THE PREDICTIVE POWER OF THE YIELD CURVE: EVIDENCE FROM SPAIN

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Abstract

The slope of the yield curve has been mentioned as a leading economic indicator of the economy's path in the future. Thus, an inversion of the curve has been interpreted as a sign of a future recession. Over the last decades, empirical research has been made with the aim of finding a significant relationship between the yield curve and future economic activity. In this paper, we examine the predictive power of the yield curve in Spain. We consider a simple linear regression model which predicts the change in the industrial production using the yield spread as an explanatory variable. To study the stability of recession forecasts over time, we divided the full dataset in two sub-samples. Moreover, as the literature states that binary models are more stable at forecasting future economic activity, we consider a probit model to predict recessions using the yield curve. Results obtained in both models are not statistically significant at any conventional significance level.

Keywords: yield curve, industrial production, short-term, long-term, government bond rates, recession.

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1. Introduction

The prediction of future economic recessions has always been of huge interest not only to economists or policymakers but also to society in general. For this reason, economists have tried to use different models to forecast the path of economic activity in order to adjust the process of decision making to the current and future economic conditions. To predict the direction of the United States economy and the probability of a recession, economists frequently used sophisticated mathematical models. Yet, less complex indicators such as interest rates, monetary aggregates or stock prices can provide an insight into the upcoming economic activity (Estrella and Mishkin, 1997). In fact, the use of the slope of the yield curve has been generalized as a predictor of future recessions as its shape changes in the different stages of the business cycle.

The interest in studying this topic is that the yield spread quantifies the gap between the average short-term interest rates that is expected to be in the future and the short-term interest rates in the present. Thus, the yield spread indicates the stance of the monetary policies. For instance, when the yield spread increases, the monetary policies become more restrictive and the probability of a recession in the following quarters is higher (Wright, 2006).

However, we may ask why we should be concerned about the yield curve's predictive power when there are large-scale macroeconomic models. The first reason to consider the information given by the yield curve is that it can be a helpful complement to complex econometric models, for instance, if estimations with the yield spread and the econometric model are the same, the confidence on the results can be higher. Nevertheless, in the case that the results obtained using the econometric models and the yield curve are different, it will be worthwhile to revise the study. Another reason is that the yield curve has the advantage that it is a quick and easy method. Hence, anyone can estimate the likelihood of a recession in the future by looking at the Government bond interest rates.

The first studies on the predictive power of the yield curve date to the 1980s. However, the fact that in 2006 the yield curve experienced an inversion in the United States reopened the debate over the value of the yield curve as a forecasting tool. Even though it is more frequent in the United States, the use of the inverted curve as a recession indicator is less common in other nations. Moreover, the correlation between the yield curve and the probability of a recession for European countries is not as consistent as for the United States although there seems to be some degree of coincidence (Chinn and Kucko, 2015).

The main objective of this analysis is to examine the relationship between economic recessions and the yield spread of Government bonds in Spain. Hence, this work focuses on the following hypothesis: *The yield spread between the one-year and ten-year Government bonds rates predicts economic recessions in the short run in Spain.*

The motivation behind the study of this topic is diverse. On the one hand, as the majority of the studies focus on the analysis of the United States economy, it would be interesting to extend this work to the case of Spain. Moreover, it is a topical issue as there was an inversion of the yield curve in the previous years to the 2008 financial crisis and as we are currently experiencing an inflationary period due to the Covid-19 crisis. Furthermore, now is the perfect time to reconsider the evidence as some relevant events have occurred in the last twenty-five years. The first one is the introduction of the euro in 1999 which may have changed the links between interest rates and production. The second one is the fact that in the middle of the 2000s, the long-term interest rate did not rise with the short-term policy rate. On the other hand, it is interesting to study the information given by the yield curve because it can provide useful insights into the evolution of economic output for policymakers. In this sense, policymakers can make use of a simple method to modify their plans in order to anticipate future economic situations. In addition, differences in the correlation between asset prices and economic output may contribute to discussions about the functioning of the macroeconomy (Chinn and Kucko, 2015).

This paper is divided into different parts. First, we examine the previous studies regarding the use of the yield spread as a future economic indicator. In addition, we also comment on the results obtained from the study of influential authors that have made huge contributions to the study of the yield curve such as Arturo Estrella and Frederic S. Mishkin.

Secondly, we make an explanation of basic concepts which comprehension is essential to understand the analysis. This part also includes the theoretical framework in which there is a demonstration of the relationship between long and short-term interest rates. After that, we present an explanation of the data employed to conduct the empirical analysis using time series graphs and a summary of the main statistics. Finally, we display the empirical models: the simple linear regression and the probit.

Results for both models are quite poor and the coefficients estimated are not statistically significant at any traditional significance level. The use of the one-year Treasury Bill rate (instead than a shorter term rate) to calculate the spread or the possibility that the yield curve is not a good forecasting tool for the Spanish economy might be reasons that explain these results.

2. Literature Review

A lot of work has been done in order to study the predictive power of the yield curve. Hence, the first studies related to the relationship between economic growth and the yield curve date to the 1980s. Harvey (1988) provided evidence, using US financial data, that the term structure of interest rates is a useful forecasting tool of consumption growth. Later, Plosser and Rouwenhorst (1994) tried to extend the previous work and studied the use of the term spread to get information about future growth of industrial production using data for US, Germany and U.K, concluding that beyond predictions about future monetary policy, the long end of the term structure contains information concerning future expansion of industrial production.

The simplest model that can be used employs a single explanatory variable (the yield spread) and a measure of the economic activity as the dependent variable. Thus, in Chinn and Kucko (2015) they use this simple linear regression employing industrial production growth as a measure of economic activity and conclude that the yield spread could hold some forecasting value. In the empirical literature, the spread between long-term (e.g., 5 or 10 years) and short-term (e.g., 3 months or 1 year) government rates is the most common way to represent the slope of the term structure (Estrella et al. 2000). Nevertheless, other authors (Ang et al. 2006; Wright, 2006) include the short-term interest rate or the federal funds rate in their regression because they point out that the inclusion of these variables as explanatory variables can improve the forecasts and provide additional information.

There is evidence that using the maximal maturity difference is the best method in order to examine the slope of the yield curve. In fact, many studies use OLS regressions with the slope of the yield curve in order to predict future economic growth (Ang et al. 2006). It is expected that the higher the slope, the larger is the economic growth. Fixing the short-term rate to one-year and raising the long-term rate increases the R^2 in the US (Mishkin,1990). In addition, the yield curve spread performs better as the forecast horizon is extended to two or four quarters. The fact that the yield spread outperforms better than other variables in the long-term makes it a valuable tool for policymakers as the policy interventions generally have extensive lag times before having an impact on the economy (Estrella and Mishkin, 1997).

A huge variety of studies related to the predictive power of the yield curve spread make use of binary response models. Thus, there is a huge consensus among economists that binary response models, such as probit models, work well in forecasting probabilities of recession in the future (Hasse and Lajauine, 2020). Moreover, it has been proven that these binary models are more successful in predicting recession than other models. For instance, in the United

States, the crises after the late-1960s were predicted by an inverted curve with the exception of a "false positive" (there was an inversion of the yield curve but it did not end in a recession) by using binary models (Ang et al. 2006). The binary response models try to estimate the probability of being in a recession using a dummy variable as a dependent variable which takes on a value 1 if and only if there is a recession between the current period and a certain period in the future and 0, otherwise. The explanatory variable is the yield curve spread although some authors also include other variables such as the federal funds rate or the return forecasting factor (Wright, 2006).

Furthermore, the yield curve spread contains information about the real interest rates and the expectations of future inflation that are fundamental to predicting the evolution of the economic output (Estrella and Mishkin,1997). Nevertheless, the capacity of the yield curve in predicting future output is linked to monetary policy (Estrella, 2005). As policy purposes can vary over time and can be different across countries, both the homogeneity and stability of their relationship are necessary for generalizing the use of yield spreads in recession forecasting (Hasse and Lajauine, 2020).

Even though there is strong evidence that the yield curve spread is a good forecasting tool, it is noteworthy that the predictive power is not stable over time. In fact, even though the beginning of a recession after an inversion of the curve can significantly vary, in the 2008 financial crisis the negative slope of the yield curve appeared two years before in the United States. This was the longest period between an inversion of the curve and the recession. This time dispersion could indicate that the yield curve may be losing its forecasting power (Mascareñas, 2013).

One of the reasons for the instability of the curve over time could be that the economy's response to real monetary shocks affects the forecasting capacity of the model. However, even when monetary authorities use the Taylor rule or when they are targeting inflation, the yield curve has predictive power for economic activity and inflation (Cinquegrana and Sarno, 2010). On the one hand, linear models that employ the output growth as the dependent variable show that the term spread ability for predicting has declined since the mid-1980s. On the contrary, binary models are more stable and effective than continuous recession prediction models. In these continuous models, the dependent variable is continuous, especially economic growth (such as the growth in real GDP or industrial production) or the inflation rate over some period of time (Estrella et al. 2000). Cinquegrana and Sarno (2010), concluded that using binary models there was no evidence of instability over the entire sample, but they found evidence of a structural break in the continuous model of US output in 1983.

In relation to the homogeneity across countries, recent empirical analyses have examined the yield spread's predictive power in an international framework. Considering that the earlier literature concentrated on the US, the aim of these studies is to see if the relationship between the probability of recession and the term spread is homogeneous across countries. One of the first international research on this topic was made by Ahrens (2002) that examined a data sample from eight countries: US, France, Canada, United Kingdom, Japan, Italy, Germany and Netherlands. The author concluded that the term spread is a reliable tool for forecasting recessions in all countries. Nonetheless, they affirm that the information given by the yield curve spread varies from nation to nation. Hence, the term spread has more predictive power in the US, Germany and Canada than it does in the Netherlands, Italy or Japan.

More recently, Chinn and Kucko (2015) used a database from nine countries: Canada, France, Germany, Italy, Japan, Netherlands, Sweden, UK and US from the year 1970 to 2013. They pointed out that the model accurately forecasted recessions for the United States, Germany, and Canada whereas the other models failed to predict the recessions of the 2000s. Recessions were not accurately predicted by the Japan and Italy models.

3. Basic concepts and theoretical framework

3.1. Bonds

There are three different types of assets in which you can invest in the financial market: bonds, currency and equity (participations and shares). Bonds are fixed-income securities that reflect loans from investors to borrowers, typically corporate or governmental. (CNMV, 2002). The main elements that compound the majority of bonds are: the issue price (price at which the issuer sells the bond; they are usually issued at par), the face value (amount of money received at maturity), the maturity date (date on which the loan ends and the issuer pays the bondholder the face value of the bond) and the coupon rate (is the percentage that the bond issuer pays on the face value).

Bonds can be classified in different ways but the most common one is according to the type of borrower. Thus, we can find bonds issued by enterprises or by the Government with the aim of satisfying their needs of capital. In this academic investigation I focus on the Government bonds, which are considered Public Debt. Another way to classify them is according to their maturity. Hence, we can distinguish between short-term, mid-term and long-term bonds. The short-term bonds are known as Treasury Bills, and they always have a maturity of one year or less. Treasury Bills promise a single payment (at face value) at the maturity date. The mid-term bonds are called Government bonds and their maturity varies between two and five years. The long-term bonds are known as Government Obligations, and they have a maturity of more than 5 years. Currently, the Spanish Treasury issues Government bonds with a maturity of three and five years and Government Obligations to ten, fifteen, thirty and fifty years. Both the bonds and obligations are securities with periodic interest rates (in form of a coupon) which pay an annual interest to maturity (this information is obtained from the Spanish Public Treasury website).

The yield to maturity of a bond is the average annual rate of return that an investor receives if he holds the bond. It is calculated as follows:

$$P = \frac{C}{(1+r)} + \frac{C}{(1+r)^2} + \ldots + \frac{C+100}{(1+r)^n} \qquad (1)$$

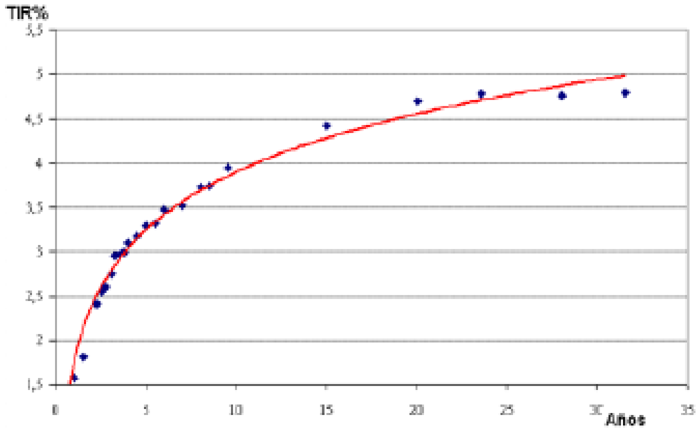
where P is the current price of a bond, C is the coupon that is paid in each period, r is the yield to maturity and 100 is the bond face value. Thus, it is noticeable that the higher is the bond price, the lower is the interest rate.

3.2. Yield Curve

One of the most frequently used concepts in the financial sector is term structure of interest rates or yield curve. This curve links the bonds returns and the time that remains up to the maturity of these bonds. Hence, the representation, at a given point in time, of the relationship between the yield to maturity and the maturity of a bond is known as the yield curve or the term structure of interest rates (Abad y Robles, 2003). It is an indicator of the evolution of the interest rates and the inflation in the future.

When we talk about the term structure of interest rates, we consider bonds with the same, or similar, level of risk of insolvency. Graphically, it is represented as a series of time points where each point represents the yield to maturity. Each point shows the yield to maturity and the period to maturity. The graphic representation of the time structure of interest rates is the curve line that connects all these points (Mascareñas, 2013). For instance, in Figure 1 we appreciate a term structure of interest rates with a positive slope.

Figure 1. Representation of a yield curve with a positive slope



Source: Juan Mascareñas (2013)

3.3. Link between short-term and long-term interest rates

According to preceding literature, this work focuses on the yield spread which is calculated as the ten-year Government bond yield less the one-year Government bond yield for Spain. For this reason, it is essential to understand the relationship between long and short-term interest rates. As it is explained in Blanchard (2012), in order to study this relationship, we will consider two different bonds: a one-year bond and a two-year zero-coupon bond. If an investor is indifferent between those bonds, the expected one-year yield must be the same:

$$1 + i_{1t} = \frac{P^e{}_{1t+1}}{P_{2t}} \qquad (2)$$

where i_{1t} denotes the interest rate of a one-year bond, P_{2t} is the price of a two-year bond and $P^e{}_{1t+1}$ is the expected price of a one-year bond next year.

The first expression denotes the yield per each euro that gives in a year a one-year bond whereas the second expression denotes the yield per each euro that is expected to give in a year a two-year bond. This relation is known as the arbitrage condition. Reorganizing the above equation:

$$P_{2t} = \frac{P^e{}_{1t+1}}{1 + i_{1t}} \qquad (3)$$

Thus, the arbitrage condition indicates that the current price of a two-year bond is equal to the present expected value of a one-year bond in the following year. The expected price of a one-year bond in the future period is linked to the expected future short-term interest rate as follows:

$$P^{e}{}_{1t+1} = \frac{N\,€}{(1 + i^{e}{}_{1t+1})} \quad (4)$$

That is, we expect that the price of a bond next year will be equal to the payment at maturity (N €), discounted by the one-year interest rate that we expect to be next year. Substituting we have that:

$$P_{2t} = \frac{N\,€}{(1 + i_{1t})\,(1 + i^{e}{}_{1t+1})} \quad (5)$$

At the same time, we can write $P_{2t} = \frac{N\,€}{(1 + i_{2t})^2}$,where i_{2t} represents the average annual return on the two-year maturity bond.

Now it has been proven the arbitrage condition which shows that the current price of a two-year bond depends on the current interest rates and the expected interest rate for next year.

To find the exact relationship between the current interest rate, two-year interest rate and the one-year interest rate expected for next year we can substitute P_{2t} in the above equation:

$$\frac{100}{(1 + i_{2t})^2} = \frac{100}{(1 + i_{1t})\,(1 + i^{e}{}_{1t+1})} \quad (6)$$

Reorganizing:

$$(1 + i_{2t})^2 = (1 + i_{1t})(1 + i^{e}{}_{1t+1}) \quad (7)$$

We can also write this exact relationship in an approximate form:

$$i_{2t} = \frac{1}{2}\,(i_{1t} + i^{e}{}_{1t+1}) \quad (8)$$

This equation indicates that the two-year interest rate is the average between the current interest rate and the one-year rate expected for next year. If we generalize for all periods, the equation will be the following:

$$i_{nt} = \frac{1}{n}(i_{1t} + i^{e}{}_{1t+1} + i^{e}{}_{1t+2} + \ldots + i^{e}{}_{1t+n-1}) \quad (9)$$

Below there is an explanation of different concepts related to the yield curve as their understanding is fundamental to study the relationship between economic recessions and the government bond's yield curve.

3.4. Industrial Production

Industrial production measures the physical volume of output of different industries and markets. It is composed of two groups: products and materials. Its significance lies in the fact that it represents 15% or 20%, approximately, of GDP (INE, 2023). This indicator gives information about the performance of different sectors such as the chemical industry, wood, paper, industrial machines, consumer electronics or fabricated metals.

Industrial production can also be measured as an index (IPI) which includes the output of mining, utilities (electricity, gas and water) and manufacturing but excludes construction. The IPI measures the joint evolution of quality and quantity, eliminating the influence of prices. In Spain, this index is calculated by the *Instituto Nacional de Estadística* (INE). A continuous monthly survey is conducted to obtain the data, looking into more than 11,500 establishments each month (INE, 2023).

This index is a fundamental short-term economic indicator due to the huge impact that the industrial activities have on the whole economy. Since it is very sensitive to the economic cycle, an increase in the index means higher growth, which is well-received by the stock markets and the currency. It provides early signals of what will tell us the national product and the national income about the state of the economy. Hence, is a good indicator of the beginning and the end of recessions because it is a procyclical index as it moves in the same direction as the economic cycle.

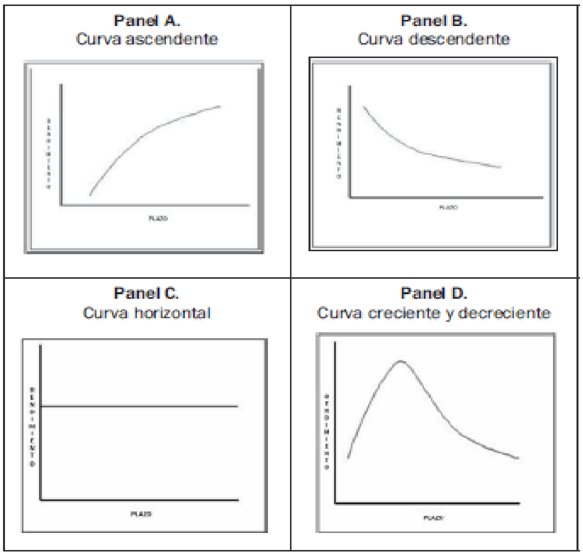
4. The slope of the yield curve

A fundamental aspect considering the yield curve is that its slope is related with market expectations of future interest rates, that is, with the short-term interest rates expected in the future. However, the yield's curve slope does not only depend on the expectation element but also depends on the risk associated with changes in the value of the bond during its lifetime. Thus, the yield curve usually has a positive slope because the longer the maturity of a bond, the higher is the yield. The reason why long-term interest rates are higher than short-term interest rates are because of the larger risk of variations in the value of the long-term bonds.

Even though the sense is that the yield curve must have a positive slope because of the higher risk implicit in the long-term bonds, it can also appear as an inverted curve, namely, a yield curve with a negative slope. The inversion indicates that the short-term yields are larger than the long-term yields meaning that there is an expectation of a lower economic activity in the future. In fact, when this is the case, investors believe that central banks will react by reducing the short-term interest rates and it leads to a decrease in the current long-term interest rates due to the expectations element. For this reason, long-term interest rates increase less than the short-term interest rates, or even decrease.

Apart from the positive and negative slope of the yield curve, it can take two other shapes: it can decrease with mounds (meaning that it first increases and then decreases) or it can be flat (Mascareñas, 2013). Álvarez Castrillón et al. (2010) show a representation of the different shapes of the yield curve.

Figure 2. Different slopes of the yield curve



Source: Durán, R., Kikut, A., Muñoz, E. (1996)

In Panel A, we can see the most common form of the yield curve. The positive slope means that the short-term interest rate is lower than the long-term interest rate. Therefore, perceived risk in the short-term is lower than in the long-term. With a positive slope there are good expectations of the performance of the economy in the future.

In Panel B, we can see the yield curve with a negative slope (also known as the inverted curve). When the yield curve has this shape there is an expectation that there will be a recession in the future and that bonds will have lower interest rates.

In Panel C, there is a representation of a flat curve meaning that the yields are the same independent of the maturity of the bond. It is believed that it is a transitory form between the increasing and decreasing curve.

In Panel D, we observe a decreasing curve with mounds indicating that short-term and the long-term yields are the same but the medium-term rates vary. There are many reasons why we can observe this curve although it is not common.

4.1. Theories that explain the slope of the yield curve

There are different theories that try to respond to how the term structure of interest rates is formed and what are the variables on which it depends. Below there is an explanation of four theories based on the information given in Mascareñas (2013).

The first one is the Theory of Market Expectations, according to which the yield curve is completely based on what the market expects of future interest rates. Initially, this theory was made by Lutz and has been studied by other economists such as Fisher or Keynes. They believe that investors don’t have identical expectations but homogeneous ones and, thus, they can certainly predict interest rates.

Based on this theory, the yield to maturity of an n-year bond is equal to the average of the yields to maturity of one-year bonds over the next n years. This means that buying a two-year government bond will give the same yield as buying a one-year government bond and reinvest the amount obtained in another one-year government bond (the explanation of the links between short-term and long-term interest rate in the previous pages come from this theory).

The second theory is the Liquidity Preference Theory, set out by Keynes, that arises because the theory of market expectations does not take into account the risk related to the investment in fixed-income assets. This theory suggests that an investor will demand a higher interest rate when the maturity is longer because they are riskier. If higher interest rates are not paid for assuming more risk, there will not be any incentive to buy these assets as individuals prefer liquidity or highly liquid assets.

For this reason, investors prefer to invest in short-term bonds because they have less sensitivity to variations in the interest rate and have more flexibility when compared to long-term bonds. Thus, the liquidity preference theory explains why the yield curve has a positive slope; the longer the maturity, the higher the risk premium required and therefore the higher the interest rate.

The Theory of Market Segmentation is another idea that was presented by Culbertson in order to explain how term structure of interest rates is formed. According to this, there is a segmentation in the market of different instruments, namely, certain instruments are traded in each market and only certain agents have access to them.

As this theory assumes that the most important aim for enterprises is to guarantee their survival, they might reduce risk. In order to do it, enterprises perfectly adjust the maturity of their assets with their debt. For instance, we can divide the term structure of interest rates in two segments: short and long-term. Thus, for each segment there will be different buyers and sellers. A commercial bank will invest in short-term bonds because its deposits are short-term products whereas a pension fund will invest in long-term bonds as it has committed to return the money in the long-term.

The Preferred Habitat Theory set out by Franco Modigliani and Richard Sutch is based on the idea that investors who match the life of their assets to the life of their debts bear the least possible risk. As investors are risk averse, the match between assets and debts is their preferred habitat. Thus, there will be premiums for maturities where there is insufficient demand as they incentivize investors to move from their preferred habitat. According to this theory, the shape of the term structure of interest rates is determined by expected interest rates and risk premiums because they force agents to leave their preferred habitats.

5. Data description and methodology

In this section we will do a simple data explanation of each variable and we will expose the methodology followed in this study. To test our hypothesis, we chose data from 1987 to 2022 for Spain.

To carry out the analysis we use two different models: a simple linear regression model and a probit model. The reason why we chose both models is that they are the most common forms used in the literature to test the predictive power of the yield curve. Moreover, it has been proved that binary models perform better at forecasting recessions than the continuous models.

For the simple linear regression model, we use the industrial production index as the dependent variable and the yield spread as the explanatory variable. Afterwards, we present the probit model using a dummy variable as an indicator of a recession and the yield spread as the explanatory variable. As there have been changes in the Spanish economy in the last decades, we split the full data set to test for the stability of the yield curve's predictive power over time. All the results are obtained using the econometric program Stata.

The first variable that we needed to construct in order to conduct the analysis was the yield spread. To do this, we selected the one-year interest rate of Treasury Bills as a representation of the short-term interest rate and the ten-year interest rate of Government bonds to represent the long-term interest rate. Hence, the variable *Yield Spread* is represented by the following equation:

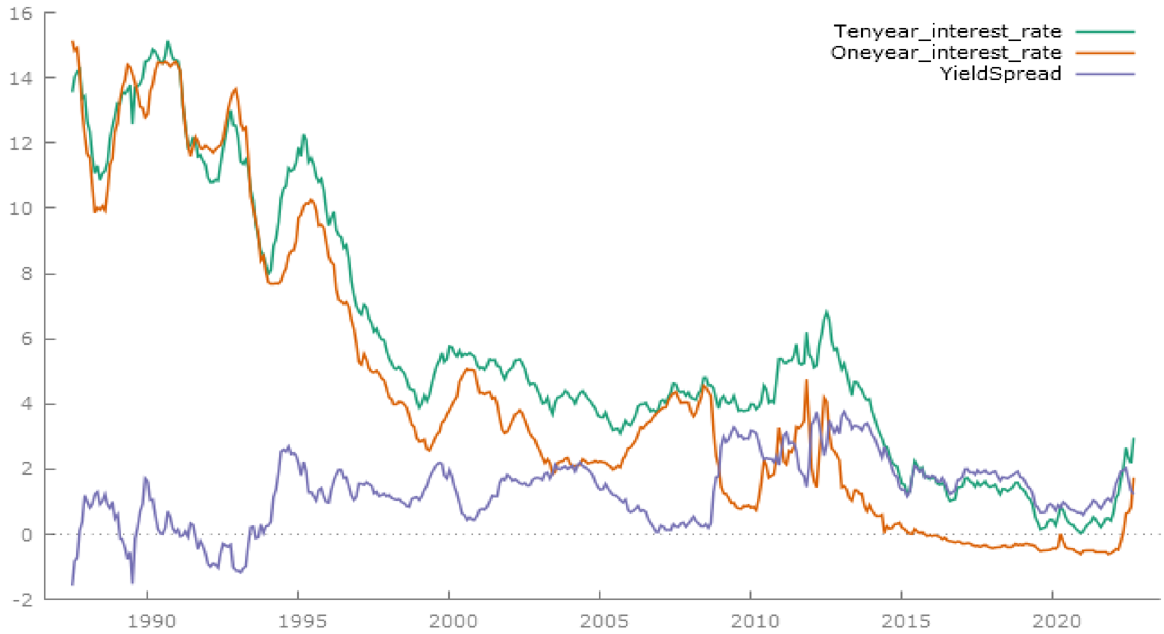
$$YieldSpread_t = i_t^{10y} - i_t^{1y} \tag{10}$$

where i_t^{10y} represents the ten-year government bond rate at time t and i_t^{1y} represents the one-year treasury bill rate at time t. Thus, the yield spread is equal to the ten-year minus the one-year government bond rates.

Both the one-year yields and the ten-year yields are expressed in percentage and monthly frequency. This data was collected from the Federal Reserve Economic Data (FRED).

Below there is a graphic representation of the evolution of the one-year interest rate, the ten-year interest rate and the yield spread in Spain from 1987 to 2022.

Figure 3. Evolution of the one-year and ten-year bond interest rates and the yield spread in Spain (1987-2022)



Source: Own elaboration, Data: FRED

It is noticeable that the short and the long-term interest rates are positively correlated as they fluctuate in the same direction. Hence, both series reached the maximum in the late 1980s with a 15.140% and then, they started decreasing until the year 2021. Moreover, we appreciate that the ten-year interest rates are higher than the one-year interest rates during the period, except for a few years in the late 1980s and the early 90s where we observe that the yield spread was negative.

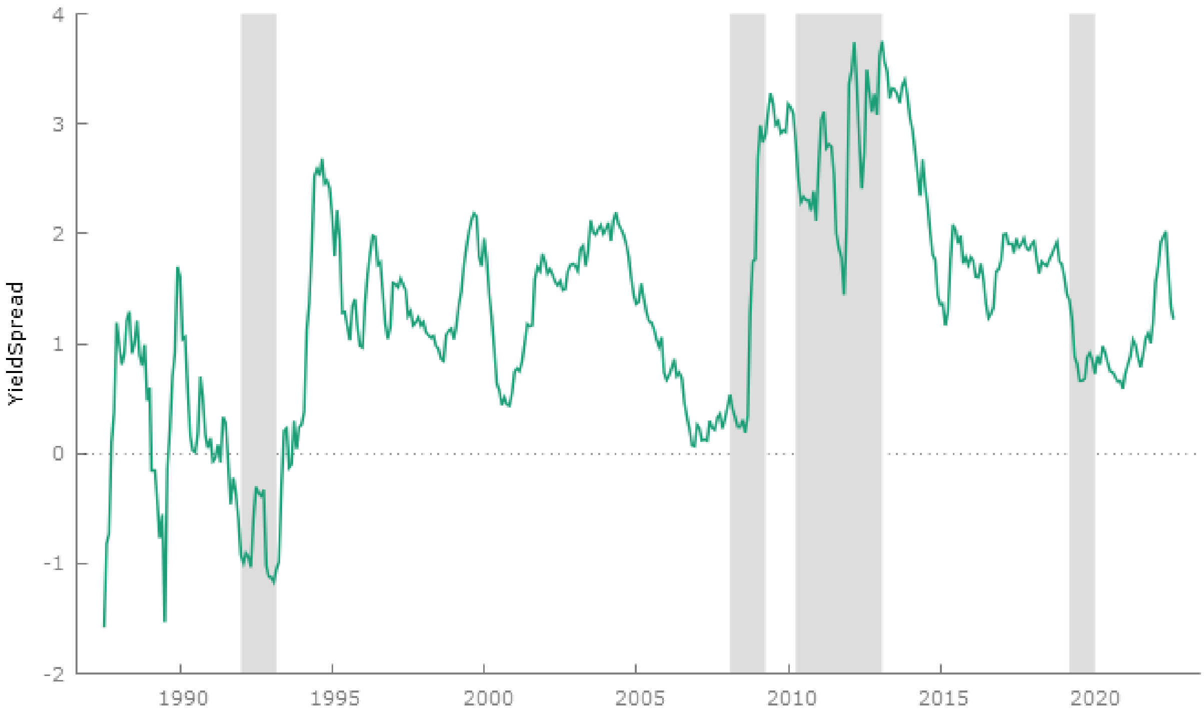
From 1993 to 1997, Spain experienced a period of recession as a consequence of the collapse of the Japanese real estate bubble in 1990 and the increase in oil prices due to the Gulf War. For this reason, we observe a decrease in short and long-term interest rates. However, two years before the 2001 crisis interest rates started to increase going from the 2.5% in 1999 to the 5% at the end of 2000 for the short-term interest rate. The long-term interest rate followed the same direction as the short-term interest rate, but it fluctuated slightly less.

Additionally, we can appreciate the same behavior of interest rates in the 2008 financial crisis. During the previous years of the crisis, both short and long-term interest rates experienced an increase and they reached 4.6% and 4.8%, respectively. Nevertheless, when the crisis started, both interest rates started to decrease. In this case, the short-term interest rate fell more than the long-term interest rate. Thus, the ten-year interest rate reached the 3.8% and the one-year interest rate fell to 0.73%. In 2015, the short-term interest rate became negative for the first time during the period and remained negative until 2021.

Due to the Covid-19 crisis in 2020, Central Banks applied an expansive monetary policy to boost investment and economic growth. However, this expansive policy and other events that have occurred during the last years (such as the war between Russia and Ukraine), led to a high inflation and, consequently, Central Banks started to increase interest rates. This could be a reason why we observe an increasing trend in the short-term and long-term interest rates since 2021.

Apart from examining the evolution of both interest rates and the term spread, it will be interesting to see a graph with a representation of the evolution of the yield spread and the recessions. Hence, Figure 4 shows the yield spread (represented by the green line) and the recessions (represented by grey columns) that took place in Spain from 1987 to 2022. To date the recessions, we used the chronology made by the Spanish Business Cycle Dating Committee in which we find the Spanish business cycle dated.

Figure 4. Evolution of the yield spread and economic recessions in Spain (1987-2022)



Source: Own elaboration, Data: FRED and Spanish Economic Association.

In relation to the evolution of the yield spread, from 1987 to 1994 there were periods in which the spread was negative, meaning that the one-year interest rate was higher than the ten-year interest rate. As the long-term rate remained above the short-term rate during the rest of the period, the yield spread stayed above zero. In addition to this, this graph can give us information related to the prediction of future recessions. As we explained in the literature review, it has been demonstrated that the inversion of the slope of the yield spread is followed by an economic recession, in some cases. Thus, the term spread can be seen as an indicator of future economic activity.

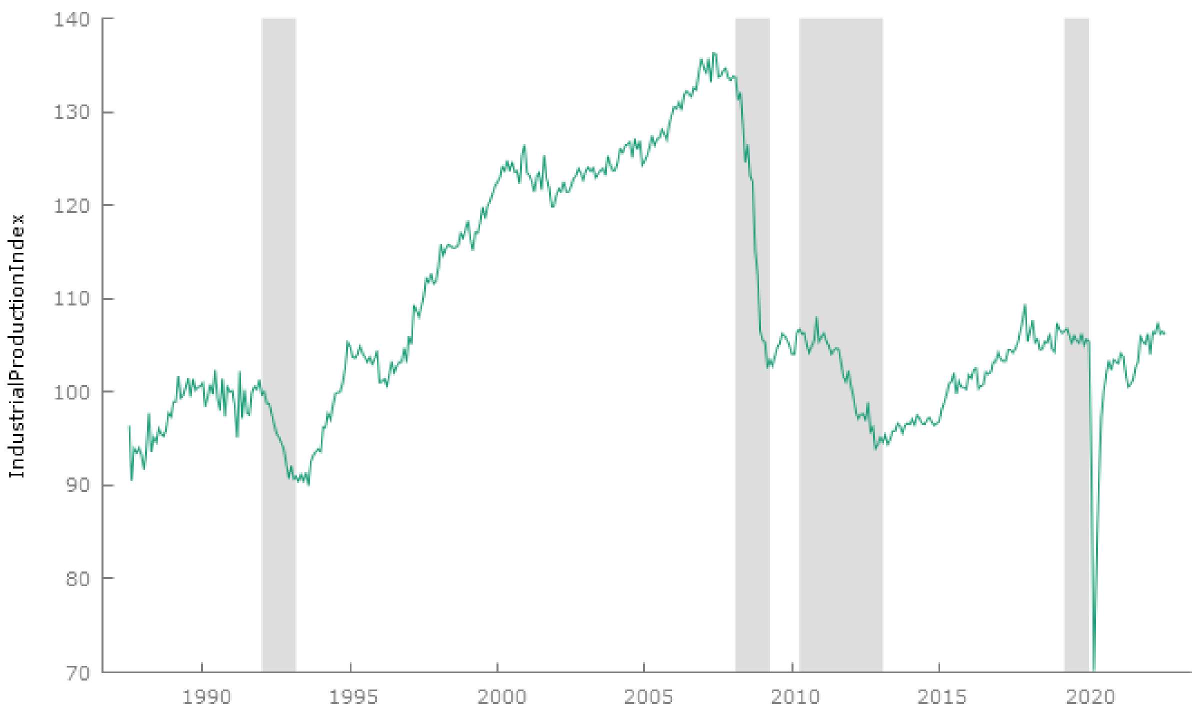
In the graph we observe four periods of recessions. The first one took place in the early 1990s and we can clearly appreciate that a few quarters before the recession there was an inversion of the curve. Similarly happened in the 2008 financial crisis as we observe that the slope of the term spread became negative in 2004. Once the financial crisis started, the yield spread started rising because of the increase in the long-term interest rates with respect to the short rates. However, in 2010 the slope of the curve turned negative and, afterwards, the Spanish economy entered a debt recession that lasted 12 quarters (this recession lasted twice as long as the 2008 crisis). The last recession was in 2019 and was also preceded by an inversion of the term spread that started four quarters before the beginning of the recession.

In short, in the case of Spain we see that the four recessions were preceded by an inversion of the slope of the yield spread. However, it is also noteworthy that the negative slope of the curve does not always mean that there will be an economic recession in the future. For instance, we appreciate that there were other periods in which the slope of the term spread was inverted and there was not a recession in the subsequent quarters.

As a measure of economic activity, we selected the Industrial Production Index for the linear regression model. Although GDP is the main indicator of economic output, industrial production has some advantages in terms of timelines and reliability as it provides more precision (Chinn and Kucko, 2015). In any case, industrial production follows GDP growth rates closely.

In Figure 5, we observe the evolution of the Industrial Production Index and the recessions in Spain from 1987 to 2022. This index is expressed in monthly frequency and referenced to 2015. We notice that the IPI followed an upward trend from 1987 to 2009. However, after the 2008 financial crisis, it started decreasing. It is noteworthy that in 2008 and 2020 (the years in which the most important recessions of the last decades took place), this index fell significantly due to the deceleration of economic activity. Thus, we appreciate a decrease in the IPI when there is a recession.

Figure 5. Evolution of the Industrial Production Index in Spain (1987-2022)



Source: Own elaboration, Data: FRED.

In Table 1, there is a summary of the main statistics of the ten-year and one-year bond rates, the yield spread and the industrial production. Observing the standard deviation, we can measure the volatility of these variables. The least volatile is the yield spread as its standard deviation is of 1.029 percentage points with respect to the average. On the contrary, the one-year government bond rate has the highest standard deviation as it deviates in 4.573 percentage with respect to the average. Both bond rates have a similar standard deviation although it is slightly higher for the one-year bond rate.

To construct the probit model, we created a dummy variable that equals 1 in case of recession between t + 1 and t + k and 0, otherwise. This variable is the recession indicator, and we will use it as the dependent variable. To create the variable, we used the business cycle dating for Spain which is published by the Spanish Business Cycle Dating Committee (Spanish Economic Association, 2015). The periods of recessions in Spain are displayed in Table 2.

Table 1. Main statistics summary

Monthly data (1987-2022)

	Mean	**Std.Dev**	**Min**	**Max**
10-year government bond rate	5.745	4.064	0.04218	15.14
1 year government bond rate	4.407	4.573	-0.6200	15.14
Yield Spread	1.338	1.029	-1.580	3.748
IPI	108.0	12.42	70.08	136.3

Note: Data based on ten-year and one-year government bond rates is downloaded from the FRED. The IPI is also downloaded from the FRED. Own elaboration

Table 2. Economic recessions in Spain (1974-2022)

Peak	**Trough**
1974Q4	1975Q2
1978Q3	1979Q2
1992Q1	1993Q3
2008Q2	2009Q4
2010Q4	2013Q2
2019Q4	2020Q2

Source: Data extracted from the Spanish Economic Association.

6. Empirical model and results

In this section we will give a detailed explanation of the construction and the results obtained in both models: the simple linear regression and the probit model.

6.1. Simple linear regression model

First, we start with a simple linear regression:

$$IPIGrowth_{t,t+k} = \beta_0 + \beta_1 YieldSpread_t + \varepsilon_{t+k} \quad (11)$$

where $IPIGrowth_{t,t+k}$ is the annualized growth rate between *t* and *t + k* and the $YieldSpread_t$ is defined as the ten-year government bond rate minus the one-year Treasury Bill yield.

With this regression we try to study if the annualized growth rate of industrial production for the k-month period starting at time t is predicted by the yield spread at time t. Following Chinn and Kucko (2015), we estimated this model using k = 12 and k = 24 (this is, the growth over a one-year and two-year time horizon).

Before doing the regression we first analyzed stationarity, heteroskedasticity and serial correlation. All the results are obtained using the statistical software Stata.

As we are working with time series, examining the stationarity of the variables is essential as it is one of the most important properties of this type of data. Stationary time series have the same mean and autocovariance at any point in time. Hence, a stationary time series process is one in which its probability distributions remain stable over time (Wooldridge, 2014). We conducted the Phillips-Perron test for unit root for both the yield spread and the industrial production growth over 12 and 24 months.

Table 3 shows the results obtained from the unit root test. As the test statistics are higher than the critical values with a 1%, 5% and 10% significance level, we can reject the null hypothesis of unit root presence and, thus, we conclude that the series are stationary.

Table 3. Phillips-Perron test for unit root

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Yield Spread				
Z (rho)	- 23.337	- 20.438	- 14.000	- 11.200
Z (t)	- 3.782	- 3.446	- 2.873	- 2. 570
IPI growth (12 months)				
Z (rho)	- 56.386	- 20.428	- 14.000	- 11.200
Z (t)	- 5.496	- 3.447	- 2.874	- 2. 574
IPI growth (24 months)				
Z (rho)	- 28.793	- 20.418	- 14.000	- 11.200
Z (t)	- 3.875	- 3.448	- 2.874	- 2. 570

Note: Table shows the values of the test statistic and the critical values at a 1%, 5% and 10% significance level. The p-values for Z (t) are 0.0031, 0.0000, 0.0022 for the Yield Spread, the IPI growth (12 months) and the IPI growth (24 months), respectively. Own elaboration.

In addition, when we work with time series it is also crucial to examine the serial correlation because it may happen that the error terms are correlated over time. In this case, the estimator would not be efficient. For this reason, it is necessary to apply a test in order to see if there is serial correlation in our error terms and calculate serial correlation-robust standard errors if it is necessary. Since the Durbin Watson test is only useful with a 1 lag length, it is not applicable to this model. Therefore, we conducted the Breusch- Godfrey test to examine the presence of serial correlation. Results from the test are displayed in Table 4:

Table 4. Serial correlation test: Breusch-Godfrey test. Full sample

	IPI growth (12 months)	IPI growth (24 months)
p-value	0.0000	0.0000

Note: Table shows the p-value obtained from the Breusch-Godfrey test. Own elaboration.

The hypothesis for the Breusch-Godfrey test is the following:

- H0: No presence of serial correlation ($\rho = 0$).
- H1: Presence of serial correlation ($\rho \neq 0$).

From the output, in both models we observe a p-value lower than a 5% significance level and, thus, we also reject the null hypothesis of no presence of autocorrelation.

Another consideration in order to obtain an efficient and consistent estimator is to examine heteroskedasticity. We need to verify if the term errors are constant over time, that is, that there is no existence of heteroskedasticity. First, we conducted the White's test which is the most general test for detecting heteroskedasticity. However, as this test does not require any particular specification, it can give us some problems. Thus, we also conducted the Breusch-Pagan test. Table 5, shows the results from both test:

Table 5. Heteroskedasticity test: Full sample

	White's test	**Breusch-Pagan**
IPI growth (12 months)		
p-value	0.0299	0.0000
IPI growth (24 months)		
p-value	0.0001	0.0000

Note: Table shows p-values obtained from the White's test and the Breusch-Pagan test. Own elaboration.

The hypothesis for the White's test is the following:

- H0: Homoskedasticity.
- H1: Unrestricted heteroskedasticity.

For the Breusch-Pagan test, the hypothesis is the following:

- H0: There is a constant variance.
- H1: There is not a constant variance.

After doing the test, we can conclude that the p-values obtained from the White's test are lower than a 5% significance level and, thus, we reject the null hypothesis of homoscedasticity. The same result gives the Breusch-Pagan test as the p-value is lower than a 5% significance level and, consequently, we reject the null hypothesis of constant variance.

As we verified that there is presence of serial correlation and heteroskedasticity in our error terms, we must employ serial correlation and heteroskedasticity robust standard errors. As it is used in Chinn and Kucko (2015), to solve this problem and obtain efficient and consistent estimators we use the Newey-West standard errors (1987).[1]

First, we did the statistical inference of the model using the entire data set (1987-2022).

Table 6. Linear regression: Full sample (1987-2022)

	Coefficient	**Newey-West Std.errors**	**p-value**
IPI (12 months growth)			
Yield Spread	0.004947	0.007058	0.484
Constant	-0.001188	0.01543	0.939
R^2	0.0069		
Observations	411		
IPI (24 months growth)			
Yield Spread	0.005521	0.014552	0.705
Constant	0.001224	0.030838	0.968
R^2	0.0046		
Observations	399		

Note: The yield spread is the ten-year minus the one-year government bond rate. Serial correlation and heteroskedasticity robust standard errors. Own elaboration.

In Table 6, we see that in both models the estimated coefficient for the yield spread is positive but not statistically significant as the p-value is higher than 0.05. The interpretation of the yield

[1] As each observation for the IPI growth (12 months) is constructed using the subsequent 12 months of Industrial Production, we used the Newey-West standard errors with a lag length of 11 to account for heteroskedasticity and serial correlation. In the case of the IPI growth (24 months) model, we use a lag length of 23.

spread coefficient in the model with k = 12 is the following: by increasing the yield spread by one percentage point, the industrial production in Spain grows by 0.0049 percentage points over the next 12 months, but this number is not significantly different from 0.

Considering the 24 months growth, by increasing the yield spread by one percentage point, the industrial production in Spain grows by 0.0055 percentage points over the next 24 months. Again, as the p-value is higher than a 5% significance level, the estimated coefficient is not statistically significant. In both regressions, the R^2 is very low, indicating that a very low percentage of the changes in the industrial production index are explained by the yield spread.

To examine the stability of the estimation over time, we divide the sample into two parts: the first one goes from 1987 to 2005 and the second one from 2006 to 2022. The choice is mostly practical as it splits the full sample into two equivalent sized sub-samples. Moreover, this division will allow us to see the changes before and after the 2008 financial crisis. Hence, we will see if there are changes in the estimated coefficients and if the strength of the relationship between the industrial production growth and the yield spread varies over time.

Next, we will do the empirical analysis for the first sub-sample, that is, from 1987 to 2005.

Table 7. Serial correlation and heteroskedasticity test (1987-2005)

	Breusch-Godfrey	**White's test**	**Breusch-Pagan**
IPI growth (12 months)			
p-value	0.0000	0.0537	0.0176
IPI growth (24 months)			
p-value	0.0000	0.0007	0.0000

Note: Table shows the p-values from the Breusch-Godfrey test for autocorrelation and the p-values obtained from the White's and Breusch-Pagan test to account for heteroskedasticity. The test was conducted for the two models (the industrial production growth over 12 and 24 months). Own elaboration.

Table 7 displays the results from the Breusch-Godfrey tests for serial correlation for the first sub-sample. In addition, there are included the White and Breusch-Pagan test to account for heteroskedasticity. Observing the p-value obtained from the de Breusch-Godfrey test, we conclude that there is autocorrelation in the error terms as the p-value is lower than a 0.05

significance level. In the case of the heteroskedasticity tests, the p-values signal presence of heteroskedasticity, except for the p-value obtained from the White' test in the 12-months industrial production growth model.

Table 8. Linear regression (1987-2005)

	Coefficient	**Newey-West Std.errors**	**p-value**
12 months growth			
Yield Spread	-0.003497	0.01710	0.838
Constant	-0.033433	0.03649	0.361
R^2	0.0002		
Observations	222		
24 months growth			
Yield Spread	-0.071589	0.058838	0.225
Constant	-0.006746	0.041601	0.871
R^2	0.0406		
Observations	222		

Note: The yield spread is the ten-year minus the one-year government bond rate. Serial correlation and heteroskedasticity robust standard errors. Own elaboration.

Table 8 presents the results of the simple linear regression for the first sub-sample. It is noticeable that the estimated coefficients are negative (in contrast to the positive coefficients obtained using the full data set) and not statistically significant. Again, the R^2 are very small, so the yield spread explains very little of the changes in the industrial production growth.

Below we will do the same analysis for the second sub-sample, that is, from 2006 to 2022.

Table 9 shows the results from the serial correlation and heteroskedasticity tests. On the one hand, as the p-value obtained from the Breusch-Godfrey test is lower than the 5% significance level, so we reject the null hypothesis of no presence of serial correlation. On the other hand, with the results from the heteroskedasticity test we can conclude that the error terms show presence of heteroskedasticity in all the cases as the p-values are lower than the 5% significance level.

Table 9. Serial correlation and heteroskedasticity test (2006-2022)

	Breusch-Godfrey	**White's test**	**Breusch-Pagan**
IPI growth (12 months)			
p-value	0.0000	0.0157	0.0000
IPI growth (24 months)			
p-value	0.0000	0.0179	0.0000

Note: Table shows the p-values from the Breusch-Godfrey test for autocorrelation and the p-values obtained from the White's and Breusch-Pagan test to account for heteroskedasticity. The test was conducted for the two models (the industrial production growth over 12 and 24 months). Own elaboration.

Table 10. Linear regression (2006-2022)

	Coefficient	**Newey-West Std.errors**	**p-value**
12 months growth			
Yield Spread	0.013033	0.01436	0.365
Constant	-0.033814	0.03673	0.359
R^2	0.0293		
Observations	189		
24 months growth			
Yield Spread	0.0345569	0.023845	0.149
Constant	-0.090507	0.059454	0.130
R^2	0.1198		
Observations	177		

Note: The yield spread is the ten-year minus the one-year government bond rate. Serial correlation and heteroskedasticity robust standard errors. Own elaboration.

The estimated coefficients from the linear regression for the second sub-sample are displayed in Table 10. In this case, the estimated coefficients for the yield spread are positive (as the ones obtained in the regression using the full data set) but they are not statistically significant at a 5% significance level.

In relation to the R^2, the yield spread explains the 2.93% and the 11.98% of the changes in the industrial production growth for the next 12 and 24 months, respectively. We observe that the R^2 are higher in the second sub-sample than the ones obtained using the full sample or the first sub-sample.

After doing the empirical analysis we conclude that the estimated coefficients are not significantly different from zero not only when the models are calculated with the full dataset but also when using the sub-samples. For this reason, with this analysis we cannot confirm that our hypothesis is true.

6.2. Probit model

To forecast the probability of an economic recession, the use of econometric probability models is fundamental to carry out the analysis. In fact, there is evidence that binary models are more successful in predicting recessions than linear regressions. Considering probability models, we reject the use of the linear probability model because it can estimate probabilities below 0 or above 1, that is to say, out of the range [0,1]. This problem can be solved using binary models such as the Logit and the Probit. In these, the estimated probabilities are bounded between 0 and 1. In our analysis, we will consider the probit model as it enables us to regress a dichotomous continuous variable on the yield spread.

Following Chinn and Kucko (2015), we try to examine the probability that the Spanish economy experiences a recession in the subsequent months. However, before constructing the model it is crucial to define what is a recession. The Spanish Business Cycle Dating Committee dates the peaks and troughs of the Spanish crisis, and it defines a recession as a "period of decline widely spread across the economy". We will date the recessions according to the formal dates given by the Spanish Business Cycle Dating Committee.

The model employed is represented by the following equation:

$$\Pr\left(R_{t+1,t+k} = 1\right) = \Phi\left(\beta_0 + \beta_1\, YieldSpread_t\right) \tag{11}$$

where Pr denotes probability, $R_{t+1,t+k}$ is the dependent variable that equals 1 if there is a recession between t +1 and t+ k months, inclusive (t is de current time period and k is the predict period), Φ represents the standard normal cumulative distribution function and the $YieldSpread_t$ denotes the spread between the ten-year and the one-year government bond rates at time t. We do the analysis using k = 6 and k = 12 (a six-month and one-year prediction).

Table 12 shows the results from the probit model over the full sample. Whereas the first block of the table contains the results for the six-month forecasting model, the second block shows the results for the 12-month forecasting model.

Table 11. Probit model results. Full sample (1987-2022)

	Coefficient	**Robust Std. Err.**	**z**	**P > |z|**
Next 6 months				
Yield Spread	0.0390	0.0771	0.51	0.613
Constant	-0.8095	0.1261	-6.42	0.000
Pseudo R^2	0.0009			
Observations	423			
Next 12 months				
Yield Spread	0.0247	0.0716	0.35	0.730
Constant	-0.6121	0.1170	-5.23	0.000
Pseudo R^2	0.0003			
Observations	423			

Note: The yield spread is calculated as the ten-year minus the one-year government bond rates. Heteroskedasticity robust standard errors. Own elaboration.

The pseudo R^2 gives a measure of the forecasting accuracy, and in both models the pseudo R^2 is extremely low. On the other hand, the statistical significance of the yield spread gives information about the reliability of the model. In this case, the p-value is higher than any conventional significance level and, thus, we conclude that the estimated coefficient of the yield spread is not significantly different from zero.

To estimate the probabilities of recession, we will use the tables of a standard normal distribution. In the equations 12 y 13, we have written the probit equation replacing the β with the results:

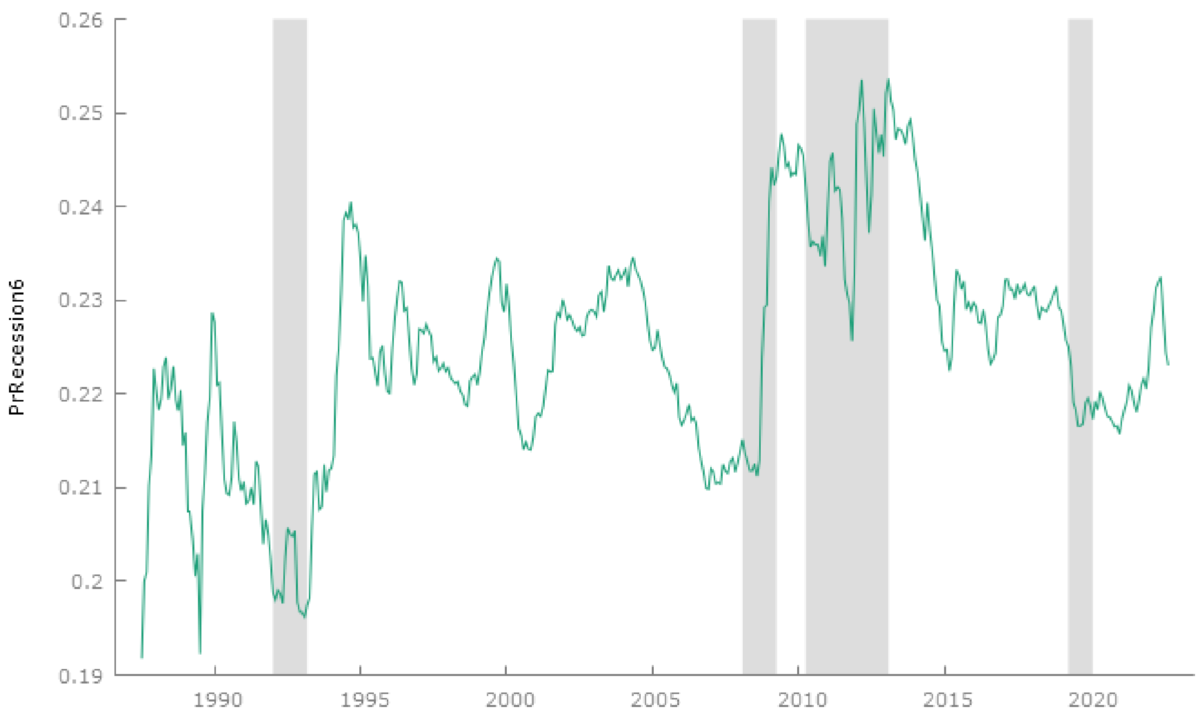
$$\Pr\left(R_{t+1,t+6} = 1\right) = \Phi\left(-0{,}8095 + 0{,}0390 YieldSpread_t\right) \tag{12}$$

$$\Pr\left(R_{t+1,t+12} = 1\right) = \Phi\left(-0{,}6121 + 0{,}0247 YieldSpread_t\right) \tag{13}$$

Thus, for each value of the yield spread at the current period, we could calculate the value in brackets and look for that value in the tables of the standard normal distribution the correspondent probability. Therefore, we would obtain the estimated probability of recession between t + 1 and t + k depending on the value of the spread.

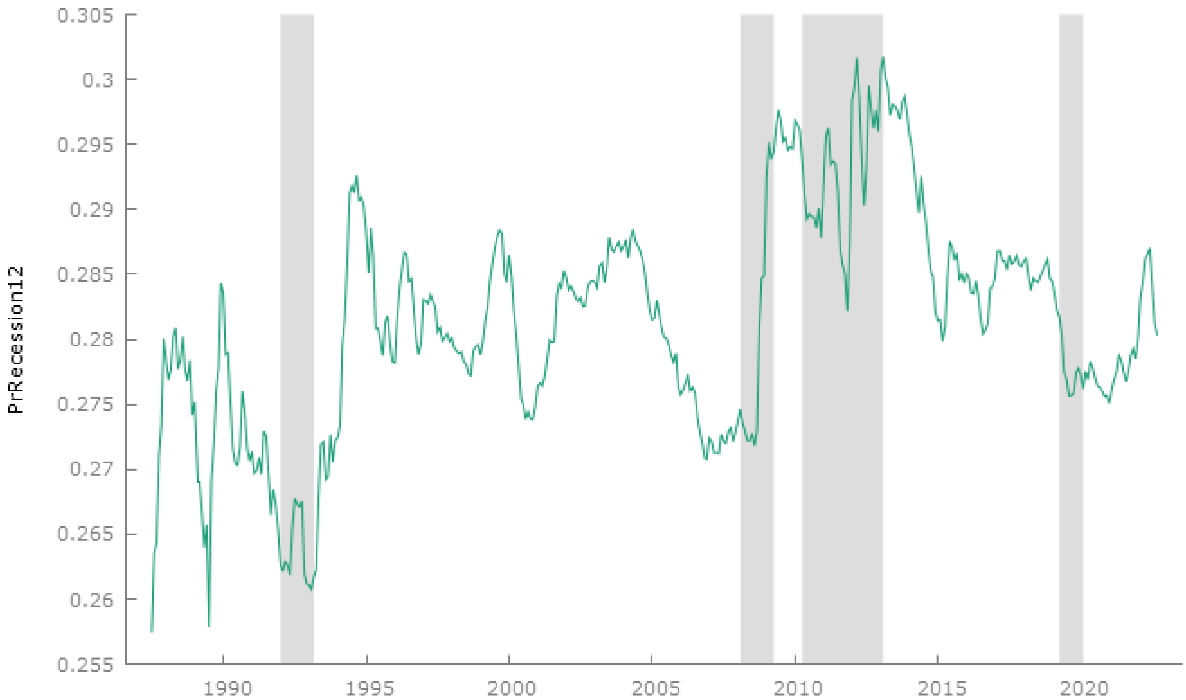
To estimate the probability for each period, we used the econometric software Stata. For a better interpretation of the results, we created a graph. Thus, Figure 6 displays the probability of recession in the subsequent 6 months and the recessions that occurred in the Spanish economy from 1987 to 2022. Similarly, Figure 7 shows the probability of recession but, in this case, in the subsequent 12 months. In both graphs, recessions were not accurately predicted by the yield spread. In fact, the estimated probability decreased in periods close to the real recessions, except for the 2008 financial crisis in which we appreciate a little increase in the probability of recession. Therefore, results are poor and the model does not explain too much.

Figure 6. Estimated probabilities of recession for the next 6 months and recessions in actuality in Spain



Source: Own elaboration.

Figure 7. Estimated probabilities of recession for the next 12 months and recessions in actuality in Spain



Source: Own elaboration.

On the other hand, it is also interesting to calculate the marginal effect of the yield spread over the probability of recession. Thus, we examine the change in the likelihood of success when the yield spread changes. Below are displayed the marginal effects for both models.

Table 12. Marginal effects of the spread over the probability of recession

	ey/ex	Std.Error	z	P > |z|
Next 6 months				
Yield Spread	0.0685	0.1047	0.65	0.513
Next 12 months				
Yield Spread	0.0391	0.0927	0.42	0.673

Note: Table shows the marginal effects of the yield spread. The top block displays the results from the six-month forecasting model and the lower block, from the 12-month model. Own elaboration.

For the six-month forecasting model, if the yield spread changes by 1%, the probability of recession increases by 6.85%. In the case of the 12-month forecasting model, the change in the probability of recession is 3.91% when the spread changes by 1%. Nonetheless, we must consider that in both cases the results are not statistically significant as the p-value is higher than all the conventional significance levels.

7. Alternatives to the yield curve for predicting recessions

Even though the use of the yield curve as an indicator of future recessions is generally known among economists, there are other financial and macroeconomic variables that are also used to predict the path of the economy.

In relation to the macroeconomic variables, an indicator that seems to be successful in forecasting economic output in the United States is the Commerce Department index of leading economic indicators. This is an index that is published monthly, and it is used to predict the future evolution of the economy. However, it is said that the success of this index is exaggerated as it is revised *a posteriori* in order to enhance its performance. An index that has been proven to perform better than the Commerce Department index is one presented in Stock and Watson (1989). They created a leading indicator forecasting model in which they used seven leading indicators to predict economic growth in the short run in the United States' economy. Although the ability of macroeconomic indicators to forecast real activity has been established, there is a serious problem with overfitting in these models as their success is maximized by choosing the components and their weights (Estrella and Mishkin, 1996).

Policymakers can also consider the advantages given by the financial variables, for instance, stock prices, which have drawn a lot of attention. According to financial theory, expectations regarding future dividend payments, which are correlated with the state of the future economy, affect stock prices. Moreover, in Estrella and Mishkin (1996) they examined the success of different financial variables in order to predict future recessions for the United States using a probit model. The variables used were interest rates and spreads, stock prices indexes and monetary aggregates and then, they were compared with traditional macroeconomic indicators. With their analysis, they concluded that stock prices and the yield curve spread are the most simple and successful indicators in predicting economic activity and that financial variables can be reliable to supplement macroeconomic models when forecasting recessions.

Another analysis was done by Estrella and Mishkin (1996) in which they compared the ability of the yield curve spread and three financial and macroeconomic variables: the New York Stock Exchange (NYSE) stock price index, the Commerce Department's index of leading economic indicators and the Stock-Watson index. With each variable they forecasted the probability of recession for the United States using a probit model. Their results showed that stock prices are successful to estimate a one or three quarters horizons.

In addition, two fundamental inferences were made regarding the performance of all the variables. The first one is that despite all the factors having some ability to predict future economic activity, the Stock-Watson index generates the best predictions. The second one is that the yield curve spread is the best indicator for predicting recessions, especially, when the time horizon is of two or more quarters in the future. Moreover, the dominance in the yield curve performance to forecast increases as the time horizon grows.

Although there is no doubt that predicting recessions with macroeconomic models is successful, the use of financial variables to supplement the forecasts is useful for many reasons. First, it can be helpful to double-check the results and to increase the confidence in the model if the results from both indicators are the same. Secondly, it is important to look at macroeconomic and financial variables because the macroeconomic models tend to have an overfitting problem. These models often use statistical regressions to obtain the results and, thus, they tend to employ explanatory variables that maximize the predictive power of the model.

8. Conclusion

This paper has studied the performance of the yield spread in forecasting future economic activity and recessions in Spain. In addition, we examined the changes in the stability of this tool to forecast the future path of the economy over time. The yield spread is calculated as the ten-year minus the one-year government bonds rates. After doing the analysis and obtaining the results, we reached some conclusions. Next, we will explain them in more detail.

First, we conducted the simple linear regression model, and the estimated coefficients were positive, meaning that an increase in the yield spread will lead to an increase in the industrial production growth. However, these results are not statistically significant at any conventional significance level. On the other hand, we divided the full dataset in both sub-samples to test the stability over time and the possibility of finding statistically significant results when using data from different years. Some authors have stated that there could be reasons why the success in forecasting recessions could not be stable over time and it has been found that this indicator has lost predictive power. Hence, models that predict future economic growth present a decrease in its predictive power since the 1980s and binary models appear to be more stable (Chinn and Kucko, 2015).

The first sub-sample includes data from 1987 to 2005. In this case, the estimated coefficients were negative which means that an increase in the yield spread increases will generate a decrease in industrial production growth. The second sub-sample contains data from 2006 to 2022 and the estimated coefficients of the yield spread were positive. Nonetheless, in both sub-samples the estimations are not statistically significant at any standard significance level.

Secondly, we carried out a probit model to obtain the probabilities of recession with the use of the yield spread. Results did not predict recessions successfully and, moreover, the estimated coefficients were not statistically significant.

These results contrast to what is shown in Figure 4 as we observe that the four recessions that took place in the Spanish economy over the period considered were preceded by an inversion of the slope of the yield curve. However, it may be mentioned that we found some "false positives" because there were periods in which a negative slope of the curve did not end in a recession. In this sense, it is essential to consider that time spreads are also affected by other factors such as the supply and demand dynamics in main markets, expected future inflation or the uncertainty about future growth or inflation. In fact, some fund managers believe that the flattering of the curve is more indicative of the bond market's complacency about the possibility of higher inflation and interest rates in the following year than a sign of economic malaise (Mascareñas, 2013).

Some explanations of these results can be related to the limitations that this work has had. On the one hand, there were some restrictions in order to find the historical data of the three-month government bonds interest rates for Spain. The data available was not sufficient to conduct the empirical analysis and, thus, we used the data of the one-year Treasury Bill as the short-term interest rate to construct the yield spread. In this sense, the yield spread was not constructed as in the vast majority of papers related to the study of this indicator. There is evidence that the most successful models use the maximal maturity difference, that is, a yield spread calculated as the ten-year minus the three-month government bond rates (Ang et al. 2006). Therefore, calculating the spread using the one-year Treasury Bill could have affected our results.

On the other hand, it could be possible that the yield spread is not a good predictor of future economic growth in Spain. For instance, in Chinn and Kucko (2015) they concluded that recessions were not accurately predicted for the case of Japan and Italy. The majority of investigations have studied the significance of the term spread as a forecasting tool in the United States and, the conclusions suggest that it is a reliable indicator for this country. Nonetheless, Oliver Jones, from Capital Economics, stated that the predictive ability of the yield curve over recessions could be irregular across countries, meaning that the ability to forecast is not the same from nation to nation (Mascareñas, 2013).

In addition, Hvozdenska (2014) did research to examine the ability of the yield curve to predict economic activity. The investigation was similar to the one conducted in this paper but it focused on fifteen EU countries from 2000 to 2013, including Spain. In it there is presented a linear regression model designed to predict real GDP growth for the next four quarters based on the current yield spread. Results from this model suggest that the spread between the ten-year and the three-month government interest rates has a significant predictive power for Austria, Denmark, Germany, United Kingdom, Sweden, France, Finland and Ireland after the 2008. However, using the full dataset, the R^2 coefficients are very low for all countries (including Spain), except for Sweden and Greece.

As it is done in this paper, in Hvozdenska (2014) the full dataset was divided into two sub-samples. In the first sub-sample the estimated coefficient was only statistically significant for Greece and, thus, she concluded that the other models were not useful as forecast models. In the second period results were also statistically insignificant for the case of Spain, Belgium, Italy, Luxemburg, Portugal and the Netherlands. Therefore, it was concluded that the model cannot be used for these countries.

The conclusion to be drawn is that there is a vast literature that examines the yield curve as a forecasting tool and it has been proven that it contains some predictive power for some economies, especially for the United States. In these countries, the yield spread can be a simple tool to double check information given by more sophisticated model forecasts. However, in other economies the use of this financial tool is not as relevant as it was expected to be. In the case of Spain, we did not find any statistically significant results for neither the simple linear regression model nor the probit model.

9. References

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