EUROPEAN CENTRAL BANK

WORKING PAPER SERIES

ECB EZB EKT BCE EKP

WORKING PAPER NO. 294

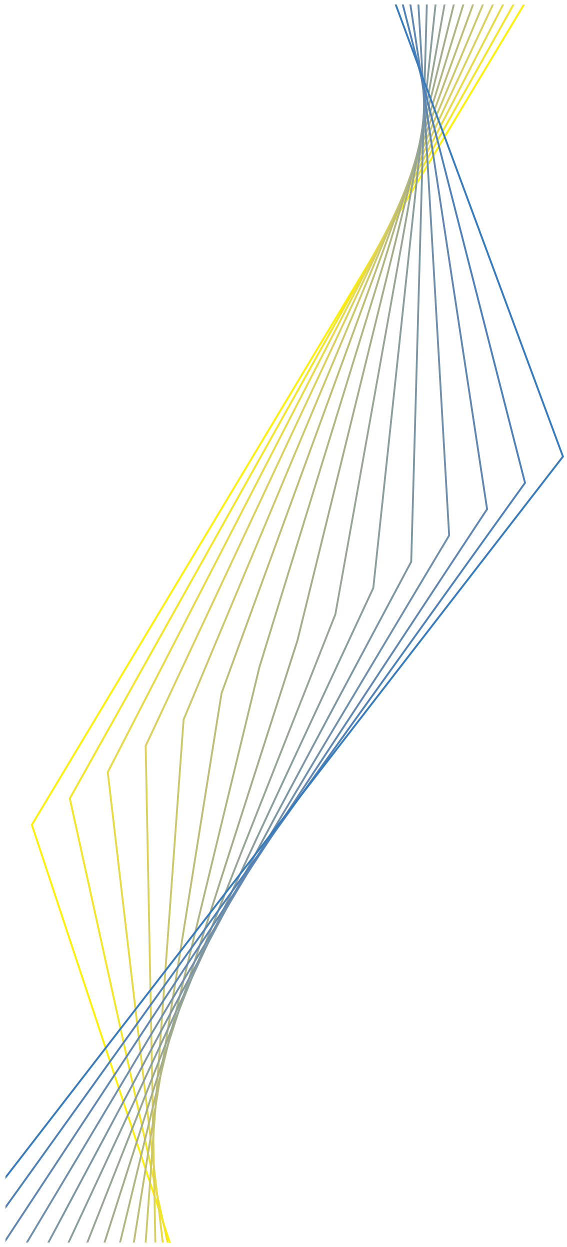
DOES THE YIELD SPREAD PREDICT RECESSIONS IN THE EURO AREA?

BY FABIO MONETA

DECEMBER 2003

EUROPEAN CENTRAL BANK

WORKING PAPER SERIES



WORKING PAPER NO. 294

DOES THE YIELD SPREAD PREDICT RECESSIONS IN THE EURO AREA?[1]

BY FABIO MONETA[2]

DECEMBER 2003

1 *This paper represents part of my work during an internship in the Capital Markets and Financial Structure Division at the European Central Bank. I am very grateful to Stéphane Guéné for introducing me to the topic and for the supervision. Special thanks to Jesper Berg, Angela Maddaloni, Antonello D'Agostino and especially John Fell for useful comments and discussions. I also wish to thanks an anonymous referee and the Editorial Board of the ECB's Working paper series for helpful and constructive comments. However, any errors remain the responsibility of the author. The views expressed in this paper are solely those of the author and not necessarily those of the European Central Bank. This paper can be downloaded without charge from http://ssrn.com/abstract_id=487474.*

2 *Address for correspondence: Finance Department, Carroll School of Management, Boston College, 140 Commonwealth Avenue, Chestnut Hill, MA 02467-3808. E-mail: moneta@bc.edu.*

Address	**Kaiserstrasse 29**
	D-60311 Frankfurt am Main
	Germany
Postal address	**Postfach 16 03 19**
	D-60066 Frankfurt am Main
	Germany
Telephone	**+49 69 1344 0**
Internet	**http://www.ecb.int**
Fax	**+49 69 1344 6000**
Telex	**411 144 ecb d**

ISSN 1561-0810 (print)
ISSN 1725-2806 (online)

Contents

Abstract

This paper studies the informational content of the slope of the yield curve as a predictor of recessions in the euro area. In particular, the historical predictive power of ten yield spreads, for different segments of the yield curve, is tested using a probit model. The yield spread between the ten-year government bond rate and the three-month interbank rate outperforms all the other spreads in predicting recessions in the euro area. The result is confirmed when the autoregressive series of the state of the economy is added in the same model.

The forecast accuracy of the spread between 10-year and 3-month interest rates is explored in an exercise of out-of-sample forecasting. This yield spread appears to contain information which goes beyond the information already available in the history of output, providing further evidence of the potential usefulness of this indicator for monetary policy purposes.

Keywords: probit model, forecasting, recessions, yield curve.
JEL Classification: E44, E52, C53

Non-technical summary

Several empirical studies have examined the usefulness of the slope of the yield curve in predicting future macroeconomic conditions and, in particular, recessions. Indeed, the yield spread between long and short-term interest rates can contain significant information about future real activity. Accordingly, this paper studies the information content in the different parts of the yield curve in order to predict recessions in the euro area.

For this purpose, we constructed a historical database on euro area interest rates. National data were retrieved and then aggregated to obtain euro area series. Quarterly data for 3-month, 1-year, 2-year, 5-year and 10-year interest rates were used. In this way, ten different spreads are regarded as explanatory variables in a standard probit model in order to examine the predictive content in different parts of the yield curve. Indeed, the probit model allows us to obtain a probability of recessions in the euro area from one to eight quarters ahead. Recessions were defined as two consecutive quarters of declining GDP. The most interesting finding is that the spread between the 10-year government bond rate and the 3-month rate, lagged 4 quarters, is the best predictor of recession.

Next, a modified probit model which includes the autoregressive series of the state of the economy (the indicator of recession or expansion) was estimated. We found that the use of this additional regressor helps to forecast historically recessions in the euro area.

The paper then presents an analysis of the out-of-sample performances of the term spread in order to assess its potential usefulness as an indicator for monetary policy purposes. In fact, an in-sample forecast is calculated using information not available at the time of the forecast. By contrast, an out-of-sample forecast only uses information available to market participants at the time of the forecast. A measure of accuracy of the forecast was calculated and compared among different specifications of the probit model. The accuracy of the forecast of the simple probit model was compared with the forecast of a model considering only a lag of the dependent variable (the indicator of recession or expansion) and with the model that considers the spread and a lagged dependent variable. The term spread performed better than the autoregressive series of the state of the economy, and the forecast accuracy, only at one quarter forecast horizon, was improved with the addition of this last variable. Therefore, we conclude that also in out-of-sample context the yield spread contains useful information, for predicting recessions in the euro area, beyond that contained in past economic activity.

The robustness of these results is tested in four ways. First, a sub-sample analysis is carried out. Second, we check whether the yield curve does better than other economic variables with potential predictive power such as the OECD Composite Leading Indicator for the euro area, the quarterly growth rate of the stock price index and the GDP growth. Third, we adopt another definition of recession related to the extraction of turning points in the business cycle. Finally, we check whether the results for the euro area and the individual countries are mutually consistent. This allows the results to be analysed in relation with the existing literature and for us to check if we could replace the synthetic euro area yield spreads with those of specific euro area countries and forecast euro area recessions equally well. It turns out that the spread 10-year minus 3-month rate outperforms both the other yield spreads and the other indicators, especially at a forecasting horizon beyond one quarter. Therefore, the robustness checks confirm our results and provide an additional evidence of the potential usefulness of the yield spread.

Overall, our work shows the best predictor of recession in the euro area considering in-sample and out-of-sample forecasts. The simple probit model, with only the spread as an explanatory variable, appears to be fairly reliable in terms of forecasting recessions in the euro area. The forecasting ability in the short run is improved using a modified probit model which includes the autoregressive series of the state of the economy. The spread 10-year minus 3-month rate therefore contains significant information to forecast euro area recessions and appears to be a useful indicator for monetary policy purposes. As pointed out by Estrella and Mishkin (1998) the attractiveness of this indicator for monetary policy purposes stems from the fact that it is instantaneously available and never revised. In fact, one of the main problems encountered in the prediction of future GDP is that it is often based on preliminary data which are subject to revision.

1 Introduction

Over the last decade, several empirical studies have examined the usefulness of the slope of the yield curve in predicting future macroeconomic conditions and, in particular, recessions. Estrella and Mishkin (1998) documented that the spread between the ten-year Treasury bond rate and the three-month Treasury bill rate performs better than composite indices of leading indicators in predicting economic recessions in the US, especially at a horizon beyond one quarter. While some sources provide additional evidence of this for some countries of the European Union[1], an analysis centred exclusively on the euro area was still unavailable. Therefore, based on this literature, this paper focuses on the study of the information content in the different parts of the yield curve in order to predict recessions in the euro area.

First, we used a standard probit model to predict recessions in the euro area from one to eight quarters ahead. For this purpose, we constructed a historical database on euro area interest rates. National data were retrieved and then aggregated to obtain euro area series, after an analysis of the different methods of aggregation. Quarterly data for 3-month, 1-year, 2-year, 5-year and 10-year interest rates were used. In this way, ten different spreads are regarded as explanatory variables in the standard probit model in order to examine the predictive content in different parts of the yield curve. A measure of fit was calculated; the most interesting finding is that the spread between the 10-year government bond rate and the 3-month rate, lagged 4 quarters, is the best predictor of recession. Second, a modified probit model which includes the autoregressive series of the state of the economy (the indicator of recession or expansion) was estimated. The measure of fit improves as well as the ability of the spread 10-year minus 3-month rates to indicate the likelihood of past recessions in the euro area.

Next, it has been deemed important to analyse the out-of-sample performances of the term spread in order to assess its potential usefulness as an indicator for monetary policy purposes. In fact, an in-sample forecast is calculated using information not available at the time of the forecast. By contrast, an out-of-sample forecast only uses information available to market participants at the time of the forecast. A measure of accuracy was calculated and it was shown that in this case the best lag for the simple model is two quarters (for the same spread 10-year minus 3-month). The accuracy of

[1] See, for example, Estrella and Mishkin (1997) and Bernard and Gerlach (1998).

the forecast of the simple probit model was compared with the forecast of a model considering only a lag of the dependent variable and with the model that considers the spread and a lagged dependent variable. The term spread performed better than the autoregressive series of the state of the economy, and the forecast accuracy, only at one quarter forecast horizon, was improved with the addition of this last variable.

Our work shows the best predictor of recession in the euro area considering in-sample and out-of-sample forecasts. The simple probit model, with only the spread as an explanatory variable, appears to be fairly reliable in terms of forecasting recessions in the euro area. The forecasting ability in the short run is improved using a modified probit model which includes the autoregressive series of the state of the economy. The spread 10-year minus 3-month rate therefore seems to be a useful indicator for monetary policy purposes.

However, cautions are warranted and checks are required when the findings of this paper are considered.

First, there are some problems of data availability. For three-month and ten-year interest rates we have long historical series since 1970. In these cases, the euro area aggregate is representative of the data of the majority of Member States. By contrast, for 1-year, 2-year, and 5-year rates it has been impossible to retrieve such long series. The results of the predictive power of some spreads may therefore be biased. In addition, it may be that what is treated as a 10-year rate is actually the return on a "long" bond with a maturity which changes over time. In order to ensure that the results are not affected by these data problems we carry out a sub-sample analysis. A limitation of this analysis is the fact that recessions are a rare event and we therefore have few recession observations which can be used in the model in order to arrive to significant parameters estimated.[2]

Second, in order to provide further evidence of the potential usefulness of the yield spread as an indicator for monetary policy purposes we check whether the yield curve does better than other economic variables with potential predictive content. Accordingly, we estimate the probit models using in turn the OECD Composite Leading Indicator (CLI) for the euro area, the

[2] As pointed out by Del Negro (2001): "the main strength of this approach [the probit model] is that it is geared specifically towards predicting turning points. The very strength of the approach, however, is also its main weakness. The probit model focuses on recessions, and recessions are rare events. Econometric models aimed at tracking real GDP have numerous observations at their disposal. Model aimed at pinning down recessions have only a handful."

quarterly growth rate of the stock price index and the GDP growth. The yield spread outperforms the other indicators, especially at a forecasting horizon beyond one quarter. Only does the CLI also appear to be a good predictor of recessions in the euro area for a very short forecasting horizon (one quarter ahead).

Third, the definition of recession that we adopted (two quarters of consecutive negative GDP growth) can be criticised[3]. Nevertheless, the results are confirmed when we adopt another chronology of recession based on a different definition. In fact, a recession can be considered as a phase of the business cycle between a peak and a trough. Therefore, we refer to some studies that have focused on the extraction of turning points in the business cycle. By using different recession dates we can confirm that the spread between the ten-year government bond rate and the three-month interbank rate outperforms the other spreads and, in addition, its explanatory power improves considerably.

Lastly, we check whether the results for the euro area and the individual countries are mutually consistent. This allows the results to be analysed in relation with the existing literature and for us to check if we could replace the synthetic euro area yield spreads with those of specific countries and forecast euro area recessions equally well.

The paper is organised as follows. The next section analyses the theoretical relationship between the slope of the yield curve and real economic growth. Section 3 provides a survey of the literature. In section 4, we describe the database that has been constructed and the aggregation issues. In Section 5, the probit model and the results of the in-sample estimation are presented. The modified version of the probit model, which includes a lagged dependent variable, is also described. Section 6 deals with the out-of-sample forecast. The robustness of the results is tested in Section 7. Section 8 concludes the paper.

[3] The 2-quarter GDP rule does not coincide, in fact, with the definition of the NBER Committee that dates the recessions in U.S. If we apply this rule to U.S. GDP we miss some recessions, such as the 1960-61 recession. It seems that this criterion is quite conservative in defining recessions given the fact that GDP has not declined for two consecutive quarters without a recession occurring.

2 The relationship between the slope of the yield curve and real economic growth

There are at least three main reasons that explain the relationship between the slope of the yield curve and real economic growth and thus explain why the yield curve might contain information about future recessions[4]. In general, this relationship is positive and, essentially, reflects the expectations of financial market participants regarding future economic growth. A positive spread between long-term and short-term interest rates (a steepening of the yield curve) is associated with an increase in real economy activity, while a negative spread (a flattening of the yield curve) is associated with a decline in real activity.

The first reason stems from the expectations hypothesis of the term structure of interest rates. This hypothesis states that long-term interest rates reflect the expected path of future short-term interest rates. In particular, it claims that, for any choice of holding period, investors do not expect to realise different returns from holding bonds of different maturity dates. The long-term rates can be considered a weighted average of expected future short-term rates[5]. An anticipation of a recession implies an expectation of decline of future interest rates that is translated in a decrease of long-term interest rates. These expected reductions in interest rates may stem from countercyclical monetary policy designed to stimulate the economy. In addition, they may reflect low rate of returns during recessions, explainable, among other factors, by credit market conditions[6] and by lower expectation of inflation. Indeed, the slope of the yield curve is calculated on nominal interest rates and therefore embodies a term representing expected inflation. Since recessions are generally associated with low inflation rates, assuming for example that a downward Phillips-curve relationship holds, this can play a role in explaining the expectation of low rate of returns during recessions. Alternatively, if market participants anticipate an economic boom and future higher rates of return to investment, then expected future short rates exceed

[4]See, for instance, Sédillot (2001).

[5]See, for example Anderson et al. (1996) for more discussion on the expectations theory of the yield curve.

[6]Indeed, as suggested by Kozicki (1997) the yield spread contains information on credit market conditions. Accordingly, long-term interest rates reflect the supply and demand conditions in credit markets. In particular, if a recession is forthcoming a reduction in demand of credit is expected which will tend to lower the long-term interest rates.

the current short rate, and the yield on long-term bonds should rise relative to short-term yields according to the expectations hypothesis.

Another reason which explains the above relationship is related to the effects of monetary policy. For example, when monetary policy is tightened, short-term interest rates rise; long-term rates also typically rise but usually by less than the current short rate, leading to a downward-sloping term structure[7]. The monetary contraction can eventually reduce spending in sensitive sectors of the economy, causing economic growth to slow and, thus, the probability of a recession to increase. Estrella and Mishkin (1997) show that the monetary policy is an important determinant of term structure spread[8]. In particular, they observe that the credibility of the central bank affects the extent of the flattening of the yield curve in response to an increase in the central bank rate.

The third reason is given by Harvey (1988) and Hu(1993) and it is based on the maximisation of the intertemporal consumer choices. The central assumption is that consumers prefer a stable level of income rather than very high income during expansion and very low income during slowdowns. In a simple model where the default-free bond is the only financial security available, if the consumers expect a reduction of their income - a recession - they prefer to save and buy long-term bonds in order to get payoffs in the slowdown. By doing that they increase the demand for long-term bond and that leads to a decrease of the corresponding yield. Further, to finance the purchase of the long-term bonds, a consumer may sell short-term bonds whose yields will increase. As a result, when a recession is expected, the yield curve flattens or inverts.

[7]In fact, as Bernard and Gerlach (1998) point out, since monetary contractions are temporary, agents raise their expectations of future short-term rates by less than the change in the current short rate.

[8]The authors show also that the monetary policy is not the only determinant of the term structure spread. In fact, there is a significant predictive power for both real activity and inflation. They demonstrate by an empirical analysis that the yield curve has significant predictive power for real activity and inflation in both the United States and Europe. See Estrella and Mishkin (1997) for further details. Estrella (1997) presents also a theoretical rational expectations model that shows how the monetary policy is likely to be a key determinant of the relationship between the term structure of interest rates and future real output and inflation.

3 Related literature

Numerous studies provide evidences on the predictive content of the term spread for real output in the US and in the major developed economies[9]. A number of authors also considered the predictive content of the term spread for inflation, but the results are less satisfactory than the prediction of GDP growth[10].

Instead of focusing on this piece of literature, we prefer to give prominence to the studies which forecast recessions rather than a quantitative measure of real output growth. For the United States, Estrella and Hardouvelis (1991) and Estrella and Mishkin (1998) documented that the yield curve slope significantly outperforms other indicators in predicting recessions, particularly with horizon beyond one quarter. This forecast is done estimating a probit model. Dueker (1997) confirms this result using a modified probit model which includes a lagged dependent variable. Moreover, he introduces a Markov-switching coefficient variation in the model. Built on these works, many papers, on the one hand, give empirical results on the fact that these evidences are present also in the major countries of the European Union and, on the other hand, they try to improve or change the model used to forecast recessions.

The first group of papers includes Bernard and Gerlach (1998), which provide a cross-country evidence on the usefulness of the term spreads in predicting the probability of recessions within eight quarters ahead. Estrella and Mishkin (1997) focus on a sample of major European economies (France, Germany, Italy and the United Kingdom). Sédillot (2001) provides an empirical evidence for France, Germany and the U. S.[11]. Ahrens (2002) evaluates

[9]Among others, we can quote Harvey (1988), Stock and Watson (1990), Estrella and Hardouvelis (1991), Hu (1993), Bonser-Neal and Moreley (1997), Estrella (1997), Davis and Fagan (1997), Smets and Tsatsaronis (1997), Dotsey (1998) and Hamilton and Kim (2002). See Stock and Watson (2001) for a survey on this literature.

[10]These studies include, for example, Mishkin (1990), Kozicki (1997).

[11]The author compares two different approaches to test the relationship between the slope of the yield curve and the rate of growth of the output. The first is a quantitative approach in which a forecast of real economic growth is given. In the second approach, recessions are forecasted using a probit model. This last approach provides an interesting alternative to the quantitative model especially for a better performance in out-of-sample forecast.

the informational content of the term structure as a predictor of recession in eight OECD countries[12].

Among the second group of papers we can quote Ahrens (1999) who uses a Markov-switching model. Shaaf (2000) investigates the power of the yield curve in predicting a recession using an artificial intelligence model called "neural networks ". The author documents a more accurate prediction especially in out of sample simulations of this nonparametric model in comparison with traditional econometric models. Three different non-linear models (probit model, logit model and a Markov regime switching model) are tested in forecasting US business cycles by Layton and Katsuura (2001)[13]. Sephton (2001) adopts a nonparametric model called multivariate adaptive regression splines (MARS) obtaining a better result than the probit model especially for in-sample recession forecasting. Chauvet and Potter (2001) compare forecasts of recessions using four different specifications of the probit models: a time invariant conditionally independent version; a business cycle specific conditionally independent model; a time invariant probit with autocorrelated errors; and a business cycle specific probit with autocorrelated errors. They provide evidence in favour of the last and more sophisticated model. Dueker (2001) applies a vector autoregression (VAR) model to forecasting qualitative variable such as a recession in the U. S.. A Bayesian VAR is presented by Del Negro (2001), but it does not perform better than the Estrella-Mishkin model.

Our paper follows the path of the first group of papers with the aim of examining the forecasting ability of the slope of yield curve in predicting recessions in the euro area. The main object of our contribution is to carry out this investigation at different segments of the yield curve - testing therefore which specific spread is the best predictor of recessions in the euro area - and to assess the potential usefulness of the euro area term spread, selected as the dominant predictor of recessions, as indicator for monetary policy purposes. We will use a traditional econometric model - the probit model - which is presented in section 5 after a presentation of the dataset used.

[12] Ahrens (ibid.) uses Markov-switching models and the term structure is confirmed to be a reliable recession indicator.

[13] A logit model is estimated also by Birchenhall et al. (2001) in order to predict UK business cycle regimes.

4 Data description and aggregation issues

To obtain evidences on the usefulness of the slope of the yield curve for predicting recessions in the euro area we need to carry out an empirical analysis. Econometrics analysis makes use of long historical series. The problem is that the euro area has only few years of life. Moreover, to the best of our knowledge, no attempt has been made to retrieve a long historical yield curve for the euro area[14]. To deal with this issue we construct a database on the interest rates of the euro area Member States in order to obtain a historical yield curve of the euro area, focusing on 5 main knot points[15]: 3-month, 1-year, 2-year, 5-year and 10-year maturity. We retrieved data on all euro area Member States using several sources (see Appendix A for details). Since reliable data are a prerequisite for solid empirical investigations, we paid specific attention to the choice of the most reliable series and how to construct area-wide data for the period before the introduction of the euro. Appendix A explains how we cope with the first issue. We end up with quarterly data from 1970 on (where possible) for all the euro area Member States. In fact, it has been difficult to have such long series for all the countries and maturity considered. The best result is for 3-month and 10-year maturity (see Appendix A for an overview of the starting dates of the series).

There is an interesting piece of literature on creating historical euro zone data. Gulde and Schulze-Ghattas (1992) compare aggregations with PPP's rates and exchange rate-based GDP weight. They conclude that PPP's-based GDP weights are preferable. Winder (1997) compares four possible aggregations: current exchange rate, fixed base-period exchange rate (1985), current purchasing power rate and fixed base-period purchasing power rate. It is preferable to use either fixed base-period exchange rates or fixed base-period PPP's rates to convert countries' output into a common currency. On an area level, the aggregated variable is the weighted average of the corresponding variables of the individual countries and the series will not depend on the specific common currency chosen. Nevertheless, as Hong and

[14]In Fagan et al. (2001) is presented a database for the euro area (Area-Wide Model database) but it provides only a short term interest rate and a long term interest rate. See also Agresti and Mojon (2001).

[15]We do not use the last part of the yield curve, i. e. the 30-year government bond yield, because a long historical series is not available for this maturity.

Beilby-Orrin (1999) point out, no single method is mathematically superior to the others since each method has relative strengths and weaknesses[16].

For our purpose, we need to aggregate national interest rates in an euro area rate. We aggregate since 1970 and therefore we decide to use a GDP weight that is available since this date. In the Monthly Bulletin (MB) of the ECB the method adopted to aggregate national government bond yields has been, until December 1998, to use also GDP weight and a 1995 purchasing power parities (PPP's) as conversion rate. Thereafter, the weights are the nominal outstanding of government bonds in each maturity band[17]. Instead of adopting a fixed weight, as in the MB, the weight is variable every year in order to take into account the variations of the relative weight of the Member States over time[18].

In order to decide the conversion rate be used, we carry out an empirical investigation. In this way it is possible to assess the sensitiveness of the results to different aggregation choices. We use and compare three different weights: GDP at PPP's 1995, national currency GDP converted using the exchange rate with the Deutsche Mark (DM) and GDP expressed in euro. In the Figure 8 of the Appendix A, we plot the 10-year government bond yield for the euro area obtained using the three different methods. The differences are quite small, and they are more relevant during the period from 1975 to 1986. During the last period from January 1994 we plotted also the official

[16]The fixed exchange rate is simple and maintains the price movements of the original national data but it is sensible to relative changes in inflation rates. Current exchange rates give growth rate in a common currency but have the disadvantage that the aggregate will be more sensitive to exchange rate shocks. Application of PPP's is useful since the theory underlying their construction is the elimination of difference in price levels between countries and volatile movements in exchange rates. This method is recommended for countries with no great homogeneous economic structures but it presents certain calculation problems (which basket of goods, which methodology).

However, it is worth mentioning also the recent contribution of Beyer, Doornik and Henfry (2001) which proposes to aggregate weighted within-country growth rates to obtain euro-zone growth rates, then cumulating this euro-zone growth rate to obtain aggregate levels.

[17]Eurostat follows ECB's method, and the OECD publishes ECB data for interest rates. Nevertheless, the approach adopted by the OECD to deal with pre-1999 series is one of excluding the exchange rate effects. For example, in order to construct a GDP series for euro area they opt for converting the data in national denomination into 'national euro' by applying the irrevocable conversion rate between the national currency and the euro. On this subject, see Schreyer and Suyker (2002).

[18]In fact, the period that we consider is very long (since 1970) in comparison with the MB where the data are aggregated since 1994.

data published in the MB. The series closest to the official one is obtained adopting a GDP weight at PPP's 1995. Finally, according to the literature and to this empirical investigation we decide to aggregate the data for the five maturity (3-month, 1-year, 2-year, 5-year and 10-year) using a GDP weight converted using PPP's 1995.

5 The models and the in-sample estimation

Following Estrella and Hardouvelis (1991) and Estrella and Mishkin (1998), we study the ability of the slope of the yield curve to predict recessions in the euro area. First, we estimate a probit model to obtain a probability of recession in the euro area between 1 and 8 quarters ahead. Then, we improve the probit model using the modification proposed by Dueker (1997).

5.1 The standard probit model

In the probit model, the variable being predicted is a dummy variable R_t where $R_t = 1$ if the economy is in recession in period t and $R_t = 0$ otherwise. The probability of recession at time t, with a forecast horizon of k periods is given by the following equation:

$$\Pr(R_t = 1) = \phi(c_0 + c_1 X_{t-k}), \tag{1}$$

where $\phi(.)$ is the cumulative standard density function, and X is the set of explanatory variable used to forecast the recessions[19].

In order to analyse the predictive informative content in different segments of the yield curve we use ten yield curve spreads as explanatory variables. We plug, therefore, in the right side of the equation 1 all the spreads listed in the panel A of Table 1 and we estimate the model[20].

Defining what is a recession is fundamental for constructing the binary time series R_t. The National Bureau of Economic Research (NBER) officially dates the beginnings and ends of US recessions and it defines a recession as "a significant decline in activity spread across the economy, lasting more than

[19] For a more complete discussion of the Probit model, see Pindyck and Rubinfeld (1997).

[20] The model is estimated using a non-liner method (the Newton-Raphson) provided by RATS.

A	Standard probit model: $\Pr(R_t = 1) = \phi(c_0 + c_1 X_{t-k})$							
Predictor	FORECAST HORIZON (Quarters)							
Spread:	K=1	K=2	K=3	**K=4**	K=5	K=6	K=7	K=8
1Y-3M	0.011	0.010	0.000	0.011	0.015	0.000	0.002	0.003
T-stat	(-1.25)	(-1.05)	(-0.25)	(-0.94)	(-1.02)	(0.12)	(0.39)	(-0.44)
2Y-3M	0.099	0.091	0.041	0.048	0.034	0.000	0.006	0.000
T-stat	(-3.64)	(-3.16)	(-2.65)	(-2.26)	(-1.99)	(-0.05)	(1.00)	(0.09)
5Y-3M	0.093	0.093	0.056	0.064	0.050	0.006	0.000	0.001
T-stat	(-3.29)	(-3.11)	(-2.81)	(-2.50)	(-2.22)	(-0.98)	(0.10)	(-0.27)
10Y-3M	0.161	0.204	0.141	**0.212**	0.204	0.053	0.006	0.010
T-stat	(-3.80)	(-3.61)	(-4.45)	(-6.01)	(-4.38)	(-3.75)	(-1.17)	(-1.38)
2Y-1Y	0.090	0.081	0.065	0.030	0.008	0.000	0.003	0.008
T-stat	(-2.45)	(-2.48)	(-2.61)	(-1.63)	(-0.74)	(-0.19)	(0.52)	(0.81)
5Y-1Y	0.085	0.087	0.080	0.056	0.032	0.013	0.001	0.000
T-stat	(-2.86)	(-3.04)	(-3.23)	(-3.16)	(-2.18)	(-1.38)	(-0.27)	(0.14)
10Y-1Y	0.072	0.107	0.135	0.105	0.074	0.047	0.010	0.000
T-stat	(-1.98)	(-2.60)	(-3.51)	(-1.97)	(-1.29)	(-1.17)	(-0.73)	(-0.20)
5Y-2Y	0.030	0.041	0.046	0.051	0.046	0.035	0.017	0.011
T-stat	(-1.58)	(-1.94)	(-2.08)	(-2.00)	(-1.85)	(-1.66)	(-1.23)	(-0.94)
10Y-2Y	0.000	0.004	0.013	0.029	0.049	0.059	0.034	0.015
T-stat	(-0.09)	(-0.49)	(-0.82)	(-1.28)	(-2.06)	(-2.70)	(-2.27)	(-1.28)
10Y-5Y	0.006	0.002	0.000	0.000	0.004	0.008	0.006	0.002
T-stat	(0.62)	(0.36)	(0.11)	(-0.15)	(-0.46)	(-0.73)	(-0.63)	(-0.30)

B	Probit model with a lagged dependent variable: $\Pr(R_t = 1) = \phi(c_0 + c_1 X_{t-k} + c_2 R_{t-k})$ (0) (1) Nested model with only c_0 (2) Nested model with c_0 and c_1 (3) Nested model with c_0 and c_2							
Spread 10Y-3M:	K=1	K=2	K=3	K=4	K=5	K=6	K=7	K=8
(0) / (1)	**0.315**	0.205	0.143	0.258	0.249	0.054	0.015	0.010
(0) / (2)	**0.188**	0.014	0.000	0.014	0.014	0.000	0.013	0.000
(0) / (3)	0.114	0.190	0.143	**0.242**	0.233	0.053	0.002	0.010

Table 1: Pseudo-R^2 Measures of Fit for Recession predictors (Estimation period 1970Q1-2002Q2)

a few months, visible in industrial production, employment, real income and wholesale retail trade ". Since there is not an official arbiter like NBER for the euro area, we adopt the rule of thumb that defines recessions by at least two consecutive quarters of declining GDP[21]. Using this convention four recessions are spotted since 1970 the dates of which are the following: 1974:Q4 – 1975:Q1, 1980:Q4 – 1981:Q1, 1982 :Q3 – 1982:Q4 and 1992:Q2 – 1993:Q1.

Another issue is raised in analysing the goodness of fit. In the classical regression model, the coefficient of determination R^2 is used as a measure of the explanatory power of the regression model. It can range in value between 0 and 1, with a value close to 1 indicating a good fit. In this kind of model it is no more likely to yield an R^2 close to 1[22]. To avoid this problem we use the measure of fit proposed by Estrella (1998). It is a pseudo-R^2 in which the log-likelihood of an unconstrained model, L_u, is compared with the log-likelihood of a nested model, L_c[23]:

$$pseudo - R^2 = 1 - \left(\frac{L_u}{L_c}\right)^{-(2/n)L_c}. \quad (2)$$

A last potential problem stems from the serially correlation of the errors. In fact, as observed by Estrella and Rodrigues (1998), since the forecast horizons are overlapped the prediction errors are in general autocorrelated. We correct this bias using the Newey-West (1987) technique and presenting thus t-statistics calculating using robust errors adjusted for the autocorrelation problem.[24]

Table 1 (panel A) presents the Pseudo-R^2 calculated after the estimation of a probit model using the different spreads as explanatory variable and with lags ranging from 1 to 8 quarters.[25] The highest Pseudo-R^2 is obtained

[21] The NBER's recession-dating committee does not actually look at GDP figures, because they come out only quarterly, not monthly, and are continually revised.

The GDP series of the euro area is an ECB calculation. This series is an aggregation of national data until the year 1991 and thereafter it is provided by Eurostat.

[22] See, for example, Pindyck and Rubinfeld (1997).

[23] The constrained model comes from a model with c_1, in equation (1), is equal to zero. The log-likelihood in the case of the probit model is given by
$L = \sum_t R_t \ln \Pr(R_t = 1|X_{t-k}) + (1 - R_t) \ln \Pr(R_t|X_{t-k})$.

[24] This is an option provided by RATS and it has been used also by Estrella and Mishkin (1998).

[25] We tried also to estimate a logit model and we obtain very similar results. The results

with the estimation of a probit model considering as predictor the spread 10-year minus 3-month. In particular, the lag which presents the best fit is $K = 4$. In this case, the Pseudo-R^2 is 0.212 and the t-statistic is -6.01[26]. This result is significant at the 1 per cent level, and if we make a comparison with the Pseudo-R^2 of the other spreads we can draw the conclusion that the best recession predictor is the spread 10-year minus 3-month lagged four quarters. Indeed, the other spreads do not present a significant measure of fit and, thus, not a significant predictive power of recessions in the euro area.

As explained above, the probit model allows us to estimate the probabilities that the economy will be in recession in a given quarter on the basis of the interest rate spread observed some quarters before. Figure 1 presents these probabilities using the spread 10-year minus 3-month lagged 4 quarters.

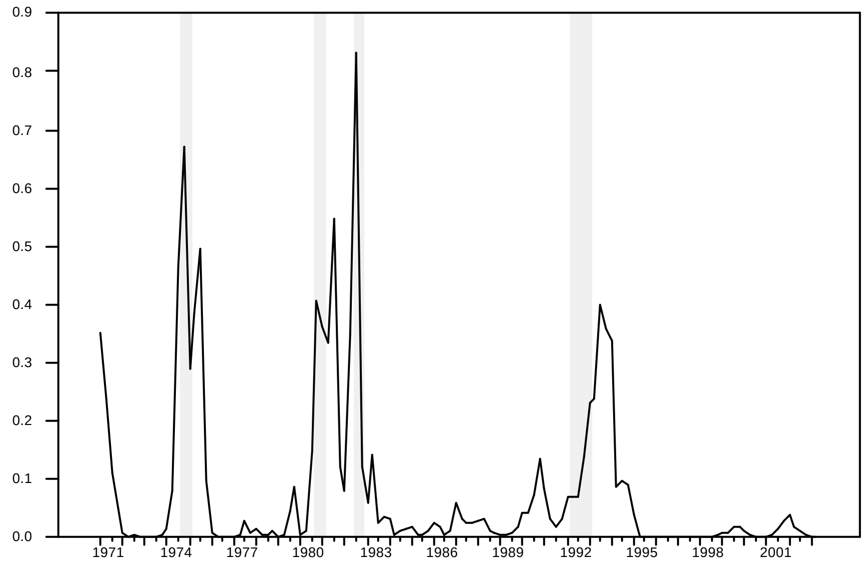


Figure 1: Estimated probability of a recession in the euro area in the current quarter using the spread 10-year - 3-month four quarters earlier.

are available from the author on request.

[26]A value of 0.212 seems low if it is interpreted as an R^2, but also in other empirical studies the Pseudo-R^2 is not very large. For example, Estrella and Mishkin (1998) yielded on U.S. data a value of 0.296 using as predictor the spread 10-year minus 3-month lagged four quarters.

Ideally, the probability should be one in the recession quarters (which are shaded in the figure) and zero otherwise. Figure 1 shows that the estimated probability increases in the recession periods and remains low in the non-recession quarters. In particular, the probability becomes 0.67 in 1974:Q4 and 0.83 in 1983:Q3 which represents the beginning of two recessions. The model provides also a warning of the 1980 recession, in fact, the estimated probability increases to the value of 0.41. For the recession of the 1990s it gives a quite late warning instead. Hence, the model appears to provide rather a good indication of the existence of a future recession considering also the fact that it gives very few false alarms.

5.2 Probit model with a lagged dependent variable

One of the main assumption of the probit model is that the random shocks u are independent, identically distributed normal random variables with zero mean. As noted earlier, in this kind of model the errors are generally autocorrelated. In traditional time series approach we deal with this problem using an autoregressive moving average filter. Here, since the shocks u are unobservable this technique is not more available. Therefore, we adopt the solution proposed by Dueker (1997) to remove the serial correlation in u by adding a lag of R_t (the indicator variable of the state of the economy). Therefore, we allow the model to use information contained in the autocorrelation structure of the dependent variable to form predictions. The probit equation becomes:

$$\Pr(R_t = 1) = \phi(c_0 + c_1 X_{t-k} + c_2 R_{t-k}). \tag{3}$$

Table 1 (panel B) presents the results of the estimations of this model using as explanatory variable the spread 10-year minus 3-month and with lags ranging from one to eight quarters. We do not present the results of the estimation considering the other spreads because there are not significantly different from the previous estimation. The pseudo-R^2 is now calculated in the same manner as explained above with the exception that we can have three different specifications. The unrestricted model L_u is calculated using also the lag of R. The restricted model L_c can come from a model with both c_1 and c_2 are equal to zero, with only c_2 is equal to zero or with only c_1 is equal to zero. Table 1 (panel B) presents the three different specifications.

In the first specification (first row in the panel B of Table 1), the restricted model is the same as the simple probit model and therefore, it is possible to compare this pseudo-R^2 with the value obtained estimating the simple probit model. Now, the pseudo-R^2 is 0.315 and the best recession predictor is the spread lagged one quarter. However, this measure is sensible to the fact that we add another explanatory variable making thus the comparison not really meaningful.

In the second specification (second row in the panel B of Table 1), we test for the informational content provided by the lagged dependent variable in addition to the information embodied in the spread. The measure of fit is significant only at one quarter forecast horizon suggesting that the lagged dependent variable provides important information only at the very short run (one quarter ahead).

In the last and most interesting case (last row in the panel B of Table 1), we test for the information content which goes beyond the information already contained in the autoregressive structure of the binary time series. The lag which presents the best fit is still $k = 4$ and the value of the pseudo-R^2 rises to 2.242, proving a good informative content of the spread.

The estimated probabilities of recession obtained from running this model are plotted together with the recession quarters in Figure 2 and they are compared with the estimated probabilities obtained previously running the standard probit model.

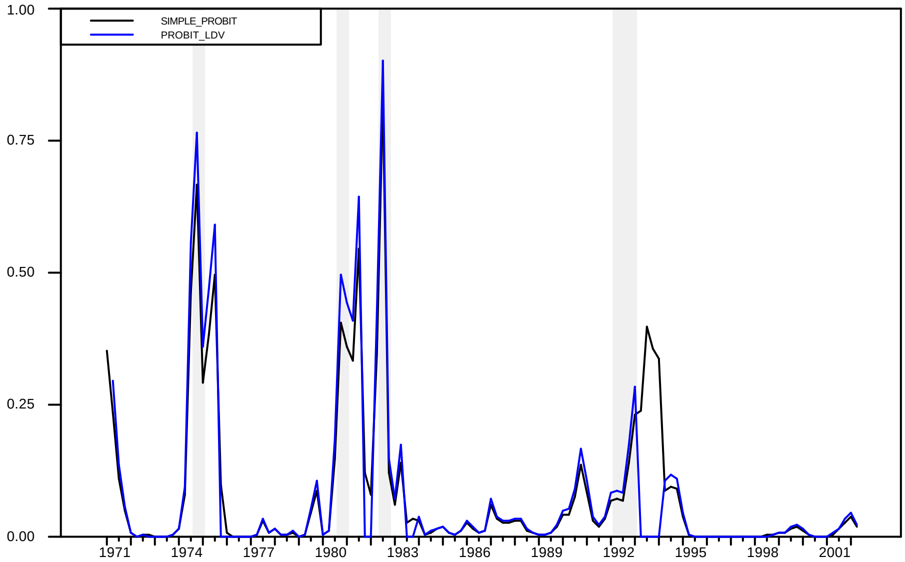


Figure 2: Estimated probability of a recession in the euro area in the current quarter using the spread 10-year - 3-month four quarters earlier and calculated using the simple probit model (dark line / simple_probit) and the probit model with a lagged dependent variable (blue line / probit_ldv).

The result using as predictor of recession the spread 10-year minus 3-month lagged 4 quarters improves. In fact, the estimated probability of the recession of 1974 rises to 0.76, of the recession of 1980 to 0.5 and of the recession of 1982 to 0.9. As before, the model does not predict very well the recession of 1992[27].

Moreover, following Stock and Watson (1990), we calculate the false positive rate and the false negative rate. The former is the average fraction of times that a recession is forecasted when in fact no recession occurs, and the latter is the average fraction of times that no recession is forecasted when in fact a recession occurs[28]. Table 2 presents the two indicators for both the standard probit model and the probit model with a lagged dependent

[27]If we regard as predictor of recession the spread lagged 1 quarter we have a better prediction of the recession of 1992. It is interesting to notice that also for U. S. data there is a poor performance in forecasting the U. S. recession of 1990. See, for example, Filardo (1999).

[28]We consider that a recession is forecasted if the estimated probability is greater or equal to 0.5.

Predictor	**False positive rate**	**False negative rate**
	Standard probit model	
Spread 10Y-3M	0.009	0.800
	Probit model with a lagged dependent variable	
Spread 10Y-3M	0.026	0.700

Table 2: Probit model to predict recessions at 4-quarter horizon using as predictor the spread 10-year minus 3-month – false positive and negative rate.

variable. On the one hand, false recession forecasts occur relatively rarely given the low value of the false positive rate for both cases. On the other hand, the false negative rate is quite large meaning that the four-quarters ahead recession probabilities rarely approach one when in fact a recession does occur. The main issue, here, is that the longest recession of the 1990s (four quarters of recession) is not forecasted and there are only 10 quarters of recession since 1970. However, the false negative rate improves with a lagged dependent variable proving a better forecast of recessions.

In short, considering in-sample forecasting it seems that the use of a lagged dependent variable helps to forecast historically recessions in the euro area. Therefore, a probit model modified with the insertion of a lagged dependent variable appears somewhat preferable than the standard probit model.

6 Out-of-sample forecasting

The main drawback of an in-sample forecast is that is calculated using information that was not available at the time of the forecast. For example, in the previous estimation we used quarterly data from 1970:Q1 to 2002:Q2 and therefore the estimated probability of a recession in 1983 was calculated estimating the model on the whole period. By contrast, an out-of-sample forecast uses only information available to market participants at the time of the forecast. Moreover, an in-sample forecast can always be improved by adding a new explanatory variable, but that can lead to an "overfitting problem ". To avoid a possible misleading indication of the true ability of the term spread to forecast a recession it is important to carry out an exercise of out-of-sample forecasting.

First, we estimate the probability of recession in out-of-sample simulations. Next, we assess the forecasting performance of the simple probit model calculating a forecast error. Finally, the Diebold and Mariano test is implemented to compare the accuracy of different forecasts.

6.1 Predicting recessions

The out-of-sample probabilities of a recession are computed by performing the following steps. First, we estimate the simple probit model over the 1970:Q1 to 1983:Q1 period in order to have a good estimation of the parameters[29]. Then, we estimate the probability of recession at a given quarter ahead and we record the value. After adding one more quarter to the estimation period, the procedure is repeated. We end up with a series of estimated probabilities. Table 3 presents the pseudo-R^2, calculated using an out-of-sample estimation, for both the standard probit model and the probit model with a lagged dependent variable.[30] Comparing with the pseudo-R^2, obtained previously in the in-sample estimation (Table 1), the values are quite similar, nevertheless in out-of-sample the best fit is yielded, for both models, with a lag of two quarters. As noted by Estrella and Mishkin (1998), the pseudo-R^2 in out-of-sample is no longer guaranteed to lie between 0 and 1. Indeed, for $k = 7$ a negative pseudo-R^2 is obtained which can be interpreted as a very poor forecast.[31]

The quality of the out-of-sample forecast for both models is evaluated in the Figure 3 and 4 comparing the probability of recession using an in-sample estimation with that obtained in an out-of-sample estimation. Before 1983, the out-of-sample probability is actually an in-sample estimation calculated over the period from 1970:Q1 to 1983:Q1. The two estimated probabilities are quite similar indicating a good quality of our forecast.[32]

[29]The explanatory variable is always the term spread 10-year minus 3-month, which has been selected as the dominant predictor of recessions in the euro area.

[30]The pseudo-R^2 is calculated using equation 2. In out-of-sample forecasting the probabilities of recession are not the same as in-sample. For the probit model with a lagged dependent variable we decide to present only the last and most meaningful specification of the pseudo-R^2(with a nested model with $c_1 = 0$).

[31]A model with just a constant would perform better than the model with the spread and a lagged dependent variable.

[32]However, qualitatively, it seems that with the standard probit model the out-of-sample estimated probabilities are closer to the in-sample probabilities than with the other model.

Out-of-sample								
Predictor	FORECAST HORIZON (Quarters)							
Spread:	K=1	K=2	K=3	K=4	K=5	K=6	K=7	K=8
	Standard probit model							
10Y-3M	0.16	**0.205**	0.142	0.188	0.144	0.052	0.003	0.007
	Probit model with a lagged dependent variable							
10Y-3M	0.118	**0.276**	0.216	0.218	0.178	0.047	-0.001	0.007

Table 3: Pseudo-R^2 Measures of Fit for Recession predictor. Out-of-sample Estimation (Estimation period: 1970Q1 - 1983Q1. Ex post forecast period: 1983QK - 2002Q2).

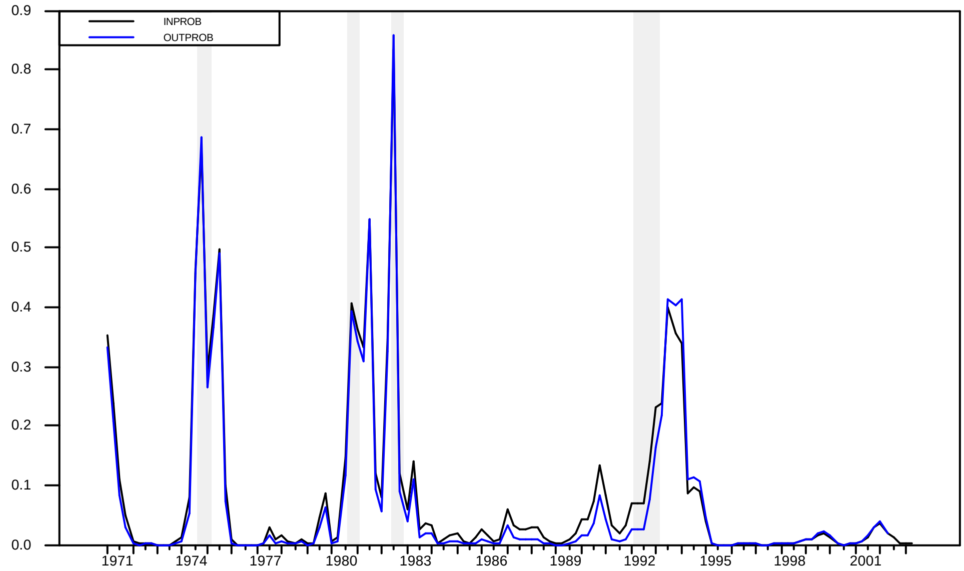


Figure 3: Estimated probability of a recession in the euro area in the current quarter using the spread 10-year - 3-month four quarters earlier and calculated in-sample (dark line/inprob) and out-sample (blue line/outprob).

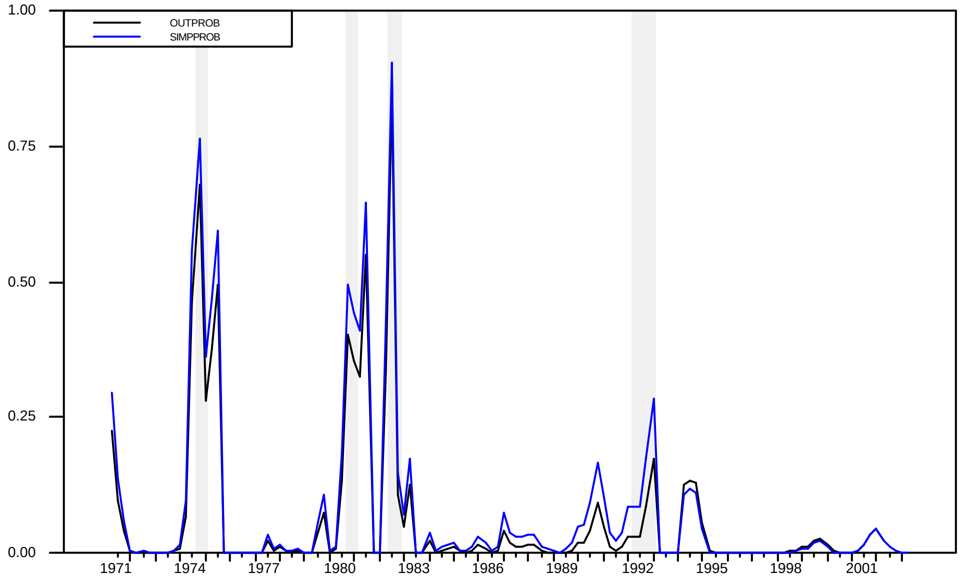


Figure 4: Estimated probability of a recession in the euro area in the current quarter using the spread 10-year - 3-month and a lagged dependent variable four quarters earlier and calculated in-sample (dark line / inprob) and out-sample (blue line / outprob).

6.2 Measures of forecasting performance

In order to be more formal and, thus, give a quantitative measure to compare predictive ability, a forecast error is calculated. The problem is that the dependent variable is not observable, but considering that an ideal model should give a probability of one in the recession period and zero otherwise we calculate the forecast error as the difference between the estimated probability and the indicator of recession (the dummy variable R_t). We use as function of loss the absolute value[33]. The results are presented in Table 4.

[33] Brier (1950) proposed a statistic to measure the accuracy of probability predictions that has been used by Diebold and Rudebusch (1989). The measure is known as the *quadratic probability score* (QPS) and is defined as follows:

$\mathrm{QPS} = \frac{1}{T}\sum_{t=1}^{T} 2\left(p_t - r_t\right)^2$,

where p_t is the predicted probability (of a recession in our case) and r_t is the realisation (in our case, is the indicator of recession). The QPS statistics can range between 0 and 2, with 0 implying a perfect forecast. We tried to use also this quadratic loss function. The results appear comparable.

Explicative variables	*1 Q forec.*	*2 Q forec.*	*3Q forec.*	*4Q forec.*
Spread	0.08301	**0.07694**	0.09354	0.08413
Lagged dependent variable	**0.08125**	0.14224	0.14365	0.14632
Spread + Lagged dep. var.	**0.03811**	0.09016	0.09224	0.06678

Table 4: Mean absolute forecast error

The lower is the forecast error, the better is the accuracy of the forecast. Three models are compared: the simple probit model with only the spread 10-year minus 3-month as explanatory variable, a probit model in which just the lag of the dependent variable is used as independent variable and the probit model with a lagged dependent variable. The best accuracy is obtained estimating the last model at one quarter forecast horizon. For the standard probit model, it is confirmed that in out-of-sample the best lag is two quarters.[34]

In summary, as noted earlier, the term spread between 10-year minus 3-month (the standard probit model) performs well and better than the history of output, at a horizon beyond one quarter, and the accuracy of the forecast can be improved, at one quarter of forecast horizon, adding a lagged dependent variable. However, when a lagged dependent variable is added, we include a variable the value of which depends on a latent variable (GDP series). The issue is that the GDP is released with a certain delay and is subject to revision[35]. Therefore, the estimated probability can not be real time neither simulated out-of-sample estimation.

6.3 Diebold-Mariano test

The Diebold and Mariano(1995, see Appendix B) test is implemented in order to compare the forecasting ability of the different methods. The null hypothesis of this test is that of equal accuracy for two forecasts. That means that in this case we test the hypothesis of equal expected absolute errors. We compare the absolute error obtained estimating the simple probit model

[34]This result is probably due to the fact that with four quarters forecast horizon is not well forecasted the 1990s recession (see Figure 1) while it is forecasted better with two quarters forecast horizon. Unfortunately, because of the few recession observations we can not extend the exercise of out-of-sample forecasting to other recessions.

[35]However, it is rather difficult that the revision affects the sign of the GDP growth. Indeed, the dependent variable as defined so far hinges on the sign of the GDP growth.

Test Diebold-Mariano	*1 Q forec.*	*2 Q forec.*	*3Q forec.*	*4Q forec.*
Spread – Lagg.dep.var.				
Test	0.486	-7.96	-5.6	-4.58
P value	0.627	$1.55431e^{-15}$	$2.09220e^{-08}$	$4.61566e^{-06}$
Spread – Spread + Lagg.dep.var.				
Test	5.275	-3.037	0.616	1.953
P value	$1.32378e^{-07}$	0.002	0.537	0.051

Table 5: Results of the Diebold-Mariano test. The null hypothesis is the equal forecast accuracy of two forecasts.

with both the absolute error obtained estimating a probit model with just a lagged dependent variable and a probit model which contains as explanatory variable the spread and the lagged dependent variable.

As showed in Table 5, only in three cases the null hypothesis is not rejected at conventional levels. The first case is when we compare, at 1 quarter forecast horizon, the simple probit model containing just the spread with the model which includes only a lagged dependent variable. Thus, at 1 quarter forecast horizon, the spread is not statistically a worse predictor than the lagged dependent variable. However, beyond 1 quarter the spread is confirmed to perform better than the lagged dependent variable. In fact, the null is rejected. Accordingly, the yield spread contains information which goes beyond the information already available in the history of output. The other two cases occur when the forecast error of the simple probit model is compared with the forecast error of the modified model with the addition of the lagged dependent variable. The spread does not prove to be statistically significantly worse predictor than the model with the addition of the lagged dependent variable for the third and fourth quarter of the forecast horizon. However, it performs better at two quarters, since the null is rejected and in Table 4 the accuracy was better. It is confirmed again that the addition of the lagged dependent variable improves the accuracy of the forecast at one quarter ahead.

Therefore, in out-of-sample forecasting the evidence concerning the preferred model is more mixed. Indeed, the use of a lagged dependent variable helps to forecast recessions but only at the very short run. A limitation of this exercise is that the out-of-sample period covers only one recession which in addition is not well forecasted by the models. However, important findings are that the spread contains more information of the state of the economy and that a parsimonious model with only the spread appear fairly reliable in terms of forecasting recessions in the euro area in both in-sample and out-of-sample forecasting.

7 Robustness of the results

The results we obtained shows that the spread 10-year minus 3-month yields is a good predictor of recessions in the euro area considering both in-sample and out-of-sample forecasts. Moreover, it contains more information than the autoregressive series of the state of the economy. Therefore, this yield spread seems an useful indicator for monetary policy purposes. However, cautions are warranted and some checks are required when these findings are considered.[36]

First, there are some data availability problems which suggest to carry out a sub-sample analysis. Second, we check whether the yield curve does better than other economic variables with potential predictive power. Third, the definition of recession that we adopted can be criticised. Therefore, it is useful to adopt another definition of recession. Lastly, we check whether the results for the euro area and the individual countries are mutually consistent. This allows the results to be analysed in relation with the existing literature and for us to check if we could replace the synthetic euro area yield spreads with those of specific euro area countries and forecast euro area recessions equally well.

7.1 Sub-sample analysis

A first problem of data availability is given by the fact that only 3-month and 10-year interest rates are really representative of the euro area. Practically, for 1-year, 2-year, 5-year we have data since 1970 only for Germany. The results of the predictive power of some spreads may therefore be biased.[37]

[36] Since the results for the standard probit model and the lagged probit model are not markedly different, in this section we will estimate only the standard probit model with only the spread as explanatory variable.

[37] In particular for two important countries of the euro area such as Italy and France we have data for 1-year, 2-year, 5-year interest rates only since the 1980's

In the construction of the database, specific attention has been paid in retrieving government bond yields with a specific maturity such as 10-year. However, it can be that what is treated as a 10-year rate is actually the return on a "long" bond with maturity changing over time. This additional data availability problem is likely to be less severe over the most recent period.

In order to make sure that the results are not affected by these data problems we split the overall sample period into two sub-periods: 1970:Q1-1985:Q1 and 1978:Q1-2002:Q2. The sub-periods overlaps in order to have in the sample some recession observations. Indeed, this analysis is complicated by the fact that recessions are a rare event and we therefore have few recession observations which can be used in the model in order to arrive to significant parameters estimated.[38]

The estimation results for the ten different spreads for the two sub-samples are shown in Tables 6 and 7. The spread 10-year minus 3-month is confirmed to be the best indicator of recession even if other spreads, such as 10-year minus 1-year, improve their measure of fit.[39] In addition, it seems that the forecasting ability of the 10-year minus 3-month to forecast recession is stronger in the first sub-sample. However, it is difficult to claim whether this is due to data availability problems or to the poor performance of the model in forecasting the 1990's recession (see Figure 1). The best forecast horizon is five quarters in the first sub-sample and becomes four in the second one.

[38]We tried to run the model from mid 1980's but because of the few recession observations the model does not arrive to accurate parameter estimates. In particular, for some spreads we obtain very high measure of fit but with coefficients not more significant. However, the spread 10-year minus 3-months appears to be significant and with a good predictive power. We tried also to split the sample in two sub-periods in order to have two recessions in each sub-period. However, since the two recessions in the 1980's are separated by only few quarters the results are sensitive to choice of the date.

[39]Adding or subtracting some quarters to the sub-sample does not change significantly the results.

Predictor	FORECAST HORIZON (Quarters)							
Spread:	K=1	K=2	K=3	K=4	K=5	K=6	K=7	K=8
1Y-3M	0.004	0.008	0.001	0.013	0.027	0.006	0.014	0.004
T-stat	(-0.50)	(-0.69)	(0.29)	(-0.83)	(-1.18)	(0.54)	(0.84)	(-0.46)
2Y-3M	0.090	0.116	0.037	0.063	0.045	0.006	0.036	0.002
T-stat	(-1.93)	(-2.08)	(-1.36)	(-1.68)	(-1.44)	(0.56)	(1.35)	(0.35)
5Y-3M	0.121	**0.149**	0.079	0.116	0.096	0.005	0.003	0.002
T-stat	(-2.22)	(-2.36)	(-1.89)	(-2.15)	(-1.99)	(-0.49)	(0.39)	(-0.29)
10Y-3M	0.093	0.178	0.131	0.326	**0.380**	0.055	0.000	0.004
T-stat	(-2.14)	(-2.65)	(-2.38)	(-2.73)	(-2.66)	(-1.63)	(0.00)	(-0.43)
2Y-1Y	0.072	0.080	0.073	0.031	0.006	0.000	0.013	0.022
T-stat	(-1.97)	(-2.05)	(-1.96)	(-1.30)	(-0.56)	(0.09)	(0.79)	(1.01)
5Y-1Y	0.090	0.101	0.103	0.074	0.041	0.018	0.001	0.000
T-stat	(-2.18)	(-2.27)	(-2.26)	(-1.95)	(-1.48)	(-0.98)	(-0.22)	(0.32)
10Y-1Y	0.042	0.081	**0.141**	0.129	0.098	0.067	0.010	0.000
T-stat	(-1.40)	(-1.71)	(-1.95)	(-2.02)	(-1.92)	(-1.68)	(-0.73)	(0.08)
5Y-2Y	0.076	0.087	0.103	0.128	0.131	0.111	0.056	0.043
T-stat	(-1.91)	(-1.98)	(-2.06)	(-2.14)	(-2.11)	(-2.03)	(-1.61)	(-1.42)
10Y-2Y	0.001	0.000	0.011	0.038	0.072	0.092	0.047	0.013
T-stat	(0.26)	(-0.18)	(-0.79)	(-1.40)	(-1.80)	(-1.95)	(-1.48)	(-0.81)
10Y-5Y	0.033	0.017	0.004	0.000	0.004	0.011	0.005	0.000
T-stat	(1.33)	(0.99)	(0.48)	(-0.01)	(-0.45)	(-0.76)	(-0.53)	(0.05)

Table 6: Pseudo-R^2 Measures of Fit for Recession predictors (Estimation period 1970Q1-1985Q1)

Predictor	FORECAST HORIZON (Quarters)							
Spread:	K=1	K=2	K=3	K=4	K=5	K=6	K=7	K=8
1Y-3M	0.005	0.005	0.001	0.022	0.032	0.003	0.002	0.031
T-stat	(-0.75)	(-0.75)	(-0.24)	(-1.48)	(-1.75)	(-0.60)	(-0.43)	(-1.67)
2Y-3M	0.117	0.106	0.061	0.073	0.005	0.002	0.001	0.005
T-stat	(-2.98)	(-2.87)	(-2.29)	(-2.44)	(-2.06)	(-0.44)	(0.36)	(-0.69)
5Y-3M	0.094	0.091	0.006	0.067	0.047	0.007	0.000	0.007
T-stat	(-2.80)	(-2.76)	(-2.31)	(-2.39)	(-2.04)	(-0.81)	(-0.14)	(-0.83)
10Y-3M	0.179	0.200	0.135	**0.205**	0.176	0.039	0.005	0.024
T-stat	(-3.48)	(-3.56)	(-3.13)	(-3.36)	(-3.23)	(-1.84)	(-0.68)	(-1.44)
2Y-1Y	**0.157**	0.138	0.097	0.031	0.005	0.000	0.008	0.015
T-stat	(-3.18)	(-3.03)	(-2.67)	(-1.65)	(-0.70)	(0.12)	(0.86)	(1.14)
5Y-1Y	0.125	0.122	0.096	0.051	0.019	0.003	0.000	0.002
T-stat	(-3.18)	(-3.13)	(-2.84)	(-2.14)	(-1.35)	(-0.57)	(0.17)	(0.42)
10Y-1Y	0.146	**0.166**	0.147	0.073	0.034	0.013	0.000	0.002
T-stat	(-3.06)	(-3.14)	(-3.02)	(-2.35)	(-1.65)	(-1.06)	(-0.17)	(0.48)
5Y-2Y	0.030	0.038	0.036	0.033	0.025	0.017	0.009	0.009
T-stat	(-1.70)	(-1.89)	(-1.82)	(-1.75)	(-1.53)	(-1.23)	(-0.95)	(-0.91)
10Y-2Y	0.000	0.000	0.002	0.010	0.023	0.033	0.022	0.006
T-stat	(-0.17)	(-0.19)	(-0.47)	(-0.94)	(-1.34)	(-1.54)	(-1.28)	(-0.74)
10Y-5Y	0.009	0.007	0.004	0.001	0.000	0.001	0.001	0.000
T-stat	(0.98)	(0.84)	(0.64)	(0.31)	(-0.05)	(-0.36)	(-0.32)	(0.02)

Table 7: Pseudo-R^2 Measures of Fit for Recession predictors (Estimation period 1978Q1-2002Q2)

Predictor	FORECAST HORIZON (Quarters)							
	K=1	K=2	K=3	K=4	K=5	K=6	K=7	K=8
CLI	**0.311**	0.153	0.058	0.037	0.037	0.022	0.010	0.006
T-stat	(-3.91)	(-3.68)	(-2.53)	(-2.05)	(-2.06)	(-1.61)	(-1.08)	(-0.84)
EuroStoxx	**0.035**	0.017	0.008	0.022	0.020	0.015	0.013	0.007
T-stat	(-1.99)	(-1.42)	(-0.98)	(-1.60)	(-1.51)	(-1.32)	(-1.25)	(-0.94)
GDP	**0.130**	0.067	0.032	0.000	0.002	0.002	0.006	0.009
T-stat	(-3.59)	(-2.79)	(-1.99)	(-0.21)	(-0.44)	(-0.48)	(-0.87)	(-1.01)

Table 8: Pseudo-R^2 Measures of Fit for Recession predictors (Estimation period 1970Q1-2002Q2)

7.2 Comparison with some other indicators

The main result so far is that the euro area yield spread - in particular, the spread between 10-year minus 3-month interest rates - contains significant information to forecast euro area recessions. In order to provide further evidence of the potential usefulness of the yield spread as indicator for monetary policy purposes we check whether the yield curve does better than other leading indicators. Accordingly, we used as predictor of recessions in the standard probit model the OECD Composite Leading Indicators (CLI) for the euro area[40], the quarterly growth of the Eurostoxx index and the quarterly growth of real GDP.

Euro area CLI contains information useful for predicting euro area recession only for a very short forecast horizon (see Table 8). However, as showed in Table 1, at a horizon beyond one quarter the yield spread performs better.[41] Comparing the predictive power of the yield spread with stock price index growth and the real GDP growth, the yield spread presents a better fit. The GDP growth, reflecting a short-term persistence of the economic activity, is a rather good predictor in the very short run.[42] By contrast with the

[40] OECD Composite Leading Indicators (CLI) for the euro area is an aggregation of the CLI of the euro area countries. OECD CLIs are aggregate time series which show a leading relationship with the growth cycles of key macro-economic indicators.

[41] For this indicator we tried also an exercise of out-of-sample forecasting and the measure of fit decreases slightly.

[42] This evidence has been presented also earlier estimating the probit model using only the indicator of recession which is linked and correlated to the GDP growth. As mentioned previously, GDP figures are subjected to revision and are available with a time lag.

findings for the US, the stock price index growth is not a significant indicator of recessions in the euro area.[43]

Therefore, we provided an additional evidence of the potential usefulness of the yield spread as indicator for monetary policy purposes.

7.3 A different definition of recession

As noted earlier, there is no official or generally agreed recession chronology for the euro area. We now take a look at whether the results are confirmed considering a different definition of recession. In particular, there is an interesting piece of the literature that deals with the extraction of business cycles[44]. In this framework, the beginning and the end of a recession are turning points in the business cycle: the beginning represents a peak in the cycle while the end represents a trough.

Bry and Boschan (1971) developed an algorithm for the NBER. In short, it is a mechanical procedure for determining the turning points in a series smoothed by a moving average. Artis et al. (1997) proposed a simplified version of the above algorithm to define reference dates for classical cycles for the G7 and the European countries, using only one time series: the industrial production. These references dates have been used by, essentially, all the empirical analysis quoted previously which focused on some specific European countries (see, for example, Bernard and Gerlach 1998). Ross and Ubide (2001) apply the methodology of Artis et al. (ibid.) to the euro area. It seems interesting to use the chronology of euro area business cycle presented in the paper of Ross and Ubide and estimate the probit model[45].

[43]Indeed, for the US Estrella and Mishkin (1998) found that stock prices are useful predictors of recessions, particularly one through three quarters ahead.

[44]"Business cycles are a type of fluctuations in the aggregate economic activities of nations that organize their production and distribution mainly in business enterprises; a cycle consists of expansion occurring at about the same time in many economic activities, followed by similarly general recessions, contractions and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration, business cycles vary from more than one year to ten to twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own." (Burns and Mitchell 1946)

[45]We did not consider the last set of tourning points (in 1995:Q2 and 1996:Q2) because, as explained by Ross and Ubide (ibid.), it stems from exchange rates issues. In addition, a recession during this period has never been gauged. Therefore, recessions are considered from 1974:Q3 to 1975:Q3, from 1980:Q2 to 1982:Q3 and from 1991:Q2 to 1993:Q3.

Predictor	FORECAST HORIZON (Quarters)							
Spread:	K=1	K=2	**K=3**	K=4	K=5	K=6	K=7	K=8
1Y-3M	0.018	0.03	0.03	0.026	0.013	0.02	0.026	0.021
2Y-3M	0.189	0.165	0.127	0.071	0.02	0.01	0.005	0.00
5Y-3M	0.183	0.185	0.165	0.118	0.059	0.038	0.024	0.006
10Y-3M	0.313	0.441	**0.514**	0.455	0.271	0.205	0.152	0.064
2Y-1Y	**0.196**	0.123	0.069	0.026	0.002	0.002	0.013	0.039
5Y-1Y	0.182	0.16	0.13	0.089	0.046	0.015	0.002	0.002
10Y-1Y	0.147	0.18	**0.197**	0.181	0.116	0.058	0.026	0.004
5Y-2Y	0.058	0.089	0.113	0.126	0.12	0.095	0.064	0.04
10Y-2Y	0.00	0.019	0.057	0.111	0.138	0.128	0.102	0.074
10Y-5Y	0.01	0.001	0.00	0.005	0.011	0.014	0.014	0.013

Table 9: Pseudo-R^2 Measures of Fit for Recession predictors (Estimation period 1970Q1-2002Q2)

Table 9 presents the results of this estimation. The previous results are borne out. The spread between 10-year and 3-month interest rates is always the best predictor of recession. In this case the measure of fit rises to 0.514, proving a better forecasting ability, and the best predictor lag is $k = 3$. Some other spreads have also a quite interesting measure of fit, like the 10-year minus 1-year and 2-year minus 1-year.

The estimated probabilities of recession obtained from running the probit model are plotted together with the recession quarters in the Figure 5. The result is considerably improved, in fact, the estimated probabilities is generally above 50 percent during the recession period, although the recession of the 1990s is still predicted with a small lag.

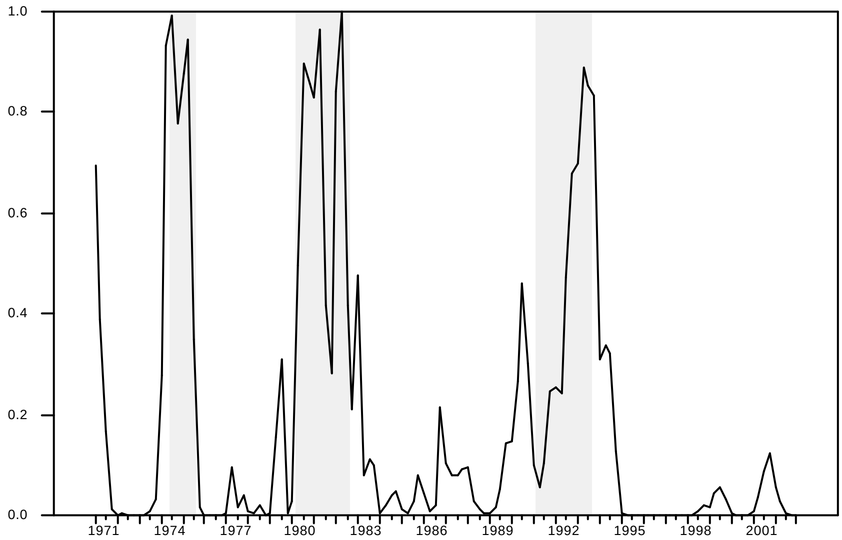


Figure 5: Estimated probability of a recession in the euro area in the current quarter using the spread 10-year - 3-month three quarters earlier.

While Artis et al. (1997) consider the turning points of the industrial production series, it is interesting to analyse also an indicator of recession coming from the turning points of the GDP series[46]. Artis et al. (1999) and Krolzig and Toro (2001) use the GDP to date an "European Business Cycle". Actually, in this case, the methodology adopted is different: it is the Markov-switching autoregression, introduced by Hamilton (1989). Contractions and expansions are modelled as switching regimes of the stochastic process generating output growth. The authors use data on an aggregated data set of five euro area countries and the United Kingdom[47]. Using the chronology provided in these recent papers, we estimate again the probit model. As shown in Table 10 the results are confirmed and improved. The best predictor of recession is always the spread between 10-year and 3-month

[46] The industrial production is decreasing in importance as indicator of the real economy. In fact, industrial production accounts, now, for only about a quarter of the total economy in the euro area.

[47] They consider the data for Germany, UK, Italy, Austria, Spain, and France. The inclusion of a non-euro area country such as the United Kingdom may bias the determination of the euro area cycle. However, Artis et al. (1999) found that the most European countries have relatively synchronous business cycles. Using their method, recession in the euro area can be dated as follows: 1974:Q2 – 1975:Q2, 1980:Q2 – 1982:Q4, and 1992:Q3 – 1993:Q2.

Predictor	FORECAST HORIZON (Quarters)							
Spread:	K=1	K=2	**K=3**	K=4	K=5	K=6	K=7	K=8
1Y-3M	0.044	0.063	0.043	0.043	0.043	0.044	0.042	0.046
2Y-3M	0.264	0.246	0.178	0.09	0.045	0.018	0.003	0.00
5Y-3M	0.314	**0.331**	0.282	0.19	0.121	0.0073	0.034	0.014
10Y-3M	0.366	0.562	**0.596**	0.421	0.278	0.165	0.07	0.02
2Y-1Y	0.187	0.121	0.064	0.022	0.001	0.008	0.039	0.087
5Y-1Y	0.253	0.236	0.19	0.135	0.068	0.024	0.002	0.003
10Y-1Y	0.108	0.146	0.147	0.118	0.059	0.017	0.00	0.008
5Y-2Y	0.166	0.226	0.267	**0.278**	0.234	0.192	0.137	0.092
10Y-2Y	0.001	0.006	0.029	0.059	0.071	0.064	0.042	0.021
10Y-5Y	0.055	0.03	0.014	0.005	0.001	0.001	0.001	0.002

Table 10: Pseudo-R^2 Measures of Fit for Recession predictors (Estimation period 1970Q1-2002Q2)

interest rate lagged three quarters with a measure of fit of 0.596. The term spreads 5-year minus 3-month and 5-year minus 2-year have also an interesting measure of fit. However, it seems difficult to claim that these spreads can be good indicators of recessions in the euro area. In fact, this result was not yielded in the previous case.

Figure 6 plots the estimated probabilities of recession, obtained from running the probit model, together with the recession quarters, showing also in this case a good performance of the yield spread chosen as best predictor of recessions in the euro area.

Recession dates	**1970s**	**1980s**	**1990s**
GDP rule	1974:Q4–1975:Q1	1980:Q4–1981:Q1 1982:Q3–1982:Q4	1992:Q2–1993:Q1
Ross and Ubide	1974:Q3–1975:Q3	1980:Q2–1982:Q3	1991:Q2–1993:Q3
Krolzig and Toro	1974:Q2–1975:Q2	1980:Q2–1982:Q4	1992:Q3–1993:Q2

Table 11: Three different chronologies of recession that have been used in the paper

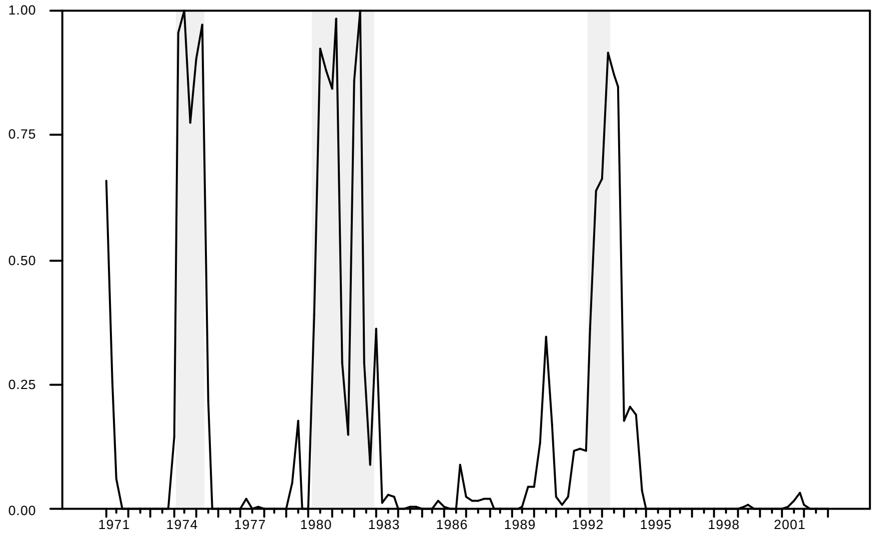


Figure 6: Estimated probability of a recession in the euro area in the current quarter using the spread 10-year - 3-month three quarters earlier.

Different recession dates have been used to construct the indicator of recession which is the dependent variable in the probit model. In Table 11 all the three different recession dates used are compared. The main difference is that during the 1980s if we consider the GDP rule (two consecutive quarters of negative growth of GDP) two recessions appear, while in the other two cases, adopting the chronology provided by Ross and Ubide and by Krolzig and Toro, only one long recession is spotted.

7.4 Are the results for the euro area and the individual countries mutually consistent?

We examine now whether the result on the usefulness of the term spread (10-year minus 3-month interest rates) as predictor of euro area recessions is confirmed estimating the probit model for the main euro area economies. This allows the results to be analysed in relation with the existing literature. Moreover, we can test whether one could replace the synthetic euro area rates with those of specific individual countries or a combination of these and forecast euro area recessions equally well.

Table 12 presents the results of the estimation of the probit model using quarterly data for Germany, France and Italy. The explanatory variables are the spread 10-year minus 3-month interest rates for the individual countries (see Appendix A for more detail about the series used) and the indicator of recession is based on the Economic Cycle Research Institute (ECRI) chronology.[48] Germany is the euro area country for which the predictive power of the domestic spread - expressed by the Pseudo-R^2 - seems the strongest. By contrast, predictive power of the French spread is the least significant. The results obtained are consistent with the literature. Indeed, Bernard and Gerlach (1998) found, estimating the probit model for Belgium, France, Germany and the Netherlands that German spread performs better with a Pseudo-R^2 which peaks at 0.722 for two quarters forecast horizon.[49] Es-

[48] The ECRI (see http://www.businesscycle.com) uses the Bry and Boschan algorithm to date classical turning points for various countries obtaining for the US a chronology identical with that of the NBER. This method is therefore comparable with that used by Artis et al.(1997) for the European countries and Ross and Ubide (2001) for the euro area. In converting from monthly to quarterly dates we followed Bernard and Gerlach (1998) saying that a quarter is considered in recession if the last month of the quarter is in recession. The recession dates are therefore as follows: Germany, 1973:Q3-1975:Q2; 1980:Q1-1982:Q3; 1991:Q1-1994:Q1; 2001:Q1-2002:Q2. France, 1974:Q3-1975:Q2, 1979:Q3-1980:Q2; 1982:Q2-1984:Q4; 1992:Q1-1993:Q2. Italy, 1974:Q2-1975:Q1; 1980:Q2-1983:Q1; 1992:Q1-1993:Q3.

[49] As we reduce the sample we see an increase of the Pseudo-R^2 with a figure more comparable to the result of the paper of Bernard and Gerlach which used data spanning 1972:Q1 - 1993:Q4. For France the results are rather different and more similar to the results of Estrella and Mishkin (1997). However, we use recession date that are not exactly the same used by Bernard and Gerlach (ibid.) which are as follow: 1974:Q3-1975:Q2; 1977:Q1-1977:Q4; 1979:Q3-1980:Q4; 1981:Q4-1982:Q3; 1992:Q2-1993Q4. We did not try for Belgium and the Netherlands because recession dates are not provide by ECRI. Indeed, it is very important to use the same criteria to define recessions in order to compare the

Predictor	FORECAST HORIZON (Quarters)							
Spread 10Y-3M:	K=1	K=2	K=3	K=4	K=5	K=6	K=7	K=8
Germany	0.532	**0.573**	0.525	0.381	0.266	0.150	0.072	0.026
T-stat	(-6.31)	(-6.15)	(-6.11)	(-5.85)	(-5.21)	(-4.09)	(-2.91)	(-1.77)
France	**0.103**	0.084	0.058	0.030	0.010	0.002	0.000	0.000
T-stat	(-3.48)	(-3.20)	(-2.67)	(-1.94)	(-1.11)	(-0.50)	(-0.13)	(0.09)
Italy	**0.288**	0.236	0.189	0.104	0.061	0.046	0.011	0.004
T-stat	(-4.94)	(-4.65)	(-4.35)	(-3.38)	(-2.63)	(-2.31)	(-1.13)	(-0.68)

Table 12: Pseudo-R^2 Measures of Fit for Recession predictors (Estimation period 1970Q1-2002Q2 for Germany and France; 1971:Q2-2002:Q2 for Italy)

trella and Mishkin (1997) also documented, studying the ability of the yield spread to predict recessions in Germany, France and Italy, that for Germany the yield spread has the best fit and the largest coefficient.[50]

Since Germany is the most important euro area country (in terms of GDP), having therefore the largest weight in the aggregation constructing the euro area yield, it could positively influence the performance of the euro area term spread in predicting euro area recessions. At this point, one could wonder whether replacing the synthetic euro area rates with those of Germany could forecast euro area recessions equally well. Table 13, therefore, shows the Pseudo-R^2, and the t statistics, for the test of the hypothesis that the parameter is zero, of the probit model estimating using the German, French and Italian term spreads in turn and all together as explanatory variables for predicting recessions in the euro area. The information content of the German yield curve for predicting euro area recessions appears significant. In fact, the coefficients are statistically significant, as suggested by the t-statistics, not only in the regression considering the German spread, but also, unlike for the French and Italian spreads, in the regression of the three national spreads beyond two quarters forecast horizon (from 3 to 7 quarters). Moreover, the German spread presents a good measure of fit: the forecast horizon which presents the best fit is five and the Pseudo-R^2 is 0.241 some-

results. In addition, for Belgium and the Netherlands we do not have so long historical series.

[50] The pseudo R^2 is 0.592 for four quarters forecast horizon and with a sample period from 1973 to 1994.

Predictor	FORECAST HORIZON (Quarters)							
Spread 10Y-3M:	K=1	K=2	K=3	K=4	K=5	K=6	K=7	K=8
Germany	0.081	0.089	0.110	0.192	**0.241**	0.133	0.037	0.009
T-stat	(-3.01)	(-3.12)	(-3.35)	(-3.86)	(-3.74)	(-3.49)	(-2.08)	(-1.04)
France	0.071	0.085	0.079	**0.118**	0.093	0.011	0.000	0.001
T-stat	(-2.90)	(-3.12)	(-3.01)	(-3.49)	(-3.17)	(-1.16)	(0.24)	(0.31)
Italy	**0.120**	0.107	0.027	0.033	0.016	0.003	0.007	0.003
T-stat	(-3.62)	(-3.45)	(-1.87)	(-1.99)	(-1.40)	(0.56)	(0.86)	(-0.62)
DE FR IT	0.197	0.201	0.144	0.232	**0.259**	0.207	0.103	0.022
DE T-stat	(-1.56)	(-1.64)	(-2.24)	(-2.86)	(-3.24)	(-3.69)	(-3.01)	(-1.44)
FR T-stat	(-1.42)	(-1.62)	(-1.33)	(-1.45)	(-0.52)	(1.76)	(1.97)	(1.05)
IT T-stat	(-2.99)	(-2.79)	(-1.05)	(-0.99)	(-0.04)	(1.74)	(1.62)	(-0.21)

Table 13: Pseudo-R^2 Measures of Fit for Recession predictors (Estimation period 1970Q1-2002Q2 for Germany and France; 1971:Q2-2002:Q2 for Italy)

what larger than in the case of the euro area spread. A slight increase is present when we use the three national spreads as explanatory variable.[51]

However, the estimated probability of recession using the German spread performs better than the euro area spread in forecasting euro area recession four quarters ahead only in the 1970's (see Figure 7).[52] By contrast, the other recessions are forecasted better using the euro area spread. The estimated probabilities of recessions using the German, French and Italian spreads are very similar to the case when only the German spread is considered.[53]

[51]However, in this case we add two variables increasing therefore the measure of fit but to the detriment of a deterioration in out-of-sample forecasting. In addition, we could have problems of collinearity between the three explanatory variables.

[52]This is can be related to the data availability problem mentioned previously: in the 1970's we could not retrieve data for all the euro area countries, even if for 10-year and 3-month interest rates euro area figures are representative of the major euro area economies.

[53]In estimating the 1990 recession the estimated probability increases more than when the euro area spread is used. However, there is not improvement in the timing. Since the pseudo-R^2 suggests as best lag k=5, we tried also to estimated the probability for five quarters ahead but the results are very similar to those presented.

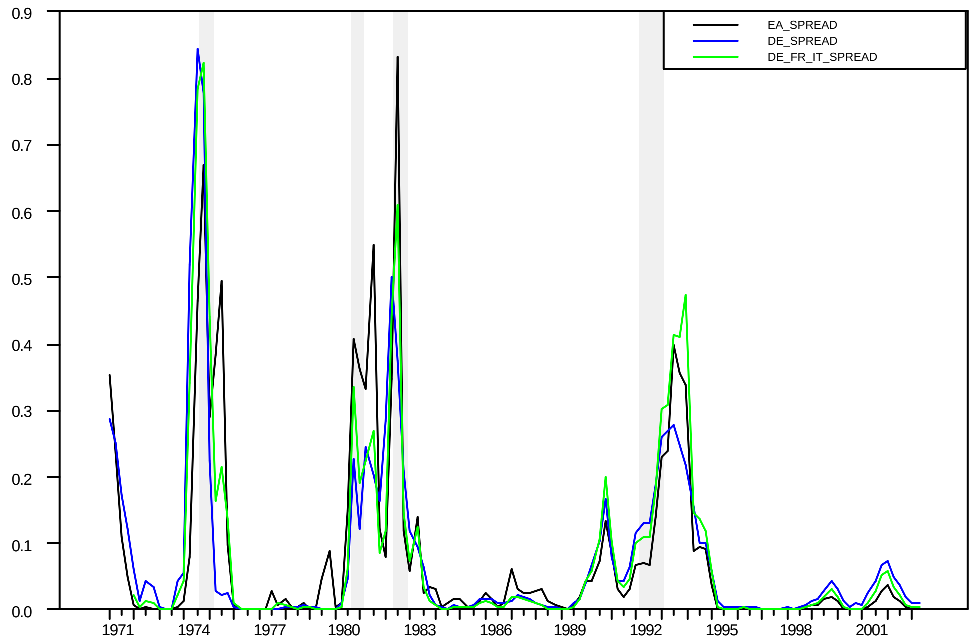


Figure 7: Estimated probability of a recession in the euro area in the current quarter using the spread 10-year - 3-month three quarters earlier.

Therefore, the German yield spread has a rather significant predictive power of euro area recessions. Hence, it could be useful to double-check the forecast of euro area recessions also with the German spread.

8 Conclusion

In this paper the importance of the use of the term spread as predictor of recessions is confirmed also for the euro area. In particular, an analysis of the predictive content of the slope of the yield curve in different parts was documented. The results of this paper show that the best predictor of recession is the spread between 10-year and 3-month interest rates. Therefore, this specific yield spread appears to contain a useful information for monetary policy purposes. To arrive to this conclusion we used two non-liner model specifications to forecast the probability of a recession in the euro area. These are the standard probit model proposed by Estrella and Mishkin (1998) and the modified probit model with the addition of a lagged dependent variable proposed by Dueker (1997). We found that the use of a lagged dependent variable helps to forecast historically recessions in the euro area.

Specific attention was paid on the accuracy of the forecast. We carried out an exercise of out-of-sample forecasting to investigate the out-of-sample performance of the probit models. The test of Diebold and Mariano was also implemented to compare the accuracy of two forecasts. We used as benchmarks for comparison different specifications of the probit model: a probit model which considers only the autoregressive series of the state of the economy and a probit model with the spread and a dependent lagged variable. The simple probit model (with just the spread 10-year minus 3-month as explanatory variable) gives the best result at 2 quarters forecast horizon and performs better than the model with only the lagged dependent variable. With the addition of the lagged dependent variable in the probit model the forecasting ability improves significantly only for one quarter ahead.

However, it is important to remember some issues about the robustness of this result. First, same data availability problems are present. We carried out a sub-sample analysis and the spread 10-year minus 3-month outperforms always the other spreads in predicting euro area recessions. Its forecasting power appears stronger in the 1970's and 1980's than in the 1990's. However, it is difficult to claim whether this is due to data availability problems or to the poor performance of the model in forecasting the 1990's recession.

Second, in order to provide an additional evidence of the potential usefulness of the yield spread as indicator for monetary policy purposes we compared its predictive power with those of the OECD Composite Leading Indicator for the euro area, the quarterly growth rate of the stock price index and the GDP growth. The spread appears the single most powerful predictor of recessions in the euro area for forecast horizons beyond one quarter, and especially for four quarters which is the most interesting forecast horizon for monetary policy purposes.

Third, the definition of recession adopted is quite conservative. In the previous section we adopted another definition of recession, considering, in particular, a recession as the period between a peak and a trough in the business cycle. Using two different recession chronologies, one proposed by Ross and Ubide (2001) and another by Krolzig and Toro (2001) we showed that the results are sensible to the definition of recession adopted. However, the findings of this paper are confirmed: not only the spread 10-year minus

3-month lagged three quarters outperforms the other spreads, but also the explanatory power measured by the Pseudo-R^2 improves significantly.

References

Agresti, A.-M., and B. Mojon, 2001. "Some stylised facts on the euro area business cycle," ECB Working Paper no. 95, December.

Ahrens, R., 1999. "Examining Predictors of U.S. recessions: a regime-switching approach," *Swiss Journal of Economics and Statistics*, vol. 135, no. 1, pp. 97-124.

Ahrens, R., 2002. "Predicting recessions with interest rate spreads: a multicountry regime-switching analysis," *Journal of international Money and Finance*, vol. 21, pp. 519-537.

Alonso, F., J. Ayuso, and J. Martinez-Pagés, 1997. "How informative are financial asset prices in Spain," Banco de Espana Working Paper, no. 26.

Anderson, N., F. Breedon, M. Deacon, A. Derry, and G. Murphy, 1996. Estimating and Interpreting the Yield Curve, John Wiley & Sons, Chichester.

Artis, M. J., Z. G. Kontolemis, and D. R. Osborn, 1997. "Business Cycles for G7 and European Countries," *Journal of Business*, vol. 70, no. 2

Artis, M. J., H.-M. Krolzig and J. Toro, 1999. "The European business cycle," CEPR discussion paper no. 2249, September.

Artis, M. J., and W. Zhang, 1999. "Further evidence on international business cycle and the ERM: is there a European business cycle?," *Oxford Economic Papers*, vol. 51, pp. 120-132.

Bernard, H., and S. Gerlach, 1998. "Does the term structure predict recessions? The international evidence," *International Journal of Finance and Economics*, vol. 3, pp. 195-215.

Beyern, A., J. A. Doornik, and D. F. Hendry, 2001. "Constructing aggregate Euro-zone data," *The Economic Journal*, vol. 111, pp. 102-21.

Birchenhall, C. R., D. R. Osborn, and M. Sensier, 2001. "Predicting UK business cycle regimes", *Scottish Journal of Political Economy*, vol. 48, no. 2.

Bonser-Neal, C., and T. R. Morley, 1997. "Does the yield spread predict real economic activity? A multicountry analysis," Federal Reserve Bank of Kansas City *Economic Review*, vol. 82, pp. 37-53.

Bry, G., and C. Boschan, 1971. "Cyclical analysis of time series: Selected procedures and computer programs," NBER Technical Paper, no. 20.

Burns, A. F., and W. C. Mitchell, 1946. "Measuring Business Cycles," NBER, New York.

Chauvet, M., and S. Potter, 2001. "Forecasting recessions using the yield curve," Federal Reserve Bank of New York, Staff Reports, no. 134, August.

Davis, E. P., and Fagan G., 1997. "Are financial spreads useful indicators of future inflation and output growth in EU countries? ," *Journal of applied econometrics*, vol. 12, pp. 701-714.

Del Negro, M., 2001. "Turn, turn, turn: Predicting turning points in economic activity," Federal Reserve Bank of Atlanta, *Economic Review*, second quarter, pp. 1-12.

Diebold, F. X, and R. S. Mariano, 1995. "Comparing predictive accuracy," *Journal of Business and Economic Statistics*, vol. 13, pp. 253-63.

Diebold, F. X, and G. D. Rudebusch, 1989. "Scoring the leading indicators," *Journal of Business*, vol. 62, pp. 369-391.

Dotsey, M., 1998."The predictive content of the interest rate term spread for future economic growth," Federal Reserve Bank of Richmond *Economic Quarterly*, vol. 84, pp. 31-51.

Dueker, M. J., 1997. "Strengthening the case for the yield curve as predictor of U.S. recessions," Federal Reserve Bank St. Louis *Review*, vol. 79, pp. 41-51.

Dueker, M., and K. Wesche, 1999. "European business cycles: new indices and analysis of their synchronicity," Universitat Bonn Sonderforschungbereich 303 discussion paper B-448, February.

Dueker, M., 2001. "Forecasting qualitative variables with vector autoregressions: a Qual VARModel of U.S recessions," Federal Reserve Bank of St. Luis, Working Paper Series, no. 012A, September.

ECB, 1999. "Euro area monetary aggregates and their role in the Eurosystems monetary policy strategy," ECB Monthly Bulletin, pp. 29-46, February.

Estrella, A., and G. A. Hardouvelis, 1991. "The term structure as a predictor of real economic activity," *Journal of Finance*, vol. 46, pp. 555-76.

Estrella, A., and F. Mishkin, 1997. "The predictive power of the term Structure of interest rates in Europe and the United States: implications for the European Central Bank," *European Economic Review*, vol. 41, pp. 1375-1401.

Estrella, A., 1997."Why do interest rates predict macro outcomes? A unified theory of inflation, output, interest and policy," Federal Reserve Bank of New York, Research Paper, no. 9717, May.

Estrella, A., 1998. "A new measure of fit for equations with dichotomous dependent variables," *Journal of Business and Economic Statistics*, vol. 16, pp. 198-205.

Estrella, A., and F. Mishkin, 1998. "Predicting U.S. recessions: financial variables as leading indicators," *Review of Economic and Statistics*, vol. 80, no. 1, pp. 45-61.

Estrella, A., and A. P. Rodrigues, (1998). "Consistent covariance matrix estimation in probit models with autocorrelated disturbances," Federal Bank of New York *Research Paper*, April.

Fagan, G., J. Henry, and R. Mestre, 2001. "An area-wide model (AWM) for the euro area," ECB Working Paper, no. 42, January.

Filardo, A. J.,1999. "How reliable are recession prediction models?," Federal Reserve Bank of Kansas City, *Economic Review*, 2nd quarter, pp. 35-55.

Gulde, A. M., and M. Schulze-Ghattas, 1992. "Aggregation of economic indicators across countries: Exchange rate versus PPP based GDP weights," IMF Working Paper, no. 36, May.

Hamilton, J. D., 1989. "A new approach to the economic analysis of nonstationarity time series and the business cycle," *Econometrica*, vol. 57, no. 2, pp. 357-384.

Hamilton, J. D., and D. H. Kim, 2002. "A reexamination of the predictability of economic activity using the yield spread," *Journal of Money, Credit, and Banking*, vol. 34, no. 2.

Harvey, C. R., 1988. "The real term structure and consumption growth," *Journal of Financial Economics*, vol. 22, pp. 305-333.

Hong, E.-P., and H. Beilby-Orrin, 1999. "Compilation Methodologies for Euro zone aggregates," OECD, available at www1.oecd.org/std/euroaggr.html.

Hu, Z., 1993. "The yield curve and real activity," IMF Staff Paper, no. 40, pp. 781-806, December.

Kozicki, S., 1997. "Predicting real growth and inflation with the yield spread," Federal Reserve Bank of Kansas City *Economic Review*, vol. 82, pp. 26-34.

Krolzig, H.-M., and J. Toro, 2001. "Classical and modern business cycle measurement: the European case," Institute of Economics and Statistics Oxford discussion paper no. 60.

Layton, A. P., and M. Katsuura, 2001. "Comparison of regime switching, probit and logit models in dating and forecasting US business cycles," *International Journal of Forecasting*, vol. 17, pp. 403-417.

Mishkin, F. S., 1990. "What does the term structure tell us about future inflation," *Journal of Monetary Economics*, vol. 25, pp. 77-95.

Newey, W., and K. West, 1987. "A simple positive semi-definite heteroskedasticity and autocorrelation consistent covariance matrix," *Econometrica*, vol. 55, pp. 703-78.

Pindyck, R. S., and D. L. Rubinfeld, 1997. "Econometric Models and Economic Forecasts," Irwin/McGraw-Hill, 4th ed.

Ross, K., and A. Ubide, 2001. "Mind the gap: What is the best measure of slack in the euro area?," IMF Working Paper, December.

Schreyer, P., and W. Suyker, 2002. "Creation of the euro area: Implications for economics statistics," OECD, Statistics Brief, no. 2, February.

Shaaf, M., 2000. "Predicting recession using the yield curve: an artificial intelligence and econometric comparison," *Eastern Econometric Journal*, vol. 26, no. 2, pp. 171-90.

Sédillot, F., 2001. "La pente des taux contient-elle de l'information sur l'activité économique future?," *Economie et Prévision*, no. 147, pp. 141-57.

Sephton, P., 2001. "Forecasting recessions: can we do better on MARS?," Federal Reserve Bank St. Louis *Review*, vol. 83, no. 2.

Smets, F., and K. Tsatsaronis, 1997. "Why the yield curve predict economic activity? Dissecting the evidence for Germany and the United States," BIS working paper, no. 49, September.

Stock, J. H., and M. W. Watson, 1990. "A probability model of the coincident indicators", ch. 4 of Lahiri, K., and G. H. Moore, 1991, "Leading economic indicators. New approaches and forecasting records," Cambridge University Press, pp.63-90.

Winder, C. C. A., 1997." On the construction of European area-wide aggregates – A review of the issues and empirical evidence," Irving Fisher Committee, Bulletin no. 1, pp. 15-23, November.

Appendix A: Overview of the euro area database

This appendix explains the sources, the method and procedures used to create the database on government bond yields for euro area. The database is composed with daily, monthly, quarterly and annual series. In the application presented in this paper we use quarterly data. The series are: 3-month interbank rate, 1-year government bond yield, 2-year government bond yield, 5-year government bond yield and 10-year government bond yield. The starting date of the series was (where possible) 1970.

- **Sources:**

- ECB
- Eurostat
- BIS
- OECD
- IMF
- Datastream
- Global Financial Data
- BANCA D'ITALIA CD-ROM
- BANCO DE ESPANA web site
- BUNDESBANK web site

The methodology adopted is to choose official data when available. For official data we mean the data published in the Monthly Bulletin of the ECB.

- **Data Transformation:**

  For all the series that we retrieved (more than 300) we plotted the graphs and we checked and compared each other in order to get the most reliable series. We interpolated daily data in case of missing points. In some cases we combined more series to create a longer historical series. In fact, if we put together series of different providers we checked, at the date when finish a series and start the other one, what is the difference of value between the two different series. Alternatively, if this difference is less than five basic points we do not do any kind of interpolation or adjustment. We get the data how they are. Instead, if the difference is more than five basic points we make the following adjustment: we interpolate backdating the series selected with the rate of growth of the longer series that we want to combine.

Table 14: starting date of the series used

	3-month interbank rate	1-year Gov. bond yield	2-year Gov. bond yield	5-year Gov. bond yield	10-year Gov. bond yield
AUSTRIA	1970 Q1	1970 Q1	1996 Q4	1989 Q1	1970 Q1
BELGIUM	1978 Q1	1987 Q3	1987 Q1	1970 Q1	1970 Q1
FINLAND	1987 Q1	1996 Q4	1996 Q4	1970 Q1	1988 Q1
FRANCE	1970 Q1	1981 Q1	1986 Q3	1984 Q1	1970 Q1
GERMANY	1970 Q1	1970 Q1	1970 Q1	1970 Q1	1970 Q1
GREECE	1988 Q4	1980 Q1	2000 Q3	1999 Q1	1992 Q4
IRELAND	1978 Q1	1996 Q4	1986 Q2	1986 Q2	1970 Q1
ITALY	1971 Q1	1980 Q1	1995 Q2	1989 Q1	1970 Q1
LUXEMBOURG	1990 Q1				1970 Q1
NETHERLANDS	1972 Q4	1999 Q1	1996 Q3	1990 Q4	1978 Q2
SPAIN	1973 Q3	1987 Q3	1978 Q2	1988 Q4	1970 Q1
PORTUGAL	1983 Q1	1989 Q1	1996 Q3	1993 Q2	1988 Q4

- **Starting dates of the national series:**

  See Table 14.

- **Aggregation method:**

  It is used a GDP weight converted in a common currency using PPP's 1995. The weight is time variant and change every year according to the variations in GDP series. We use annual GDP figures and the source is OECD database.

  As in the official data we do not consider data for Luxembourg. The Greece data are considered and aggregated only from 2001.

  In Figure 8 we compare three different aggregation methods plotting the 10-year government bond yield for the euro area obtained using three different methods. The difference in the methods stems from the use of three different weights: GDP at PPP's 1995, national currency GDP converted using the exchange rate with DM and GDP expressed in euro. Since 1994 is plotted also the official data published in the Monthly Bulletin.

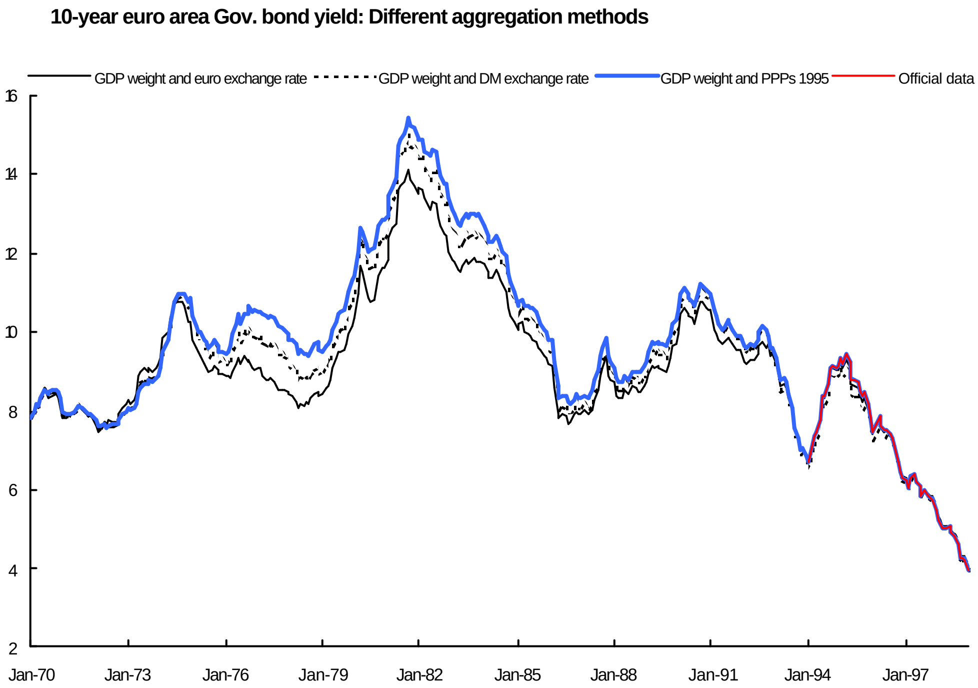


Figure 8: Empirical investigation

Appendix B: Diebold-Mariano test

Diebold and Mariano (1995) proposed a test of equal forecast accuracy of two competitive forecasts. It allows to use a wide variety of accuracy measures and forecast errors can be non-Gaussian, nonzero mean, serially correlated and contemporaneously correlated.

For a pair of k-steps ahead forecast errors (e_{it}, $i = 1, 2$, $t = 1, ..., T$), the quality of forecast can be judged on some specific function $g(e)$ of the forecast error e. The null hypothesis of equal forecast accuracy for two forecasts is $E[g(e_{it}) - g(e_{jt})] = 0$. Define a new series by $d_t = g(e_{it}) - g(e_{jt})$. d_t is the loss differential.

The asymptotic distribution of the loss differential is given by

$$\sqrt{T}\left(\bar{d} - \mu\right) \to N\left(0, 2\pi f_d(0)\right),$$

where μ is the population mean loss differential, $\bar{d}$ is the sample mean of d_t, and

$$f_d(0) = \frac{1}{2\pi} \sum_{\tau=-\infty}^{\infty} \gamma_d(\tau)$$

is the spectral density of the loss differential at frequency 0.

$\gamma_d(\tau) = E[(d_t - \mu)(d_{t-\tau} - \mu)]$ is the autocovariance of the loss differential at displacement τ.

Under H_o, $\mu = 0$, the Diebold-Mariano test is then

$$S_1 = \frac{\bar{d}}{\sqrt{\frac{2\pi \hat{f}_d(0)}{T}}}$$

and it has an asymptotic standard normal distribution.

$\hat{f}_d(0)$ is a consistent estimator of $f_d(0)$. A consistent estimate of $2\pi f_d(0)$ is obtained by taking a weighted sum of the available sample autocovariaces,

$$2\pi \hat{f}_d(0) = \sum_{\tau=-(T-1)}^{(T-1)} I\left(\frac{\tau}{S(T)}\right) \hat{\gamma}_d(\tau),$$

where

$$\hat{\gamma}_d(\tau) = \frac{1}{T} \sum_{t=|\tau|+1}^{T} \left(d_t - \bar{d}\right)\left(d_{t-|\tau|} - \bar{d}\right).$$

$I\left(\frac{\tau}{S(T)}\right)$ is the lag window. It is used the Bartlett lag window, defined by $I\left(\frac{\tau}{S(T)}\right) = 1 - \frac{|\tau|}{S(T)}$ for $\left|\frac{\tau}{S(T)}\right| \leq 1$ and 0 otherwise. $S(T)$ is the truncation lag, that has been chosen as $int\left(4\left(\frac{T}{100}\right)^{0.25}\right)$.

European Central Bank working paper series

For a complete list of Working Papers published by the ECB, please visit the ECB's website (http://www.ecb.int).

202 "Aggregate loans to the euro area private sector" by A. Calza, M. Manrique and J. Sousa, January 2003.

203 "Myopic loss aversion, disappointment aversion and the equity premium puzzle" by D. Fielding and L. Stracca, January 2003.

204 "Asymmetric dynamics in the correlations of global equity and bond returns" by L. Cappiello, R.F. Engle and K. Sheppard, January 2003.

205 "Real exchange rate in an inter-temporal n-country-model with incomplete markets" by B. Mercereau, January 2003.

206 "Empirical estimates of reaction functions for the euro area" by D. Gerdesmeier and B. Roffia, January 2003.

207 "A comprehensive model on the euro overnight rate" by F. R. Würtz, January 2003.

208 "Do demographic changes affect risk premiums? Evidence from international data" by A. Ang and A. Maddaloni, January 2003.

209 "A framework for collateral risk control determination" by D. Cossin, Z. Huang, D. Aunon-Nerin and F. González, January 2003.

210 "Anticipated Ramsey reforms and the uniform taxation principle: the role of international financial markets" by S. Schmitt-Grohé and M. Uribe, January 2003.

211 "Self-control and savings" by P. Michel and J.P. Vidal, January 2003.

212 "Modelling the implied probability of stock market movements" by E. Glatzer and M. Scheicher, January 2003.

213 "Aggregation and euro area Phillips curves" by S. Fabiani and J. Morgan, February 2003.

214 "On the selection of forecasting models" by A. Inoue and L. Kilian, February 2003.

215 "Budget institutions and fiscal performance in Central and Eastern European countries" by H. Gleich, February 2003.

216 "The admission of accession countries to an enlarged monetary union: a tentative assessment" by M. Ca'Zorzi and R. A. De Santis, February 2003.

217 "The role of product market regulations in the process of structural change" by J. Messina, March 2003.

218 “The zero-interest-rate bound and the role of the exchange rate for monetary policy in Japan” by G. Coenen and V. Wieland, March 2003.

219 “Extra-euro area manufacturing import prices and exchange rate pass-through” by B. Anderton, March 2003.

220 “The allocation of competencies in an international union: a positive analysis” by M. Ruta, April 2003.

221 “Estimating risk premia in money market rates” by A. Durré, S. Evjen and R. Pilegaard, April 2003.

222 “Inflation dynamics and subjective expectations in the United States” by K. Adam and M. Padula, April 2003.

223 “Optimal monetary policy with imperfect common knowledge” by K. Adam, April 2003.

224 “The rise of the yen vis-à-vis the (“synthetic”) euro: is it supported by economic fundamentals?” by C. Osbat, R. Rüffer and B. Schnatz, April 2003.

225 “Productivity and the (“synthetic”) euro-dollar exchange rate” by C. Osbat, F. Vijselaar and B. Schnatz, April 2003.

226 “The central banker as a risk manager: quantifying and forecasting inflation risks” by L. Kilian and S. Manganelli, April 2003.

227 “Monetary policy in a low pass-through environment” by T. Monacelli, April 2003.

228 “Monetary policy shocks – a nonfundamental look at the data” by M. Klaeffing, May 2003.

229 “How does the ECB target inflation?” by P. Surico, May 2003.

230 “The euro area financial system: structure, integration and policy initiatives” by P. Hartmann, A. Maddaloni and S. Manganelli, May 2003.

231 “Price stability and monetary policy effectiveness when nominal interest rates are bounded at zero” by G. Coenen, A. Orphanides and V. Wieland, May 2003.

232 “Describing the Fed’s conduct with Taylor rules: is interest rate smoothing important?” by E. Castelnuovo, May 2003.

233 “The natural real rate of interest in the euro area” by N. Giammarioli and N. Valla, May 2003.

234 “Unemployment, hysteresis and transition” by M. León-Ledesma and P. McAdam, May 2003.

235 “Volatility of interest rates in the euro area: evidence from high frequency data” by N. Cassola and C. Morana, June 2003.

236 "Swiss monetary targeting 1974-1996: the role of internal policy analysis" by G. Rich, June 2003.

237 "Growth expectations, capital flows and international risk sharing" by O. Castrén, M. Miller and R. Stiegert, June 2003.

238 "The impact of monetary union on trade prices" by R. Anderton, R. E. Baldwin and D. Taglioni, June 2003.

239 "Temporary shocks and unavoidable transitions to a high-unemployment regime" by W. J. Denhaan, June 2003.

240 "Monetary policy transmission in the euro area: any changes after EMU?" by I. Angeloni and M. Ehrmann, July 2003.

241 Maintaining price stability under free-floating: a fearless way out of the corner?" by C. Detken and V. Gaspar, July 2003.

242 "Public sector efficiency: an international comparison" by A. Afonso, L. Schuknecht and V. Tanzi, July 2003.

243 "Pass-through of external shocks to euro area inflation" by E. Hahn, July 2003.

244 "How does the ECB allot liquidity in its weekly main refinancing operations? A look at the empirical evidence" by S. Ejerskov, C. Martin Moss and L. Stracca, July 2003.

245 "Money and payments: a modern perspective" by C. Holthausen and C. Monnet, July 2003.

246 "Public finances and long-term growth in Europe – evidence from a panel data analysis" by D. R. de Ávila Torrijos and R. Strauch, July 2003.

247 "Forecasting euro area inflation: does aggregating forecasts by HICP component improve forecast accuracy?" by K. Hubrich, August 2003.

248 "Exchange rates and fundamentals" by C. Engel and K. D. West, August 2003.

249 "Trade advantages and specialisation dynamics in acceding countries" by A. Zaghini, August 2003.

250 "Persistence, the transmission mechanism and robust monetary policy" by I. Angeloni, G. Coenen and F. Smets, August 2003.

251 "Consumption, habit persistence, imperfect information and the lifetime budget constraint" by A. Willman, August 2003.

252 ""Interpolation and backdating with a large information set" by E. Angelini, J. Henry and M. Marcellino, August 2003.

253 "Bond market inflation expectations and longer-term trends in broad monetary growth and inflation in industrial countries, 1880-2001" by W. G. Dewald, September 2003.

254 “Forecasting real GDP: what role for narrow money?” by C. Brand, H.-E. Reimers and F. Seitz, September 2003.

255 “Is the demand for euro area M3 stable?” by A. Bruggeman, P. Donati and A. Warne, September 2003.

256 “Information acquisition and decision making in committees: a survey” by K. Gerling, H. P. Grüner, A. Kiel and E. Schulte, September 2003.

257 “Macroeconomic modelling of monetary policy” by M. Klaeffling, September 2003.

258 “Interest rate reaction functions and the Taylor rule in the euro area” by P. Gerlach-Kristen, September 2003.

259 “Implicit tax co-ordination under repeated policy interactions” by M. Catenaro and J.-P. Vidal, September 2003.

260 “Aggregation-theoretic monetary aggregation over the euro area, when countries are heterogeneous” by W. A. Barnett, September 2003.

261 “Why has broad money demand been more stable in the euro area than in other economies? A literature review” by A. Calza and J. Sousa, September 2003.

262 “Indeterminacy of rational expectations equilibria in sequential financial markets” by P. Donati, September 2003.

263 “Measuring contagion with a Bayesian, time-varying coefficient model” by M. Ciccarelli and A. Rebucci, September 2003.

264 “A monthly monetary model with banking intermediation for the euro area” by A. Bruggeman and M. Donnay, September 2003.

265 “New Keynesian Phillips Curves: a reassessment using euro area data” by P. McAdam and A. Willman, September 2003.

266 “Finance and growth in the EU: new evidence from the liberalisation and harmonisation of the banking industry” by D. Romero de Ávila, September 2003.

267 “Comparing economic dynamics in the EU and CEE accession countries” by R. Süppel, September 2003.

268 “The output composition puzzle: a difference in the monetary transmission mechanism in the euro area and the US” by I. Angeloni, A. K. Kashyap, B. Mojon and D. Terlizzese, September 2003.

269 “Zero lower bound: is it a problem with the euro area?" by G. Coenen, September 2003.

270 “Downward nominal wage rigidity and the long-run Phillips curve: simulation-based evidence for the euro area” by G. Coenen, September 2003.

271 “Indeterminacy and search theory” by N. Giammarioli, September 2003.

272 “”Inflation targets and the liquidity trap” by M. Klaeffling and V. López Pérez, September 2003.

273 “Definition of price stability, range and point inflation targets: the anchoring of long-term inflation expectations” by E. Castelnuovo, S. Nicoletti-Altimari and D. Rodriguez-Palenzuela, September 2003.

274 “Interpreting implied risk neutral densities: the role of risk premia” by P. Hördahl and D. Vestin, September 2003.

275 “Identifying the monetary transmission mechanism using structural breaks” by A. Beyer and R. Farmer, September 2003.

276 “Short-term estimates of euro area real GDP by means of monthly data” by G. Rünstler, September 2003.

277 “On the indeterminacy of determinacy and indeterminacy" by A. Beyer and R. Farmer, September 2003.

278 “Relevant economic issues concerning the optimal rate of inflation” by D. R. Palenzuela, G. Camba-Méndez and J. Á. García, September 2003.

279 “Designing targeting rules for international monetary policy cooperation” by G. Benigno and P. Benigno, October 2003.

280 “Inflation, factor substitution and growth” by R. Klump, October 2003.

281 “Identifying fiscal shocks and policy regimes in OECD countries” by G. de Arcangelis and S. Lamartina, October 2003.

282 “Optimal dynamic risk sharing when enforcement is a decision variable” by T. V. Koeppl, October 2003.

283 “US, Japan and the euro area: comparing business-cycle features” by P. McAdam, November 2003.

284 “The credibility of the monetary policy ‘free lunch’” by J. Yetman, November 2003.

285 “Government deficits, wealth effects and the price level in an optimizing model” by B. Annicchiarico, November 2003.

286 “Country and sector-specific spillover effects in the euro area, the United States and Japan” by B. Kaltenhaeuser, November 2003.

287 “Consumer inflation expectations in Poland” by T. Łyziak, November 2003.

288 “Implementing optimal control cointegrated I(1) structural VAR models” by F. V. Monti, November 2003.

289 “Monetary and fiscal interactions in open economies” by G. Lombardo and A. Sutherland, November 2003.

290 “Inflation persistence and robust monetary policy design” by G. Coenen, November 2003.

291 “Measuring the time-inconsitency of US monetary policy” by P. Surico, November 2003.

292 “Bank mergers, competition and liquidity” by E. Carletti, P. Hartmann and G. Spagnolo, November 2003.

293 “Committees and special interests” by M. Felgenhauer and H. P. Grüner, November 2003.

294 “Does the yield spread predict recessions in the euro area?” by F. Moneta, December 2003.