INFLUENCE OF SOVEREIGN RISK ON THE MATURITY STRUCTURE OF SOVEREIGN DEBT IN THE EUROZONE

Abstract

The aim of this paper is to analyze the relation between the maturity structure and the sovereign risk. We use panel data methodology to analyze data on a group of countries in the Economic and Monetary Union for the period between 1980 and 2012. The results indicate that risk shortens the maturity structure of sovereign debt because it reduces the stock of long-term debt and the average maturity of sovereign debt. However, the relationship between the two variables differs depending on the risk of the countries analyzed (non-monotonic relationship). The sample was divided into two subgroups with different risk levels, PIIGS (Portugal, Ireland, Italy, Greece and Spain) and core countries. For the first group, the relationship between risk and average maturity remains indirect, but for the core countries, the relationship is direct, indicating that these countries can be financed with long-term debt—because the borrowing costs for long-term debt are lower.

JEL Classification: G12, G15, H63, F34.

Keywords: maturity structure, sovereign risk, debt maturity, sovereign debt market.

1. INTRODUCTION

The sovereign debt crisis has highlighted the importance of the management of public debt by monetary authorities and has become an important line of research. This crisis is especially important in Europe, particularly in PIIGS (Portugal, Ireland, Italy, Greece and Spain), where the turmoil in government bond markets reached hardly acceptable limits for the countries' public finance systems. Terms such as risk premiums, Credit Default Swaps (CDS) and rating agencies are frequently in press headlines. Within this context, the objective of this paper is to analyze the impact of sovereign risk on the average maturity and maturity structure of sovereign debt for a group of Economic and Monetary Union (EMU) countries. For this purpose, we analyze the average maturity and maturity structure, measured as the percentage of long-term debt to total debt, and their relationship with various proxies for sovereign risk, namely, the risk premium, CDS and sovereign ratings. We also study the existence of a non-monotonic relationship between average maturity and sovereign risk (Diamond, 1991) by splitting the sample into two subgroups of countries (low and high risk countries). Finally, this study differentiates between highly and less indebted countries to analyze the relationship between average maturity and sovereign risk, following the approaches of Alesina et al. (1992) and Drudi and Giordano (2000).

Economic agents use the maturity structure of sovereign debt and its average maturity to postpone or advance their debt payment obligations depending on their liquidity needs. In this sense, the relationship between average maturity and credit risk has been analyzed in depth in the field of corporate finance, for instance, in the works of Myers (1977), Flannery (1986) and Diamond (1991) and, more recently, in those of Baker (2003) and Brunnermeier and Oehmke (2013), among others. However, there are

fewer studies in the field of public finance in which the relationship between maturity and sovereign risk is analyzed, as public finance studies have paid more attention to other research topics, such as debt levels and risk premiums. Moreover, maturity structure and average maturity are fundamental tools in managing sovereign debt (Goudswaard, 1990). Therefore, this paper attempts to extend the existing literature on this line of research, which is particularly interesting in the context of the current financial crisis that we are experiencing.

The results show that the sovereign risk and average maturity of sovereign debt are inversely related. This finding indicates that an increase in the risk level reduces the average maturity for the sample. Furthermore, the analysis of the debt maturity structure suggests that the average maturity is reduced when the sovereign risk increases as the proportion of long-term debt reduces. Another interesting result is the existence of a non-monotonic relationship between sovereign risk and the average maturity of debt. We find evidence that in high-risk countries (PIIGS), the average maturity of the debt is reduced because of the increase in sovereign risk. However, in countries with lower risk (core countries[1]), this inverse relationship is not so clear, and the average maturity of debt may even increase when the risk rises. If the sovereign risk goes up, the yields of long-term bonds from countries with higher sovereign risk (PIIGS) increase to a greater extent than those of short-term bonds, i.e., the increase in the sovereign risk increases the term premium. Therefore, these countries resort to issuing short-term debt to reduce their funding costs. However, the yields of long-term government bonds hold constant for core countries and can even decrease, since they become safe havens. Therefore, core countries can issue debt at longer maturities without drastically increasing their financing costs. Finally, we find no evidence that the relationship between risk and maturity depends on the level of indebtedness of the country.

Thus, the aim of this study is to extend the literature on the maturity structure and average maturity of sovereign debt. Specifically, we attempt to provide the following contributions to the literature:

- Analyze the effect of sovereign risk on the average maturity and maturity structure of sovereign debt for a set of EMU countries.
- Further knowledge of the determinants of the maturity structure of sovereign debt, for which several sovereign risk proxies are included.
- Test the existence of a non-monotonic relationship between average maturity and sovereign risk depending on the risk level of two subgroups of countries (PIIGS and core countries).
- Determine whether differences exist in the relationship between sovereign risk and average maturity depending on the level of indebtedness of the countries.

The paper is organized as follows. The following section contains a summary of the literature on the relationship among average maturity, maturity structure and risk. In section 3, we describe several proxies for sovereign risk identified in the literature. Section 4 presents the main hypotheses to be tested in the study. Section 5 describes the data and methodology. In section 6, the results are presented. Finally, section 7 summarizes the main conclusions.

[1] Several papers refer to the countries of the euro area that are not included within PIIGS as core countries. See Gatkowski and Kalbaska (2012) in this regard. We consider the following core countries: Germany, Austria, Belgium, Finland, France and the Netherlands.

2. LITERATURE REVIEW

The analysis of debt maturity structure and its relationship with the credit risk has been and remains a major research topic in the field of finance, especially corporate finance. One of the pioneering works in the study of the determinants of maturity structure is Myers (1977). He examines why some companies borrow more than others do and why some do so with short-term instruments while others do so with long-term instruments. Subsequently, Flannery (1986) proposes a model to analyze the maturity structure of corporate debt in the context of asymmetric information. They claim that risk and debt maturity move in the same direction. Therefore, a higher credit risk implies a greater share of long-term debt, lengthening the maturity of sovereign debt. Diamond (1991) states that the relationship between credit risk and debt maturity is not linear. He posits that a non-monotonic relationship exists, which indicates that companies with high or low credit risk behave differently from those with intermediate credit risk. In this sense, the latter have a greater portion of long-term debt, while firms with high and low risk have higher levels of short-term debt.

The works of Flannery (1986) and Diamond (1991), especially the latter, have been the basis for other authors to analyze the relationship between debt maturity and credit risk. Barclay and Clifford (1995) analyze industrial companies and conclude that those with greater information asymmetries issue more short-term debt, which is consistent with the model proposed by Diamond (1991). The non-monotonic relationship between credit risk and debt maturity also appears in Stohs and Mauer (1996) and Scherr and Hulburt (2001). However, there are studies that contradict this hypothesis. Berger et al. (2005) compared the implications of the Flannery and Diamond models for a set of American companies until the mid-1990s. Their results show that debt maturity is an increasing function of risk and therefore confirm the arguments of Flannery (1986) and contradict those of Diamond (1991), who suggests that higher risk companies borrow over the short term.

Berger et al. (2005) suggest that studies that analyze the Flannery and Diamond models may not be adequate because their models take into account new debt issues and not the maturity of the stock of accumulated debt. In this sense, there are also studies that solve this problem and that focus on the maturity of new debt issues. Among them, Mitchell (1993) discusses signaling, tax and monitoring theories and their relationship with the maturity structure of corporate debt for a set of corporate bonds issued by industrial companies in the 1980s. She finds evidence that lower risk firms have a longer average maturity of debt than higher risk companies.

Moreover, Baker et al. (2003) analyze new debt issues and their relationship with the maturity structure of debt by using data on an annual basis for a set of U.S. companies for the period between 1953 and 2000. Their results show an inverse relationship between the volume of long-term debt and the term premium (the difference between yields on long and short term), as obtained in Guedes and Opler (1996).

In the Spanish context, there are also studies that examine the relationship between maturity and credit risk. González (2009) uses the Altman Z to measure credit risk and to analyze its relationship with the average maturity of corporate debt for a set of Spanish firms for the period between 1995 and 2006 and confirms the arguments of Diamond (1991). Specifically, he states that companies with low and high risk levels have a larger share of short-term debt, while intermediate-risk firms have a higher volume of long-term debt.

Considering the literature review, we observe that there are many works that focus on analyzing the relationship between credit risk and maturity structure in corporate finance. However, in the field of the public finance, few studies analyze debt maturity and its relation with sovereign risk. Within this line of research, Kanzcuk Alfaro (2009) discuss the advantages and disadvantages of borrowing over the short or long term and conclude that shortening the maturity structure implies higher levels of welfare. Park (1999) studies the management of U.S. debt. Specifically, he analyzes the influence of maturity on sovereign bond yields. The results indicate that shortening the debt maturity structure, i.e., using more short-term debt, reduces the yields of these instruments but increases those of long-term bonds. Lee et al. (2011) examine the relationship between Macaulay duration and sovereign risk for a sample of bonds issued in U.S. dollars by Asian countries for the period between 1997 and 2009. They find that risk reduces the duration of the bonds and confirm the results of Xie et al. (2009). Moreover, this effect is strengthened during recession periods and when sovereign credit ratings are worse.

Broner et al. (2014) indicate that the average maturity of sovereign debt in PIIGS has increased since the creation of the euro—to levels similar to those existing in France and Germany—as a result of the financial stability introduced by the Monetary and Economic Union. A more detailed analysis of the relationship between debt maturity and sovereign risk is provided by Broner et al. (2013), who analyze the relationship between those two variables for a set of emerging countries for the 1990s and the first decade of the century, taking into account the existence of a crisis during this period. They use the term “excess premium” to refer to the difference in the term premium between emerging and developed countries. They confirm their hypothesis that investors ask for a higher risk premium on long-term bonds, which indicates that the countries analyzed prefer to issue short-term debt to reduce their funding costs. They also obtain evidence that this trend intensifies in times of crisis, since in this case, the risk premium that investors incorporate into long-term bonds is higher than that in times of financial stability. Drudi and Giordano (2000) deepen the analysis of the optimal maturity structure and find that lengthening the maturity structure decreases the risk of default whereas shortening the maturity structure increases default risk, therefore requiring that the optimal maturity structure be lengthened. However, they also state that, for highly indebted countries, it is likely that the risk premium in long-term instruments is so high that issuing short-term debt is the only viable option. These results confirm those reported by Alesina et al. (1992), who obtain an inverse relationship between the risk premium and average maturity only for countries with a high level of indebtedness.

This work is part of this last line of research, which focuses on analyzing the relationship between average debt maturity and sovereign risk in different countries and geographical areas. Specifically, the aim of this paper is to analyze this relationship for a sample of EMU countries by using different measures of sovereign risk.

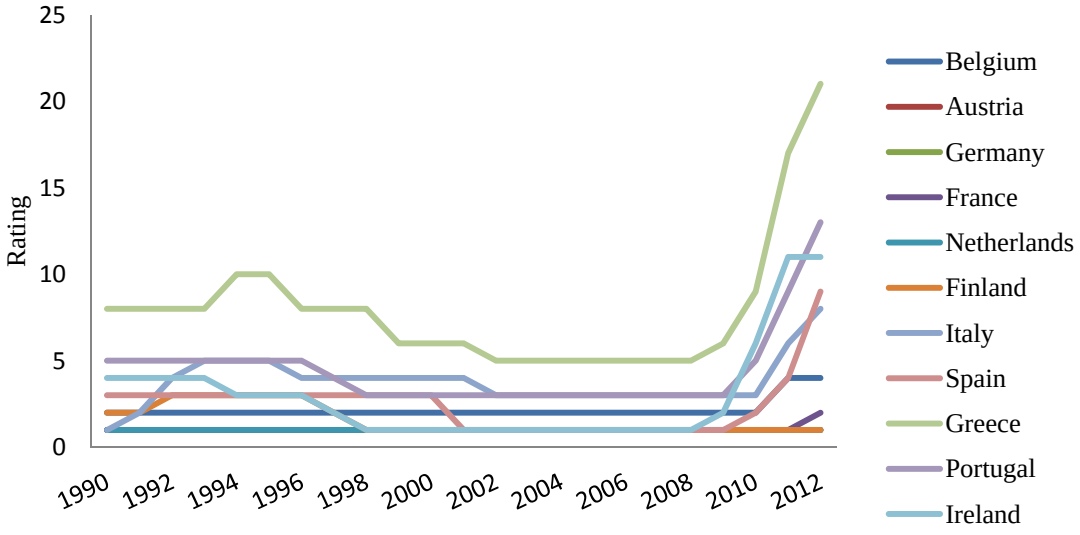
3. SOVEREIGN RISK PROXIES

One of the main aspects of analyzing the impact of sovereign risk on the maturity structure of sovereign debt is determining which variables are used to measure the sovereign risk.

In the literature on corporate finance, various proxies are used to measure credit risk. Some studies use the value obtained from the measure developed by Altman (1968) or the Altman Z (González, 2009), whereas others use the value of the spread between long- and short-term bonds (Baker et al., 2003) or the ratings (Mitchell, 1993). However, this work focuses on public finance, and the proxies used in the literature on public finance are different but share some similarities with those used in the literature on corporate finance.

In the case of sovereign risk, there are various proxies, which approximate the value of the credit risk of a country or region. Ratings from rating agencies have been used in several studies (Datta et al., 1999; Remolona et al., 2007). However, the drawback of using ratings is that they are infrequently reviewed and therefore show low variability, making the proxy less dynamic for analysis. In addition, Altman and Rijken (2004) indicate that rating agencies focus on a long-term horizon and that they do not take into account short-term movements.

Figure 1. Evolution of Moody's rating



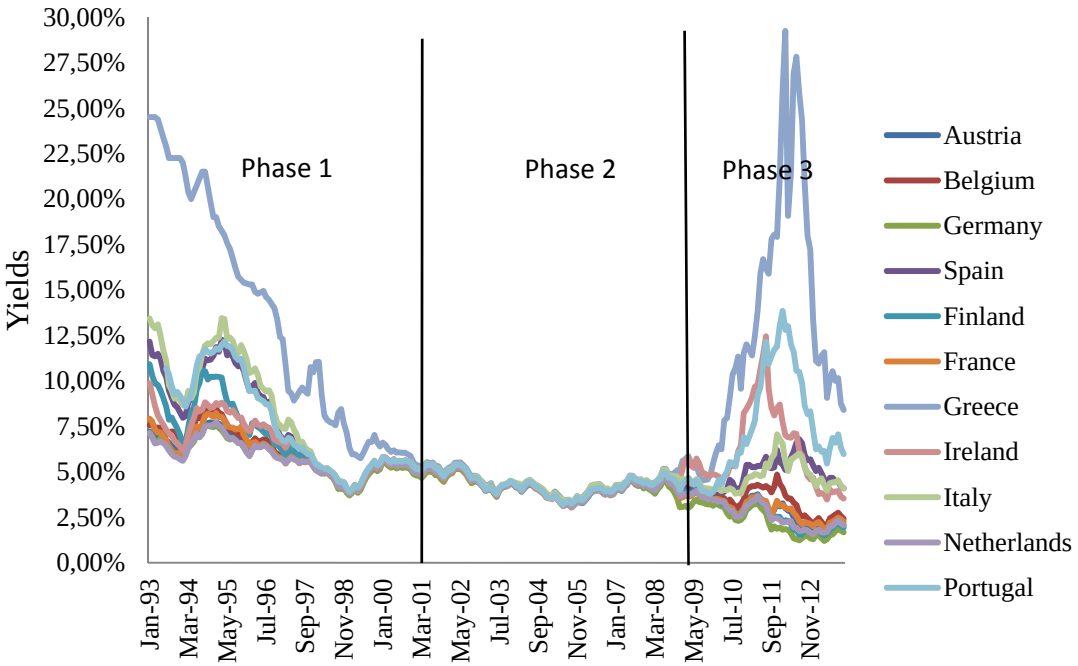
Source: own elaboration with data from Moody's..

The evolution of the ratings, which are transformed into numerical values, as explained later in the description of the variables, is shown in Figure 1. The ratings show low variability over the last 20 years for many countries (Germany, Finland and the Netherlands, among others). Moreover, since 2008, PIIGS show a worsening of their ratings due to the greater perception in the measurement of sovereign risk by rating agencies.

The use of sovereign spreads is also common in the literature (Bayoumi et al, 1995; Bernoth et al, 2004; Agca and Celasun, 2005). Risk premiums represent the difference between the sovereign bond yields of a specific country and a specific maturity relative

to a bond with similar characteristics for a country that acts as a benchmark[2]. Thus, one of the main disadvantages of using spreads is that it is necessary to exclude the benchmark country from the analysis.

Figure 2. Evolution of 10-year bond yields (1993-2013)

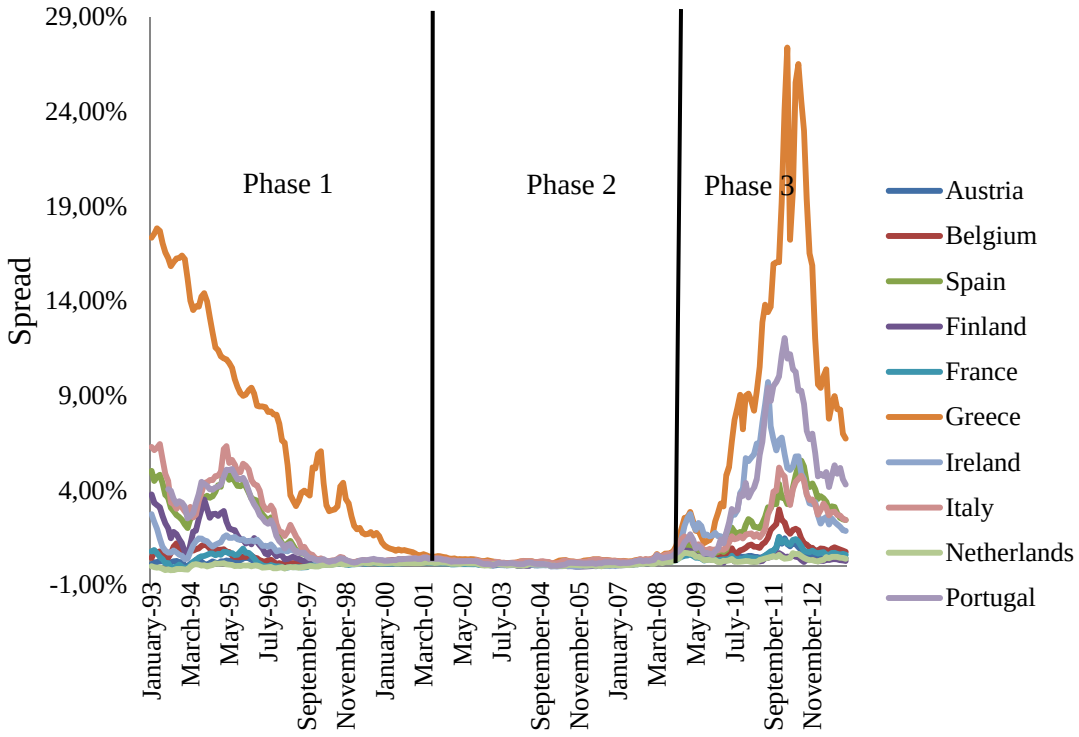


Source: own elaboration with data from the European Central Bank (ECB).

The evolution of the monthly returns of the 10-year sovereign bonds for the period between January 1993 and November 2013 for the eleven European countries included in the analysis is shown in Figure 2. We observe three different phases in the evolution of the sovereign yields. The first stage is a convergence phase that extends from the beginning of the time horizon until the end of 2001, coinciding with the start of the third stage of the EMU. At this point, all the countries show a trend toward convergence, including Greece, which already showed higher yields than the rest of countries. In 2002, the second phase, which shows higher stability, starts with yields of about 5% and runs until the end of 2007, when the financial turmoil begins. Subsequently, the final phase extends from 2008 to the end of time horizon. At this stage, we observe a dispersion of the yields, which increase exponentially, especially in Greece, Portugal and Ireland, as well as in Italy and Spain, although with less intensity. In other countries, the yields decrease progressively to about 2.5%. The evolution of the spread relative to bonds for German, which acts as benchmark in Europe, is shown in Figure 3, where we distinguish the same phases that are observed for the yields.

[2] In the case of Europe, the difference between the sovereign 10-year bond yields from a European country and that from the same instrument in Germany is used.

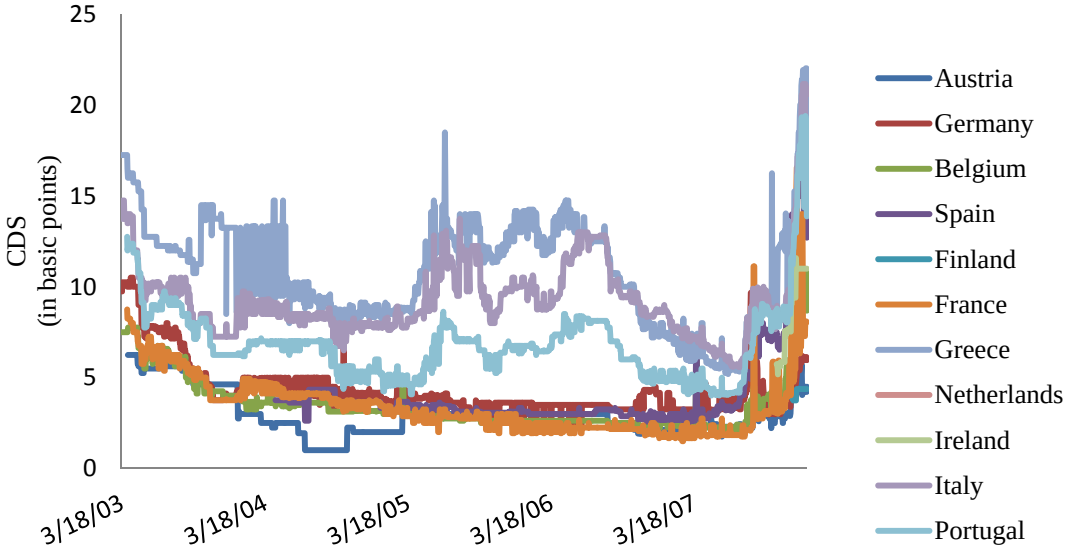
Figure 3. Evolution of 10-year bond spreads (1993-2013)



Source: own elaboration with data from the ECB

However, in recent years, because of the financial turmoil, credit default swaps or CDS are frequently used (Delatte et al., 2012; Arce et al., 2013; Buchel, 2013, among others). CDS are contracts whereby one party ensures the payment compliance of a country's sovereign bonds in exchange for an amount of money, so they resemble a sort of insurance on the probability of default or bankruptcy of a country. CDS are the most appropriate proxy to analyze sovereign risk, as they are less distorted by the reduction in liquidity and funding that occurred in the financial markets as a result of the financial crisis that began in 2007 (Ejsing and Lemke, 2009).

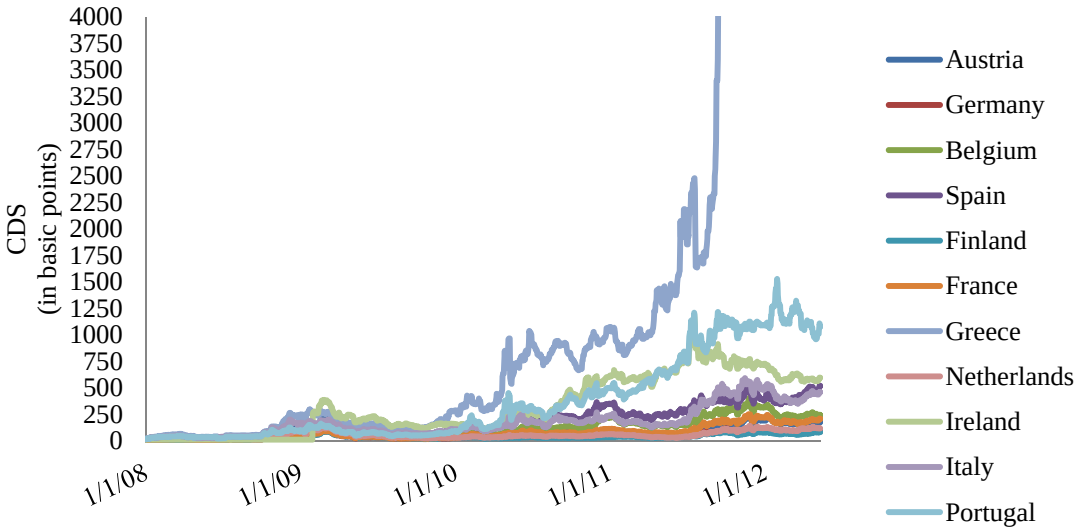
Figure 4. Evolution of CDS (2003-2007)



Source: own elaboration with data from Bloomberg.

The evolution of the daily values of CDS between 2003 and 31 December 2007, when the effect of the financial crisis begins, is shown in Figure 4. During that period, the CDS were illiquid instruments, hardly being negotiated in financial markets. The values therefore show small variation, and the price range is below 25 basis points.

Figure 5. Evolution of CDS (2008-2012)



Source: own elaboration with data from Bloomberg.

This situation changed radically in the third stage, and the CDS became more liquid and were traded in greater volume, as investors fear the default probability of some countries and try to cover their fixed income portfolios with CDS. Thus, the price range for the countries in the sample begins to increase, and in 2012, only Finland and Germany show CDS with a value lower than 100 basis points. In contrast, Portugal and Greece show 1,500 and 4,000 basis points, respectively.

In short, any of these proxies[3] can be used to measure or quantify sovereign risk, but each one of them presents advantages and disadvantages.

4. HYPOTHESES FORMULATION

In this section, we propose the hypotheses to be tested in the study based on the arguments that have been previously discussed and analyzed in the literature and that serve to justify their formulation.

4.1. Relation between sovereign risk and average maturity

The first hypothesis concerns the direction of the relationship between the average maturity of sovereign debt and sovereign risk, regardless of the proxy used to measure risk. Most of works on this subject find an inverse relationship between the two variables. Broner et al. (2013) report that, in an environment where borrowers or investors are risk averse, the cost of long-term financing is greater than that of the short-term financing, which produces a term premium. If the risk rises, this term premium increases, as long-term bond yields experience a greater increase than that yielded by short-term instruments. The relationship between the measure of sovereign risk and average maturity is indirect because an increase in the term premium shortens the average maturity of the debt. Moreover, all these proposed relationships intensify in times of crisis. These arguments are supported by the results of Xie et al. (2009) and Lee et al. (2011), who analyze the relationship between sovereign risk and duration instead of maturity.

Therefore, Broner et al. (2013) examine a scenario of risk-averse investors according to theory on behavioral finance. In this context, sovereign risk is a direct function of time, and therefore, if the risk increases, it leads to a greater uncertainty in long-term investments. In this case, investors tend to protect themselves by choosing shorter maturities for investments and to incorporate term premiums in long-term bonds that leads governments to issue debt with shorter maturities to reduce their cost of funding. According to the above arguments, we propose the following hypothesis:

Hypothesis 1a: An increase in sovereign risk reduces the average maturity of sovereign debt.

Under this hypothesis, an increase in the risk premium or CDS, as well as a downgrade in the sovereign rating, leads states to issue more short-term debt and, therefore, to reduce the average maturity of sovereign debt. Thus, the cost of borrowing is reduced because both the risk and term premium increase to a greater degree with longer bond maturities. Moreover, this relationship affects not only the average maturity but also the maturity structure of sovereign debt. In this sense, we establish the following hypotheses:

Hypothesis 1b: An increase in sovereign risk shortens the maturity structure of sovereign debt by reducing the stock of long-term debt.

[3] Another measure to quantify the sovereign risk is used by Alesina et al. (1992), who use the ratio of sovereign bond yields to corporate bond yields, as well as the difference between them.

If sovereign risk reduces the average maturity of debt, it shortens the maturity structure, as the share of short-term debt in total debt is increased, while the share of long-term debt is decreased.

4.2. Diamond´s model (1991) and its application in the analysis of average maturity and sovereign risk

As indicated in the literature review section, Diamond (1991) establishes that a non-monotonic relationship exists between credit risk and debt maturity in companies. This means that both variables are related in a different way depending on the level of risk. In companies with a high or low level of risk, an increase in the credit risk shortens the maturity structure. In contrast, companies with an intermediate level of risk resort to long-term funding. Subsequently, several studies have confirmed the existence of this non-monotonic relationship (Barclay and Smith, 1995; Stohs and Mauer, 1996, Berger et al 2005; González 2009, among others). We transfer this hypothesis from the field of corporate finance to the set of countries analyzed in this study and determine the validity of the non-monotonic hypothesis in the field of public finance.

Therefore, the following hypothesis tests whether a non-monotonic relationship exists between sovereign risk and debt maturity for the countries in our sample, which are divided into two subgroups with different risk levels: on the one hand, PIIGS, which are the countries that have suffered more strongly from the debt crisis and that show higher risk, and, on the other hand, core countries, which show the lowest risk. According to Diamond (1991), the relationship between sovereign risk and the average maturity of debt has to differ for the two subgroups.

Hypothesis 2: The relation between sovereign risk and the average maturity of debt differs depending on the risk level.

We aim to determine whether a non-monotonic relationship exists between the main variables of this analysis. Therefore, we split the sample into two subgroups with different risk levels. Support for this hypothesis would allow us to transfer the theory of Diamond (1991) from the field of corporate finance to the field of public finance. Thus, in countries with a high risk level, the spread requested by investors in their long-term bonds can make the issuance of such instruments unaffordable. Therefore, the only viable option is short-term debt (Drudi and Giordano, 2000). For countries with lower sovereign risk, this inverse relationship between risk and average maturity may not be as clear or may not even be a direct relationship. Within this non-monotonic relationship, the risk has an indirect influence in countries with high risk but a negligible or direct influence in countries with low risk.

4.3. Does the stock of debt influence the relationship between sovereign risk and the average maturity of sovereign debt?

Drudi and Giordano (2000) establish that when the stock of debt is very high, the risk premium of long-term bonds may be unsustainable. In this case, governments are forced to issue short-term debt, and the average maturity of the debt therefore is reduced. These results confirm the results for a set of OECD countries reported by Alesina et al. (1992). They indicate that the indirect relationship between the average maturity and sovereign risk, measured as the ratio and the difference between yields on public and private debt, is obtained only for highly indebted countries. On the basis of these arguments—and to complete the analysis—we propose the following hypothesis:

Hypothesis 3: The indebtedness level of the analyzed countries influences the relationship between sovereign risk and the average maturity of sovereign debt.

This hypothesis attempts to analyze whether the relationship between sovereign risk and debt maturity differs for highly indebted countries. For this purpose, we distinguish two groups of countries: the first contains countries with a higher stock of debt, and the second one includes those with a reduced level of debt.

Table 1. Summary of the hypotheses

Hypotheses	Effect of sovereign risk on the average maturity and maturity structure of sovereign debt	
	If risk increases	If risk decreases
H_{1a}: An increase in sovereign risk reduces the average maturity of sovereign debt.	The average maturity is reduced	The average maturity is increased
H_{1b}: An increase in sovereign risk shortens the maturity structure of sovereign debt because the long-term debt stock is smaller.	The maturity structure of sovereign debt is shortened	The maturity structure of sovereign debt is lengthened
H_2: The relationship between sovereign risk and average maturity differs depending on the country risk level.	The average maturity is reduced (PIIGS) The average maturity is increased (*core countries*)	The average maturity is increased (PIIGS) The average maturity is reduced (*core countries*)
H_3: The indebtedness level of the countries influences the relationship between average maturity and sovereign risk.	The average maturity is reduced (highly indebted countries) No relationship (less indebted countries)	The average maturity is increased (highly indebted countries) No relationship (less indebted countries)

The table presents a summary of the hypotheses. The first column presents the assumptions, and columns 2 and 3 then indicate the expected effect of changes in sovereign risk on the average maturity and the maturity structure.
Source: own elaboration.

The hypotheses in the study are shown in Table 1. The first two (H_{1a} and H_{1b}) concern the relation between sovereign risk and both average maturity and debt maturity structure. We expect an indirect relationship, i.e., an increase in sovereign risk reduces the average maturity. Similarly, an increase in sovereign risk is expected to shorten the maturity structure. The second hypothesis attempts to confirm the theory of Diamond (1991), which proposes that a non-monotonic relationship exists between risk and debt maturity. In this sense, with a higher risk level, an inverse relationship exists between the variables, while the relationship is direct for countries with lower risk. The third hypothesis states that the indebtedness level of a country affects the relationship between the variables. It is expected that an inverse relationship exists between risk and maturity for highly indebted countries, while in other countries, there is either no relationship (Alesina et al., 1992) or a direct relationship (Drudi and Giordano, 2000).

5. DATA AND METHODOLOGY

In this section, we describe the data and methodology that are used to analyze the relationship between the average maturity of debt and sovereign risk and to test the hypotheses. We use data for a sample of eleven European countries from the EMU (Germany, Austria, Belgium, Spain, Finland, France, Greece, Holland, Ireland, Italy and Portugal) for the period between 1980 and 2012[4].

5.1. Data

The variables that are included in the analysis, as well as the data sources are as follows.

- The dependent variables are the average maturity of sovereign debt and the ratio of long-term debt to total debt. Data for the first variable were obtained from the OECD Central Government Debt Statistical Yearbook and European Central Bank Statistical Data Warehouse[5]. The OECD defines the average maturity of sovereign debt as the weighted average maturity of negotiable sovereign debt, including all instruments of government debt, regardless of the local and regional debt and social security funds. The ratio of long-term debt to total debt allows us to analyze the impact of sovereign risk on the maturity structure of sovereign debt. The data for this variable were obtained from the European Central Bank Statistical Data Warehouse[6], which collects data from the European System of Central Banks (ESCB), Eurostat and national central banks. This ratio represents the volume of long-term debt from all sectors of the economy to the total debt[7].

- We consider the following control variables as determinants of the average maturity of sovereign debt (Goudswaard, 1990):
    - Inflation: This variable is expressed as the increase over the previous period. It is expected that the coefficient for this variable has a negative sign because higher inflation increases uncertainty about the long-term bonds. This uncertainty generates a trend toward investing in short-term maturities. The data were obtained from the European Central Bank Statistical Data Warehouse.
    - Gross Domestic Product (GDP): This variable is used as a proxy for the business cycle and to control the size of the economy. It is expected that an increase in GDP leads to an increase in the average maturity and therefore a lengthening of the maturity structure. The data were obtained from the Eurostat Statistics Database.
    - Debt/GDP ratio: Data for this variable were obtained from the database of OECD Central Government Debt Statistics. The data refer to the negotiable

[4] The time horizon is selected considering the availability of data for one of the dependent variables, the average maturity of sovereign debt. These data are on an annual basis.

[5] The ECB provides the average maturity of sovereign debt for the period between 1990 and 2012 but does not include Germany, Spain and Ireland. These data were obtained from the OECD database and the Spanish Treasury. The value of the average maturity for 2010 in Germany and Ireland remains constant for the years 2011 and 2012 to include their series until 2012.

[6] Ireland has not been included, as there are no data for this country in the database.

[7] The ECB provides the ratio of short-and long-term debt over GDP and the volumes of short- and long-term debt. To construct the ratio of long-term debt to total debt, we consider total debt to be the sum of short- and long-term debt, and we subsequently calculate the ratio. The ECB defines government debt as consolidated gross debt, including all sectors of the economy and excluding financial derivatives and loans.

debt of the central government, which excludes local and regional debt and social security funds[8].

To analyze sovereign risk and its relationship with both the average maturity of the debt and the maturity structure, we have selected the following proxies for sovereign risk:

- Annual 10-year sovereign bond yields: This proxy is calculated as the average of the monthly returns published in the European Central Bank Statistical Data Warehouse. A high value of returns is generally indicative of greater sovereign risk, and therefore, we expect to find a negative relationship with the average maturity and the ratio of long-term debt to total debt.
- Spreads (Broner et al, 2013; Perez, 2013.): This proxy allows us to measure the default risk of a country. Spreads are calculated as the difference between the 10-year sovereign bond yields and German bond yields of the same maturity, which were both obtained from European Central Bank Statistical Data Warehouse. We also use risk premiums relative to 10-year U.S. bonds (Bernoth et al., 2010) to include Germany in the study and as a robustness test. Data for U.S. bond yields were obtained from the database of the Federal Reserve Bank of St. Louis. A high spread indicates greater risk, and therefore, the expected sign for this variable is negative.
- CDS: CDS are instruments that function as protection or insurance against the default risk of a given country. They are often used in studies with high frequency data (daily or weekly). We use the values of 5-year CDS because they incorporate greater liquidity. The data come from Datastream and are annualized by averaging the values for the days for which there was negotiation. It is expected that the relationship of this proxy with the average maturity is inverse, as with the other proxies for sovereign risk.
- Sovereign Ratings: We construct a numerical variable to approximate the Moody's agency ratings (Remolona et al., 2007). The scale assigns a greater score to ratings with higher risk; therefore, the sign of this variable is expected to coincide with the sign of the rest of sovereign risk proxies. We assign a value of 1 to the rating Aaa, a value of 2 to Aa1 and so on[9]. The results are depicted in Figure 1. However, ratings have the disadvantage that their variability is not very high, as they are not frequently reviewed by rating agencies. We expect to find an inverse relation between this proxy and average maturity, as with the other proxies for sovereign risk.

[8] We also use the debt/GDP provided the ECB that includes all sectors of the economy, including regional and local debt and social security funds. The results are available upon request from the authors.

[9] When there is more than one rating during the year, we calculate the average numerical value of the ratings. If there are favorable prospects, we round the value representing the lowest risk and vice versa.

Table 2. Expected signs of the correlations between the dependent and the explanatory variables

	Variables	Average maturity	Long-term debt to total debt ratio
Control Variables	Inflation	-	+
	GDP	+	-
	Debt/GDP	+	-
Sovereign risk proxies	Yields	-	+
	Spread	-	+
	Spread USA	-	+
	Credit Default Swaps	-	+
	Ratings	-	+

The table shows the expected signs for the correlations between the dependent variables (average maturity and ratio of long-term debt to total debt) and the explanatory variables, which are divided into control variables and proxies for sovereign risk.
Source: own elaboration.

5.2. Methodology

The management of the average maturity and maturity structure of the different countries in the sample depends on their national contexts. For this reason, the results are not homogeneous for all countries; rather, they are conditioned by the circumstances of each state and its institutions, as well as their particular characteristics.

In this sense, every country has its own structural features that modify their maturity structure and the average maturity. Therefore, we consider the econometric panel data technique to well suit the available data and to allow us to determine whether there are differences between the countries included in the sample. Specifically, we consider a data set that includes 11 countries and 33 year periods to analyze the relationship between sovereign risk and debt maturity according to the following equations:

$$\text{Mat}_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Risk_{it} + \delta_{it} + \varepsilon_{it} \quad (1)$$

$$\text{LTDebt/TDebt}_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Risk_{it} + \delta_{it} + \varepsilon_{it} \quad (2)$$

where the subscripts *i* and *t* represent individuals and analysis periods, respectively. The dependent variable in equation (1), Vto_{it} is the average maturity of sovereign debt. In the case of equation (2), the dependent variable is the ratio of long-term debt to total debt (*LTDebt/TDebt*). X_{it} is a vector that represents the control variables included in the study as determinants of the average maturity. $Risk_{it}$ represents the different proxies for sovereign risk, and its analysis is the fundamental objective of the study to draw conclusions about their relationships with the dependent variables. Finally, δ_{it} represents country effects, and ε_{it} is the error term.

One aspect to consider in panel data methodology is the choice between fixed or random effects for the coefficient estimates. In the fixed-effects model, β_0 is treated as another parameter regression, whereas random-effects model consider it to be part of the random disturbance. For this purpose, we use the Hausman test (1978), which establishes as null hypothesis that the individual effects of each country are not correlated with the other explanatory variables and, therefore, that the random effects

model is appropriate. The rejection of the null hypothesis indicates that the fixed-effects estimation is the most consistent.

However, panel data methodology can produce biased or inconsistent results if endogeneity exists among the variables. In this sense, Alesina et al. (1992) indicate that the relation between debt maturity and risk may be bidirectional, i.e., they may influence each other, which could introduce endogeneity. It is desirable, therefore, to conduct an analysis with instrumental variables to correct for possible endogeneity bias. The validation of the instrumental variables is performed by using the underidentification test (Kleibergen-Paap and Anderson, 2006) and the overidentification test (Sargan-Hansen, 1982). The first test is used to detect whether the instruments are weak under the null hypothesis that the excluded instruments are relevant. The Sargan-Hansen test is used to check whether the instruments are correlated with the error term, given the null hypothesis that the instruments are exogenous and therefore valid. A high value in this test support rejection of the null hypothesis and shows that the selected instruments are correlated with the error. Therefore, a low value for this statistic is required to not reject the null hypothesis.

To analyze the relationship between sovereign risk and maturity according to the risk level of the country in order to detect a non-monotonic relationship, the sample has been split into two subgroups: on the one hand, countries with high risk (PIIGS) and, on the other hand, low risk countries (core countries). Although intuitively and according to previous figures it is clear which countries have more or less risk, we run tests of differences in means and medians by using the Welch test (Welch, 1947) and the Mann Whitney-Wilcoxon test (Wilcoxon, 1945 y Mann Whitney, 1947), respectively. These non-parametric tests[10] for independent samples allow us to determine whether there are differences between the groups according to the risk level risk. Thus, we test whether subgroups are heterogeneous with respect to each other. Specifically, we use spreads to test whether differences exist between low and high risk countries.

6. RESULTS AND DISCUSSION

In this section, we present and discuss the results of the analysis. Namely, we show the estimates of the relationship between sovereign risk and both the average maturity and the maturity structure of sovereign debt, as well as the results regarding these relations are the non-monotonic according to the risk and the indebtedness level.

6.1. Sovereign risk, average maturity and maturity structure

The main results of the analysis between the average maturity and sovereign risk are presented in Table 3.

We use the following control variables in all models: inflation, GDP and debt/GDP ratio. These variables are used in the literature as determinants of the average maturity of sovereign debt (Goudswaard, 1990; Missale and Blanchard, 1994;De Haan, 1995; Bodnaruk, 1999).

[10] These tests are considered to be the most appropriate when the series does not follow a normal distribution and when the population variances are not equal.

Table 3. Panel data regression on sovereign risk (dependent variable: logarithm of the average maturity of sovereign debt)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Inflation	-1.048	-0.745	-0.805	-1.018	-4.120***
	(-1.03)	(-0.72)	(-0.81)	(-1.07)	(-3.81)
GDP (in logarithms)	0.295***	0.429***	0.431***	1.005***	0.326***
	(4.57)	(9.06)	(9.46)	(6.74)	(6.59)
Debt/GDP	0.253**	0.483***	0.386***	0.433**	-0.178
	(2.03)	(3.31)	(2.94)	(2.34)	(-1.31)
Yields	-3.257***				
	(-3.49)				
Spread		-5.983***			
		(-4.86)			
Spread USA			-4.140***		
			(-4.44)		
CDS (in logarithms)				-0.031***	
				(-2.71)	
Rating (in logarithms)					-0.019
					(-0.45)
Constant	-2.072***	-4.033***	-4.085***	-11.609***	2.291***
	(-2.36)	(-6.23)	(-6.54)	(-5.85)	(-3.43)
Hausman test	0.077	0.000	0.000	0.000	0.001
F statistic	35.88***	38.64***	38.58***	13.31***	22.70***
R^2	0.46	0.50	0.48	0.47	0.33
N	179	164	178	73	197

The table shows the estimates of a panel data regression of the dependent variable logarithm of the average maturity of sovereign debt on sovereign risk. The variables that are used to measure sovereign risk are 10-year bond yields (Yields), the risk premiums between 10-year bond yields and German bond yields of the same maturity (Spread), the risk premiums for the benchmark of 10-year U.S. bonds (Spread USA), the value of Credit Default Swaps (CDS) and the sovereign rating (Rating). The control variables that are considered are inflation, the logarithm of GDP and debt/GDP ratio. We use fixed or random effects according to the results provided by the Hausman test, which are also included in the table. T statistics are shown in brackets.
*Significant at 10%, **significant at 5%, *** significant at 1%.

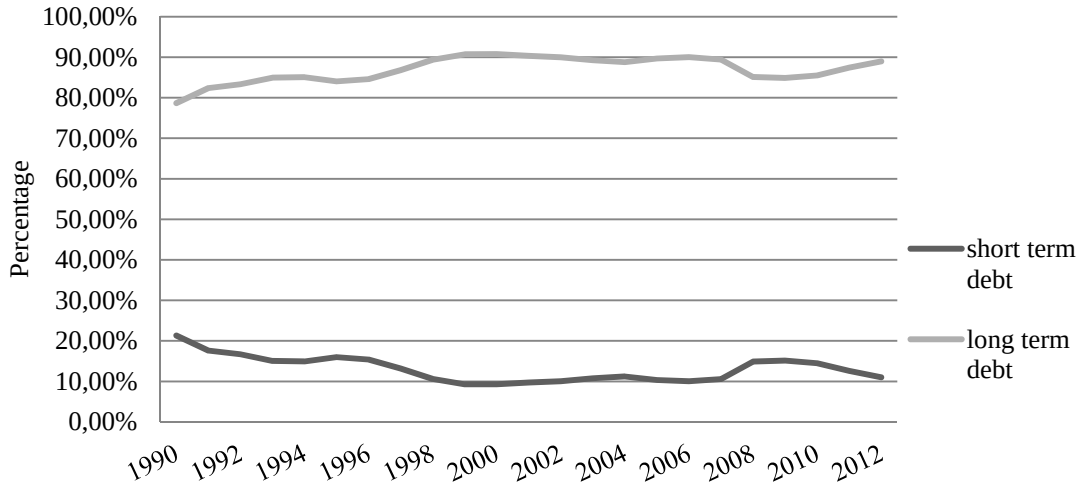
The values of the Hausman test (1978) provide a p-value that leads to the rejection of the null hypothesis. Therefore, we choose to use the fixed-effects estimation instead of the random-effects estimation.

In model 1, we use yields as measure of sovereign risk, and the sign is as expected. An inverse relationship is found between of 10-year bond yields and the average maturity of sovereign debt. Subsequently, we use spreads relative to German bonds (Spread) and to U.S. bonds (Spread USA), CDS and, finally, ratings as measures of sovereign risk. We find that the correlation between all variables that approximate sovereign risk and the average maturity of debt is indirect and significant, except for the correlation between ratings and average maturity (model 5), which is not statistically significant. The results show that the correlation with spreads presents the highest coefficient for all sovereign risk proxies.

The results are in contrast to hypothesis H_{1a}, which states that the average maturity is reduced when the sovereign risk increases. These results agree with those obtained by Broner et al. (2013) for a sample of emerging countries and with those of Xie et al. (2009) and Lee et al. (2011), who use the bond duration, instead of maturity, as the dependent variable.

Another hypotheses proposes that a relationship exists between sovereign risk and maturity structure, i.e., how debt maturities are managed by country authorities. The evolution of the average ratios of short- and long-term debt to total debt is shown in Figure 6. We observe an upward trend in long-term debt, which coincides with the period of convergence of bond yields. Subsequently, the ratio of long-term debt to total debt shows a period of stability that ends in 2007 with the outbreak of the financial crisis. At this time the ratio of long-term debt to total debt reduces until 2010, after which it begins to increase gradually.

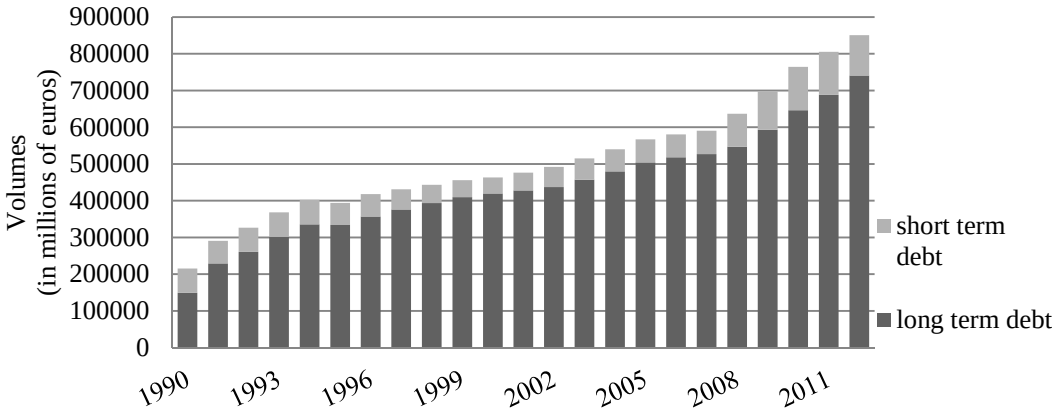
Figure 6. Evolution of short-term and long-term debt ratios



Source: own elaboration with data from the ECB.

The analysis of the volume of short-term and long-term debt produces similar conclusions. The data of average volumes of short- and long-term debt are shown in Figure 7. A reduction in the volume of long-term debt is observed starting in the 2007 as a result of the financial turmoil.

Figure 7. Evolution of short-term and long-term debt volumes



Source: own elaboration with data from the ECB.

According to the results presented in Table 3, it can be inferred that an increase in sovereign risk reduces the average maturity. Therefore, the maturity structure shortens as the share of long-term debt to total debt reduces. To test hypothesis H_{1b} we run a panel data regression between the ratio of long-term debt to total debt and sovereign risk. The results are shown in Table 4.

The results of the Hausman test (1978) do not allow us to reject the null hypothesis, and for this reason, we use the random-effects estimation. We incorporate the control variables into the model in the same way as we did in the previous models, and we obtain the estimations for each of sovereign risk proxies that have been considered, resulting in five models. The coefficients obtained for these variables are significant for all the models analyzed, except for that for sovereign ratings. In addition, the coefficient for the spread has the highest value.

The signs of both the risk premium and the rest of sovereign risk variables are as expected. These results indicate that an increase in risk causes a decrease in the ratio of long-term debt to total debt. Therefore, the maturity structure of sovereign debt shortens with higher risk, confirming hypothesis H_{1b}.

The results indicate that sovereign risk reduces the average maturity and shortens the maturity structure of sovereign debt and that these effects are especially strong when we use spreads as the proxy for sovereign risk. For the following analysis, we consider only the yields, spreads and risk premiums relate to U.S. bond yields because these variables are better indicators of risk than CDS and sovereign ratings[11].

[11] CDS are more suitable for analysis with high frequency data; we have few observations that are not very homogeneous in the time horizon considered. In case of ratings, they exhibit low variability and therefore may lead to biased estimates.

Table 4. Panel data regression on sovereign risk (dependent variable: long-term debt to total debt ratio)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Inflation	-0.319	0.088	0.208	0.045	-1.604***
	(-0.83)	(0.24)	(0.58)	(0.17)	(-4.52)
GDP (in logarithms)	-0.042**	-0.005	-0.003	0.001	0.006
	(-2.41)	(-0.43)	(-0.28)	(0.01)	(0.43)
Deuda/PIB	-0.057	0.012	-0.002	0.082*	-0.122***
	(-1.45)	(0.29)	(-0.04)	(1.77)	(-2.83)
Yields	-1.505***				
	(-5.36)				
Spread		-2.571***			
		(-7.51)			
Spread USA			-2.302***		
			(-8.22)		
CDS (in logarithms)				-0.014***	
				(-5.23)	
Rating (in logarithms)					-0.008
					(-0.53)
Constant	1.556***	0.995***	0.926***	0.850***	0.919***
	(6.46)	(5.15)	(5.38)	(3.06)	(4.57)
Hausman test	0.537	0.976	0.999	0.994	0.416
Wald test	68.60***	100.54***	116.43***	38.50***	34.55***
R^2	0.30	0.40	0.42	0.17	0.17
N	171	156	170	70	184

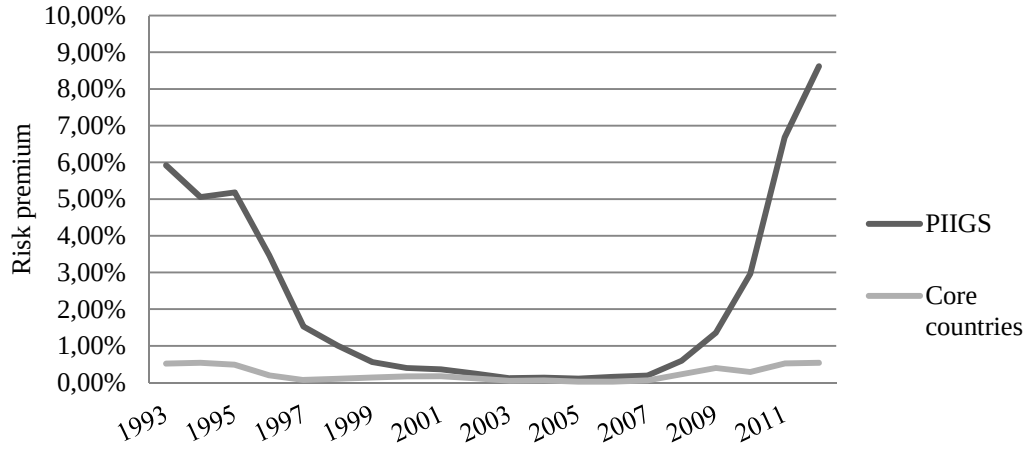
The table shows the estimates of a panel data regression of the dependent variable long-term debt to total debt ratio on sovereign risk.. The variables that are used to measure sovereign risk are 10-year bond yields (Yields), the risk premiums between 10-year bond yields and German bond yields of the same maturity (Spread), the risk premiums for the benchmark of 10-year U.S. bonds (Spread USA), the value of Credit Default Swaps (CDS) and the sovereign rating (Rating). The control variables that are considered are inflation, the logarithm of GDP and debt/GDP ratio. We use fixed or random effects according to the results provided by the Hausman test, which are also included in the table. T statistics are shown in brackets.

*Significant at 10%, **significant at 5%, *** significant at 1%.

6.2. Analysis of the non-monotonic relation between sovereign risk and average maturity

One objective of the study is to test whether there is a non-monotonic relationship between average maturity and sovereign risk, which Diamond (1991) explained based on the existence of different relationships between these variables depending on the level of credit risk. To analyze this non-monotonic relationship in this study, we split the sample into two subgroups: the first one includes PIIGS, which are the countries in the euro area with high risk, and the other one includes core countries, which are the countries with a lower risk level.

Figure 8. Evolution of risk premium for PIIGS and core countries



Source: own elaboration with data from the ECB.

The annual evolution of the mean values of the sovereign spreads for the two subgroups of countries is presented in Figure 8. PIIGS show great divergence from the core countries in the pre-euro period and during the financial crisis stage. To verify this division of countries, we run tests of differences in means and medians for the two subgroups (Table 5). These tests seek to determine whether the population means or medians are equal, which is the null hypothesis. If the null is rejected, we can assume that there are significant differences between the groups.

Table 5. Difference in means and medians of risk premiums between PIIGS and core countries

Grupo de países	Mean	Median
PIIGS	0.022	0.002
Core countries	0.005	0.001
Welch	0.000***	
Mann Whitney-Wilcoxon		0.000***

The table shows the results of the tests of differences in means (Welch test) and medians (Mann Whitney-Wilcoxon) for the variable risk premium.
*Significant at 10%, **significant at 5%, *** significant at 1%.

We obtain evidence of significant differences between the subgroups (PIIGS and core countries), as the results of both the mean and median difference tests are statistically significant.

Once we have verified the division of the sample, we proceed to perform the panel data estimates for each of the subgroups (Table 6). We exclude variables related to CDS and ratings from the analysis and therefore obtain six models.

Table 6. Panel data regression on sovereign risk distinguishing between PIIGS and core countries

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variables	PIIGS	PIIGS	PIIGS	Core countries	Core countries	Core countries
Inflation	0.114	-0.642	-0.464	1.228	0.993	1.341
	(0.09)	(-0.49)	(-0.36)	(0.98)	(0.75)	(1.07)
GDP (in logarithms)	0.504***	0.646***	0.660***	0.216*	0.220***	0.194***
	(7.14)	(10.39)	(10.80)	(1.98)	(3.85)	(3.59)
Debt/GDP	0.313*	0.449**	0.384*	0.348**	0.245	0.320**
	(1.76)	(2.12)	(1.97)	(2.58)	(1.54)	(2.32)
Yields	-4.716***			0.265		
	(-4.56)			(0.16)		
Spread		-5.447***			6.420*	
		(-3.42)			(1.93)	
Spread USA			-4.530***			0.483
			(-4.16)			(0.31)
Constant	-4.760***	-6.855***	-7.019***	-1.303	-1.247	-0.988
	(-5.03)	(-8.00)	(-8.28)	(-0.86)	(-1.61)	(-1.34)
Hausman test	0.000	0.000	0.000	0.000	0.000	0.000
F statistic	59.52***	54.69***	56.37***	4.28***	4.31***	3.83***
R^2	0.78	0.77	0.77	0.15	0.17	0.14
N	74	74	74	105	90	104

The table shows the estimates of a panel data regression of the dependent variable logarithm of the average maturity of sovereign debt on sovereign risk, distinguishing between countries with low (core countries) and high risk (PIIGS). The PIIGS group includes Portugal, Ireland, Italy, Greece and Spain. The core countries group comprises Austria, Belgium, France, Finland and the Netherlands when we use the spread variable and includes Germany as well when yields and spread USA variables are used. We use fixed- or random-effects models depending on the results provided by the Hausman test, which are also included in the table. T statistics are shown in brackets.
*Significant at 10%, **significant at 5%, *** significant at 1%.

To verify the existence of a non-monotonic relationship, we must find different relationships between the groups. In the case of PIIGS, the sign of the variables measuring sovereign risk is negative and significant. An increase in risk reduces the average maturity of sovereign debt, as shown in Table 3. However, the results for the core countries show a different pattern. In this subgroup of countries, whether a relationship exists between the two variables is less clear, and the relation is even positive and significant sign when we use spreads as the proxy for sovereign risk. Therefore, the average maturity increases as the risk increases. These results confirm that the relation between sovereign risk and average maturity differs depending on the country risk level, and therefore, we can confirm hypothesis H_2, which proposes that a non-monotonic relationship exists between sovereign risk and the average maturity of sovereign debt. Thus, we find evidence that Diamond's (1991) hypothesis that a non-monotonic relationship exists between credit risk and average maturity for companies also holds for countries, although with some differences. Diamond (1991) considers three levels of risk (low, intermediate and high) and concludes that companies with high and low risk reduce the average maturity, while those with intermediate risk increase it. The present study distinguishes between high and low risk and concludes that in countries with higher risk, the relationship between risk and average maturity is inverse and that, in countries with less risk, the relationship is direct or not existent.

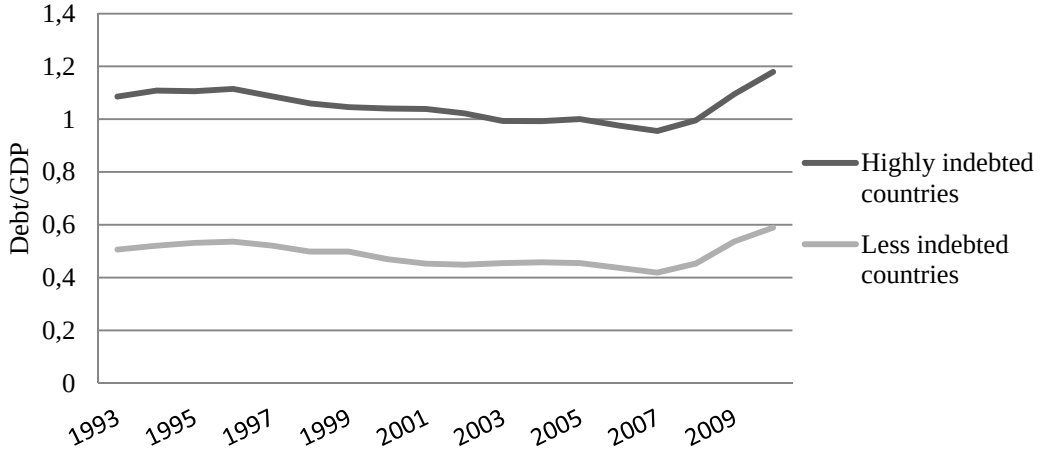
This non-monotonic relation can be explained by the high term premiums in fixed income instruments in high risk countries. Because of these high term premiums, these countries resort to issuing short-term debt to reduce their funding costs, and as a result, the average maturity of the debt is reduced. However, countries with lower risk premiums have lower term premiums, and their long-term yields may even decrease, since they become safe havens. In this case, these countries can choose to issue long-term debt. Thus, they can defer the repayment of debt and can finance at a lower cost, which leads to an increase in the average maturity of the debt.

6.3. Relation between sovereign risk and average maturity depending on the indebtedness level

Another objective of the study is to analyze the relationship between sovereign risk and average maturity based on the level of indebtedness of the countries analyzed to evaluate the arguments of Alesina et al. (1992) and Drudi and Giordano (2000). According to these authors, the inverse relationship between the two variables is obtained only in highly indebted countries, because if the stock of debt is large, term premiums rise, and countries can only resort to issuing short-term to reduce the cost of debt.

We use the debt/GDP ratio to split the sample between countries with a high level of debt and countries with a low level of debt. Specifically, the first group is considered to consist of those countries with a debt/GDP ratio above 80% (Drudi and Giordano, 2000), while the second group contains those that are below that value[12].

Figure 9. Evolution of the debt/GDP ratio for highly and less indebted countries



Source: own elaboration with data from the OECD.

The evolution of the average debt/GDP ratio of the two groups of countries is presented in Figure 9. Countries with higher debt are Belgium, Greece and Italy, while

[12] We also divide the sample based on the median of debt/GDP ratio. For this analysis, we calculate the mean values of each of the countries and obtain the median, which is 50.80% for Austria. Thus, countries whose values are above this value compose the group of highly indebted countries, and the states with values below this value compose the group of countries with lower debt levels. The results do not differ from those obtained by applying the debt threshold established in Drudi and Giordano (2000), and they are available upon request from the authors.

the rest have a lower debt level (Germany[13], Austria, Spain, Finland, France, Netherlands, Ireland and Portugal). The evolution of the debt/GDP ratio differs between the groups, with the ratio for the highly indebted countries double that of the rest over the last 20 years. Specifically, the average value of debt/GDP ratio is 98.7% for the group of highly indebted countries but only 47.3% for the other group. Moreover, the median values are 102.9% and 46.9% for groups of countries with high and low debt levels, respectively.

As we have distinguished between the two groups of countries with high and low debt levels, we present the estimates of the panel data regression for each of the groups (Table 7):

Table 7. Panel data regression on sovereign risk distinguishing between highly and less indebted countries

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variables	Higly indebtess countries	Higly indebtess countries	Higly indebtess countries	Less indebtess countries	Less indebtess countries	Less indebtess countries
Inflation	0.049	0.738	0.519	-0.941	-0.743	-0.533
	(0.03)	(0.49)	(0.34)	(-0.80)	(-0.60)	(-0.46)
GDP (in logarithms)	0.665***	0.851***	0.826***	0.150***	0.341***	0.361***
	(7.58)	(11.59)	(11.42)	(3.01)	(6.14)	(6.91)
Debt/GDP	0.315	0.511**	0.411**	0.323**	0.610***	0.512***
	(1.57)	(2.50)	(2.19)	(2.16)	(3.52)	(3.28)
Yields	-3.130**			-4.092***		
	(-2.32)			(-4.22)		
Spread		-4.901***			-7.440***	
		(-3.38)			(-4.39)	
Spread USA			-3.830***			-4.398***
			(-3.23)			(-3.67)
Constant	-7.081***	-9.858***	-9.450***	-0.165	-2.885***	-3.199***
	(-5.99)	(-8.89)	(-8.76)	(-0.24)	(-3.88)	(-4.54)
Hausman test	0.000	0.000	0.000	0.000	0.000	0.000
F statistic	48.57***	56.70***	55.33***		23.08***	22.16***
Wald test				77.91***		
R^2	0.83	0.85	0.85	0.38	0.46	0.42
N	45	45	45	134	119	133

The table shows the estimates of a panel data regression of the dependent variable logarithm of the average maturity of sovereign debt on sovereign risk, distinguishing between highly and less indebted countries. The group with the higher level of debt includes Belgium, Greece and Italy. The group of countries with lower debt levels comprises Austria, Spain, Finland, France, the Netherlands, Ireland and Portugal when the spread variable is used and includes Germany as well when yields and spread USA variables are used We use fixed- or random-effects models depending on the results provided by the Hausman test, which are also included in the table. T statistics are shown in brackets.
*Significant at 10%, **significant at 5%, *** significant at 1%.

Based on these results, we do not find differences between the groups. The indirect relationship between sovereign risk and the average maturity of the debt remains for both highly and less indebted countries. We find evidence that sovereign yields have no relationship with the average maturity in less indebted countries, but we cannot make solid conclusions since the other sovereign proxies keep their negative sign. Moreover, the rates of spread and spread USA in countries with lower debt levels are highly significant, and the coefficient for spreads for this group is quite large. This result might

[13] Germany is excluded in the estimates when the spread variable is used as the sovereign risk proxy.

be obtained because, when we use spreads, we do not include Germany in the study, and this country has a low level of debt, so the results might be biased in some way.

Therefore, we cannot confirm the arguments of Drudi and Giordano (2000) and Alesina et al. (1992), who claim that this relationship exists only for highly indebted countries, as the results confirm hypothesis H_3.

6.4. Instrumental variables analysis

To complete the study, we analyze the average maturity, the maturity structure, and their relationships with the sovereign risk by using a regression with instrumental variables. We perform this analysis to correct for possible endogeneity bias that may exist between the variables. Alesina et al. (1992) indicate that debt maturity and sovereign risk can influence each other. Broner et al. (2013) have also used this methodology to analyze the relationship between risk and debt maturity. For this reason, we consider the variable that measures sovereign risk to be endogenous, and we instrument it. We also consider the debt/GDP ratio to be endogenous because since the maturity structure or average maturity can also influence on the indebtedness level of a country.

Table 8. Panel data regression with instrumental variables on sovereign risk

	Model 1	Model 2	Model 3	Model 4
Variables	Maturity	Maturity	long-term debt to total debt ratio	long-term debt to total debt ratio
Inflation	8.849	8.888	5.653***	5.707***
	(1.18)	(1.14)	(2.94)	(2.90)
GDP (in logarithms)	0.062	0.069	-0.033**	-0.034**
	(1.33)	(1.52)	(-2.55)	(-2.57)
Debt/GDP	0.814*	0.611*	2.087**	0.167**
	(1.95)	(1.77)	(2.35)	(2.30)
Spread	-54.992***	-54.738***	-16.409***	-16.169***
	(-2.85)	(-2.74)	(-4.49)	(-4.52)
Constant	0.492	0.536	1.132***	1.160***
	(0.88)	(0.94)	(6.62)	(6.81)
Sargan-Hansen	0.495	0.437	0.444	0.381
Kleibergen-Paap	0.059*	0.063*	0.001***	0.001***
Instrumented	*Spread*	*Spread* Debt/GDP	*Spread*	*Spread* Deuda/PIB
Instruments	Maturity(-1) Maturity(-2)	Maturity(-1) Maturity(-2) Debt/GDP(-1)	Long-term debt/total debt(-1) Long-term debt/total debt(-2)	Long term debt /total debt (-1) Long term debt /total debt (-2) Debt/GDP(-1)
F statistic	6.48***	7.36***	6.08***	5.85***
N	158	158	150	150

The table shows the estimates of a panel data regression with instrumental variables. The dependent variable is the logarithm of the average maturity of sovereign debt in models 1 and 2 and is the long-term debt to total debt ratio in models 3 and 4. The variable that is used to measure sovereign risk is the risk premium relative to German bonds (Spread). The control variables that are considered are inflation, the logarithm of GDP and debt/GDP ratio. The validity of the instruments that are used is tested by using the Sargan-Hansen and Kleibergen-Paap tests. T statistics are shown in brackets.
*Significant at 10%, **significant at 5%, *** significant at 1%.

The estimates of the instrumental variables regression of average maturity (models 1 and 2) and maturity structure (models 3 and 4) on sovereign risk[14] (Spread) are shown in Table 8. The instruments that are used are the first two lags of the dependent variable when only the spread is instrumented (models 1 and 3), and we add the first lag of the debt/GDP ratio when we also instrument this variable (models 2 and 4) because it is assumed that lags act as external variables. The results of the Kleibergen-Paap (2006) test indicate that the instruments that are included are adequate. In addition, the Sargan-Hansen overidentification test suggests that the included instrumental variables are valid.

The results confirm the findings of the previous analyzes. We find an inverse relationship between the average maturity of sovereign debt and sovereign risk, measured as spreads relative to German bonds, as well as for the share of long-term debt to total debt. Furthermore, the results maintain their signs and significance when we instrument the debt/GDP ratio. As obtained in Broner et al. (2013), we observe a significant increase in the correlation between average maturity and spreads when the latter is instrumented, according to the value of the coefficients for the spread variable.

Therefore, after correction for possible endogeneity bias, the results remain robust and reaffirm the existence of an inverse relationship between sovereign risk and the average maturity of debt for the sample analyzed. We also confirm that risk premium shortens the maturity structure of sovereign debt, reducing the share of long-term debt to total debt.

7. CONCLUSIONS

The aim of this paper is to deepen into the analysis of the relationship between sovereign risk and the average maturity and maturity structure of sovereign debt for a set of countries in the European Monetary Union and thus to contribute in extending the existing literature on this matter (Broner et al., 2013; Xie et al., 2009, among others). In addition, we analyze the existence of a non-monotonic relationship between sovereign risk and average maturity based on the arguments of Diamond (1991). Finally, we evaluate the arguments of Alesina et al. (1992) and Drudi and Giordano (2000), who suggest that the indebtedness level of the countries analyzed may influence the relationship between average maturity and sovereign debt.

The results confirm the existence of an inverse relationship between sovereign risk and the average maturity of sovereign debt, regardless of the proxy that is used to measure sovereign risk. When risk increases, risk premiums in long-term instruments increase more than the short-term instruments, which increases term premiums. In this context, states choose to issue more short-term debt to reduce their funding costs. Thus, the average maturity of the debt is reduced because more short-term fixed income instruments are issued. In addition, sovereign risk affects not only the average maturity but also the maturity structure of sovereign debt. Based on the analysis, we can conclude that sovereign risk increases the share of short-term debt to total debt, so an increase in risk sovereign shortens the maturity structure of the debt.

[14] We use spreads as the sovereign risk proxy because Alesina et al. (1992) and Broner et al. (2013) consider this variable to be endogenous.

The analysis of whether a non-monotonic relationship exists between sovereign risk and the average maturity of debt also provides interesting results. According to the analysis performed, the relationship between sovereign risk and debt maturity is indirect for countries with a higher risk level (PIIGS). However, for other countries with lower sovereign risk (core countries), the relationship is less clear or direct. For these countries, the long-term yields are lower than those for PIIGS and may even tend to decrease, as they become safe havens when risk increases. Accordingly, core countries can finance themselves with longer maturities and simultaneously have low funding costs in a context of financial turmoil with risk-averse investors who seek protection for their sovereign debt.

Finally, we analyze the relation between sovereign risk and maturity according to the indebtedness level of the countries. However, in this case, we cannot confirm the hypothesis that proposes that an inverse relationship exist between risk and average maturity for highly indebted countries only, since the inverse relationship between the two variables holds for both highly indebted countries and less indebted countries.

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