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The Term Structure as a Predictor of Real Economic Activity

The Case of Sweden

Abstract

This thesis studies if the term spread of interest rates can be used as a leading indicator of future real growth in Sweden. An upward-sloping yield curve is most often associated with a future increase in real growth and, in contrast, a flat or inverted yield curve precedes downturns and recessions. Previous research on other countries has documented a strong connection between the yield curve and subsequent growth. Since Sweden has not yet been studied in this area, our thesis offers useful out-of-sample evidence. In order to quantify this relationship, three different models have been constructed where the term spread is modeled together with the nominal and the real Riksbank's interest rates. We have also examined the stability of the proposed models with respect to changes in monetary policy. The results suggest that the spread has some predictive power, but that due to a structural break at the end of 1992, this power has diminished.

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1 INTRODUCTION

There is considerable interest in finding variables which can be employed to predict future real activity. There are numerous reasons for this large interest. Companies, for instance, need to estimate the future demand in order to decide the capacity today. Investors can use such a prediction to determine in which assets to invest. But most importantly, more precise predictions of future growth enable central banks to make monetary policy decisions with greater accuracy. In this way, central banks will be able to increase the quality of their decisions.

Many different types of variables, economic as well as financial, have been assessed in various models, but especially financial variables have been of interest to researchers. The rationale is rather straightforward: the financial market participants take the future into account and prices on securities incorporate expectations of future economic events. For example, long-term interest rates are regularly analyzed as weighted averages of short-term rates. It is therefore reasonable to assume that data from financial markets can assist in projecting future real growth. Research in this area has in particular raised the attention for one specific financial variable: the term spread between long- and short-term interest rates. Particularly the work of Stock and Watson (1989) has demonstrated the importance of the term spread. They analyzed numerous variables that could possibly predict future growth, and found that term spreads were among the best predictors.

Most of the research has been carried out on U.S. data, but also many other industrialized countries have been studied in this area. Sweden, however, has not yet been subject to such a study. This paper therefore analyzes whether the relationship between the term spread and future real activity exists in Sweden or not. Three different models to predict future cumulative and marginal real growth are constructed, and the results analyzed. The models follow those of Estrella and Hardouvelis (1991) as well as Wright (2006) meaning that we focus on the term spread, the central bank's policy rate, and the central bank's real interest rate. The results that these authors and many other researchers have obtained are interesting as they show that the term spread can successfully be used to predict real economic

activity. Hence, this thesis can enrich the existing literature with valuable out-of-sample evidence from a country that has not yet been studied.

We also examine if there is a structural break in the models. The breakpoint is assumed to be known and is set to the end of year 1992. This is motivated by changes in the monetary policy and a change from a fixed to a floating exchange rate at that date – changes that have been shown to affect the relationship that is studied (Jardet, 2004).

The shape of the yield curve changes throughout the business cycle. In recessions, yields on long-term bonds tend to be high, while short-term bonds tend to trade on low yield levels. This results in an upward sloping yield curve. Conversely, in times of expansion, short-term bonds trade on high yield levels and long-term ones on low levels, resulting in a flattening of the yield curve. These facts hint that the spread between long- and short-maturity spreads entail some information about the future. Indeed, it has empirically been shown that there is, or at least has been, a relationship between the term spread and future growth. But why should the yield curve be able to predict output at all? Fact is that, despite the great amount of empirical research in this area, there is no standard theory for why the relationship exists. One reason referred to is that the yield curve tends to flatten when the central bank raises the interest rate, and that this is followed by a slowdown in the economy with a lag (Estrella, 2005). Another reason mentioned (Chen, 1991) is that under rather general assumptions, the term structure is related to expected growth rates of GNP and consumption. Since individuals want to smooth their consumption, they will borrow in times when future output is expected to be higher than the current output level. In this way, the will bid up the interest rates. Estrella (2005) constructs a rational expectations model to examine the link between interest rates and future growth and finds that the relationship is not structural. Instead, he concludes that it is influenced by the monetary policy regime.

The remainder of the paper is structured as follows: Section 2 gives a review of the earlier research on the subject. The models and data that are used are presented in sections 3 and 4, respectively. The quantitative results of the econometric models are presented in section 5 and conclusions drawn upon the results are offered in section 6.

2 A REVIEW OF EARLIER RESEARCH

An extensive literature has studied variables that help predict business cycles and many authors have provided evidence for a predictive relationship between the slope of the yield curve and subsequent real growth. The research on this subject goes back at least to Mitchell (1913) who analyzed the behavior of interest rates of different maturities over the business cycle. Kessel (1965) was however maybe the first who verbally referenced the behavior of term spreads, revealing that at the beginning of recessions, various spreads are inclined to be low. Butler (1978) stated that the current yield curve could be used to estimate the market consensus on expected future yield curves, which in turn could provide a basis for certain cyclical comparisons.

In the late 1980's, the research on the subject surged. Harvey (1989) and Chen (1991) used a term structure spread in predicting either future real output growth or future recessions, and found that the yield curve and its slope are useful. Furlong (1989) also found predictive power for recessions, but still doubted that the yield curve could be a reliable leading indicator at that time. Stock and Watson (1989) built up indexes of coincident and leading economic indicators, where the latter could be used to predict growth. In this index, two term spreads were included. Their search for a leading economic indicator was quite extensive, which gives more substance to their conclusions that the yield spread is an important component of their index. Estrella and Hardouvelis (1991) uncovered empirically that the yield spread between the ten-year U.S. Treasury bond rate and the three-month Treasury bill rate help predict future growth in real economic activity, consumption, consumer durables, investments, and the probability of a recession dated by the NBER[3]. Estrella and Mishkin (1997) also confirmed that the yield curve, both in the U.S. and in Europe, contains useful information for predicting real economic activity.

2.1 THE ROLE OF OTHER VARIABLES

Researchers have also studied other explanatory variables to find the ones best suited for predictive purposes. Estrella and Hardouvelis (1991) ran regressions in which one

[3] The National Bureau of Economic Research (NBER) is the largest economics research organization in the United States.

explanatory variable is the term spread and the other is a vector of alternative explanatory variables. They found that the term spread is useful in these regressions. It has also extra predictive power over and above the predictive power of the other variables – among others lagged output growth, lagged inflation, and the level of real short-term interest rates. Dotsey (1998) compared the yield curve with other variables and found that the term spread contains information that other variables do not. Estrella and Mishkin (1998) used probit[4] models in which they evaluated the power of the term spread for predicting recessions in comparison to a number of other variables. They concluded that the term spread is the best variable in tests of statistical significance.

Hamilton and Kim (2002), and authors referred to in their article, estimated GDP using both the spread and quarterly GDP growth lagged one to four quarters. Their findings are similar to previous studies, showing that the estimated coefficient on the spread is significant at conventional levels up to eight quarters ahead. Following Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), and Estrella and Mishkin (1997), they included the federal funds rate, two monetary aggregates as measures of monetary policy, and growth rate of oil prices in the vector of alternative variables. They found that even when all these variables are included together, the yield spread still helps to predict growth up to eight quarters into the future.

Ang, Piazzesi, and Wei (2006) built a dynamic non-arbitrage model and concluded – in contrast to previous research – that the short rate has more predictive power than any term spread. This was confirmed by successful out-of-sample GDP forecasting. Further, their model suggests use of lagged GDP and the maximal maturity difference for the term spread.

Wright (2006) used probit models in which he included, among others, the spread, the federal funds rate, and the real federal funds rate as explanatory variables. His results show that for estimating the probability of a recession there is more information in the shape of the yield curve than what is provided by the term spread alone.

[4] Models where the dependent variable of the equations only takes two values: either 1, when the economy is in a recession, or 0, at all other times.

2.2 STRUCTURAL STABILITY

Though research has shown that the inversion of the U.S. yield curve has been a good predictor of recessions, it has not been perfectly accurate. In 1967, the yield curve got inverted, but the NBER did not classify the following decline in real activity as a recession. However, the more troubling failure occurred in 1990-1991, when the curve only got flat prior to the recession. This launched a series of articles investigating the term spread's predictive ability. Dueker (1997) as well as Estrella and Mishkin (1997, 1998) used probit models and showed that the spread is still useful for predicting real activity. Haubrich and Dombrosky (1996) used simple regressions with different variables and concluded that the yield curve can accurately predict real economic growth. Indeed, in the studied period from 1965 to 1995, the ten-year, three-month spread was the best predicting variable for forecasting real growth four quarters into the future. However, they also found that over the last ten years of the period, this variable had been less successful. In fact, the yield curve offered the *worst* forecasts among the studied variables. These findings were also confirmed by Dotsey (1998) who concluded that the yield curve had been a good predictor of real activity but that it has not been as useful over more recent periods.

Estrella, Rodrigues, and Schich (2003) studied the U.S. as well as Germany and employed two kinds of stability tests, one in which the breakpoints are assumed to be unknown and the other in which they are known. Their general conclusion is that the term spread can be utilized to predict recessions, but that the models employing it should be used with caution since they, due to some degree of instability, are not perfectly reliable.

Jardet (2004) ran a statistical test to detect breaks in the empirical relationship between the term spread and GDP growth rate in the United States. She found a single break in the first quarter of 1984 and pointed out that this breakpoint can be connected to a change of the monetary policy to a regime more concerned with inflation. She also investigated why the slope of the yield curve had lost its predictive power after 1984. Her results prove that this loss in predictive power is a result of a considerable drop in the contributions of monetary policy and supply shocks.

One problem in finding structural breaks in the models is that changes might come slowly. Giacomini and Rossi (2006) used, among others, a type of test with power properties against such multiple, slowly-evolving structural breaks. They found clear empirical evidence of forecast breakdowns – in particular during the 1970's and 1980's – and commented that the breakdowns can be linked to changes in monetary policy.

Apart from the research showing on structural breaks, some of the papers that present evidence for the predictive power of the interest rates have also been heavily criticized of other reasons. Watkins (1997) commented on deficiencies in the empirics, referring to the lack of discussion around issues such as stationarity or possible spurious correlations. He also criticized the choice of explanatory variables, pointing out that using the nominal term spread implies assuming either (1) that the real interest rate is constant, or (2) that the expected rate of inflation is constant and that models forecasting growth in real GNP use information in the real term structure. Watkins further claims that as none of these assumptions are reasonable, the empirical evidence that is based upon them is flawed.

3 THE MODELS

We have constructed three models to predict the future GDP growth. The construction of the models follows the works of Wright (2006) and Estrella and Hardouvelis (1991). The models have the following form:

Model 1: $y^{c}_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \varepsilon_t$

Model 2: $y^{c}_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CBI_t + \varepsilon_t$

Model 3: $y^{c}_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CBI_t + \beta_3 CBR_t + \varepsilon_t$

Definitions of the variables are found in the box below.

In the basic Model 1, quarterly observations of growth in real GDP are regressed on the difference between the long and short market interest rates for government bonds and bills. Model 2 is augmented with the central bank's interest rate, a measure of the monetary policy stance. Finally, Model 3 also includes the real central bank interest rate, which algebraically corresponds to expanding Model 2 to include inflation. The dependent variable, $y^{c}_{t,t+k}$, which is the same in all cases, is the cumulative annualized growth rate between quarter *t* and *t+k*. The forecast horizon is set to range from one to twelve quarters ahead.

Box 1 Definitions of variables

Cumulative GDP growth	$y^{c}_{t,t+k} = \frac{400}{k} \log\left(\frac{Y_{t+k}}{Y_t}\right)$ *k = 1 to 12*
Marginal GDP growth:	$y^{m}_{t+k-j,t+k} = \frac{400}{j} \log\left(\frac{Y_{t+k}}{Y_{t+k-j}}\right)$ *k = 1 to 12*, *j = 1 or 4*
Difference between the long and short market interest rates in period t:	$SPREAD_t = GVB10Y_t - SSVX3M_t$
Central bank's interest rate at period t:	CBI_t
Central bank's real interest rate at period t:	$CBR_t = CBI_t - \hat{\pi}_t$
Instrumental variable for rate of inflation at t:	$\hat{\pi}_t = \beta_0 + \sum_{i=1}^{4} \beta_i \pi_{t-i}$

The models will also be employed with marginal growth, $y^{m}_{t+k-j,t+k}$, as the dependent variable. That is, by studying the term spread and the central bank's interest rates in the current quarter, the growth rates between the future quarters $t+k-j$ and $t+k$, where $j = 1$ for $k = 1$ to 8 and $j = 4$ for $k = 12$, are estimated. By studying the marginal percentage change, it is possible to obtain more precise information on how far into the future the models are able to predict real economic activity.

The choice of which variables to include in the models is based on the results gained in previous research[5]. Consistent with results obtained by other authors, we expect the *SPREAD* coefficient to have a positive sign, indicating that a larger spread implies a higher future output growth. In contrast, larger *CBI* is expected to have a negative effect on future growth since a higher central bank interest rate is likely to cool off the economy. The sign of the parameter estimate of *CBR* is however more difficult to envisage. This variable fluctuates not only with the level of the *CBI*, but also with the level of inflation. As the effect of inflation on future growth can be both positive and negative and the central bank uses the *CBI* to keep the inflation in check, it is difficult to foretell the sign of the parameter of *CBR*. The number of included variables has been restricted due to the aim to construct simple models and study the predictive power of the term structure of interest rates in isolation. Indeed, more variables could have been added to the models if the purpose solely had been growth forecasting rather than to examine the relationship between the term structure of interest rates and real economic activity.

Several previously written articles on the subject, e.g. Estrella and Hardouvelis (1991), Estrella and Mishkin (1997, 1998), and Wright (2006), use or are supplemented with probit models with a binary dependent variable that takes the value 1 when a recession is observed. Recessions are frequently defined as two consecutive quarters of negative growth and in studies on US data the classification of recessions made by the NBER is typically used. Models with a binary variable are chosen because the yield curve is assumed to be a better predictor of drastic changes in real GDP and the models will therefore be more stable than continuous models. In this study such a binary variable will not be considered even though it would have

[5] See section 2.

been plausible. This is because of the relative shorter sample period, 22 years compared to at least 40 years for studies on US data, and the number of recessions (1) in the period. The use of a binary recession variable is further hindered by the lack of an objective dating of the Swedish business cycle (Jonung, 2005). Although Edvinsson (2005) has presented such a study, it is not applicable for this thesis as it is only based on yearly data.

The proposed models will by their form generate autocorrelated error terms of order k - 1 because of the overlapping forecast horizons. This will make the standard errors of the coefficients obtained by OLS regression inconsistent as well as too small. Therefore, Newey and West (1987) corrected standard errors will be calculated, which take the overlapping forecasts into account and are also insensitive to conditional heteroskedasticity. The stationarity of the included variables has been examined and is not an obstacle for the functional form of the models. The results of the tests for stationarity are presented in Appendix A.

In order to test the stability of the predictive power of the term spread, the sample has been divided into two sub-samples, namely 1984 – 1992 and 1993 – 2006. The choice to divide the sample at this point in time is due to the changes in monetary policy and exchange rate regime. These changes are likely to have had an impact on the relationship between the term spread and future real activity. In fact, Jardet (2004) found that changed monetary policy in the US during the early 1980s, i.e. the disinflation policy pursued by the Fed chairman Paul Volcker, caused a structural break.

Drastic changes in the Swedish central bank's (the Riksbank) monetary policy occurred and the exchange rate regime of the Swedish krona occurred in the end of November 1992 when the krona's fixed exchange rate was abandoned. In the beginning of 1993 the Riksbank's monetary policy objective was restated into attaining price stability. Before 1993, monetary policy had to be pursued in order to keep the exchange rate stable and to protect the foreign exchange reserves. With the fixed exchange rate, monetary policy was tied up and could not react to fluctuations in real economic activity. This stands in sharp contrast to the monetary policy employed under a floating exchange rate and an explicit inflation target. Under such a regime

with a flexible inflation target, the central bank sets its policy rates depending on its inflation forecast and conjectures of the resource utilization in order to steer inflation to its target within a two-year horizon (Svensson, 2002). Because of this, we anticipate that the structural relationship between the term spread and future growth may have changed during the sample period and the break point is *ex ante* assumed to be at the end of 1992:Q4.

3.1 THE RELATIONSHIP BETWEEN *CBI* AND *SPREAD*

The central bank sets its policy rate (*CBI*) after reviewing economic indicators as well as financial variables, including the market interest rates, and bases its decisions on its conjecture of future economic activity. Because of this, the *CBI* cannot be considered as being a strictly exogenous variable. In fact, both the *SPREAD* and the *CBI* may be regarded as endogenous variables.

The effects of changes in the monetary policy stance on the term structure of interest rates can be observed empirically: unexpected rate hikes by the central bank make the *SPREAD* lower and vice versa. This is a result of the control that the central bank has on the short end of the term structure. A monetary policy tightening, i.e. a raised central bank interest rate (*CBI*), will have a direct influence on the available credit volumes in the market and thereby affect the short-term interest rates. The nominal yield on securities with longer maturities, on the other hand, is actually a compilation of investors' demand for real compensation and compensation for the expected inflation. Changes in the *CBI* will affect the inflation expectations and will therefore have less effect on the long-term interest rates than on the short-term rates, consequently affecting the *SPREAD*. It could be the case that a rate hike affects the inflation expectations in such a great extent that the nominal yields of long-term maturities actually fall.

In order to address the problem of endogenousity and examine how changes in the *CBI* affect the term structure, an AR model with the following form is used:

$$SPREAD_t = i_t^{long} - i_t^{short} = \alpha_0 + \sum_{i=0}^{4} \beta_i CBI_{t-i} + \sum_{i=1}^{4} \gamma_i i_{t-i}^{short} + \sum_{i=1}^{4} \delta_i i_{t-i}^{long} + \varepsilon_t$$

where i_t^{long} is the ten-year government bond rate and i_t^{short} the three-month bill rate. The equation states that the contemporaneous ordering is assumed to go from *CBI* to *SPREAD*. Hence, the central bank is assumed to have influence over the *SPREAD* by it controlling the *CBI* (Estrella and Mishkin, 1997). The parameter of interest is β_0, which represents the effect that changes in the *CBI* have on the *SPREAD*.

Further, it is of interest to study the stability of the relationship given the changes in monetary policy and exchange rate regime from 1992. Therefore, the sample has been divided into two sub-samples and analyzed separately. The results from the regressions are presented in the table below.

Table 1 Test of stability in the relationship between the *CBI* and the *SPREAD*

Period	β_0	$\sum_{i=0}^{4}\beta_i$	$\sum_{i=1}^{4}\gamma_i$	$\sum_{i=1}^{4}\delta_i$	$\overline{R}^2$	*SEE*
1984 - 2006	-0.180*	-0.040	-0.781	0.776	0.889	0.547
	(0.021)					
1984 - 1992	-0.197*	-0.218	-0.624	0.517	0.893	0.731
	(0.033)					
1993 - 2006	-0.629*	0.373	-1.087	0.704	0.777	0.399
	(0.227)					

Notes: * Significant at the 5% level Newey and West (1987) standard errors in parentheses

Table 1 shows that the overall fit of the regressions can be considered to be reasonably good, especially for the first sub-sample with adjusted R^2 around 0.89. The value of β_0 is significantly negative for both the sub-samples and the sample as a whole, which implies that a monetary tightening flattens the yield curve, i.e. lowers the *SPREAD*. In absolute terms, β_0 is also greater for the period after 1992. This is somewhat expected since central banks in countries with floating exchange rates may have a stronger influence on the term structure (Estrella and Mishkin, 1997). Although the standard errors of the individual β_0 coefficients are fairly low, the standard error of the estimates (SEE) are considerably high given that *CBI* is normally adjusted by 25 to 50 basis points.

A Chow test was conducted to test for a break in the relationship between *CBI* and *SPREAD*. The test fails to reject the null hypothesis of parameter stability, as the observed value is F (13, 61 df) = 1.65 and F-critical = 1.88 at the 5%-level. However,

when β_0 is tested separately it is found to be significantly smaller in the 1993 – 2006 sub-sample: t (41 df) = 1.903 and t-critical = 1.683 at the 5%-level.

We conclude the following; firstly, the central bank can influence the shape of the yield curve but cannot be said to control it. Secondly, the central bank's impact on the *SPREAD* is believed to be greater in the post 1992 period. Thirdly, we conclude that the *SPREAD* contains information that is not captured by the stance of monetary policy, i.e. the *CBI*, and may therefore contain additional predictive power for future real activity.

4 DATA

The data used as input in this study consists of the three-month bill rate (*SSVX3M*), the ten-year bond rate (*GVB10Y*), real GDP adjusted for calendar and season effects, inflation measured as the change in the consumer price index (*KPI*) and the Riksbank's key policy interest rate, all for the period of 1984:Q1 to 2006:Q1. The sample period was set according to the availability of the data and is restricted by the length of the series for market interest rates of the government bonds. All data has been gathered from the Riksbank except for the consumer price index which was obtained from Statistics Sweden (SCB).

The sample size is limited by the heavy regulations which the Swedish financial market was subject to until the beginning of the 1980's. Because of the regulations, it is hard to find meaningful and reliable historical data for the market interest rates of Swedish bills and bonds. Good quality data for the two series can only be found from 1983:Q1 and 1984:Q1 respectively.

The Riksbank's most important instrument interest rate has been renamed three times during the sample period as the procedures for implementation of monetary policy has evolved. Until 1986:Q4 the *Diskonto* was used, thereafter the *Marginalränta* until 1994:Q2 and from then onwards the *Reporänta*. The compounded series seems to be stable with respect to the name changes as no breaks occur with them. However, some extreme values are present: in the defense of the Swedish krona's fixed exchange rate the Riksbank raised the *Marginalränta* during two days of September 1992 to an incredibly high 500% (!). The rate hike was however not enough and the fixed exchange rate had to be abolished by November 19th the same year. As this study makes use of quarterly average interest rates, these extreme values do not hit directly into our sample.

The consumer price index used has 1980 as reference year and inflation is measured as quarterly relative year-to-year change. It is calculated according to: $\pi_t = \left(KPI_t - KPI_{t-4}\right) / KPI_{t-4}$. Since there is an information lag – the rate of inflation for period t is only observable after period t – an instrumental variable must be used, denoted $\hat{\pi}_t$. The instrumental variable is obtained from an autoregression model (AR)

with the form: $\pi_t = \beta_0 + \sum_{i=1}^{4} \beta_i \pi_{t-i} + \mu_t$ and hence $\hat{\pi}_t = \beta_0 + \sum_{i=1}^{4} \beta_i \pi_{t-i}$. The equation states that agents form their inflation expectations based on the observed inflation during the past four quarters. The use of an instrumental variable obviously introduces noise to the model. However, assuming that inflation expectations are formed based on the observed inflation for the previous periods is plausible. For instance, Blinder (1996) argues that the best estimate about the inflation rate in the subsequent period is the rate of inflation in the current period.

The time series for real GDP that is used is corrected for calendar effects and adjusted for seasonal variations. The series has been produced by the Riksbank for the period 1980 – 1992 and for 1992 and onwards by Statistics Sweden. A description of the methods that are used for adjustments and corrections can be found in a report by Öhlén (2003). During the sample period, changes in the measurement of GDP have occurred. The new standard, SNA 93-ENS 95, was introduced in May 1999 and concurrently Statistics Sweden introduced a new method for seasonal adjustment, namely TRAMO/SEATS. These changes may have negative effects on the reliability of any inferences that are drawn using the sample. However, the effects are considered to be small or negligible.

5 RESULTS

The results from the regressions of Model 1 are presented in Table 2. The coefficient of the *SPREAD* is positive on all horizons. This is consistent with results of previous research, showing that a steeper yield curve implies a faster future growth. However, as the forecasting horizon is extended, the effect of the *SPREAD* is weakened. The *SPREAD* significantly predicts the cumulative growth up to twelve quarters ahead and the one-quarter marginal growth up to three quarters into the future. In the case of the cumulative growth, the adjusted R^2 is rather high especially for shorter forecasting horizons. For marginal growth, however, the adjusted R^2 drops rapidly after the second quarter.

Table 2 Model 1, Sample 1984:1 – 2006:1

Cumulative Growth: $y^{c}_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \varepsilon_t$

Marginal Growth: $y^{m}_{t+k-j,t+k} = \beta_0 + \beta_1 SPREAD_t + \varepsilon_t$

Forecast Horizon: k Quarters Ahead	Cumulative Growth			Marginal Growth		
	β_1	$\overline{R}^2$	*F sig.*	β_1	$\overline{R}^2$	*F sig.*
1	0.899**	0.327	0.000	0.899**	0.327	0.000
	(0.203)			(0.203)		
2	0.887**	0.404	0.000	0.884**	0.315	0.000
	(0.216)			(0.250)		
3	0.785**	0.356	0.000	0.602*	0.140	0.000
	(0.200)			(0.232)		
4	0.708**	0.315	0.000	0.498	0.092	0.003
	(0.189)			(0.251)		
5	0.638**	0.285	0.000	0.387	0.051	0.021
	(0.182)			(0.259)		
6	0.566**	0.245	0.000	0.244	0.013	0.151
	(0.177)			(0.295)		
7	0.512**	0.215	0.000	0.230	0.010	0.181
	(0.182)			(0.346)		
8	0.470*	0.193	0.000	0.222	0.008	0.203
	(0.186)			(0.327)		
12	0.343**	0.130	0.001	0.116	-0.005	0.434
	(0.171)			(0.267)		

Notes: * Significant at the 5% level
** Significant at the 1% level
Newey and West (1987) standard errors in parentheses
j = 1 for k ≤ 8; j = 4 for k = 12

The column denoted *F sig.* presents the significance level obtained in an *F*-test for significance of the *SPREAD* variable. This test is used to test for the overall

significance of a multiple regression, but since there is only one explanatory variable here it gives the same result as a *t*-test. The *F sig.* overstates the significance in our models since it does not penalize for autocorrelation and conditional heteroskedasticity.

Table 3 below shows the results from the regressions on Model 2. As displayed in the Cumulative Growth panel of the table, the sign of the *SPREAD* is still positive, but the *CBI* is consistently negative. This is natural, as an increase of the central bank interest rate will cool off the economy. The adjusted R^2 of Model 2 is higher than those of Model 1 on all horizons. Nevertheless, the *CBI* coefficients in Model 2 are only significant on a forecast horizon of two quarters for cumulative as well as marginal growth. Further, the *SPREAD* loses the significance it had in Model 1 in predicting cumulative growth. Here, it is only significant on forecast horizons of one and two quarters, while it was significant on all horizons in the first model.

The fact that the coefficients are not as significant as in Model 1 despite higher adjusted R^2 hints that there is a correlation between the *SPREAD* and the *CBI*. This is not surprising, recalling that the *CBI* was shown to have an influence on the *SPREAD* in section 3.1. Due to the correlation between the variables, we can not say which one is better at predicting future growth. *F*-tests for joint significance of the coefficients show that the coefficients are significantly different from zero at the 1% level on all forecast horizons. However, the tests also show that the model is not suited to forecast the marginal growth on longer horizons since it is not possible to reject the null hypothesis that both coefficients are equal to zero.

Table 3 Model 2, Sample 1984:1 – 2006:1

Cumulative Growth: $y^{c}_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CBI_t + \varepsilon_t$

Marginal Growth: $y^{m}_{t+k-j,t+k} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CBI_t + \varepsilon_t$

Forecast Horizon: k Quarters Ahead	Cumulative Growth				Marginal Growth			
	β_1	β_2	$\overline{R}^2$	$F\ sig.$	β_1	β_2	$\overline{R}^2$	$F\ sig.$
1	0.683*	-0.095	0.335	0.000	0.683*	-0.095	0.335	0.000
	(0.298)	(0.080)			(0.298)	(0.080)		
2	0.543*	-0.152*	0.447	0.000	0.386	-0.220**	0.389	0.000
	(0.272)	(0.068)			(0.286)	(0.069)		
3	0.481	-0.136	0.393	0.000	0.332	-0.120	0.154	0.000
	(0.294)	(0.082)			(0.385)	(0.133)		
4	0.436	-0.122	0.345	0.000	0.263	-0.106	0.099	0.005
	(0.299)	(0.093)			(0.365)	(0.144)		
5	0.368	-0.122	0.318	0.000	0.040	-0.156	0.080	0.012
	(0.277)	(0.094)			(0.288)	(0.110)		
6	0.307	-0.118	0.278	0.000	-0.030	-0.125	0.026	0.128
	(0.249)	(0.094)			(0.255)	(0.120)		
7	0.274	-0.109	0.245	0.000	0.071	-0.073	0.006	0.292
	(0.229)	(0.098)			(0.268)	(0.136)		
8	0.235	-0.109	0.225	0.000	-0.034	-0.118	0.018	0.185
	(0.203)	(0.097)			(0.254)	(0.118)		
12	0.112	-0.110	0.176	0.000	-0.131	-0.118	0.015	0.214
	(0.130)	(0.092)			(0.300)	(0.116)		

Notes: * Significant at the 5% level
** Significant at the 1% level
Newey and West (1987) standard errors in parentheses
j = 1 for k ≤ 8; j = 4 for k = 12

Results from regressions on Model 3 are presented in Table 4 below. As apparent, the Riksbank's nominal interest rate is significantly useful in predicting future cumulative growth on forecast horizons of four quarters and above. The real Riksbank rate is also significant on longer forecast horizons for cumulative growth, starting from five quarters ahead. Both variables have significant coefficients on forecast horizons of between three and eight quarters ahead for marginal growth. These results indicate that both *CBI* and *CBR* have some predictive power and that the *CBI* is slightly more significant.

Evaluating the results for cumulative growth against Model 1, the adjusted R^2 is consistently higher in Model 3. Compared to Model 2, however, we get diverse results on different forecast horizons. For horizons up to two quarters, Model 2 has a higher

adjusted coefficient of determination. On three quarters, the models are equal and on all longer forecast horizons, Model 3 has higher adjusted R^2.

Studying the Marginal Growth panel of Table 4 and comparing with Model 1 and 2, it is apparent that by including the *CBR*, the adjusted R^2 increases. Especially on forecast horizons longer than two quarters, this model has the highest adjusted R^2 values and *CBI* as well as *CBR* are significant.

Tests of overall significance of the model also show that jointly, the variables are significantly different from zero on all horizons for both cumulative and marginal growth.

Table 4 Model 3, Sample 1984:1 – 2006:1

Cumulative Growth: $y^{c}_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CBI_t + \beta_3 CBR_t + \varepsilon_t$

Marginal Growth: $y^{m}_{t+k-j,t+k} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CBI_t + \beta_3 CBR_t + \varepsilon_t$

Forecast Horizon: k Quarters Ahead	Cumulative Growth					Marginal Growth				
	β_1	β_2	β_3	$\overline{R}^2$	*F sig.*	β_1	β_2	β_3	$\overline{R}^2$	*F sig.*
1	0.693*	-0.082	-0.017	0.327	0.000	0.693*	-0.082	-0.017	0.327	0.000
	(0.311)	(0.139)	(0.107)			(0.311)	(0.139)	(0.107)		
2	0.548*	-0.146	-0.009	0.441	0.000	0.384	-0.222	0.003	0.382	0.000
	(0.278)	(0.120)	(0.094)			(0.291)	(0.117)	(0.091)		
3	0.443	-0.186	0.066	0.393	0.000	0.205	-0.290*	0.221*	0.201	0.000
	(0.301)	(0.120)	(0.090)			(0.391)	(0.134)	(0.092)		
4	0.356	-0.227*	0.136	0.370	0.000	0.053	-0.382**	0.356**	0.237	0.000
	(0.299)	(0.114)	(0.088)			(0.341)	(0.115)	(0.099)		
5	0.259	-0.263*	0.180*	0.376	0.000	-0.187	-0.452**	0.376**	0.236	0.000
	(0.270)	(0.108)	(0.089)			(0.262)	(0.129)	(0.121)		
6	0.171	-0.294**	0.223*	0.381	0.000	-0.303	-0.479**	0.449**	0.254	0.000
	(0.239)	(0.107)	(0.095)			(0.254)	(0.156)	(0.142)		
7	0.118	-0.312**	0.255*	0.394	0.000	-0.205	-0.432**	0.453**	0.237	0.000
	(0.217)	(0.106)	(0.097)			(0.263)	(0.160)	(0.141)		
8	0.069	-0.325**	0.272**	0.411	0.000	-0.271	-0.429*	0.390*	0.186	0.000
	(0.190)	(0.106)	(0.098)			(0.278)	(0.192)	(0.160)		
12	-0.041	-0.315**	0.254**	0.399	0.000	-0.262	-0.294	0.219	0.089	0.020
	(0.113)	(0.097)	(0.082)			(0.297)	(0.171)	(0.134)		

Notes: * Significant at the 5% level
** Significant at the 1% level
Newey and West (1987) standard errors in parentheses
j = 1 for k ≤ 8; j = 4 for k = 12

5.1 FORECASTING

A stringent measure for the models' predictive power of out-of sample forecasting is the root mean square error (*RMSE*). By evaluating according to *RMSE*, the fallacy of overfitting is avoided. The *RMSE*'s were calculated using the parameters of regressions from the period 1984:1 to 2000:4 for predicting cumulative growth in the period 2001:1 to 2006:1. The choice of the end date was set with respect to keeping enough observations to make the calculations meaningful:

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{y}^{c}_{t,t+k} - y^{c}_{t,t+k})^{2}}$$

where T denotes the number of out-of-sample forecasts. The results from the calculations are presented in the table below.

Table 5 **Root Mean Square Errors in Out-of-Sample Forecasts**

Forecast Horizon: k Quarters Ahead	Model 1		Model 2		Model 3		
	$RMSE$	$\overline{R}^2$	$RMSE$	$\overline{R}^2$	$RMSE$	$\overline{R}^2$	$St.dev.of\ y^{c}_{t,t+k}$
1	1.391	0.327	1.518	0.335	1.519	0.327	2.325
2	1.772	0.404	1.445	0.447	1.454	0.441	2.079
3	1.030	0.356	1.195	0.393	1.242	0.393	1.964
4	0.899	0.315	1.033	0.345	1.108	0.370	1.888
5	0.703	0.285	0.878	0.318	0.984	0.376	1.792
6	0.549	0.245	0.734	0.278	0.874	0.381	1.716
7	0.442	0.215	0.585	0.245	0.741	0.394	1.653
8	0.412	0.193	0.487	0.225	0.656	0.411	1.595
12	0.599	0.130	0.406	0.176	0.491	0.399	1.399

A comparison between the *RMSE* and the standard deviation of the cumulative growth rate of GDP gives an indication of how good the forecasts are. Judging by the size of *RMSE*, the basic Model 1 seems to dominate both the other models on all forecast horizons except on the very long twelve quarter horizon. However, the adjusted

coefficient of determination is consistently lower for Model 1 compared to the other two models, a fact that can not be neglected and also makes the preference of the models less obvious.

5.2 SUB-SAMPLES

Turning to the results of regressions on the two sub-samples, we see signs of a structural break. In Table 6, the outcome of the regressions on Model 1 are presented. In the first period, the *SPREAD* significantly predicts future real cumulative growth on forecast horizons up to seven quarters ahead, while it can not significantly forecast future growth at all during the second period. The estimates are not significant with the *F*-test on any horizon either. Note also that the adjusted R^2 is rather high for shorter forecast horizons in the first sub-sample period, while it is not adequate at all in the second period. Furthermore, the parameter estimates differ radically between the two sub-samples.

Table 6 Model 1 divided into two sub-samples

Cumulative Growth: $y^c_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \varepsilon_t$

Forecast Horizon: k Quarters Ahead	Sample 1984:1 – 1992:4			Sample 1993:1 – 2006:1		
	β_1	$\overline{R}^2$	*F sig.*	β_1	$\overline{R}^2$	*F sig.*
1	0.977**	0.332	0.000	0.481	0.039	0.084
	(0.248)			(0.280)		
2	0.995**	0.441	0.000	0.383	0.034	0.101
	(0.280)			(0.261)		
3	0.855**	0.366	0.000	0.209	-0.001	0.334
	(0.241)			(0.239)		
4	0.759**	0.314	0.000	0.046	-0.020	0.821
	(0.215)			(0.231)		
5	0.675**	0.271	0.001	-0.069	-0.018	0.707
	(0.193)			(0.231)		
6	0.572**	0.204	0.003	-0.143	-0.006	0.396
	(0.181)			(0.230)		
7	0.480*	0.147	0.012	-0.161	0.002	0.303
	(0.192)			(0.231)		
8	0.393	0.097	0.036	-0.124	-0.006	0.399
	(0.198)			(0.221)		
12	0.098	-0.019	0.559	0.111	-0.001	0.334
	(0.151)			(0.188)		

Notes: * Significant at the 5% level Newey and West (1987) standard errors in parentheses
** Significant at the 1% level

A division into two sub-sample periods for Model 2 leads, as demonstrated by Table 7, to a loss of the very few significant coefficients of the *SPREAD* variable obtained earlier (see Table 3). Note also the *F*-tests which indicate that the model is not very useful for the second sub-sample period. However, despite the fact that there are not any significant predictors of output growth, adjusted R^2 is still quite high in the first period. Once again, this may be a consequence of a correlation between *SPREAD* and *CBI*.

The parameter estimates for *SPREAD* differ greatly between the two sub-samples. This also holds for *CBI*, except for on a forecast horizon of three quarters.

Table 7 Model 2 divided into two sub-samples

Cumulative Growth: $y^{c}_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CBI_t + \varepsilon_t$

Forecast Horizon: k Quarters Ahead	Sample 1984:1 – 1992:4				Sample 1993:1 – 2006:1			
	β_1	β_2	$\overline{R}^2$	*F sig.*	β_1	β_2	$\overline{R}^2$	*F sig.*
1	0.885	-0.048	0.315	0.001	0.400	-0.107	0.039	0.139
	(0.484)	(0.155)			(0.318)	(0.139)		
2	0.657	-0.176	0.478	0.000	0.308	-0.098	0.037	0.148
	(0.455)	(0.149)			(0.286)	(0.139)		
3	0.675	-0.094	0.365	0.000	0.137	-0.096	0.004	0.343
	(0.480)	(0.164)			(0.257)	(0.138)		
4	0.695	-0.034	0.296	0.001	-0.015	-0.081	-0.021	0.614
	(0.455)	(0.164)			(0.244)	(0.136)		
5	0.631	-0.023	0.250	0.003	-0.117	-0.063	-0.026	0.675
	(0.392)	(0.151)			(0.245)	(0.130)		
6	0.559	-0.007	0.180	0.014	-0.180	-0.049	-0.018	0.559
	(0.332)	(0.137)			(0.247)	(0.121)		
7	0.498	0.009	0.121	0.045	-0.184	-0.032	-0.016	0.528
	(0.303)	(0.132)			(0.248)	(0.112)		
8	0.385	-0.004	0.069	0.116	-0.135	-0.017	-0.028	0.680
	(0.284)	(0.128)			(0.237)	(0.104)		
12	-0.029	-0.066	-0.032	0.640	0.122	0.023	-0.021	0.569
	(0.193)	(0.114)			(0.199)	(0.072)		

Notes: Newey and West (1987) standard errors in parentheses

Analogous to the results obtained on the sub-samples of Model 2, Model 3 loses some significant coefficients when the whole period is divided into two sub-samples. The results are presented in Table 8 below. On longer forecast horizons, however, the *CBI* and *CBR* can still predict the cumulative growth. This time, the *CBR* is actually

slightly better at predicting the cumulative growth, starting from six quarters ahead compared to seven quarters ahead in the case of the *CBI*. The parameter estimates for all regressors differ substantially across the two sub-samples, comparable to results presented above, and none of the *F*-tests for joint significance of the parameters show signs of the regression being significant in the second period.

Comparing the last three sets of regressions on the sub-samples with those carried out on the whole period, the results tend to incline that there is a structural break in the data. The regressions on the first sub-sample period has consistently better goodness of fit as proven by the higher adjusted R^2 values. Moreover, the test for overall significance of the model can not reject the null hypothesis that all coefficient are equal to zero. This hints that the models are worse at predicting future output in the latter period.

Table 8 Model 3 divided into two sub-samples

Cumulative Growth: $y^c_{t,t+k} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CBI_t + \beta_3 CBR_t + \varepsilon_t$

Forecast Horizon: k Quarters Ahead	Sample 1984:1 – 1992:4					Sample 1993:1 – 2006:1				
	β_1	β_2	β_3	$\overline{R}^2$	*F sig.*	β_1	β_2	β_3	$\overline{R}^2$	*F sig.*
1	0.888	-0.043	-0.004	0.294	0.003	0.466	-0.018	-0.130	0.025	0.239
	(0.581)	(0.453)	(0.270)			(0.360)	(0.258)	(0.270)		
2	0.592	-0.313	0.107	0.475	0.000	0.326	-0.073	-0.037	0.018	0.282
	(0.543)	(0.344)	(0.187)			(0.328)	(0.259)	(0.265)		
3	0.581	-0.291	0.155	0.375	0.000	0.113	-0.128	0.047	-0.016	0.536
	(0.589)	(0.367)	(0.190)			(0.291)	(0.271)	(0.277)		
4	0.557	-0.323	0.228	0.346	0.001	-0.079	-0.167	0.126	-0.031	0.683
	(0.560)	(0.319)	(0.156)			(0.263)	(0.266)	(0.271)		
5	0.457	-0.389	0.288	0.354	0.001	-0.221	-0.204	0.206	-0.009	0.473
	(0.483)	(0.263)	(0.130)			(0.248)	(0.251)	(0.250)		
6	0.351	-0.443	0.343*	0.351	0.001	-0.301	-0.212	0.238	0.023	0.266
	(0.413)	(0.237)	(0.127)			(0.234)	(0.227)	(0.224)		
7	0.263	-0.485*	0.389**	0.363	0.001	-0.296	-0.183	0.221	0.026	0.251
	(0.371)	(0.222)	(0.122)			(0.226)	(0.196)	(0.185)		
8	0.128	-0.544*	0.425**	0.383	0.000	-0.228	-0.141	0.183	0.001	0.393
	(0.335)	(0.209)	(0.115)			(0.215)	(0.169)	(0.148)		
12	-0.239	-0.508**	0.348**	0.241	0.008	0.046	-0.069	0.143	0.011	0.339
	(0.212)	(0.176)	(0.093)			(0.161)	(0.102)	(0.094)		

Notes: * Significant at the 5% level Newey and West (1987) standard errors in parentheses
** Significant at the 1% level

5.3 STRUCTURAL STABILITY

In order to formally address the apparent differences between the sub-samples found in the preceding tables we employ a Chow test and investigate if there is a structural break in between the periods:

$$F = \frac{(RSS_{1984:1-2006:1} - (RSS_{1984:1-1992:4} + RSS_{1993:1-2006:1}))/j}{(RSS_{1984:1-1992:4} + RSS_{1993:1-2006:1})/(n-2j)} \sim F_{(j,n-2j)}$$

where *RSS* represents Residual Sum of Squares. Under the null hypothesis, the regressions of the sub-samples are the same, i.e. there is no structural change or break. The test statistics follow the *F*-distribution with j and $n-2j$ degrees of freedom, where j denotes the number of explanatory variables and n the number of observations. The alternative hypothesis is that the regressions of the sub-samples are different. The results are presented in Table 9.

Table 9 Chow's test of structural stability

Forecast Horizon: k Quarters Ahead	Model 1			Model 2			Model 3		
	F	*F-critical at 5%*	H_0	*F*	*F-critical at 5%*	H_0	*F*	*F-critical at 5%*	H_0
1	1.163	3.104	Not Rej.	0.435	2.715	Not Rej.	0.369	2.484	Not Rej.
2	2.439	3.105	Not Rej.	0.897	2.716	Not Rej.	0.907	2.486	Not Rej.
3	3.615	3.107	Rejected	1.101	2.717	Not Rej.	1.114	2.487	Not Rej.
4	5.328	3.108	Rejected	2.103	2.719	Not Rej.	1.815	2.489	Not Rej.
5	6.974	3.109	Rejected	2.938	2.720	Rejected	2.666	2.490	Rejected
6	7.990	3.111	Rejected	3.561	2.722	Rejected	3.227	2.492	Rejected
7	8.356	3.112	Rejected	3.942	2.723	Rejected	3.519	2.494	Rejected
8	7.958	3.114	Rejected	3.601	2.725	Rejected	3.520	2.495	Rejected
12	8.859	3.120	Rejected	4.212	2.732	Rejected	2.167	2.503	Not Rej.

The null hypothesis is rejected for all three models on forecasting horizons longer than four quarters. Hence, the regressions with horizons of more than four quarters are

believed to be different between the sub-samples due to a structural break. When studying the parameter estimates for the shorter horizons the numbers tend to incline a change in the relationship as the estimates for the latter sub-sample only are a fraction of those of the former. However, failure to reject the null hypothesis does not imply that the null hypothesis is true as the power of the test might be weak.

6 CONCLUSIONS

In this thesis, we have examined three models to predict future real output growth using the term spread of interest rates and the central bank's interest rates. Based on our results, we conclude that the *SPREAD* is, or at least has been, a useful variable for forecasting future growth in GDP. This finding is consistent with previous research on data from other countries. We have presented evidence that there is a significant relationship between the term structure of interest rates and cumulative growth in real GDP on forecast horizons up to twelve quarters. Further, it can also significantly predict the one-quarter marginal growth on forecast horizons up to three quarters.

When the *SPREAD* is modeled together with the Riksbank's nominal and/or real interest rates, the adjusted R^2 increases, suggesting a better goodness of fit. However, the significance of the coefficients for the *SPREAD* is lost as a result of the correlation between the variables. Hence, we conclude that models that use both the *SPREAD* and the Riksbank's interest rates have supplementary predictive power compared to models only based on the *SPREAD* as they provide better in-sample fit and only a moderate loss of out-of-sample predictive performance. The preferred model out of the three that have been presented would be Model 3 mainly because of its superior goodness of fit on longer forecasting horizons.

We have also examined the relationship of the yield curve to the Riksbank's interest rates. The results show that the Riksbank's policy rates have significant influence on the term spread of interest rates, especially in the period after 1993, but are not likely the sole determinant. We therefore conclude that the term spread of interest rates contains information that is not captured by measures of the monetary policy stance and consequently is a useful variable for growth forecasting.

Our tests for structural breaks in the models reveal that there is such a break at the end of the fourth quarter of 1992. This is assumed to be a result of the drastic changes in monetary policy at the time and the introduction of a floating exchange rate. Therefore, the observed correlations are not thought to be policy invariant. The conclusion that the structural break is a result of a shift in monetary policy is also

consistent with previous research by Jardet (2004) who proved that changes in monetary policy in the U.S. have affected the predictive ability of the yield curve.

The structural break brings an almost complete loss of the fairly good predictive power obtained using the whole sample. When the models are used with only observations post 1992, the predictive power of the models are very low. The usefulness of the models must therefore be questioned and if employed, they should be used with caution due to the apparent structural break.

Further analysis on why the predictive power of the yield curve has diminished is left for future research. Also, it is necessary to study the role of other variables that might be able to predict future growth. Additionally, it would be interesting to employ probit models to determine whether the term spread – either alone or in combination with other variables – can be used to predict recession. This, however, requires an objective classification of recessions in Sweden similar to that by the NBER in the United States. In order to get reliable results, such models also require a larger number of observations in which recessions have occurred at least a couple of times. Studies of these kinds are left for future research.

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APPENDIX A TESTS OF STATIONARITY

All empirical work on time series data requires that the time series in question are stationary. Formally, a stochastic time series Y_t is weakly stationary if the following properties hold (Gujarati, 2003):

Mean: $E(Y_t) = \mu$

Variance: $\text{var}(Y_t) = E(Y_t - \mu)^2 = \sigma^2$

Covariance: $\text{cov}(y_t, y_{t+k}) = E\left[(Y_t - \mu)(Y_{t+k} - \mu)\right] = \gamma_k$

To test for stationarity, Dickey-Fuller tests in three different forms have been conducted, allowing the unit root process to take forms of (1) a random walk, (2) a random walk with drift and (3) a random walk with drift around a stochastic trend. By estimating three different equations, the risk for specification errors is avoided, although the procedure could be considered as data mining. To avoid the former, potential critique for the latter is anticipated. Hence, the estimated equations are:

1. Y_t is a random walk: $\Delta Y_t = \delta Y_{t-1} + \mu_t$
2. Y_t is a random walk with drift: $\Delta Y_t = \alpha_1 + \delta Y_{t-1} + \mu_t$
3. Y_t is a random walk with drift around a stochastic trend: $\Delta Y_t = \alpha_1 + \beta_1 t + \delta Y_{t-1} + \mu_t$

where $\delta = \rho - 1$ and t is a time variable. For each estimated equation, the null hypothesis is that the series contains a unit root: $\delta = 0$, and the alternative hypothesis is stated as $\delta < 0$, i.e. the series is stationary. Under the null hypothesis, the estimated t-values follow the τ statistic and the null is rejected if the absolute value of the test statistic is greater than the critical value.

As shown by Table 10 below, the null hypothesis is rejected for all variables except for *SPREAD* and for all the estimated equations at least at the 5% level and most of them even at the 1% level. We therefore conclude that the time series can be considered as being stationary. It should be noted that the *GROWTH* variable is

constructed as the logarithm of the first difference of GDP and it is therefore very unlikely that it would contain a unit root.

For the *SPREAD* variable, the presence of a unit root cannot be ruled out as the test statistics for equations 2 and 3 are insignificant at any conventional significance level. However, as described by Estrella (2005), it is the shape of the yield curve – i.e. the value of the spread – that contains predictive power, not the change in it. One possible explanation for this would be that the term spread contains an element of expected changes in interest rates. Hence, the use of a transformed series with first differences, which would be difference-stationary, is infeasible. For the reasons stated above, the models will be constructed using the *SPREAD* variable. This may have a negative effect on the econometric validity of the obtained results, and any inferences or conclusions drawn upon them must be done with this in mind.

Table 10 Unit Root Tests

Test	Variable	δ	t	Critical τ (1%)	Critical τ (5%)
1.	GROWTH	-0.198**	-2.977	-2.60	-1.95
	SPREAD	-0.113*	-2.274	"	"
	REPO	-0.086*	-2.067	"	"
	REAL	-0.240**	-3.479	"	"
2.	GROWTH	-0.396**	-4.541	-3.51	-2.89
	SPREAD	-0.158	-2.745	"	"
	REPO	-0.277**	-3.719	"	"
	REAL	-0.471**	-5.216	"	"
3.	GROWTH	-0.412**	-4.655	-4.04	-3.45
	SPREAD	-0.195	-3.071	"	"
	REPO	-0.530**	-5.657	"	"
	REAL	-0.505**	-5.504	"	"

Notes: * Significant at the 5% level
** Significant at the 1% level