t-k}$	0.0075	0.0042	0.0123	0.0110

Table 13: Correlation of series one-month rate one month ahead (1m1m), two-month rate one month ahead (2m1m), one-month rate two months ahead (1m2m) and three-month rate three months ahead (3m3m). January 1986-May 1992.

1m1m	$fp_t^{k,t-k}$	$E_t(\Delta_{t,k} r^{t-k})$	$rp_t^{k,t-k}$	$u_t^{k,t-k}$
$E_t(\Delta_{t,k} r^{t-k})$	0.9189	-	-	-
$rp_t^{k,t-k}$	-0.0719	-0.4596	-	-
$u_t^{k,t-k}$	-0.0367	-0.0068	-0.0653	-
$\Delta_{t,k} r^{t-k}$	0.6259	0.7047	-0.3724	0.7047
2m1m				
$E_t(\Delta_{t,k} r^{t-k})$	0.8315	-	-	-
$rp_t^{k,t-k}$	-0.2589	-0.7519	-	-
$u_t^{k,t-k}$	-0.1254	-0.0832	-0.0041	-
$\Delta_{t,k} r^{t-k}$	0.4437	0.5885	-0.4966	0.7567
1m2m				
$E_t(\Delta_{t,k} r^{t-k})$	0.7534	-	-	-
$rp_t^{k,t-k}$	-0.1853	-0.7857	-	-
$u_t^{k,t-k}$	-0.0951	-0.1358	0.1134	-
$\Delta_{t,k} r^{t-k}$	0.5596	0.7362	-0.5738	0.5705
3m3m				
$E_t(\Delta_{t,k} r^{t-k})$	0.6337	-	-	-
$rp_t^{k,t-k}$	-0.1597	-0.8648	-	-
$u_t^{k,t-k}$	-0.1140	-0.1482	0.1151	-
$\Delta_{t,k} r^{t-k}$	0.3746	0.6163	-0.5434	0.6875

Table 14a: Components of the possible failure of the expectations hypothesis. The underlined figures indicate the greatest absolute value for each term. January 1986-December 1997.

Term	Deviations from rational expectations b_{ee} $-\frac{Cov(u_t^{k,t-k}, fp_t^{k,t-k})}{Var(fp_t^{k,t-k})}$	Existance of risk premia b_{rp} $\frac{Cov(rp_t^{k,t-k}, fp_t^{k,t-k})}{Var(fp_t^{t-k})}$	Regression-coefficients $=1 - b_{ee} - b_{rp}$
1m1m	0.0700	-0.6362	1.57
	(not significant)	(not significant)	
2m1m	0.1039	-1.0606	1.96
	(not significant)	(significant)	
1m2m	0.0987	-0.5300	1.43
	(not significant)	(significant)	
3m3m	0.2565	-0.9932	1.74
	(not significant)	(significant)	

Table 14b: Components of the possible failure of the expectations hypothesis. The underlined figures indicate the greatest absolute value for each term. January 1986-May 1992.

Term	Deviations from rational expectations b_{ee} $-\frac{Cov(u_t^{k,t-k}, fp_t^{k,t-k})}{Var(fp_t^{k,t-k})}$	Existance of risk premia b_{rp} $\frac{Cov(rp_t^{k,t-k}, fp_t^{k,t-k})}{Var(fp_t^{t-k})}$	Regressio n-coefficients $=1 - b_{ee} - b_{rp}$
1m1m	0.0412	-0.0320	0.99
	(not significant)	(not significant)	
2m1m	0.2271	-0.2182	0.99
	(not significant)	(significant)	
1m2m	0.1245	-0.1969	1.07
	(not significant)	(not significant)	
3m3m	0.2431	-0.2461	1.00
	(not significant)	(not significant)	

Table15a: Results from fitting equation (5) and (6) to data. Newey and West (1989) standard errors are given in parentheses. The standard errors are corrected for overlapping observations. January 1986-December 1997.

	1m1m	2m1m	1m2m	3m3m
α_{14}	0.0029	0.0022	0.0036	0.0029
Standard error	(0.0011)	(0.0006)	(0.0014)	(0.0017)
t: $\alpha_{14} = 0$	2.6835	3.5944	2.6226	1.7262
β_{14}	-0.6362	-1.0606	-0.5300	-0.9932
Standard error	(0.4049)	(0.2713)	(0.1225)	(0.2108)
t: $\beta_{14} = 0$	1.5711	3.9089	4.3352	4.7105
β_{15}	-0.0700	-0.1039	-0.0987	-0.2565
Standard error	(0.0870)	(0.1779)	(0.1171)	(0.2512)
t: $\beta_{15} = 0$	0.8022	0.5839	0.8436	1.0211

Table15b: Results from fitting equation (5) and (6) to data. Newey and West (1989) standard errors are given in parentheses. The standard errors are corrected for overlapping observations. January 1986-May 1992.

	1m1m	2m1m	1m2m	3m3m
α_{14}	0.0013	0.0010	0.0016	0.0010
Standard error	(0.0004)	(0.0004)	(0.0009)	(0.0010)
t: $\alpha_{14}= 0$	3.0932	2.7913	1.6428	1.0198
β_{14}	-0.0320	-0.2182	-0.1969	-0.2461
Standard error	(0.0606)	(0.0968)	(0.1316)	(0.1869)
t: $\beta_{14} = 0$	0.5272	2.2548	1.4963	1.3169
β_{15}	-0.0412	-0.2271	-0.1245	-0.2431
Standard error	(0.0957)	(0.1373)	(0.1103)	(0.2333)
t: $\beta_{15} = 0$	0.4303	1.6539	1.1283	1.0418

Table 16: Components of the possible failure of the expectations hypothesis in Luthman (1998), Froot's study on U.S. data during the time 1969-1986, Batchelor's study on U.S. data during October 1982-March 1987 and MacDonald/Macmillan's study on UK data during October 1989-October 1992. The underlined figure indicates the greatest absolute premium for each term.

Author	Term	Deviations from rational expetations b_{ee} $-\frac{Cov(u_t^{k,t-k}, fp_t^{k,t-k})}{Var(fp_t^{k,t-k})}$	Existence of risk premia b_{rp} $\frac{Cov(rp_t^{k,t-k}, fp_t^{k,t-k})}{Var(fp_t^{t-k})}$	Regression-coefficients $= 1 - b_{ee} - b_{rp}$
Luthman (1998)	6m3m T-bills	-0.1794 (not significant)	0.2663 (significant)	0.91
Luthman (1998)	6m6m T-bills	-0.2183 (not significant)	0.3323 (significant)	0.89
Froot	3m3m T-bills	0.338 (not significant)	0.602 (significant)	0.059
Froot	3m3m Euro-dollar	0.016 (not significant)	0.557 (significant)	0.427
Bachelor	3m1m T-bills	0.6413 (not significant)	0.3994 (significant)	-0.041
MacD/Macm	3m3m Interbank rate	0.1147 (not significant)	0.5846 (significant)	0.268

Figure 2: Forecasted interest rates from equation (1) with different lags.

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Figure 3a: Actual- and expected interest rates. The one-month rate one month ahead (1m1m). January 1986-December 1997.

Figure 3b: Actual- and expected interest rates. Two-month rate one month ahead (2m1m). January 1986-December 1997.

Figure 3c: Actual- and expected interest rates. One-month rate two months ahead (1m2m). January 1986-December 1997.

Figure 3d: Actual- and expected interest rates. Three-month rate three months ahead (3m3m). January 1986-December 1997.

Figure 4a: Forward premium, risk premium and expected interest rate differential. One- month rate one month ahead (1m1m). January 1986-December 1997.

Figure 4b: Forward premium, risk premium and expected interest rate differential. Two-month rate one month ahead (2m1m). January 1986-December 1997.

Figure 4c: Forward premium, risk premium and expected interest rate differential. One- month two months ahead (1m2m). January 1986-December 1997.

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Figure 4d: Forward premium, risk premium and expected interest rate differential. Three-month rate three months ahead (3m3m). January 1986-December 1997.

Figure 5a: Actual- and expected interest rate differential and expectation error. One-month rate one month ahead (1m1m). January 1986-December 1997.

Figure 5b: Actual- and expected interest rate differential and expectation error.
Two-month rate one month ahead (2m1m). January 1986-December 1997.

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Figure 5c: Actual- and expected interest rate differential and expectation error.
One-month rate two months ahead (1m2m). January 1986-December 1997.

Figure 5d: Actual- and expected interest rate differential and expectation error. Three-month rate three months ahead (3m3m). January 1986-December 1997.

Figure 6a: Risk premium and expectation error. One-month rate one month ahead (1m1m). January 1986-December 1997.

Figure 6b: Risk premium and expectation error. Two-month rate one month ahead (2m1m). January 1986-December 1997.

Figure 6c: Risk premium and expectation error. One-month rate two months ahead (1m2m). January 1986-December 1997.

Figure 6d: Risk premium and expectation error. Three-month rate three months ahead (3m3m). January 1986-December 1997.

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