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Keskusteluaiheita - Discussion papers

No. 334

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THE TERM STRUCTURE AND INTEREST RATES IN THE FINNISH MONEY MARKETS - THE FIRST THREE YEARS

ISSN 0781-6847 17.08.1990

MURTO, Risto, THE TERM STRUCTURE AND INTEREST RATES IN THE FINNISH MONEY MARKETS. Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 1990, 27 p. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; no. 334).

ABSTRACT: The aim of the paper is to investigate empirically the determination of the term structure of interest rates in the Finnish money markets. The expectations theory is tested using HELIBOR-interest rates in the period 1987 - 1989. In spite of its simple structure, the pure expectations theory fits the Finnish money market data reasonably well. The results, however, probably underestimate the market's ability to forecast future short-term movements in interest rates, because at the same time there was some predictability in so-called excess returns.
We also examine the reaction of interest rates and the term structure to changes in the banks' call money market position.

KEY WORDS: call money window, expectations theory, risk premium

1. INTRODUCTION

The aim of this study is to investigate empirically the determination of the term structure of interest rates in the Finnish money markets. We are also interested in the information content of the term structure. The term structure of interest rates has been of great interest to financial economists over the last several decades. In spite of the extensive work done in the last few decades, some of the most recent studies have still been able to find some interesting new facts about the term structure.

For example, Fama (1984) noticed that the forward rates incorporated in the term structure can help predict the spot rate one month ahead. After that it has become clear that the term structure helps predict both the so called excess returns on money market instruments and the changes in the spot rate. Campbell (1987) have found that the term structure can even help to predict other assets' excess returns as well.

In Finland we have been able to study these issues with true money market data only just recently, because the markets matured in the beginning of the 1987, relative late internationally speaking. Early studies must rely on the relative illiquid bond market data or so-called euromarkka rates. The importance of these issues has also grow with the importance of market determined interest rates.

Special interest is place on the connection between banks' daily call money position movements and the term structure. The money markets differ from other sectors of the financial markets in the respect that the price behaviour depends heavily on banks and the central bank. This is true especially concerning the movements in the so-called over night rates, which are clearly linked to the banks liquidity positions vis-a-vis the central bank.

The organization of the paper is as follows. In the next section we discuss the expectations theory and the possibility of the time-varying risk premium. In the third section we derive the equations that will be estimated and present the data. The data set will consists the HELIBOR-rates. The fourth section presents the empirical results from the Finnish money markets. In the fifth section we concentrate on the liquidity and the term structure. The last section summarizes the principal conclusions.

2. THE EXPECTATIONS THEORY AND THE TIME-VARYING RISK PREMIUM

The term structure is a very basic concept in the financial markets. It measures the relative returns on assets that are very close substitutes: they only differ with respect to the maturity. It is natural that the long and extensive work on this topic has produced diverse versions of the expectations theory. The expectations theory in its purest form is nevertheless intuitively very clear, which is perhaps one of the reasons why it has been so popular.

All the various forms of the expectations theory are based on the comparison of the returns from different investment strategies in the money and the bond markets.[1] One of the basic alternatives is to compare the returns from short-term investments, which must be rolled over, to the return from securities, whose maturities corresponds the desired investment horizon. In that case we can derive so-called linearized expectations theory, which states that the long-term interest rate is the average of current and future short term rates:

$$(1) \quad R(t, T) = (1/N) \left((r(t, t+1) + E_t\, r(t+1, t+2) + \dots + E_t\, r(t+(N-1), T) \right) + E_t\, \Phi(t) ,$$

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[1] We are concentraiting on the pure discount notes so we need not to take into consideration the complications that arise when using data from coupon bonds.

where $R(t, T)$ = long-term interest rate at time t,
$r(t, t + 1)$ = short-term interest rate,
$\Phi(t)$ = the risk premium and
E_t = expectation operator conditional on the information set at time t.

Equation (1) is quite informative because it reveals immediately the assumptions one must make in order to make the equation testable. In empirical work expectations theory inevitably incorporates joint hypotheses regarding assumptions about formation of the expectations and possible intertemporal behavior of the risk premium.

Nowadays the standard approach to treat expectations is to use rational expectations hypothesis, which states that agents will not make systematic forecasting errors (see however Shiller, Campbell and Schoenholtz (1983) and Mankiw and Summers (1984)). There is not such a strong standard on how to deal with possible risk premium. One often used possibility is to treat the risk premium as a constant, which also makes the estimation straightforward. A special case of this is the restriction that the risk premium is zero, which corresponds to the so-called pure expectations theory. According the pure expectations theory the slope of the term structure reflects only the expectations of the future interest rate movements.

When $E_t\ \Phi(t)$ is time-varying, the situation is different.The changes in the term structure reflect both the changes in the expected values of the interest rates and changes in the required risk premium. In this case, the equation (1) is no longer testable without an explicit model for the time-varying risk premium. Some of these models are referred to later. To keep the terminology compact, we will hereafter restrict the concept expectation theory to correspond to situations where the risk premium is constant or zero.

A few years ago it seemed that the extent to which term structure can help to forecast future movements in interest rates or future relative returns was very low. For example, pure expectations theory have been rejected many times before the 1980's (see for example Jones and Roley (1983) and references therein). The most recent studies, e.g Fama (1984), Fama and Bliss (1987) and Hardouvelis (1988), have however changed the picture. In these studies, they have found that the term structure is capable of forecasting future interest rates. Fama and Bliss report that the predictability of the interest rates is the most evident over the long horizon, i.e. over a period of at least one year. On the other hand, Hardouvelis found that the term structure is capable to forecast interest rate over the very short horizon, i.e over a period of one to 24 weeks.

The information content of the term structure dos not seems to been restricted to treasury bills and bonds. Campbell (1987) demonstrated that the state of the term structure of interest rates also predicts stock returns. Fama (1990) reports that the slope of the term structure can help to predict future inflation rates. Harvey (1988) have found that the term structure can compete successfully with the commercial econometric models in forecasting changes in the U.S. personal consumption.

The demonstrated predictability of the asset returns gives us in principle two possibilities: either there is a time-varying risk premium or the markets are inefficient. Most of the studies have interpreted these results as possible implications from time-varying risk premium. The modern asset pricing models, such as CCAPM by Breeden (1979), suggest that the risk premium, $E_t\ \Phi(t)$ should be time varying. The empirical work utilizing Euler equations and estimating parameters using various moments restrictions implied by a model has not, however, been able to produce positive evidence in favor of these models.

Another approach, due to Mehra and Prescott (1985), is to compare the statistical properties of different asset prices to those generated by a theoretical model. This is known as a model calibration. The results have been quite negative here too: the models with the reasonable parameter values do not generate the same kind of statistical moments as have been observed. Backus, Gregory and Zin (1989) try to generate U.S. Treasury market risk premiums with a monetary version of the Mehra-Prescott model. They conclude that the theory can explain neither the variability, the magnitude, nor even the sign of risk premiums observed at the short end of the term structure of interest rates !

3 DATA AND REGRESSION EQUATIONS

3.1 Regression equations

The starting point in this empirical analysis will be a version of equation (1) where we have assumed that expectations are formed according to the rational expectations hypothesis and the possible risk premium is constant. In that case we can easily derive intuitively clear forecasting equations for interest rates.

In the case of two short-term interest rate we can rewrite equation (1) as:

$$(2)\qquad R(t, T) = (1/2)\,((r(t, t+1) + r(t+1, T)) + \Phi + u(t),$$

where $R(t, T)$ = long-term interest rate,
$r(t, t+1)$ = short-term interest rate and
$u(t)$ = error term.

Equation (2) can easily be written as:

$$(3)\qquad r(t+1, T) - r(t, t+1) = -2\Phi + 2\,(R(t, T) - r(t, t+1)) + u(t).$$

Equation (3) links the changes in the future interest rate to the shape of the term structure $(R(t, T) - r(t, t+1))$. The testable regression equation is:

$$(4) \quad r(t + 1, T) - r(t, t + 1) = \alpha + ß (R(t, T) - r(t, t + 1)) + u(t).$$

In the other words, according to equations (3) and (4) the difference between the long- and short-term interest rates forecast the future movements in the short-term rates. In the empirical part we also test the pure expectations theory implied by the resrictions $\alpha = 0$ and $ß = 2$. According to the null hypothesis, there is no constant risk premium. We will investigate equation (4) with one- and three-months, six- and three-months and six- and twelwe-months interest rate pairs.

In the case three short-term interest rates equation (3) can be rewritten as:

$$(5) \quad r(t + 2, T) + r(t + 1, t + 2) - 2 r(t, t + 1) = -3\Phi + 3 (R(t, T) - r(t, t + 1)) + u(t).$$

The left side of equations (5) and (6) can interpreted as two changes in short-term interest rates $(r(t + 1, t + 2) - r(t, t + 1))$ and $(r(t + 2, T) - r(t, t + 1))$. The slope of the term structure now forecasts the next two period's interest rate movements. In the case of the pure expectations theory we get the restrictions as $\alpha = 0$ and $ß = 3$. We will investigate equation (5) with one- and three-months, two- and six-months and three- and nine-months interest rate pairs.

In the above equations we have made the assumption that $E_t \Phi(t) = \Phi$. If the risk premium is time-varying, the regression will produce biased estimates of the term structure coefficients. This can explain even negative slope coefficient estimates. However, if the variance of the $E_t \Phi(t)$ is dimishing in relation to the variance of the expected change in the interest rate, the estimate of the slope coefficient will converge to the theoretical value implied by the expectations theory.

The time-varying risk premium can produce noise to the term structure slope variables and so the regression results can underestimate the markets ability to predict future interest rates. In order to investigate the possible time-varying risk premium we follow the approach of Fama (1984) and many others. We calculate the ex post excess returns from different investment opportunities (so-called term premiums by Fama's terminology). After that we select some instrumental variables, which were observable when the investment decisions were made. If these instrumental variables are able to predict ex post excess returns, this can be tell us about possible time-varying risk premium in the Finnish money markets. Naturally the predictibility of the excess returns can also be explained by market inefficiency.

A problem regarding this kind of approach is that the theory is not really guiding what ex ante instruments to use to forecast the term premium. Here we are interested in the information content of the term structure so it is natural to restrict our attention to the term structure variables. In testing the expectations theory we are interested in how the term structure can help to predict future interest rate movements. Here we are interested how the term structure can help to predict future excess returns.

3.2 The Data

The data is from the Finnish money markets, which did not emerge until the beginning of 1987. The most liquid security in the money market are certificates of deposits (CDs) issued by banks and the Bank of Finland. The empirical work in the study is based on HELIBOR-rates. The Bank of Finland calculates daily HELIBOR-rates (Helsinki Interbank Offer Rates) for 1, 2, 3, 6, 9 and 12 month maturities as the average bid rate for the bank's CDs quoted by the five large banks. All rates and investments returns in the estimation are presented as annualized compounded percent returns.

The banks' CDs are not homogenous instruments per se issued only by a sole party, such as Treasury notes. Since the number of issuers has been limited, because of the small number of banks in Finnish money markets, the CDs have been nevertheless quite homogenous. The market participants also treat these banks very creditworthy so CDs have been the basic instruments in the Finnish money markets. The difference between rates for the treasury bills and the banks' CDs have been negliable.

Figure 1. Helibor-rates

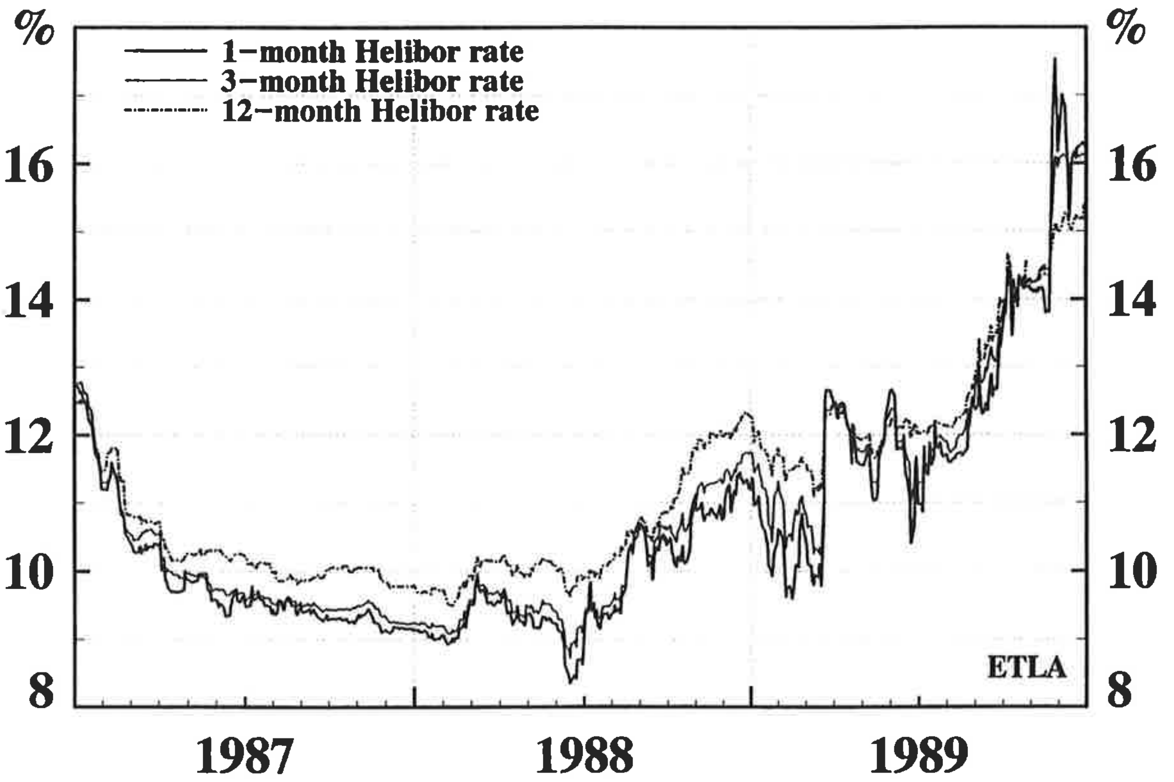


Table 1. Summary statistics for interest rates, yield differentials and changes in interest rates in the period 1987 - 1989

				Autocorrelation coefficients									
Variable	Obs.	Mean	Std.	1	2	3	4	5	6	7	8	9	10
1. Interest Rates													
r(0, 1)	155	11.18	1.84	0.92	0.85	0.79	0.71	0.69	0.66	0.63	0.60	0.56	0.52
r(0, 2)	155	11.23	1.80	0.94	0.88	0.82	0.76	0.73	0.69	0.66	0.63	0.59	0.56
r(0, 3)	146	10.98	1.33	0.93	0.86	0.80	0.75	0.70	0.69	0.62	0.58	0.55	0.52
r(0, 6)	146	11.00	1.28	0.93	0.88	0.83	0.79	0.75	0.71	0.67	0.64	0.62	0.59
r(0, 12)	133	10.76	0.92	0.95	0.91	0.87	0.84	0.81	0.77	0.73	0.69	0.67	0.64
2. Yield differentials													
r(0, 2) - r(0, 1)	155	0.05	0.16	0.38	0.09	0.17	0.10	0.09	0.08	0.08	0.03	0.06	-0.01
r(0, 12) - r(0, 3)	150	0.10	0.20	0.63	0.41	0.29	0.20	0.15	0.13	0.19	0.05	0.01	-0.04
r(0, 6) - r(0, 3)	146	0.02	0.13	0.63	0.47	0.32	0.29	0.27	0.25	0.28	0.19	0.12	0.08
r(0, 12) - r(0, 6)	133	- 0.02	0.18	0.76	0.59	0.49	0.39	0.28	0.24	0.23	0.20	0.21	0.18
r(0, 6) - r(0, 2)	141	0.07	0.20	0.72	0.45	0.33	0.25	0.23	0.25	0.25	0.13	0.04	-0.01
r(0, 9) - r(0, 3)	133	0.06	0.22	0.74	0.53	0.43	0.32	0.24	0.20	0.20	0.13	0.10	0.05
3. Changes in interest rates													
r(1, 2) - r(0, 1)	155	0.11	0.89	0.70	0.43	0.21	0.00	0.00	0.10	0.16	0.15	0.12	0.03
r(3, 6) - r(0, 3)	146	0.42	1.25	0.91	0.82	0.73	0.65	0.58	0.52	0.47	0.40	0.34	0.27
r(6, 12) - r(0, 6)	133	0.71	1.46	0.93	0.86	0.79	0.74	0.69	0.63	0.58	0.53	0.49	0.44
r(2,3) - r(1,2) - 2r(0,1)	150	0.42	1.91	0.83	0.66	0.53	0.44	0.38	0.34	0.25	0.13	0.07	0.05
r(4,6) - r(2,4) - 2r(0,2)	141	0.69	2.31	0.90	0.78	0.70	0.62	0.55	0.47	0.39	0.30	0.24	0.20
r(6,9) - r(3,6) - 2r(0,3)	133	0.94	2.49	0.91	0.80	0.71	0.63	0.57	0.51	0.46	0.42	0.38	0.33

Table 2. Summary statistics for holding period returns and term premiums in the period 1987 - 1989

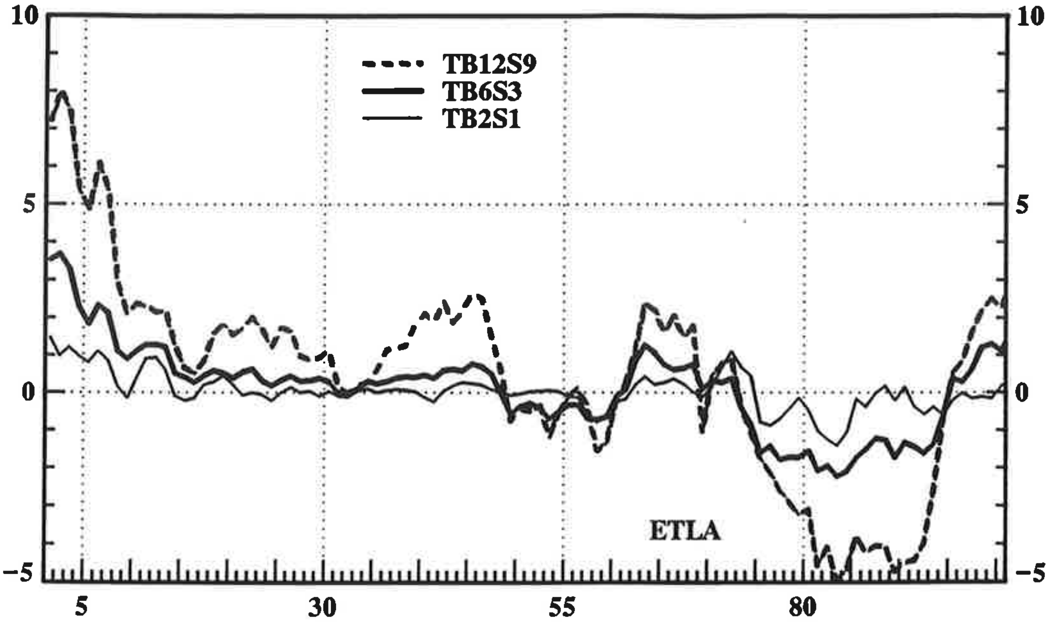
				Autocorrelation coefficients									
Variable	Obs.	Mean	Std.	1	2	3	4	5	6	7	8	9	10
1. Holding period returns													
B1S0	154	11.14	1.78	0.93	0.83	0.76	0.73	0.69	0.66	0.63	0.59	0.55	0.51
B1S0R	154	11.11	1.77	0.83	0.92	0.88	0.84	0.80	0.76	0.72	0.68	0.64	0.60
B2S1	154	11.03	1.81	0.84	0.66	0.51	0.42	0.40	0.43	0.45	0.42	0.36	0.32
B3S2	154	10.93	1.99	0.76	0.54	0.33	0.18	0.17	0.23	0.29	0.27	0.24	0.17
B6S3	146	10.52	1.46	0.88	0.75	0.63	0.55	0.46	0.38	0.32	0.26	0.20	0.14
B9S6	146	10.20	2.10	0.90	0.79	0.68	0.59	0.51	0.41	0.33	0.25	0.17	0.10
B12S9	146	10.35	2.80	0.91	0.81	0.71	0.62	0.54	0.44	0.35	0.27	0.19	0.12
2. Term premiums													
TB2S1	154	- 0.11	0.81	0.75	0.53	0.32	0.15	0.12	0.13	0.18	0.14	0.14	0.06
TB3S2	154	- 0.21	1.48	0.78	0.59	0.40	0.24	0.20	0.20	0.24	0.21	0.22	0.16
TB6S3	146	- 0.40	1.65	0.91	0.83	0.75	0.69	0.61	0.53	0.47	0.40	0.33	0.26
TB9S6	146	- 0.72	2.58	0.93	0.86	0.79	0.73	0.66	0.59	0.52	0.45	0.38	0.32
TB12S9	146	- 0.57	2.34	0.93	0.87	0.79	0.73	0.67	0.59	0.52	0.45	0.38	0.32

Table 1 presents means, standard deviations and autocorrelation coefficients of the interest rate levels, yield differentials and changes in interest rates. Not surprisingly, the levels of the interest rates are highly autocorrelated. The means of the yield differentials are positive except for the difference between twelwe- and six-month interest rates. The overlapping nature of data is evident in ex post changes in interest rates: weekly observations of the changes are highly autocorrelated.

Table 2 shows the same statistics as table 1, but for the holding period returns and the term premiums. Holding period returns and term premiums are expressed in terms of the transactions they imply. For example, the one-month return obtained by buying a two-month security now and selling it after one month as a one-month investment is labelled B2S1. We have calculated returns from five investment strategies: B2S1, B3S2, B6S3, B9S6 and B12S9. So the investment horizonis one month in two cases and three months in three cases. Besides these we calculated two returns from one-month investment B1S0, which correspond to the one-month HELIBOR-rate, and B1S0R, which corresponds to rolling over three succesive one-month investments. The term premia TBXSY is return BXSY minus the return from a one-month investment. So, for example, TB2S1 is B2S1 minus B1S0. The term premium is not known at time t when the investment decision is made. When calculating the returns from different investment strategies, will take the bid-ask spread in the considerations as a cost.

On average the short term investments have yielded higher returns than the return from the premature selling strategy. For example, the strategy to buy 12 months paper and sell it after three-months have produced on average 0.57 percentage point less than the strategy of rolling over three successive one-month paper. Figure 2 shows how the ex post term premium has developed. The volatility of the term premium has increased towards to the end of the estimation period.

Figure 2. **Ex post term premium**



Equations (4) and (5) will be estimated by the weekly interest rate observations. In this case the forecasts will be overlapping, which leads problems in normal OLS estimation. The serial correlation in the equation error, that arises from overlapping observations, dos not affect the consistency of the OLS coefficient estimates, but requires an adjustment in the estimated covariance matrix of these estimates. Hansen and Hodrick (1980), following Hansen (1982), have proposed a consistent estimate of the covariance matrix, which is the following:

$$(6) \qquad S = (X'X)^{-1} A (X'X)^{-1};$$

$$A = \sum_{k=-n+1}^{n-1} \sum_{t=1}^{T} u(t) X'(t) X(t-k) u(t-k),$$

where X is the matrix of regressors, X(t) is the vector of regressors at time t, u(t) is the residual at time t from the OLS regression and T is the sample size.

4 REGRESSION RESULTS

4.1 The Expectations Theory

In the table 3 are results from the expectations theory. The table represents among other things the estimated constant coefficients and slope coefficients with their corrected t-ratios and the regression R-squared.

In all equations the coefficients are relatively near to the case of pure expectations hypothesis. In the first three equations the coefficient of the term structure is near two and in the case of the last three equations near three, as predicted by the pure expectations theory. Also the coefficient of the constant variable is near zero. This variable is also insignificant in all cases. In the above point of view, the results are quite favourable to the pure expectations theory.

Table 3. Results from the expectations theory

Table 3a

Dependent variable	α	β_1	β_2	β_3	$\bar{R}^2$	CHII1	CHII2	n
r(1, 2) - r(0, 1)	- 0.006 (- 0.04)	2.287 (3.09)			0.158	0.16	9.83	155
r(3, 6) - r(0, 3)	0.359 (0.89)		2.580 (1.20)		0.064	2.49	12.78	146
r(6, 12) - r(0, 6)	0.710 (1.24)			0.566 (0.21)	0.000	1.69	59.37**	133

α is constant. β_1, β_2 ja β_3 are the corresponding term structure slope coefficients. Under the coefficients are autocorrelation consistent t-ratios. CHII1 is χ^2 - statistics, which tests the hypothesis that $\alpha = 0$ and $\beta = 2$. CHII2 is Newey and West (1987) D-statistics and tests the stability of the coefficients. The significance of χ^2 - statistics: * = significant at 5 percent level. ** = significance at 1 percent level. n is the number of the observations.

Table 3b

Dependent variable	α	β_4	β_5	β_6	$\bar{R}^2$	CHII1	CHII2	n
r(2, 3) + r(1, 2) - 2 r(0, 1)	0.040 (0.08)	3.75 (3.32)			0.146	0.57	19.83*	150
r(4, 6) + r(2, 4) - 2 r(0, 2)	0.408 (0.49)		3.962 (1.91)		0.107	4.75	58.44**	141
r(6, 9) + r(3, 6) - 2 r(0, 3)	0.724 (0.71)			3.89 (1.32)	0.113	2.72	44.96**	131

α is constant. β_1, β_2 ja β_3 are the corresponding term structure coefficinets. Under the coefficinents are presented autocorrelation constant t-ratios. CHII1 is χ^2 - statistics, which tests the hypothesis that $\alpha = 0$ and $\beta = 3$. CHII2 is Newey and West (1987) D-statistics and tests the stability of the coefficients. The significance of χ^2 - statistics: * = significant at 5 per cent level; ** = significant at 1 percent level. n is the number of the

The next question is how much information does the term structure have about the future interest rate changes. According to the results the slope of the term structure seems to have information about the future interest rate movements. In all but one case the adjusted R-squared is between six and sixteen percents. The exception is that the difference between twelwe- and six-months interest rate do not help predict change in six-months HELIBOR-rates in six-months forecasting horizon. This results is not necessary related to the longer forecasting horizon, because the difference between three- and and nine-months interest rate has more predictive power about the change in three-months interest rates in the same six-months forecasting horizon. These results seems to indicated that the less active trading in the longest maturities decrease the information content of the term structure.

The results here seems to be quite favourable to the expectations theory insofar. The inspection of Figure 1 and results from recursive least squares estimation (not reported here) suggests, however, that there have been a break in the interest rate series, starting approximately from the beginning of the June 1988.

In order to investigate the stability of the estimates, we re-estimated the equations by the Generalized Method of Moments estimator. Hansen (1982) and Newey and West (1987) have provided tools to test restrictions with the GMM. More specially we used the two-step, two stage least square procedure described in Cumby, Huizinga and Obsfeld (1983) to re-estimate the equations. The test statistic, D, was calculated as a difference of the restricted and unrestricted objective functions for the GMM estimator. The unrestricted objective function was calculated in estimating the above equations with extra variables. The added variables were calculated as old variables (constant and term structure variable) times the dummy. The dummy is zero before the hypothetical structural break and one after that. The restricted objective functions was calculated in estimating the normal equations, but using the same covariance matrix as in the unrestricted case. When calculating the covariance matrix, we used the Hansen and Hodrick formula presented in the section 3. The test statistics are distributed in large samples as a chi-squared random variable. The instrumental variables chosen were the Bank of Finland's currency index and banks' aggregate call money position.

The results reported in table 3 indicate that the stability was a problem in four equations. Only in the cases of 1/2 and 3/6 interest rate pairs was the null hypothesis of the stability of the coefficients not rejected. So these results cast some doubt about the usefulness of the term structure variables for forecasting purposes.

Mankiw and Miron (1986) have estimated the equation (4) with quarterly U.S. data. Their estimation period was rather long. They used two data sets. The first one was three-month and six-month Treasury bill yields from 1959 to 1972. The second data set were the time rates available at New York banks from 1890 to 1958. This period was divided in to four regimes in the estimation. They concluded that the the slope of the term structure did not have any significant forecasting power during the period 1915 - 1979. The only exception was the period 1890 - 1914, where the R-squared was 0.40.

Hardouvelis (1988) has recently re-investigated the information content of the term structure in the 1970's and 1980's and got considerably different results. He used weekly Treasury bill rates with maturities of one to twenty-six weeks. What is interesting is that Hardouvelis used estimations periods, the length's of which correspond to the ones used in this study. Hardouvelis concentrated on examing the information content of the forward rates.

Hardouvelis results from forecasting horizons from one month to six months are quite the same as reported here. For example, the R-squared in the last period (10/14/82 - 11/07/85) is between

0.218 and 0.001. The most predictable interest rate movements were, however, in the very short-term horizon, which were not investigated here. In the one week horizon, the R-squared is 0.652 in the above mentioned period. These results are quite the opposite to the results reported in Mankiw and Miron (1986).

Table 4 present the results from the term premium regressions. We find that the term structure have some information about the future excess returns in the money markets. The adjusted R-squared are between six and fourteen percents. The term structure variables were not, however, significant in any usual level in any case.

These results do not rule out the possible time-varying risk premium, even if they do not show any strong evidence in favour it. In the case of time-varying risk premium, the market's ability to forecast interest rate changes can be better than was indicated in the expectations theory regressions, because the time-varying term premium produce noise for the slope variables.

It is interesting to check if other forecasting variables have any ability to predict interest rate changes. The possible time-varying risk premium can indicate that the extra variables can help predict better the future short-term interest rate movements.

We choose the possible extra variables to be the current interest rate levels. The current level of an interest rate will forecast changes in the interest rates for a range of stochastic processes in which the level has a mean-reverting tendency. Rantala (1989) reports that the daily observations of the one-month Helibor-rate follows first order autoregressive process in period 1987 - 1988.

Table 4. Results from term premium regressions

Dependent variable	constant	r(0, 3)	r(0,6)-r(0,3)	$\bar{R}^2$	CHII1	CHII2	n
TB2S1	1.892 (1.50)	- 0.179 (- 1.48)	- 1.085 (- 1.10)	0.063	2.28	0.93	151
TB3S2	4.088 (1.81)	- 0.384 (- 1.79)	- 1.98 (- 1.19)	0.095	3.32	1.08	151
TB6S3	5.442 (1.18)	- 0.525 (- 1.19)	- 4.031 (- 1.14)	0.142	2.08	3.48	146
TB9S6	8.632 (1.26)	- 0.842 (- 1.29)	- 5.685 (- 1.03)	0.143	2.31	4.90	146
TB12S9	10.456 (1.22)	- 0.993 (- 1.22)	- 6.529 (- 0.92)	0.116	1.68	7.88	146

r(0,3) and r(0,6) are 3 and 6-months Helibor-rates respectively. Under the coefficients are autocorrelation consistent t-ratios. CHII1 is χ^2- statistics, which tests the hypothesis that all the coefficients are zero. CHII2 is the Newey and West (1987) D-statistics and it tests the stability of the coefficients. The significance of χ^2- statistics: * = significant at 5 per cent level; ** = significant at 1 per cent level. n is the number of the observations.

Table 5 shows that the current level of interest rate dos not have much ability to forecast changes in the interest rates. All the coefficients of the current level are insignificant at usual significance levels. One must notice however that the possible mean reverting tendency of the interest rates can be stronger over the longer horizons than what was investigated here.

In table 6 are results from multiple regressions. In most cases the interest rate level dos not add to the forecasting power appreciably. The most notable exception is the 3/6 interest rate pair. There the current interest rate level seems to help to predict changes in the interest rates.[2]

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[2] The results reported here do not exclude out the possibility that there are some other ex ante variables that have forecasting power regarding the interest rates. For example, when observations of the Bank of Finland's currency index were added to the regression equations, the forecasting power increased considerably. One must however be cautious when interpreting these results, because the currency index works

Table 5. Simple regressions of interest rate changes in the current interest rate level

Dependent variable	constant	r(0,1)	r(0,3)	r(0,6)	$\bar{R}^2$	CHII1	CHII2	n
r(1, 2) - r(0, 1)	- 0.304 (- 0.37)	0.037 (0.48)			0.000	0.74	2.31	155
r(3, 6) - r(0, 3)	- 2.031 (- 0.65)		0.222 (0.73)		0.050	1.55	2.95	146
r(6, 12) - r(0, 6)	- 1.297 (- 0.26)			0.186 (0.39)	0.010	1.79	56.63**	133

α is constant. r(0,1), r(0,3) and r(0,6) are 1, 3 and 6-months Helibor-rates respectively. Under the coefficients are autocorrelation consistent t-ratios. CHII1 is χ^2- statistics, which tests the hypothesis that coefficients are zero. CHII2 is Newey and West (1987) D-statistics and tests the stability of the coeffcients. The significance of χ^2 - statistics: * = significant at 5 per cent level. ** = significant at 1 per cent level.

Table 5b

Dependent	constant	r(0,1)	r(0,2)	r(0,3)	$\bar{R}^2$	CHII1	CHII2	n
r(2, 3) + r(1, 2) - 2 r(0, 1)	- 3.097 (- 0.81)	0.318 (0.87)			0.054	1.25	3.58	150
r(4, 6) + r(2, 4) - 2 r(0, 2)	- 1.489 (- 0.24)		0.202 (0.33)		0.004	1.36	6.39	141
r(6, 9) + r(3, 6) - 2 r(0, 3)	0.661 (0.09)			0.026 (0.04)	0.000	1.37	33.08**	133

α is constant. r(0,1), r(0,3) and r(0,6) are 1, 3 and 6-months Helibor-rates respectively. Under the coefficients are autocorrelation consistent t-ratios. CHII1 is χ^2 - statistics, which tests the hypothesis that coefficients are zero. CHII2 is Newey and West (1987) D-statistics and tests the stability of the coeffcients. The significance of χ^2 - statistics: * = significant at 5 per cent level. ** = significant at 1 per cent level.

Table 6. Multiple regressions of interest rate changes

Dependent variable	constant	r(0,x) - r(0,y)	r(0,y)	$\bar{R}^2$	CHII1	CHII2	n
r(1, 2) - r(0, 1)	- 1.109 (- 1.28)	2.59 (3.04)	0.097 (1.18)	0.190	10.66**	2.21	155
r(3, 6) - r(0, 3)	- 4.34 (- 1.35)	4.59 (1.81)	0.42 (1.37)	0.221	5.16	3.56	146
r(6, 12) - r(0, 6)	- 5.153 (- 1.10)	2.85 (1.20)	0.545 (1.27)	0.063	14.45**	44.00**	133
r(2, 3) + r(1, 2) - 2 r(0, 1)	- 3.905 (- 1.07)	3.931 (2.91)	0.354 (1.01)	0.216	9.86	2.97	150
r(4, 6) + r(2, 4) - 2 r(0, 2)	- 5.564 (- 0.81)	5.268 (2.21)	0.543 (0.82)	0.167	12.17**	5.04	141
r(6, 9) + r(3, 6) - 2 r(0, 3)	- 7.437 (- 0.92)	6.017 (1.99)	0.748 (0.99)	0.178	16.29**	15.50*	133

The r(0,x) and r(o,y) are x and y-months Helibor-rates at time t. Under the coefficients are the autocorrelation consistent t-ratios. CHII1 is χ^2 - statistics, which tests the hypothesis that all coeffcients are zero. CHII2 is Newey and West (1987) D-statistics and tests the stability of the coefficients. The significance of χ^2- statistics: * = significant at 5 per cent level; ** = significant at 1 per cent level. n is the number of the observations.

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like a dummy in the estimation period. It has two levels, before and after the revaluation, within which changes are dimishing. It can been that these results can interpreted as additional evidence of the instability of the coefficients.

5 THE TERM STRUCTURE AND BANKS' CALL MONEY WINDOW POSITION

5.1 The Closer Look on the Impact of Liquidity

The money market differs from capital markets in the respect that the central bank has more direct influence on asset prices, i.e. interest rates. The policy makers' interventions and institutional arrangements affect especially the shortest-term interest rates, which constitute the front end of the term structure (see for example Englund, Hörngren and Viotti (1989), Ho and Lee (1985)). In this section we will present some preliminary results about how interest rates and the term structure have reacted to the changes in the banks' liquidity as measured by the aggregate call money position.

One of the most central transmission channels for monetary policy in the money and bond markets is the Bank of Finland's call money window. The call money window serves as a source of residual finance for banks. Banks can also deposits their short-term funds at the call money window. By affecting the banks' free reserves the central bank can influence the interest rate formation. What kind and how permanent these influence is depends in turn e.g. upon the degree of monetary policy autonomy the central bank has.

The rate of interest paid on the call money deposits has been markedly lower than the market rates, while the rate of interest levied on the call money credits have been higher than the market rates. It has thus been costly for banks to go to the call money window. This is different from the system e.g. in the U.S., where the interest rate paid by banks borrowing from the FED has been often lower than the market rate of interest. When Finnish banks have been forced to borrow from the central bank's call money markets, their effective overnight rate has increased.

In the following we are interested to study closer how the changes in the banks' call money position have influenced the interest rates and the term structure. We estimate the response of the HELIBOR-rates to changes in the call money market position with the following regression:

$$r(t+1) - r(t) = \alpha + \beta_1 (call(t) - call(t-1)) + \beta_2 call(t), \tag{7}$$

where $r(t)$ = interest rate at time t,
$call(t)$ = banks' aggregate net call money deposits at time t.

Equation (7) states that the change in the banks' aggregate net call money deposits today will lead to changes in the interest rates tomorrow. The level of the net call money deposits is also incorporated in the equation. We will regress the equation (7) with daily interest rate observations. The timing of the explanatory variables is chosen so that the call money position is known by the market participant's (from 10.08.1987).

By investigating the structure of the coefficients across different maturities we can study how the market participant's have interpreted the news incorporated in the liquidity changes as measured by the aggregate call money position. According to the expectations theory the changes in the term structure should reflect systematically only the changes in the expectations.[3]

Another interesting question is to see how the relationship between the banks' aggregate call money position and the term structure has changed. The Bank of Finland made three major changes in the call money arrangements in our estimation period. The basic development was that it come costlier to the banks to

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[3] The restriction is that we are not (yet) able to discriminate between different observations by any a prior means in the spirit of Cook and Hahn (1989). The common view among market participants is that the majority of changes in the call money market position is due only to sources, which should have little or no impact to long-term interest rate expectations. In that case we should find that the impact is decreasing with the maturity.

use the call money window. These changes are reported in greater detail in Appendix I. The system of the call money window is reported, for example, in Aaltonen and Aurikko (1989).

Due to these changes we divided the period into three subperiods. The first subperiod is from 01.08.1987 to 15.10.1988. The six first months are omitted because in that time the call money markets were just developing. The second subperiod ends on the date 15.06.1989. The last subperiod, which is also the shortest time period, ends on 29.12.1989.

Also the information concerning the banks' aggregate liquidity position changed in the estimation period. Prior to 10.08.1987 the Bank of Finland informed the market of call money credits and deposits only once of week. After that the central bank have reported aggregate call money credits and deposits daily with a lag of one day.

5.2 The Preliminary Results from Daily Data

The results are reported in table 7. The table presents the estimated coefficients, adjusted R-squared and Durbin-Watson test statistics from all different estimation periods.

Signs of the coefficients are reasonable in almost all cases. The tighened liquidity i.e. decreased discount window net deposits has lead to higher inerest rates. The overall impression of the structure of the coefficients and R-squares are reasonable. In all periods the coefficient of liquidity changes is the greatest in the one-month maturity and after that the coefficients decrease nearly monotonously. This means that the slope of the term structure has changed in response to the liquidity changes. According to the expectations theory the observed pattern of responses across maturities arises when most of the changes in the liquidity are due to the random shocks or actions, which are not expected to raise interest rate in the future.

There are clear differencies between time periods. In the first period both the difference of the levels and the level itself is highly significant. Also the adjusted R-squares are biggest in this period.

In the second period the only significant variables are changes in the call money position. In this period the liquidity has also had the greatest impact on the interest rates: the coefficients of the changes in the call window position are clearly bigger than in the other two periods. The widening of the difference between the call money deposit and credit rate along with better information increased the impact of the liquidity.

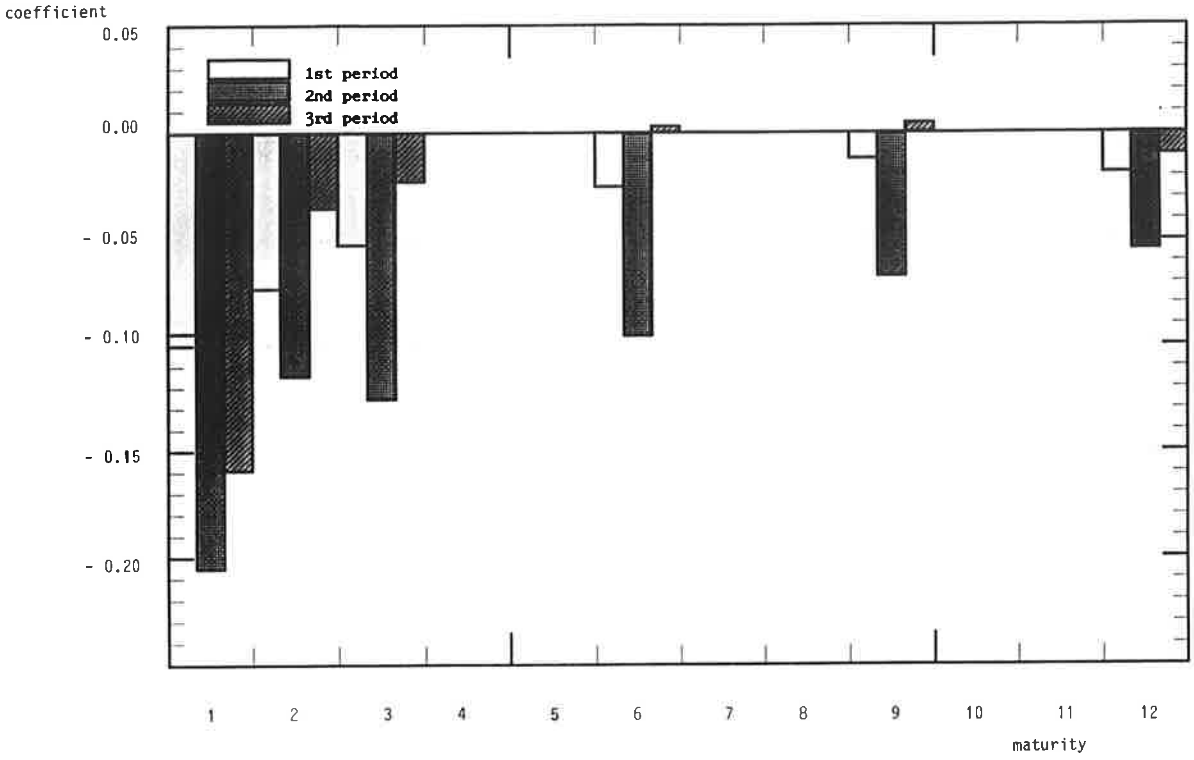
The most recent period differs from the others: the change coefficient is significant only in the case of one-month interest rates. In all other maturities it is insignificant at usual significance levels. On the other hand, the level of the net deposits is clearly significant in all maturities. It seems to be that in the new system, where the use of the call money window was severly restricted, banks and other market participants have reacted more to the deposit/debt - level than to changes in that level.

Table 7. The effect of changes in the banks' call window position on money market interest rates

	Period 1	Period 2	Period 3
	01.07.1987 - 05.10.1988	06.10.1988 - 15.06.1989	16.06.1989 - 29.12.1989
1 months			
constant	0.0178 **	0.0067	0.0960 **
call(t) - cal(t-1)	- 0.0943 **	- 0.2053 **	- 0.1592 **
call(t)	- 0.0245 **	- 0.0088	- 0.1382 **
R^2	0.203	0.178	0.148
D.W.	1.88	1.50	1.87
2 months			
constant	0.0167 **	0.0071	0.0867 **
call(t) - call(t-1)	- 0.0728 **	- 0.1146 **	- 0.0349
call(t)	- 0.0224 **	- 0.0087	- 0.1224 **
R^2	0.172	0.050	0.116
D.W.	1.66	1.96	1.94
3 months			
constant	0.0150 **	0.0074	0.0698 **
call(t) - call(t-1)	- 0.0522 **	- 0.1255 **	- 0.0224
call(t)	- 0.0190 **	- 0.0002	- 0.08464 **
R^2	0.137	0.116	0.090
D.W.	1.90	1.38	2.05
6 months			
constant	0.0146 **	0.0075	0.0539 **
call(t) - call(t-1)	- 0.0250 **	- 0.0955 **	0.0030
call(t)	- 0.0190 **	- 0.0014	- 0.0600 **
R^2	0.094	0.096	0.048
D.W.	1.89	1.53	2.02
9 months			
constant	0.0133 **	0.0077	0.0489 **
call(t) - call(t-1)	- 0.0120	- 0.0672 **	0.0045
call(t)	- 0.0176 **	- 0.0023	- 0.0578 **
R^2	0.068	0.078	0.059
D.W.	1.83	1.65	2.00
12 months			
constant	0.0104 **	0.0073	0.0421 **
call(t) - call(t-1)	- 0.0187 *	- 0.0544 **	- 0.0099
call(t)	- 0.0134 **	- 0.0021	- 0.0473 **
R^2	0.048	0.065	0.048
D.W.	2.18	1.68	2.14

Period 1: 325 observations
Period 2: 176 observations
Period 3: 137 observations
* : significant at 5 % level
** : significant at 1 % level
Call money deposits are measured as million markkas.

Figure 3. The coefficients of the changes in the banks' call money window positions



6 CONCLUSIONS

The expectations theory is a basic statement of the determination of the term structure. In the light of the modern intertemporal asset pricing models, which produce time-varying risk premiums in most environments, the expectations theory, and the pure expectation version especially, severly restrict the intertemporal behavior of the risk premium. However, in spite of its simple structure, the pure expectations theory seems to fit the Finnish money market data reasonable well. The slope coefficient are close to the pure expectations case. Furthermore, the results indicate quite clearly that there are no constant risk premiums observed in the estimation period.

The empirical evidence in this paper indicates that the longer maturities contain less information than the shorter maturities. This confirms the common market wisdom than the less active trading in longer interest rates decreases the information incorporated in the term structure.

The evidence from the term premium and multiple regressions did not, however, exclude the possibility of a time-varying risk premum. There was some predictability in the excess returns. A time-varying risk premium would generate noise for the slope coefficients, so that the results probably underestimate the market's ability to forecast future short-term movements in interest rates. This suggest that in order to build an interest rate forecasting model, it is useful to check other than term structure variables as well.

In the last section we examined the reaction of interest rates and the term structure to changes in the banks' call money market position. We found that the impact of the liquidity has varied with the changes in the call money market arrangements. Furthermore in all cases the structure of the coefficients was reasonable. The long-term maturities have reacted less than the short-term maturities to the changes in banks' call money market position. According to the expectations theory this means that the most of the changes in the banks' call window position have been due to policy actions or random shocks, which have not been expected to affect the level of interest rates in the future. These preliminary results concerning the term structure and the call money market leave, however, plenty of room for a further research, which we hope to see in the future.

APPENDIX I

The call money conditions as reported in the Bank of Finland's Monthly Bulletin:

October 6, 1988:

The differential between the call money deposit rate and the call money credit rate is widened with effect from October 6, 1988. The rate on call money credits is raised from 11 per cent to 13 per cent while the rate on call money deposits is lowered from 7.5 per cent to 4 per cent.

June 16, 1989:

With the effect from June 16, 1989, the Board of Management of the the Bank of Finland decides to abolish the bank-specific quotas for call money credit of the banks entitled to central bank financing. At the same time, the penalty interest charged on borrowing in excess of quota, which last stood at 19 per cent, is abolished. In addition, the call money credit rate is raised from 13 per cent to 15 per cent; the call money deposit rate remains at 4 per cent.

November 6, 1989:

With effect from November 6, 1989, the Bank of Finland amends the term of the call money credit system so that the 5-day moving average of a bank's position may be negative but in this case the call money credit rate will be charged at double the normal rate. It was a condition of the revision of June 1989 that the moving average of a bank's 5-day call money position should not be negative. The call money credit rate remains unchanged at 15 per cent and the call money deposit rate at 4 per cent.

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