ERASMUS UNIVERSITY ROTTERDAM

ERASMUS SCHOOL OF ECONOMICS

BSc Economics & Business

The expectations theory of interest rates and the European money market

ABSTRACT

Using data of short rates from the Netherlands, United Kingdom, Norway and Switzerland money market, I find predictive power in the term spread of 3-, 6-, and 12 month maturities for the future one-month interest rate. Evidence with regard to the pure expectations theory is ambiguous, the theory is generally rejected for the Netherlands, Switzerland and Norway. However for the UK market I am unable to reject the implications of the pure expectations theory.

Keywords:

[interest rates, term spread, expectations hypothesis, monetary policy]

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1. INTRODUCTION

The expectations theory of interest rates provides an explanation in the relation between short- and long-term interest rates. This theory states that interest rates are determined by expectations of market participants regarding the future change of interest rates. Understanding of the behavior of the term structure is of great importance for monetary- and economic policy makers and researchers alike, as assumptions about it are fundamental to economic models and theory.

Central in this research is to test the expectation theory of the term structure of interest rates (from now expectations theory). The majority of research regarding the term structure of interest rates is conducted on a U.S. market setting. The expectation theory however, seems to find greater support on markets outside the U.S. (e.g. Gerlach and Smets, 1997, Hardouvalis, 1994). Also predictability of short term interest rates possible differs among currencies. With respect to these two considerations, this research therefore examines the performance of the expectation theory on the European market. That is the United Kingdom, Netherlands, Switzerland and Norway. Furthermore, the introduction of the European Monetary Union also provides a new monetary context, for which empirical research regarding the term structure thus far is scarce. This research therefore aims to increase understanding of the expectations theory in this setting.

The expectations theory claims that the long term interest rates are weighted averages of current and expected future short rates (Hardouvalis, 1994). This implies that change in long rates is due to an expected change in future short rates (of the same sign). In other words, there is a positive correlation between long rates and future short rates. According to the theory, the difference between long rates and short rates, also known as the term spread of interest rates, is therefore predictive about the future change in short term interest rate.

The main research question is:

Is the term spread predictive about the relation between short- and longer–term interest rates?

As indicated, a great amount of research seems to reject the expectation theory on a U.S. market setting. This could be due to market specific circumstances such as the monetary policy employed by the central bank. Several researchers (e.g. Mankiw and Miron, 1986, Cook and Hahn, 1990) argue that by intervening on the money market, central banks affect

the behavior of the yield curve. The European Central Bank, Bank of England, Swiss National Bank and the Norges bank each are responsible for the execution and implementation of the monetary policy in the countries enclosed in my dataset. The monetary policy of these central banks primarily focuses on price stability and therefore can be described as inflation rate targeting. To understand the possible effect of monetary policy on the interest rate behavior, this research also provides a qualitative examination of the effects of inflation rate targeting on the predictability of interest rate behavior.

The structure of this thesis is as follows. Section 2 describes the expectations theory of interest rates and the empirical results regarding its implications. Furthermore, the effects of monetary policy on the interest rate behavior are discussed. Section 3, describes the methodology and dataset and finally in sections 4 and 5 the results of the research are given and discussed.

2. LITERATURE

2.1.1 THE EXPECTATIONS THEORY

The "expectations theory of the term structure of interest rates" (Lutz, 1940) gives an explanation on the relationship between the yield and maturity for money- and capital market investments. In other words, it explains the correlation between short- and long-term interest rates. The theory states that 'the expected return from holding a long term money or capital market investment (from now investments[1]) until maturity is equal to the expected return from rolling over a series of short term investment with a total maturity equivalent to that of the long term investment'. This implies that the long term investment yield is the average of the expected short rates. Equally, the forward rate[2] is the expected future short rate (Kim and Orphanides, 2007). Expectations of market participants determine variations in the yield curve[3]. If market participants expect the interest rate to increase, the slope of the yield curve is also expected to rise and vice versa (Cook & Hahn, 1990).

The underlying assumption of the expectations theory is the rational expectations hypothesis. The hypothesis states that investors form their expectations of future interest rates rationally. This implies that: (1) there is a stable economic environment. (2) Investors understand this environment and are able to make predictions about future interest rates, that (3) are not systematically wrong and (4) are formed using all public information available at that time. This means that market participants do not systematically over- or under-valuate the current and future interest rate (Cook & Hahn, 1990).

An important implication of the expectations theory is that of the information content in the forward rates. The forward rate is supposed to be equal to the future short term rate. In other words, the forward rate derived today predicts the spot rate tomorrow. Literature focuses on (dis)proving this suspected relation between forward rate and future spot rate. The results of this literature will be extensively discussed in the next paragraph.

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[1] Examples of money- and capital market investments: government bonds, corporate bonds, certificates of deposits, treasury bills, etc.

[2] The hypothetical yield on a future bond

[3] A line that plots the interest rates, at a set point in time, of money and capital market investments having equal credit quality, but differing maturity dates

2.1.2 TERM PREMIUM

The point of controversy regarding the expectation theory of interest rates, concerns the incorporation of risk in the theory. Investors in money and capital market investments, for instance bonds are exposed to a certain degree of uncertainty. The nominal return on a bond (unless it's hold to maturity) is unknown. The nominal return of a bond not hold to maturity is dependent on the future interest rate. If nominal interest rate rises, the price of a bond will generally fall (i.e. future coupons payments lose value). This is referred to as interest rate risk (Kim and Orphanides, 2007). Other risks that investors in bonds are exposed to: (1) credit risk; the risk a borrower is unable to settle payments of a bond. (2) Liquidity risk; entails the loss stemming from being unable to sell a bond fast enough, due to a lack of trading in the market. (3) Currency risk; the potential loss due to a possible depreciation of exchange rate (only applies to foreign investors). (4) Inflation risk; the decrease in real return, due to a rise in inflation rate. The greater the duration of the bond, the longer the investors are exposed to the risks associated with these investments. Investors are believed to require a compensation for this increased exposure, in the form of a higher interest rate for bonds with a longer maturity (Kim and Orphanides, 2007). This compensation is labeled the 'term premium' and is also defined as the forward rate minus the expected future spot rate. The existence of a term premium would explain the normal upward sloping characteristic of the yield curve.

From the risk perspective we can differentiate among three variations of the theory. The pure version of the expectations theory assumes the term premium to be equal to null, therefore ignores the risks associated with money- and capital-market investments. The normal version of the expectations theory does incorporate risk. The term premium is expected to be a possible non-zero constant. The normal version acknowledges the existence of a term premium but considers this premium to be constant over time. The weak version of the expectation theory, regards the term premium as a non-constant (time-varying) value significantly different from null. This version reflects the notion of variation in compensation demanded by investors, depending on the perceived uncertainty regarding inflation, real economic activity and monetary policy (Kim and Orphanides, 2007).

2.2.1 EMPIRICAL OBSERVATIONS

One of the first important empirical researches on the expectations theory of the term structure is conducted by Modigliani and Shiller (1973). They provide a new framework to test the joint hypothesis of rational expectations and the expectations theory of the term

structure. In their research Modigliani and Shiller (1973) concluded that the long-term interest rate is a weighted average of the expected future interest rate for the U.S. post 1945-period and that expectations regarding this future interest rate are formed rationally. Research that followed was however unable to provide a clear result on the validity of the expectations theory. Sargent (1979) and Shiller (1981) for example find evidence in favor of the expectations theory. Studies by Friedman (1979), Nelson (1972), Jones and Roley (1983) though, reject the joint hypothesis of rational expectations and expectations theory. Mankiw and Miron (1986) point out that, although a lot of research from 1970s and early 1980s reject the expectation theory. The majority of this research examines identical periods of historic U.S. Treasury bills market data. Therefore these studies are not independent from one another.

From the second half of the 1980s an increasing amount of empirical research seems to find evidence for predictability of long term interest rates with the help of forward rates. In a study by Fama (1984) on one- to six-month U.S. Treasury bills predictive power in the forward rates is found. Fama uses a sample that covers the period between 1959 through 1982. In roughly the first half of the sample, the forward rates are shown to be informative for spot rates three to five months ahead. In the second half of the sample the information content is reduced to one month ahead. Although Fama finds evidence of predictability using forward rates, he still rejects the pure expectations hypothesis.

Mankiw and Miron (1986) studied 3- and 6-month interest rates in the US. The sample in use incorporated data over the period 1890 through 1979. The authors compare the predictability of the term structure before and after the founding of the Federal Reserve. Before the founding of the Federal Reserve (1890-1913) they found predictive power in the term structure of interest rates. In all following episodes however they rejected the expectations theory. The authors argue this is due to the interference of the Federal Reserve on the money and capital markets in the periods after it was founded, where much of the Federal Reserve's policy was aimed at interest rate stabilization. This leads the authors to conclude that monetary policy of central banks has distorting effects on the predictability of interest rates.

Cook & Hahn (1990) provide additional evidence for this notion of monetary policy interference on the predictability of interest rates. They compare the forecasting power of the yield curve for 3- and 6-months U.S. Treasury Bills against the forecasting power on shorter and longer maturities from earlier studies. The yield curve from 3 to 6 months is found to

have little forecasting power, this result is hardly surprising considering earlier studies using this data (e.g. Jones and Roley 1983, Mankiw and Miron, 1986). Prior studies (e.g. Fama 1984, Hardouvalis 1988) do however find forecasting power in the yield curve for one-month maturities. Similar results are found regarding the yield curve of long term maturities. Fama and Bliss (1987) for example, find substantial predictive power in the yield curve from one to five years. Therefore, the expectations theory seems to hold on the short as well as the long-end of the maturity spectrum, nevertheless is rejected for maturities ranging between 3 and 12 months. Cook & Hahn (1990) argue this is due to the interference of the Federal Reserve. By (directly or indirectly) steering the interest rate in the short term, the ability of market participants to predict the future interest rate on the 3 to 12 month spectrum decreases dramatically.

Where previous studies mainly focus on the U.S. market, Hardouvalis (1994) takes another approach. In his study he uses a sample that consists of 3-months and 10-year rates taken from the G-7 countries[4]. The study found that the expectations theory appeared to explain the behavior of the interest rates for all countries except the interest rate behavior in the U.S. This is a remarkable finding, since prior literature put its attention to the US, to (dis)prove the expectations theory. Hardouvalis (1994) is however unable to provide an explanation of this observation.

Gerlach and Smets (1997) continued on the finding that interest rates on markets outside the U.S. better comply to the implications of the expectations theory. They conducted a study for the 1-, 3-, 6- and 12-month interest rates of 17 European countries. For all countries the term spread contained information about the future short term rates. On top of this they were unable to reject the expectation hypothesis for the majority of countries. In line with earlier studies, this research rejected the expectation theory for the U.S. market as well. Gerlach and Smets (1997) argue this is due to country specific characteristics such as, monetary policy, tax and or legal considerations that are believed to influence predictability of interest rates between countries. The fact that the expectation theory finds greater support outside the U.S. is striking as the common perception was that there is no predictive power in the yield curve for short term maturities. This was, according to Gerlach and Smets (1997) the direct result of

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[4] United States, France, Italy, Canada, Japan, Germany, and the UK.

the narrow scope of prior literature that primarily focused on the U.S. Treasury bill and bond market.

2.2.2 SUMMARY

Literature regarding the expectations theory of the term structure is mostly conducted in a U.S. market setting and in particular the U.S. Treasury Bill and Bond market. One advantage of using the U.S. Treasury Bills is the elimination of credit risk. Treasury Bills are effectively backed by the U.S. tax payer, therefore the risk of default is slim to none (Campbell, 1995). The downside is however, that focus on this market could make research regarding the expectation hypothesis rather one-sided. Country specific characteristic such as monetary policy could obscure unbiased testing of the expectation hypothesis. As research has shown that the interference of the central bank could at least partially explain the lack of forecasting power in the term structure of interest rates. In all, this predominantly U.S. market focus, could explain the rejection of the expectation in the 70s and early 80s. Following studies that incorporated data of a broader array of countries and maturities contradict earlier findings. In countries outside the U.S. evidence is found in favor of the expectation theory. Therefore this thesis contributes to current research by examining the expectations theory for a European market setting and especially with regard to the introduction of the European Monetary Union. That provides a new monetary context for which research with regard to the expectation theory thus far is scarce.

Table A – Summary of Empirical Research

Author	Data	Results
Friedman (1979)	Survey data of market professionals regarding their expectations about future 3-month U.S. Treasury Bill.	Pure expectations theory is rejected. There is evidence for a positive term-premium for long-term rates
Shiller (1981)	5-year U.S. Treasury Notes, estimation period: 1955-1973, semi-annual data	Result are (albeit weak) in favor to the expectations theory for short to intermediate term bond yields.

Jones and Roley (1983)	3-, 6- month U.S. Treasury Bills, esimation period: 1970-1979, weekly data	Expectations theory is rejected.
Fama (1984)	1-, 6-month U.S. Treasury Bills, estimation period: 1959 -1982, monthly data	Forward rates have predictive power for one month spot rates up to 5 months in the future, pure expectations theory is rejected.
Fama and Bliss (1987)	1-, to 5- year U.S. Treasury Bonds, estimation period: 1964-1985, monthly data	Current 1-year forward rates on 1- to 5 year bonds are predictive about the term structure of 1- year bond rates.
Mankiw and Miron (1986)	3-, 6- month U.S. Treasury Bills, estimation period, 1959- 1979 and 3-, 6- month loans of New York banks, estimation period: 1890 - 1958, quarterly data	Before founding of Federal Reserve, the term spread has predictive power for future interest rates.
Cook and Hahn (1990)	3-, 6,- month U.S. Treasury Bills, estimation period: 1952- 1986, monthly data	There is little to no forecasting power in the yield curve for 3 to 6 months U.S. Treasury Bills. This is possible due to distorting effect of monetary policy.
Hardouvalis (1994)	For Canada,USA, UK, Germany, France and Italy 10 year government bonds, estimation period: 1953 till 1992. Japan: corporate bonds, estimation period 1961 till 1992, frequency unknown.	In Italy and France the ET* holds, in Canada, Japan, Germany and Uk the long rate does move opposite of ET, this is explained because of white noise error. In the US the ET does not hold.
Gerlach and Smets (1997)	1-, 3-, 6-, 12-month euro-rates of 17 european countries, estimation period: 1964 - 1993, monthly data.	Term spread contains information in all countries, for 35 of 51 regressions unable to reject ET.

* Expectations theory

2.3.1 MONETARY POLICY

Prior research (e.g. Mankiw and Miron 1986, Cook and Hahn 1990) has shown that monetary policy has possible negative effects on the forecasting power of the yield curve. This paragraph discusses these possible effects of monetary policy on the predictive power of the yield curve. Implementation of central bank's monetary policy is strongly dependent on the long term objective of the central bank. Most common forms of monetary policy seen today are: (1) interest rate targeting, where the central bank aims to maintain a certain interest rate level to control the price of money. (2) Inflation rate targeting, in this case the central bank steers inflation to a predetermined desirable level to control a country's general price level. (3) Exchange rate targeting, in which the central bank maintains a certain (semi) fixed exchange rate with one or a basket of foreign currencies. The European Central Bank (responsible for the monetary policy of the Netherlands), Swiss National Bank, Norges Bank and the Bank of England all implement an inflation rate targeting policy. Therefore I will continue discussing the effects of inflation rate targeting on the behavior of the yield curve. Since objectives and policy implementations of the different central banks in my dataset are similar, I will present the policy of the ECB as an example of a central bank striving to price stability.

2.3.2 EUROPEAN MONETARY UNION

Since the introduction of the European Monetary Union (EMU) the European Central Bank (ECB) is responsible for the monetary policy in the Euro area and this includes the Netherlands. The ECB implements an inflation rate targeting policy. Its goal is to maintain a low and stable level of inflation, which is formalized by the objective to sustain an inflation rate of under but close to 2% per year. The primary policy instrument of the ECB is interest rate intervention. The ECB is entitled to control the short term interest rate by intervening on the money market. It does so by controlling the main refinancing rate, marginal lending facility and deposit facility. The main refinancing rate is the minimum interest rate at which the ECB lends money to other eligible banks and provides the gross of the market liquidity. The marginal lending facility is an overnight loan from the ECB to an eligible commercial bank. Its primary use is to increase the eligible bank's liquidity and thereby facilitating short term settlement of liabilities. To use this facility the bank is required to pay the marginal lending (interest) rate. When an eligible bank holds a surplus of capital it can deposit money

at the ECB using the deposit facility and will receive interest at the deposit facility rate. These three instruments are the main tools of the ECB to control the short term interest rates.

Through these tools the ECB is able to set the conditions under which regular banks borrow and lend to and from one another. The marginal lending facility provides the upper ceiling at which a bank lends money on the short term. The deposit facility provides the lower ceiling at which a bank receives interest on its short term deposits. In between these two boundaries sits the interest rates at which banks lend to one another. In the EMU this is also known as the Euro Interbank Offered Rate (EURIBOR). The EURIBOR determines in turn the interest rates at which the public saves and borrow from the commercial banks.

By governing the interbank interest the ECB controls the monetary base and thereby steers inflation. When inflation is expected to be above target the ECB increases the short term interest rate, to encourage saving and discourage consumption, thereby slowing down the economy and reduce chances on inflation. If inflation is below target the opposite is true, the short term interest rate is lowered, to encourage lending and consumption, effectively stimulating the economy and increase chances on inflation. In a nutshell, the ECB effectively has control over the interest rates on the money market.

2.3.3 EFFECTS MONETARY POLICY ON THE PREDICTABILITY OF FUTURE SPOT RATE

Several researchers have argued that the interference of central banks on the money and capital market affects the predictability of the future spot rate using the yield curve (e.g. Mankiw and Miron, 1986, Hardouvalis 1988, Cook & Hahn 1990). Mankiw and Miron (1986) claim that the use of interest rates as a monetary instrument make the short term interest rate a random walk. This causes a reduction of predictability of future spot rates using the term spread. They test this notion by comparing the predictive power of the term spread of short term loans before the establishment of the Federal Reserve against the term spread of U.S. Treasury Bills after its founding. In this period the Federal Reserve's monetary policy actively targeted a stable interest rate. This policy can be described as; setting the short rate at a level it strives to maintain. Mankiw and Miron (1986) found that the term spread of short term loans did indeed have significant predictive power before the establishment of the Federal Reserve. The term spread of U.S. Treasury Bills (after the establishment of the Federal Reserve), did not show significant forecasting power. Therefore they conclude that,

the term spread at the short end of the maturity spectrum, seems to lose its predictive power after the Federal Reserve began to actively pursue interest rate stability.

This view of decreasing predictability resulting from monetary policy is supported by Cook and Hahn (1989) they find that changes in the federal funds rate target in the mid 70s caused large fluctuations of short term interest rates. Cook and Hahn (1990) also provide a more general explanation for the effects of monetary policy on the forecasting power of the term structure. They argue, that monetary policy aimed at steering the interest rate in the short term, is not a continues process. Instead it is characterized by periods with release of new policy information (such as federal fund rate announcements) and followed by periods of no new policy information. During the periods where no new policy information is brought out, news on economic conditions and variables that are believed to influence future policy decisions builds up and eventually triggers a new policy information announcement by the central bank. This behavior of the central bank is to some extent random and therefore hard to predict by market participant. This mechanism is believed to decrease the ability of market participants to predict the future interest rate in the short term.

Although Mankiw and Miron (1986) and Cook & Hahn (1990) both study the U.S. market, their conclusions can also be applied for the European market. Throughout the second half of the twentieth century, the Federal Reserve applied a policy of interest rate targeting as opposed to inflation rate targeting policy of the European Central Bank, Norges Bank, Swiss National Bank and the Bank of England. Although goals of these two policies are different, the execution of these policies could have comparable effects on the predictability of future interest rates. In both policies the central bank directly sets the short term interest rate in response to changing economic conditions. This similarity provides reason to assume that central banks on the European market may equally decrease the predictability of future short term interest rates, through the mechanism proposed by Mankiw and Miron (1986) and Cook and Hahn (1990).

In a nutshell, change in short term interest rates sets in motion a process that directly and indirectly influences the price level in the euro zone as well as other European markets. Prior literature provides an explanation to how monetary policy could influence the information content in the forward rates. Monetary policy using interest rates as policy instruments, can decrease predictability of future interest rate through the discontinued nature of monetary interventions. Monetary policy could therefore influence expectations theory testing.

3. METHODOLOGY

3.1 HYPOTHESIS DEVELOPMENT

The expectations theory assumes that long term interest rates are weighted averages of current and expected future interest rates (Hardouvalis, 1994). This assumption implies that the term spread predicts the weighted average change in the future one-period interest rate. To put it more strictly, the term spread of a j-period money market investment is equal to the expected return from rolling over a series of shorter investments (minus the current one-period spot rate) with a total maturity equivalent to the j-period. For this implication to hold two assumptions are made: (1) there is no term premium and (2) market participants have rational expectations. Literature examining this particular implication (e.g. Gerlach and Smets, 1997) of the "pure" expectations theory is extensive. I follow prior research and the first hypothesis of my research is therefore:

H1 = the roll-over spread for a j-period investment is equal to the weighted average change in the j-period term spread.

This hypothesis is tested for the Netherlands, United Kingdom, Switzerland and Norway. The specific conditions under which this hypothesis is rejected are discussed in the next chapter. If this hypothesis is rejected, this could imply (1) there is evidence for a possible non-constant term premium, (2) market participants have non-rational expectations and / or (3) the model is incorrect. In much prior literature (e.g. Fama 1984, Jones and Roley 1983) this pure versions of the expectations theory is rejected. Researchers argue this is either evidence of a possible time varying term premium or possible interference of monetary policy on the predictability of the term structure (Cook & Hahn 1990, Mankiw and Miron 1986). Considering these earlier results, I formulate the implications of the expectations hypothesis in my second hypothesis less strictly.

H2 = There is forecasting power in the term spread about the future one-period interest rate.

For this hypothesis to hold, the roll-over spread is not required to move one-on-one in accordance with the term spread of interest rates. This hypothesis therefore allows for a less strict interpretation of the expectations theory, where forecasting power of the term spread varies either through a possible time varying term premium or interference in the short term rates through monetary policy. The second hypothesis is tested for the Netherlands, United

Kingdom, Switzerland and Norway. The specific conditions under which this hypothesis is rejected are discussed in the next chapter.

Prior research on the strong form of the expectations theory has yielded ambiguous results. Much works has rejected the implications of the pure expectations hypothesis, the majority of this research however was focused on a U.S. market setting. European market based research has shown more evidence in favor of the expectation theory. Nevertheless, evidence from the European market was still ambiguous with respect to the 'pure expectations theory'. I therefore expect to find mixed support for hypothesis one.

With regard to hypothesis two, European market research (Gerlach and Smets, 1997) did find compelling evidence in favor of the notion of forecasting power in the term spread. Considering my focus on the European market, I therefore expect to find evidence for predictive power in the term spread.

3.2 EMPIRICAL MODEL

To examine the predictive power of the term spread several regression specifications have been developed. The most common model used in literature from the 1980s is first proposed by Shiller (1979). It has two basic underlying assumptions: (1) investments of different maturity are perfect substitutes. This means that investors require a constant term premium between investments of different maturity. (2) Investors form their expectations of future interest rates rationally. Therefore investors do not systematically over- or under-estimated future interest rates. The specification of this regression developed by Shiller (1979) is as follows:

(1) $$r_{t+i} - r_t = \alpha + \beta[f(t+i_t) - r_t] + \varepsilon_t$$

Where r_{t+i} is the realized t+i period interest rate, r_t is the t period interest rate and $f(t+i)$ depicts the forward rate implied by the current t+i and t period interest rate. Although this model is effective in testing the implications suggested by the expectations theory, it does however have one major disadvantage. The regression specification is only suited to test the expectation theory on long rates that have a maturity that is equal to twice the maturity of the short rate. Research that utilizes this regression is therefore restricted in using a limited number of maturity pairs (depending on type of investment). For instance, the 3- and 6 months or 6-and 12-months U.S. Treasury Bills are commonly used. This research however

examines the predictive power of the term spread between 1- to 3-month, 1- to 6-month and 1- to 12 month deposit rates. This requires a modification of the standard used regression specification to measure the cumulative predictive power of the term spread between one-period and longer period maturities.

A model that incorporates this requirement is the roll-over spread model as used by Gerlach and Smets (1997) and Hardouvalis (1994). Specification (1) is adjusted to construct the empirical framework for my research. The model tests whether the expected return on rolling over the 1-period bond is equal to holding the j-period bond until maturity. This implication of the expectations theory can be tested by estimating:

(2) $$rs_t^{(j)} = \alpha + \beta(R_t^{(j)} - r_t) + v_t$$

where,

(2a) $$, rs_t^{(j)} \equiv \sum_{i=1}^{j}(r_{t+i-1} - r_t)/j$$ (2b) $$v_t \equiv \sum_{i=0}^{j-1}(r_{t+i-1} - E_t r_{t+i})/j + \varepsilon_t,$$

In equation (1) $rs_t^{(j)}$ denotes the roll-over spread for a j-period investment (j = 3, 6 or 12 months) at time t, $R_t^{(j)}$ the j-period interest rate, r_t the one-period interest rate and v_t is the error term. The error term v_t is defined by the sum of expectation errors $(r_{t+i-1} - E_t r_{t+i})$, where $E_t r_{t+i}$ is the expected one-period interest at time t. For the pure expectations theory to hold the coefficient β should be equal to one (this corresponds to hypothesis one). This implies that the term spread ($R_t^{(j)} - r_t$) is informative about the future one-period interest rate, as it predicts the weighted average of change in the future one-period interest rate. If β is significantly greater than null but not equal to one, the pure expectations theory does not hold, however the term spread still is informative about the future one-period interest rate (this corresponds to hypothesis two). A value of zero for the coefficient β would be evidence of no forecasting power in the term spread. In table B there is an overview of these restrictions and there relation to the hypotheses and their interpretation.

Table B – Regression Tests

Coefficient Restriction	Hypotheses	Interpretation
$\beta = 1$	H1 and H2 both hold.	Pure expectations theory holds, the term spread is 100% predictive about the future one-period interest rate.
$0 < \beta < 1$	H1 is rejected, H2 holds.	Pure expectations theory does not hold, there is however predictive power in the term spread about the future one-period interest rate.
$\beta = 0$	H1 and H2 both are rejected.	Expectations theory is rejected and there is no predictive power in the term spread.

3.3 DATA

This research uses a dataset of 1-, 3-, 6- and 12-month maturities from the British, Dutch, Norwegian and Swiss money market. The interest rates collected from these respective markets are: The EURO Deposit rates (EURODEP), the Sterling Certificates of Deposits (SCD), the Norwegian Interbank Deposits Rate (NIBR) and the Swiss Franc Inter Bank Rate (CHFIBR). The dataset covers a period of 1975 till 2011, depending on availability. Data of the SCD and CHFIBR are available from February 1975. Data of the NIBR is available since February 1993 and data of the EURODEP is available since the introduction of the EMU starting January 1999. The frequency of all data is monthly, as is common practice in this type of study (see literature overview). This results in a sample of 436 observations per maturity for the United Kingdom, 220 observations per maturity for Norway, 436 observations per maturity for Switzerland and 140 observations per maturity for the Netherlands. From this original dataset several new variables are constructed. First, the 3-, 6- and 12-month term spread is computed by subtracting the j-period interest rate with the one period interest rate $(R_t^{(j)} - r_t)$. This procedure is repeated for every country. Second, the 3-, 6- and 12-month roll-over spread is calculated for every country using formula (2a).

4. RESULTS

4.1 REGRESSION TESTS

Before results can be interpreted the data / regressions have to be checked for autocorrelation and heteroskedasticity. These statistical phenomena could influence the standard error of the regression coefficients and therefore affect hypothesis testing. To examine this the Durban-Watson and the White's heteroskedasticity tests are executed. The results of these are depicted in table C. In all regressions either autocorrelation, heteroskedasticity or both is found. To correct for this problem the Newey-West procedure is applied to all regression.

Table C - tests for serial correlation and heteroskedasticity			
Country	Maturity	Durbin-Watson statistic	White's Heteroskedasticity test
Netherlands	3	0,623*	3,693*
	6	0,203*	2,024
	12	0,082*	3,845*
United Kingdom	3	1,030	9,351*
	6	0,437*	6,429*
	12	0,178*	4,039*
Switzerland	3	1,333	12,242*
	6	0,617*	17,628
	12	0,333*	1,931
Norway	3	0,831*	0,591
	6	0,285*	0,252
	12	0,148*	0,498
* significant at 5 percent level			

Table D provides an overview of the estimates for the coefficients in equation (2), there corresponding standard errors and the results for the coefficient tests. For all tests a significance level of 5 percent is taken into consideration. Hypothesis two ($\beta = 0$) is rejected for all maturities and countries except the Netherlands. Accordingly, there is significant evidence that the term spread has predictive power about the future one-month spot rate for

the United Kingdom, Switzerland and Norway. Hypothesis one ($\beta = 1$) is not rejected in 5 of 12 cases.

The coefficients (0,838 0,726 0,656) for the UK market all are positive and significantly different from zero. Accordingly, the hypothesis $\beta = 0$ is rejected. This means there is significant evidence that the 3-, 6-, and 12-, month term spread has forecasting power regarding the future one-month spot rate for the United Kingdom. The hypothesis $\beta = 1$ is not rejected for all maturities. This can be interpreted as: the coefficients are not significant different from the value (1) implied by the expectations theory. The UK market therefore provides strong evidence in favor of the expectations theory.

The estimates for the regressions of the Swiss market (0,481 0,421 0,375) are positive and significantly different from zero. This is evidence that the term spread has predictive power for the future one month spot rate for the Swiss market. The coefficient test $\beta = 1$ is however rejected for all maturities. Empirical evidence from the Swiss market is therefore mixed. The term spread does contain information regarding the future interest rate, it doesn't however move one-on-one with the predictions of the pure expectations theory.

For the Norwegian market the coefficients (0,501 0,684 0,850) are all positive and significant greater than zero. Again this is evidence that the term spread is informative about the future one month spot rate. The coefficient test $\beta = 1$ is rejected for the 3- and 6-month maturity, but not for the 12-month maturity. In all, evidence from the Norwegian market regarding the expectations theory seems to be mixed. The pure form of the theory is rejected for 2 out of 3, the term spread does however seem to be predictive about the future one month interest rate.

As noted before the coefficients (0,126 0,248 0,333) for the Dutch market are positive but not significantly different from zero. Consequently the hypothesis $\beta = 1$ is rejected for all maturities as well. This can be interpreted as: (1) the expectations theory is rejected and (2) the term spread is not informative about the future one-month interest rate for the Dutch market. This is an unexpected outcome considering the results of other countries, where strong evidence is found that the 3-, 6-, and 12-month term spread is at least predictive about the future one-month spot rate. A possible explanation for this observation is that the sample size for the Netherlands is too small. The Netherlands has a sample size of 140 observations, this is considerably smaller compared to the other countries. Sample size directly influences

the standard errors of the regression coefficients[5] and therefore coefficient testing as well. This problem of high standard errors is mitigated by increasing the sample size.

In table E the regression specification (2) is recalculated for the Netherlands using bi-monthly data. The sample size is effectively increased by a factor of two, resulting in 280 observations. This modification appears to have some of the desired effect. The standard errors are greatly reduced and the regression coefficients (0,214 0,270 0,300) using bi-monthly observation are all positive and significant different from zero. The hypothesis $\beta = 1$ is however still rejected for all maturities. Therefore when sample size is increased there appears to be significant evidence for forecasting power in the term spread. This is in line with the results found in other countries.

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[5] For proof of this notion inspect the following equation: $Standard\ error\ =\ variance/\sqrt{n}$

Table D - Estimates of Regressions

	Maturity	Alpha (s.e.)	Beta (s.e.)	a = 0	b = 0	b = 1
Netherlands 1999M01 2011M07 N = 140	3-month	**0.029** 0.018	**0.126** 0.184	0.128	0.496	0.000
	6-month	**-0.085** 0.044	**0.248** 0.222	0.053	0.266	0.001
	12-month	**-0.189** 0.085	**0.333** 0.328	0.027	0.311	0.044
United Kingdom 1975M02 2011M07 N = 436	3-month	**-0.070** 0.028	**0.838** 0.157	0.014	0.000	0.303
	6-month	**-0.097** 0.073	**0.726** 0.155	0.183	0.000	0.077
	12-month	**-0.178** 0.138	**0.656** 0.161	0.196	0.000	0.034
Switzerland 1975M02 2011M07 N = 436	3-month	**-0.092** 0.034	**0.481** 0.162	0.008	0.003	0.002
	6-month	**-0.153** 0.066	**0.421** 0.143	0.019	0.003	0.000
	12-month	**-0.206** 0.124	**0.375** 0.182	0.097	0.040	0.001
Norway 1993M06 2011M07 N = 220	3-month	**-0.077** 0.032	**0.501** 0.138	0.015	0.000	0.000
	6-month	**-0.171** 0.073	**0.684** 0.131	0.019	0.000	0.017
	12-month	**-0.277** 0.123	**0.850** 0.155	0.026	0.000	0.334

* A significance level of 5 percent is applied to all coefficient tests.

Table E - Estimates of Regressions

	Maturity	Alpha (s.e.)	Beta (s.e.)	a = 0	b = 0	b = 1
Netherlands 1999M01 2011M07 N = 280	3-month	**-0,029** 0,018	**0,126** 0,184	0,128	0,496	0,000
	6-month	**-0,085** 0,044	**0,248** 0,222	0,053	0,266	0,001
	12-month	**-0,189** 0,085	**0,333** 0,328	0,027	0,311	0,044

* A significance level of 5 percent is applied to all coefficient tests

4.2 DISCUSSION

In 7 out of 12 cases the first hypothesis is rejected, support for the pure expectations hypothesis is therefore in generally mixed. It is interesting to see that for the United Kingdom the pure expectations theory is not rejected for all maturities. The British market therefore provides strong support in favor of the pure expectations theory. Taking into perspective the other countries, the evidence in favor of the pure expectations theory deteriorates. In Norway and the Netherlands, I was unable to reject the first hypothesis for both the 12 month maturities, where in the regression for the Netherlands high standard errors might have influenced regression testing. In all other cases the first hypothesis is rejected. These results are somewhat in line with my expectations regarding the first hypothesis. Based on prior research I anticipated that the pure expectations theory would hold in several cases throughout the sample. Evidence however in favor of the pure expectations theory is mainly found in the British market.

Considering the fact that the Bank of England conducts an inflation targeting policy similar to the monetary policies of the European Central Bank, Swiss National Bank and the Norges Bank, this is an interesting result. Cook and Hahn (1990) and Mankiw & Mirion (1984) predict a decreasing forecasting power of the term spread through the interference of monetary policy. The rejection of hypothesis one and therefore the pure expectations theory for the Netherlands, Switzerland and Norway seems to support this notion. The results in the UK market contradict the notion of decreasing predictability of the term spread. For the UK market interference of the central bank on the short term interest rates does not seem to reduce forecasting power to the extent that the implications of the expectations theory no longer hold. The difference between the monetary policies carried out by the Federal Reserve and Bank of England (interest rate targeting vs. inflation targeting), could be a possible explanation as to why the notion of Mankiw and Mirion (1984) and Cook and Hahn (1990) doesn't apply to the British market. Perhaps market participants are more able to predict future interest rates when central banks conduct a price stability policy. This explanation however still not answers the question as to why the pure expectation theory is rejected for the other markets. Another explanation suggested by literature is the existence of a time-varying term premium. The presence of non-constant term premium violates the basic assumption of the pure expectation theory. This is because a time-varying term premium distorts the ability to forecast future interest rates. Therefore it provides an explanation for coefficients estimates from the regression that are below one.

The second hypothesis assumes a less strict interpretation of the expectations hypothesis and provides a different picture. In first instance, this hypothesis is not rejected in all cases except in the Netherlands. This rejection in the Netherlands is probably due to a small sample size. Using a bi-monthly dataset I am unable to reject the second hypothesis for all maturities in the Netherlands. I therefore conclude that there is significant evidence for predictive power in the short end of the yield curve about the future one-period interest rate for all countries. Considering prior research, these results are in line with my anticipations. Another observation is that the predictive power of the term spread varies among countries and maturities. The lowest estimates are found in the Netherlands and the highest in the United Kingdom and Norway.

5. CONCLUSION

I examine the expectations theory of interest rates for four European countries. I find mixed evidence with regard to the pure expectation theory. Implications of the pure expectations theory are generally rejected for the Netherlands, Switzerland and Norway. The UK market does however provide evidence in favor of the theory. I suggest two possible explanations for this observation. First, the interference of the central bank on the money market might decrease the forecasting power of the term spread. Second, rejection of the pure expectations theory is due to a possible time-varying term premium. The existence of a time-varying term premium is a violation of the basic assumption of the expectations theory.

Nevertheless, when relaxing the assumption of no term premium, the regressions provide substantial evidence for the notion of predictive power in the short end of the yield curve. This is true, at least for the future one-period interest rate. Forecasting power does seem to vary among the countries. Therefore the answer to the main question whether "*the term spread is predictive about the relation between short and longer –term interest rates?*" is positive. In my opinion the observations give evidence that the term structure of interest rates in general moves according the predictions of the expectations theory albeit not on a one-to-one basis. The expectations theory therefore provides a valuable framework to explain the behavior of interest rates.

6. APPENDIX

6.1 REFERENCE LIST

1. Campbell, J.Y. 1995. Some lessons from the Yield Curve, Journal of Economic Perspective 9, 129-152

2. Cook, Timothy, and Thomas Hahn. 1989. The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s. *Journal of Monetary Economics* 24 (November): 331–51.

3. Cook, T, and Hahn, T 1990. Interest Rate Expectations and the Slope of the Money Market Yield Curve. Federal Reserve Bank of Richmond *Economic Review* 76(5): 3–26.

4. Friedman, B.M., 1979. Interest rate expectations versus forward rates: Evidence from an expectations survey, *Journal of Finance* 34,965-973.

5. Fama, E F. (December 1984). The Information in the Term Structure. *Journal of Financial Economics* 13: 509-528.

6. Fama, Eugene F. and Bliss, Robert R. (1987). The Information in Long-Maturity Forward Rates, *The American Economic Review*, Vol. 77, No. 4 pp. 680-692

7. Gerlach, S. and Smets, F. 1997. The term structure of Euro-rates: some evidence in support of the expectations hypothesis", Journal of International Money and Finance 16, 305-321

8. Hardouvelis, G. A. (1988) The predictive power of the term structure during recent monetary regimes. *Journal of Finance* 43, 339-356.

9. Hardouvelis, G. A. (1994) The term structure spread and future changes in long and short rates in the G-7 countries: Is there a puzzle? *Journal of Monetary Economics* 33, 255-283.

10. Jones D. S. and Roley, V. V. (1983) Rational expectations and the expectations model of the term structure: a test using weekly data. *Journal of Monetary Economics* 12, 453-465.

11. Kim, D.H. and Orphanides, A (2007). The bond market term premium: what is it, and how can we measure it? Bank of international Settlements.

12. Lutz, F.A. 1940. The structure of interest rates, *the quarterly journal of economics.*

13. Mankiw, N. G. and Miron, A. J. (1986) The changing behavior of the term structure of interest rates. *Quarterly Journal of Economics* 101, 211-228.

14. Modigliani, F. and R.J. Shiller, 1973, Inflation, rational expectations and the term structure of interest rates, *Economica* 40, 12-43.

15. Nelson, C.R., 1972. The term structure of interest rates (Basic Books, New York).

16. Sargent, T.J., 1979. A note on maximum likelihood estimation of the rational expectations mode1 of the term structure, Journal of Monetary Economics 5, 133-143.

17. Shiller, Robert J. 1979. "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure." *Journal of Political Economy* 87 (December): 1190–1219.

18. Shiller, R.J., 1981. Alternative tests of rational expectations models: The case of the term structure, *Journal of Econometrics* 16, 71-87.