BOND YIELDS, SOVEREIGN RISK AND MATURITY STRUCTURE

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Abstract

The aim of this paper is to analyze the relation between maturity structure, sovereign bond yields and sovereign risk estimated through different proxies. We use panel data methodology to analyze data on a group of countries in the Economic and Monetary Union for the period between 1990 and 2013. The results indicate that risk shortens the maturity structure of sovereign debt because it reduces the stock of long-term debt. The relationship between maturity structure and sovereign bond yields differs depending on the risk of the countries analyzed (non-monotonic relationship). We distinguish two subgroups with different risk levels, perifherical countries (Portugal, Italy, Greece and Spain) and core countries. For the first group, the relationship between sovereign bond yields and maturity structure remains indirect, but for the core countries, this indirect relationship is not so clear, indicating that these countries can be financed with long-term debt—because the borrowing costs for long-term debt are lower. If we control for the indebtedness level of these countries, the results show that the relationship between the sovereign bond yields and maturity strengthens as the debt level increases.

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

EFM classification codes: 340, 550

JEL classification codes: G12, H63, C33

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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 perifherical countries (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 maturity structure of sovereign debt for a group of Economic and Monetary Union (EMU) countries. For this purpose, we analyze the maturity structure, measured as the percentage of long-term debt to total debt, and its relationship with sovereign bond yields and various proxies for sovereign risk, namely, the risk premium, and sovereign ratings. We also study the existence of a non-monotonic relationship between maturity structure, sovereign bond yields and risk premium (Diamond, 1991) by distinguishing two subgroups of countries (perifherical and core

countries). Finally, this study differentiates between highly and less indebted countries to analyze the relationship between the maturity structure and sovereign bond yields 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 to postpone or advance their debt payment obligations depending on their liquidity needs. In this sense, the relationship between the maturity structure 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 is a fundamental tool 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 sovereign bond yields, sovereign risk and the maturity structure of sovereign debt are inversely related. This finding indicates that an increase in the risk level shortens the maturity structure for the sample. Furthermore, the analysis of the debt maturity structure suggests it 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 bond yields and the maturity structure debt. We find evidence that in high-risk countries (i.e., perifherical countries), the maturity structure of the debt shortens because of the increase in sovereign bond yields. However, in countries with lower risk (i.e., core countries[1]), this inverse relationship is not so clear. If sovereign bond yields increase, the yields of long-term bonds from countries with higher sovereign risk (i.e., perifherical countries) increase to a greater extent than those of short-term bonds, i.e., the increase in the sovereign bond yields 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 because they become safe havens. Therefore, core countries can issue debt at longer maturities without drastically increasing their financing costs. Finally, we also find evidence that the relationship between sovereign bond yields and maturity is stronger when the indebtedness level of the country is high.

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

- Analyze the effect of sovereign bond yields and sovereign risk on the 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 the maturity structure and sovereign bond yields and sovereign risk depending on the risk level of two subgroups of countries (perifherical and core countries).

[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.

- Determine whether differences exist in the relationship between sovereign bond yields and sovereign risk and maturity structure 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.

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, Alfaro and Kanzcuk (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. Arellano and Ramanarayanan (2008) apply a dynamic model that takes into account the possibility of default to analyze the optimal maturity structure in emerging countries. They obtain evidence that the composition of the maturity structure of sovereign debt is related to interest rate differentials. Hatchondo and Martinez (2013) analyze the effect of sudden stops on duration[2], and they find evidence that sudden stops increase the average optimal duration by one year and that the long term debt to GDP ratio increases 10%. The authors indicate that this phenomenon is not convenient for countries that are facing a high sovereign risk. 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

[2] See also Hatchondo, Martinez and Padilla (2011) for further analysis of the relationship between duration and sovereign default risk.

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.

[Insert Figure 1 here]

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, perifherical countries 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[3]. Thus, one of the main disadvantages of using spreads is that it is necessary to exclude the benchmark country from the analysis.

[3] 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.

[Insert Figure 2 here]

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.

[Insert Figure 3 here]

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).

In short, any of these proxies[4] can be used to measure or quantify sovereign risk, but each one of them presents advantages and disadvantages. In this paper, we use the spread referenced to the German bond, the spread referenced to the USA bond and the credit rating from Moody's[5] to measure sovereign risk, and we use the 10-year bond sovereign yields to approximate sovereign yields.

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 maturity structure of sovereign debt and sovereign bond yields and sovereign risk, regardless of the proxy used to measure risk. Most of works on this subject find an inverse relationship between these 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

[4] 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.

[5] The proxies used to approximate sovereign risk are selected according to data availability.

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 maturity structure is indirect because an increase in the term premium shortens the maturity structure of sovereign 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. 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 bond yields or sovereign risk shortens the maturity structure of sovereign debt.

Under this hypothesis, an increase in the 10-year bond sovereign yields (or in the risk premium) and a downgrade in the sovereign rating leads states to issue more short-term debt and, therefore, to shorten the maturity structure 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.

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

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, perifherical countries, 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 bond yields, sovereign risk and the maturity structure of sovereign 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 distinguish 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 the maturity structure 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. Stock of debt influence on the relationship between sovereign bond yields, sovereign risk and debt maturity

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 maturity structure of the debt therefore is shortened. These results confirm the results for a set of OECD countries reported by Alesina et al. (1992). They indicate that the indirect relationship between 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 bond yields, sovereign risk and the maturity structure of sovereign debt.

This hypothesis attempts to analyze whether the relationship between sovereign risk and debt maturity differs for highly indebted countries.

[Insert Table 1 here]

The hypotheses in the study are shown in Table 1. The first hypothesis concerns the relation between sovereign risk and debt maturity structure. We expect an indirect relationship, i.e., an increase in sovereign risk or in sovereign bond yields 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, Netherlands, Italy and Portugal) for the period between 1990 and 2013[6].

[6] 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.

5.1. Data

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

- The dependent variable is the ratio of long-term debt to total debt[7]. 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, 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[8].
- We consider the following control variables as determinants of the average maturity of sovereign debt:
    - Inflation (Missale and Blanchard, 1994; Goudswaard, 1990; De Haan et al, 1995): 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 (Goudswaard, 1990) 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 (Missale and Blanchard, 1994; De Haan et al, 1995; Bodnaruk, 1999): Data for this variable were obtained from European Central Bank Statistical Data Warehouse.[9].
    - Borrowing requirements of the public administration: the borrowing requirement covers all financial transactions in government debt instruments. The data were obtained from European Central Bank Statistical Data Warehouse.
    - Average maturity of sovereign debt: the residual maturity of government debt expressed in years. The data were obtained from European Central Bank Statistical Data Warehouse.

To analyze sovereign bond yields, sovereign risk and their relationship with 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

[7] The ECB provides the average maturity of sovereign debt for the period between 1990 and 2013 but does not include Germany and Spain. These data were obtained from the OECD database and the Spanish Treasury.

[8] 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.

[9] The debt/GDP provided by the ECB includes all sectors of the economy, including regional and local debt and social security funds.

greater sovereign risk; therefore, we expect to find a negative relationship with 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.
- 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[10]. 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 the maturity structure of sovereign debt, as with the other proxies for sovereign risk.

[Insert Table 2 here]

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. 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 10 countries and 24 year periods to analyze the relationship between sovereign risk and debt maturity according to the following equations:

$$LTDebt / TDebt_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Risk_{it} + \delta_{it} + \varepsilon_{it} \quad (1)$$

where the subscripts *i* and *t* represent individuals and analysis periods, respectively. The dependent variable in equation 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 maturity structure. $Risk_{it}$ 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.

[10] 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.

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.

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 Wilcoxon rank-sum test (Wilcoxon 1945; Mann and Whitney 1947) and the K-sample equality-of-medians test, respectively. These non-parametric tests[11] 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 bond yields, sovereign risk 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 bond yields, sovereign risk and maturity structure

The first hypotheses proposes that a relationship exists between sovereign bond yields, 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.

[Insert Figure 4 here]

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.

[Insert Figure 5 here]

The main results of the analysis between the maturity structure, and sovereign bond yields and sovereign risk are presented in Table 3.

[11] 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.

[Insert Table 3 here]

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). We also add the average maturity of sovereign debt and the borrowing requirements of the public administration as explanatory variables.

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[12]. We also provide the results for the OLS estimation as the results do not differ from those obtained with the fixed effects estimation. Regarding the control variables, the average maturity of sovereign debt and the borrowing requirements of the public administration show statically significant coefficients with the expected sign, and they seem to be the control variables that most affect maturity structure.

Regarding the relationship between maturity structure and sovereign risk in models 1 and 4, we include sovereign bond yields. An inverse relationship is found between 10-year bond yields and the maturity structure of sovereign debt. Subsequently, we use spreads relative to German bonds (Spread) and to U.S. bonds (Spread USA) as measures of sovereign risk. We find that the correlation between all variables that approximate sovereign risk and the maturity structure of debt is indirect and significant.

The signs of both the sovereign bond yields 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 yields and higher risk, thus confirming hypothesis H_1.

6.1. Robustness tests

To ensure that the relationship between sovereign bond yields, sovereign risk and maturity structure remains robust, we run different analyses to control the effects of different variables. In table 4, we control for the time variability of the data. For this purpose we include time dummy variables and a time trend. In this way, we control for temporal variation in our dependent variable[13]. We also add a time trend to capture the effect of the passage of time rather than control for a particular period.

[Insert Table 4 here]

The results show that the inverse relationship between sovereign bonds yields, sovereign risk and the maturity structure remains significant regardless of the temporal variation and the time trend. Therefore, the results are robust to the time variance and allow us to confirm that an increase in the sovereign bond yields or risk premiums shortens the maturity structure of sovereign debt. We have also included the time dummy variables and the time trend simultaneously, and the results do not differ of those shown in Table 4.

We also control for the international risk aversion and for the LTROs. The latter are three months liquidity providing operations that attempt to provide funds to the

[12] The results for the random-effects estimation provide similar results to those obtained with the OLS or fixed effects estimation. These results are available upon request to the authors.

[13] A phenomenon can vary between years for reasons that are not adequately captured by the explanatory variables in the model. Therefore, not controlling for temporal variation may lead to a bias in the results.

financial sector in the Euro area. To control for the international risk aversion, we use the S&P volatility index (VIX), and to control for the LTROs, we use the total annual allotted amount in logs. The results are quite striking, and they are shown in Table 5. We observe that the coefficients for the variables that approximate sovereign risk, including sovereign bond yields, lose their significance, and the coefficient for the LTROs is highly significant in the three models.

[Insert Table 5 here]

The results indicate that the effect of sovereign risk on the maturity structure disappear when we take into account the effect of the LTROs. The explanation for this result is that the financial sector obtains funds at a very low interest rate that are mostly used to buy sovereign debt at short maturities to obtain a profit in the operation. This operation relieves pressure on sovereign debt, and the effect of sovereign risk on debt maturity disappears. At the same time, these large LTROs, which have been particularly important after the financial crisis, lead to a shortening of the maturity structure of sovereign debt. Therefore, on the one hand, the LTROs serve to alleviate the pressure of the sovereign risk premiums, but on the other hand, they shorten the maturity structure of sovereign debt, which can be harmful in the context of a debt crisis, even when the expansion of maturity is essential to reduce the risk of a crisis of these characteristics (Cole and Kehoe, 2000).

In short, we have found evidence that an inverse relationship exists between sovereign bond yields, sovereign risk and the maturity structure of sovereign debt. This inverse relationships remains robust regardless of the temporal variance of the data, which allows us to confirm our first hypotheses. Nevertheless, the LTROs seem to have a more important effect on debt maturity than sovereign risk does.

6.2. Analysis of the non-monotonic relation between sovereign bond yields, sovereign risk and maturity structure

One objective of the study is to test whether there is a non-monotonic relationship between maturity structure 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 perifherical countries, 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.

[Insert Figure 6 here]

The annual evolution of the mean values of the sovereign spreads for the two subgroups of countries is presented in Figure 6. Perifherical countries 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 6). 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.

[Insert Table 6 here]

We obtain evidence of significant differences between the subgroups (i.e., perifherical 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 7). For this

purpose, we use various interactions between the sovereign bond yields, the sovereign risk and a dummy variable that distinguish between perifherical and core countries. Namely, the variable takes is equal to one for perifherical countries, and zero otherwise.

The results show that only the interaction between sovereign bond yields and the dummy variable that captures the different effects between perifherical and core countries is significant and with the expected sign. By contrast, the coefficients for the spread on the German bond and the spread on the USA bond lose their significance and seem to be captured by the dummy variable. This result indicates that it is not the risk itself that influences maturity structure but whether we are considering a perifherical country or not.

[Insert Table 7 here]

Regarding the sovereign bond yields and according to the results we observe that there exists a different relationship between the variables depending on the group of countries we are analyzing. In Figure 7, we observe that the slopes for these subgroups of countries are different. For the perifherical countries, the graph shows a negative slope, indicating that for this subgroup an increase in sovereign yields shortens the maturity structure of sovereign debt. By contrast, for the core countries, the slope is slightly positive.

[Insert Figure 7 here]

To be exhaustive in the analysis, we also calculate the average marginal effects for the yields on the dependent variable for the perifherical and core countries (Figures 8 and 9). We can observe that the differences between perifherical and core countries are significant for values of the sovereign bond yields higher than 0.04.

[Insert Figures 8 and 9 here]

The graphs show that the perifherical/core differences increase as the value of the yields increase, and this difference is statistically significant for values greater than 4%. According to these results, we can confirm that a different behavior exists between sovereign bond yields and maturity structure, but only when the yields reach a value higher than 4%. Below this threshold, there are no differences between perifherical and core countries.

The average marginal effects for the spread on the German bond and for the spread on the USA bond are shown in Figures 10-11 and 12-13, respectively. As we have deduced from the coefficients of the interaction term, there is no evidence of a significant difference in the effect of sovereign risk on the maturity structure of sovereign debt between perifherical and core countries.

[Insert Figures 10-13 here]

The results show that there exists a non-monotonic relationship between maturity structure and sovereign bond yields in perifherical and core countries but only when the yields exceed the 4% threshold. This non-monotonic relation can be explained by the high yields in the fixed income instruments in perifherical countries. Because of these high yields, these countries resort to issuing short-term debt to reduce their funding costs, and as a result, the maturity structure of the debt shortens. However, countries with lower yields have lower term premiums, and their long-term yields may even decrease because 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 a lengthening of the maturity structure of the debt

By contrast, we cannot confirm this different behavior depending on the risk level proxied by the spread on the German bond or the spread on the USA bond. According to these outcomes, we are not able to assert the existence of a non-monotonic relationship between the maturity structure and sovereign risk in the countries analyzed.

6.3. Relation between sovereign bond yields, sovereign risk and maturity structure depending on the indebtedness level

Another objective of the study is to analyze the relationship between sovereign bond yields, sovereign risk and the maturity structure of sovereign debt 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.

For this purpose, we combine the variable debt/GDP ratio with the variables that approximate sovereign bond yields and sovereign risk, to analyze the existence of nonlinear effects. We present the estimates of the panel data regression for each of the groups (Table 7):

[Insert Table 8 here]

Based on these results, we find evidence that only the coefficient for the interaction between debt/GDP ratio and the sovereign bond yields is statistically significant with the expected negative sign. The results for the other proxies of sovereign risk do not provide significant results. Regarding the sovereign bond yields, as we can observe in Figure 14, an increase in the debt to GDP/ratio slightly increases the negative slope between the dependent variable and the yields.

[Insert Figure 14 here]

Therefore, according to the results obtained, we cannot roundly confirm the arguments of Drudi and Giordano (2000) and Alesina et al. (1992), who claim that the inverse relationship between risk and maturity exists only for highly indebted countries. Nevertheless, we do find evidence that the inverse relationship between sovereign bond yields and maturity is stronger when the level of debt is higher, so we can partially confirm hypothesis H_3

7. CONCLUSIONS

The aim of this paper is to deepen into the analysis of the relationship between sovereign bond yields, sovereign risk and the 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 bond yields, sovereign risk and 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 maturity and sovereign risk.

The results confirm the existence of an inverse relationship between sovereign bond yields, sovereign risk and the maturity structure of sovereign debt, regardless of the proxy that is used to measure sovereign risk and the time variance of the variables

employed. When sovereign bond yields or risk increases, risk premiums in long-term instruments increase more than the short-term instruments, which increase term premiums. In this context, states choose to issue more short-term debt to reduce their funding costs. Thus, the maturity structure of the debt shortens because more short-term fixed income instruments are issued. Therefore, sovereign debt increases the share of short-term debt to total debt. However, this inverse relationship does not appear when we take into account the effect of the LTROs that attempt to provide liquidity to the financial sector. In this case, it is not the risk the variable that shortens the maturity structure, but the LTROs do. The results provide evidence that these LTROs lead to the financial sector but to large amounts of sovereign debt at short maturities, which shortens the maturity structure of sovereign debt absorbing the effect of sovereign bond yields and sovereign risk.

The analysis of whether a non-monotonic relationship exists between sovereign bond yields, sovereign risk and maturity structure also provides interesting results. According to the analysis performed, the relationship between sovereign bond yields and debt maturity show a negative slope for countries with a higher risk level (i.e., perifherical countries). However, for countries with lower sovereign risk (i.e., core countries), this inverse relationship is not significant. For these countries, the long-term yields are lower than those for perifherical countries 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. The results indicate that the differences between perifherical and core countries are greater for higher levels of the yields, and the difference becomes significant for a value of the yields larger than the 4% threshold

Finally, we analyze the relation between sovereign bond yields, sovereign risk and maturity according to the indebtedness level of the countries. In this case, the results indicate that the effect of the sovereign bond yield on debt maturity structure is slightly enhanced for the effect of the indebtedness level of the country. Therefore, in countries with higher levels of debt, an increase in sovereign bond yields generates a higher shortening in the maturity structure of sovereign debt.

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Table 1. Summary of the hypotheses

Hypotheses	Effect of sovereign risk on the maturity structure of sovereign debt	
	If risk increases	If risk decreases
H_{1a}: A variation in sovereign bond yields or in sovereign risk modifies the maturity structure of sovereign debt.	The maturity structure of sovereign debt is shortened	The maturity structure of sovereign debt is lengthened
H_2: The relationship between sovereign risk and the maturity structure differs depending on the country risk level.	The maturity structure is shortened (perifherical countries)	The maturity structure is lengthened (perifherical countries)
	The maturity structure is lengthened (*core countries*)	The maturity structure is shortened (*core countries*)
H_3: The indebtedness level of the countries influences the relationship between debt maturity and sovereign bond yields and sovereign risk.	The maturity structure is shortened (highly indebted countries)	The maturity structure is lengthened (highly indebted countries)
	No relationship (less indebted countries)	No relationship (less indebted countries)

This 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 maturity structure.
Source: own elaboration.

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

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

This 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.

Table 3. Panel data regression of maturity structure on sovereign bond yields and on sovereign risk

Dependent variable: long term debt to total debt ratio	*OLS estimation*			*Fixed effects estimation*		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Average maturity	0.0207***	0.0248***	0.0231***	0.0224*	0.0222*	0.0229**
	(0.00297)	(0.00309)	(0.00300)	(0.0100)	(0.0101)	(0.00995)
GDP (in logs)	-0.0301***	-0.0357***	-0.0245***	-0.0736	-0.0342	-0.0421
	(0.0109)	(0.00971)	(0.00901)	(0.0496)	(0.0457)	(0.0452)
Debt/GDP	0.00673	0.0210	0.0129	0.0157	0.0386	0.0312
	(0.0247)	(0.0243)	(0.0243)	(0.0654)	(0.0726)	(0.0717)
Inflation	0.00156	0.00317	0.00286	0.00418	0.00343	0.00432
	(0.00334)	(0.00338)	(0.00337)	(0.00486)	(0.00538)	(0.00518)
Borrowing requirements	-0.00364***	-0.00295**	-0.00249**	-0.00305*	-0.00319*	-0.00262*
	(0.00115)	(0.00124)	(0.00126)	(0.00146)	(0.00146)	(0.00136)
Yields	-0.296*			-0.599*		
	(0.171)			(0.266)		
Spread		-0.574**			-0.552*	
		(0.232)			(0.292)	
Spread USA			-0.603***			-0.660**
			(0.220)			(0.249)
Constant	1.173***	1.181***	1.062***	1.725**	1.162*	1.271**
	(0.143)	(0.122)	(0.116)	(0.613)	(0.555)	(0.555)
Observations	196	181	196	196	181	196
R-squared	0.263	0.274	0.276	0.283	0.277	0.286

This table shows the estimates of a panel data regression of the dependent variable and the long term debt to total debt ratio on sovereign bond yields and on sovereign risk. The variable employed to measure sovereign yields is the 10-year government bond yields (Yields). The variables to measure sovereign risk are the risk premiums between 10-year bond yields and German bond yields of the same maturity (Spread) and the risk premiums for the benchmark of 10-year U.S. bonds (Spread USA)[14]. The control variables considered are the inflation, the logarithm of GDP, the debt/GDP ratio, the average maturity of sovereign debt and the borrowing requirements of public administrations as a share of the GDP. We present the OLS and fixed effect estimations. The R-squared shown in the table represents the within R-squared.

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[14] We also use the Moody's sovereign rating to measure sovereign risk, but it does not provide significant results, as this variable does not vary much with time. The results for this variable are available upon request to the authors.

Table 4. Panel data regression of maturity structure on sovereign bond yields and sovereign risk with time dummy variables and a time trend

Dependent variable: long term debt to total debt ratio	Model 1	Model 2	Model 3	Model 4	Model 4	Model 4
Average maturity	0.0239**	0.0250**	0.0237*	0.0228*	0.0239**	0.0242**
	(0.0106)	(0.00994)	(0.0108)	(0.0104)	(0.0106)	(0.0100)
GDP (in logs)	0.0620	0.0438	0.0381	0.000112	0.0620	0.0358
	(0.146)	(0.133)	(0.167)	(0.143)	(0.146)	(0.134)
Debt/GDP	0.0658	0.0599	0.0679	0.0496	0.0658	0.0583
	(0.0955)	(0.102)	(0.0936)	(0.0990)	(0.0955)	(0.101)
Inflation	0.00712	0.00475	0.00762	0.00326	0.00712	0.00418
	(0.00472)	(0.00482)	(0.00508)	(0.00511)	(0.00472)	(0.00506)
Borrowing requirements	-0.000913	-0.00252	-0.000871	-0.00314*	-0.000913	-0.00250
	(0.00205)	(0.00146)	(0.00207)	(0.00152)	(0.00205)	(0.00139)
Yields	-0.696**	-0.735**				
	(0.306)	(0.255)				
Spread			-0.713**	-0.550*		
			(0.305)	(0.292)		
Spread USA					-0.696**	-0.666**
					(0.306)	(0.253)
Constant	-0.0262	0.230	0.210	0.730	-0.0858	0.276
	(1.850)	(1.710)	(2.090)	(1.820)	(1.853)	(1.722)
Time dummy variables	Yes	No	Yes	No	Yes	No
Trend	No	Yes	No	Yes	No	Yes
Observations	196	196	181	181	196	196
R-squared	0.429	0.305	0.278	0.283	0.429	0.295

This table shows the estimates of a panel data regression of the dependent variable, long term debt to total debt ratio on sovereign bond yields and on sovereign risk. The variable employed to measure sovereign yields is the 10-year government bond yields (Yields). The variables to measure sovereign risk are the risk premiums between 10-year bond yields and German bond yields of the same maturity (Spread) and the risk premiums for the benchmark of 10-year U.S. bonds (Spread USA). The control variables that are considered are inflation, the logarithm of GDP and debt/GDP ratio, the average maturity of sovereign debt and the borrowing requirements of public administrations as a share of the GDP. We include time dummy variables and a time trend to control for the time variability in the variables. The results are obtained using the fixed effects estimation. The R-squared shown in the table represents the within R-squared.

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5. Panel data regression of maturity structure on sovereign bond yields and on sovereign risk (robustness test)

Dependent variable: long term debt to total debt ratio	Model 1	Model 2	Model 3
Average maturity	0.00313	0.00274	0.00313
	(0.00299)	(0.00281)	(0.00299)
GDP (in logs)	0.121	0.105	0.121
	(0.0844)	(0.111)	(0.0844)
Debt/GDP	0.0363	0.0391	0.0363
	(0.0564)	(0.0541)	(0.0564)
Inflation	0.0118**	0.0121**	0.0118**
	(0.00407)	(0.00443)	(0.00407)
Borrowing requirements	-0.000651	-0.000574	-0.000651
	(0.00171)	(0.00174)	(0.00171)
Yields	0.172		
	(0.330)		
Spread		0.142	
		(0.340)	
Spread USA			0.172
			(0.330)
VIX	-0.00196	-0.00203	-0.00195
	(0.00118)	(0.00129)	(0.00117)
LTROs (in logs)	-0.0275**	-0.0264**	-0.0275**
	(0.00938)	(0.0105)	(0.00943)
Constant	-0.208	0.00442	-0.194
	(1.065)	(1.327)	(1.071)
Time dummy variables	Yes	Yes	Yes
Trend	Yes	Yes	Yes
Observations	144	132	144
R-squared	0.439	0.423	0.440

This table shows the estimates of a panel data regression of the dependent variable, long term debt to total debt ratio on sovereign bond yields and on sovereign risk. The variable employed to measure sovereign yields is the 10-year government bond yields (Yields). The variables to measure sovereign risk are the risk premiums between 10-year bond yields and German bond yields of the same maturity (Spread) and the risk premiums for the benchmark of 10-year U.S. bonds (Spread USA). The control variables that are considered are inflation, the logarithm of GDP and debt/GDP ratio, the average maturity of sovereign debt and the borrowing requirements of public administrations as a share of the GDP. We control for the international risk aversion using the VIX index[15] and for the longer term refinancing operations (LTROs) of the Eurosystem. We include time dummy variables and a time trend to control for the time variability in the variables in all models simultaneously. The results are obtained using the fixed effects estimation. The R-squared shown in the table represents the within R-squared.
Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6. Difference in means and medians of risk premiums between PIIGS and core countries.

Group of countries	Mean	Median
Perifherical countries	0.029	0.010
Core countries	0.004	0.002
Wilcoxon rank-sum test	0.000***	
K-sample equality-of-medians test		0.000***

The table shows the results of the tests of differences in means (Wilcoxon rank-sum test) and medians (K-sample equality-of-medians test) for the variable risk premium.
*** p<0.01, ** p<0.05, * p<0.1

[15] We also use the VSTOXX index to approximate international risk aversion. The results do not vary regarding the presented in Table 5.

Table 7. Panel data regression of maturity structure on sovereign bond yields and on sovereign risk distinguishing between perifherical and core countries

Dependent variable: long term debt to total debt ratio	Model 1	Model 2	Model 3
Average maturity	0.0296***	0.0358***	0.0330***
	(0.00548)	(0.00592)	(0.00501)
GDP (in logs)	-0.0111	-0.0297***	-0.0160
	(0.0131)	(0.00920)	(0.0132)
Debt/GDP	-0.0176	-0.0105	-0.0208
	(0.0503)	(0.0461)	(0.0489)
Inflation	0.0154	0.0126	0.00887
	(0.0132)	(0.0121)	(0.0127)
Borrowing requirements	0.00109	0.000554	0.00125
	(0.00216)	(0.00204)	(0.00228)
Yields	1.456***		
	(0.492)		
Spread		0.320	
		(1.556)	
Spread USA			0.133
			(1.384)
Perifherical	0.0229	-0.0429*	-0.0597**
	(0.0221)	(0.0243)	(0.0240)
PerifhericalxYields	-1.918***		
	(0.546)		
PerifhericalxSpread		-0.976	
		(1.374)	
PerifhericalxSpreadUSA			-0.571
			(1.126)
Constant	0.683***	1.010***	0.879***
	(0.197)	(0.138)	(0.156)
Time dummy variables	Yes	Yes	Yes
Trend	Yes	Yes	Yes
Observations	196	181	196
R-squared	0.484	0.389	0.377

This table shows the estimates of a panel data regression of the dependent variable, long term debt to total debt ratio on sovereign bond yields and on sovereign risk. The variable employed to measure sovereign yields is the 10-year government bond yields (Yields). The variables to measure sovereign risk are the risk premiums between 10-year bond yields and German bond yields of the same maturity (Spread) and the risk premiums for the benchmark of 10-year U.S. bonds (Spread USA). The control variables that are considered are inflation, the logarithm of GDP and debt/GDP ratio, the average maturity of sovereign debt and the borrowing requirements of public administrations as a share of the GDP. We include time dummy variables and a time trend to control for the time variability in the variables in all models simultaneously. We include the interaction between the sovereign bond yields and sovereign spreads and a dummy variable that takes is equal to one for perifherical countries and zero otherwise. The R-squared shown in the table represents the within R-squared.

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8. Panel data regression of maturity structure on sovereign bond yields and on sovereign risk distinguishing by the debt level

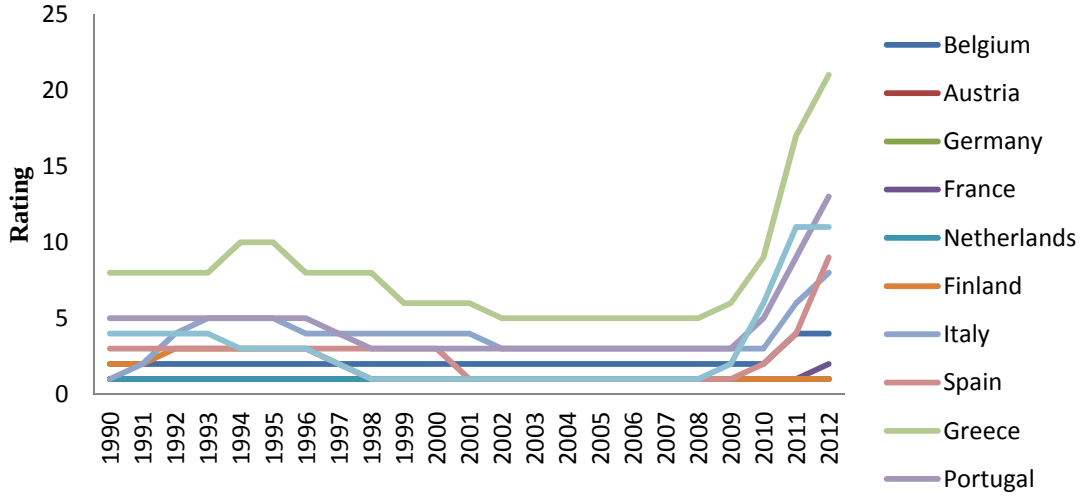
Dependent variable: long term debt to total debt ratio	Model 1	Model 2	Model 3
Average maturity	0.0237*	0.0258*	0.0252**
	(0.0105)	(0.0114)	(0.0109)
GDP (in logs)	0.0851	0.0400	0.0672
	(0.151)	(0.174)	(0.150)
Inflation	0.00583	0.00518	0.00499
	(0.00427)	(0.00503)	(0.00477)
Borrowing requirements	-0.00123	-0.00180	-0.00173
	(0.00183)	(0.00180)	(0.00175)
Yields	1.191		
	(0.878)		
Spread		1.425	
		(1.412)	
Spread USA			-1.206
			(0.793)
Debt/GDP	0.180**	0.0995	0.0900
	(0.0773)	(0.0895)	(0.0908)
Debt/GDPxYields	-1.436**		
	(0.547)		
Debt/GDPxSpread		-1.464	
		(0.891)	
Debt/GDPxSpreadUSA			-1.206
			(0.793)
Constant	-0.506	0.128	-0.197
	(1.916)	(2.175)	(1.907)
Time dummy variables	Yes	Yes	Yes
Trend	Yes	Yes	Yes
Observations	196	181	196
R-squared	0.482	0.456	0.451

This table shows the estimates of a panel data regression of the dependent variable, long term debt to total debt ratio on sovereign bond yields and on sovereign risk. The variable employed to measure sovereign yields is the 10-year government bond yields (Yields). The variables to measure sovereign risk are the risk premiums between 10-year bond yields and German bond yields of the same maturity (Spread) and the risk premiums for the benchmark of 10-year U.S. bonds (Spread USA). The control variables that are considered are inflation, the logarithm of GDP and debt/GDP ratio, the average maturity of sovereign debt and the borrowing requirements of public administrations as a share of the GDP. We include time dummy variables and a time trend to control for the time variability in the variables in all models simultaneously. We include the interaction between the sovereign bond yields and sovereign spreads and the debt/GDP ratio. The R-squared shown in the table represents the within R-squared.

Robust standard errors in parentheses

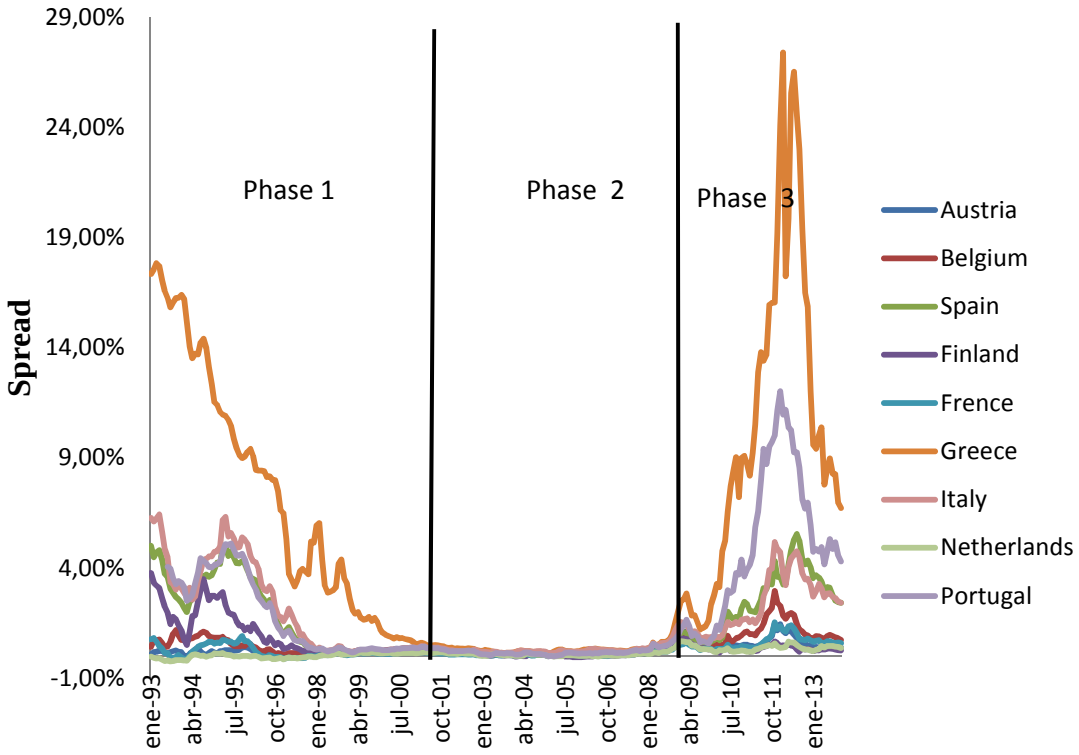
*** p<0.01, ** p<0.05, * p<0.1

Figure 1. Evolution of Moody's rating



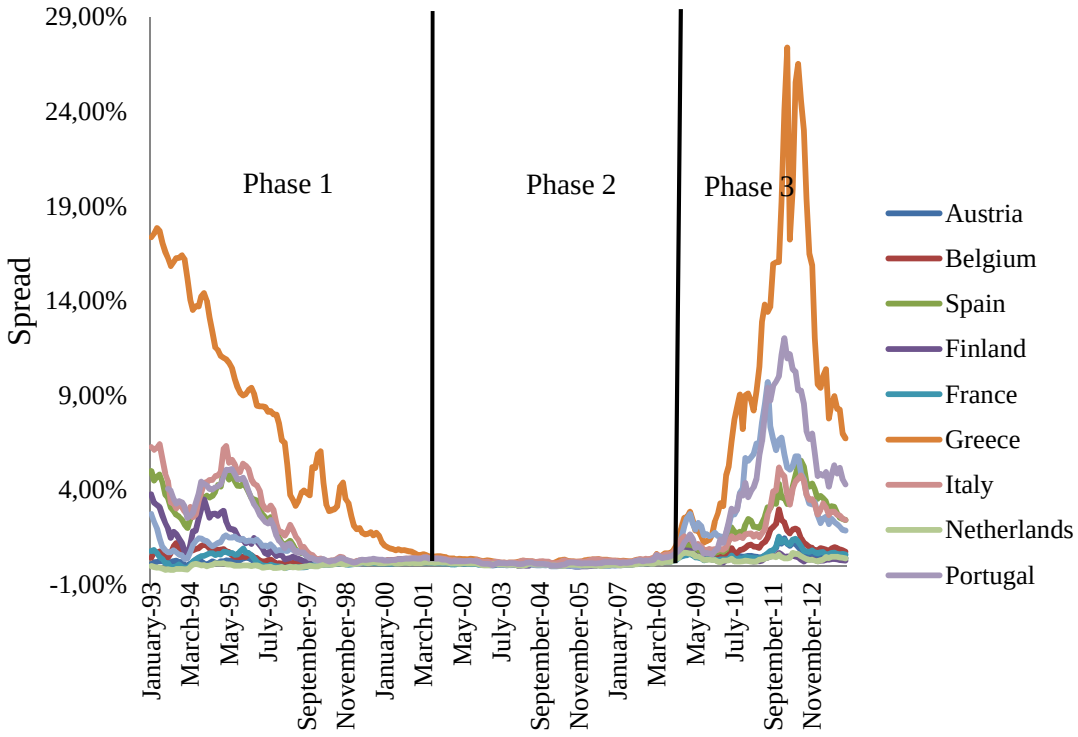
Source: own elaboration.

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



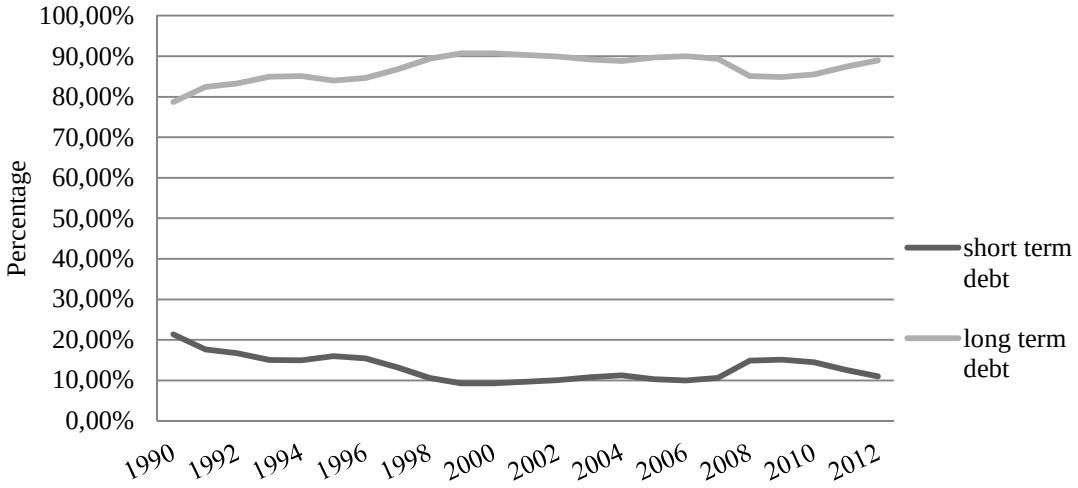
Source: own elaboration with data from the ECB

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



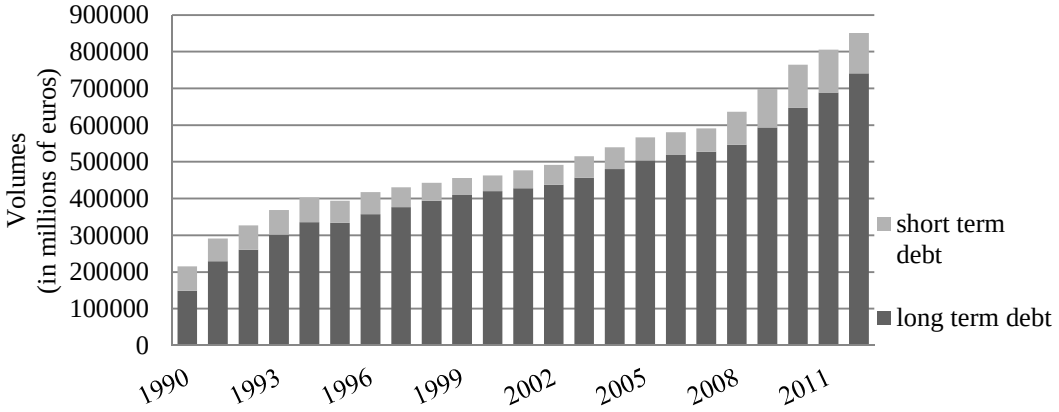
Source: own elaboration with data from the ECB

Figure 4. Evolution of short-term and long-term debt ratios



Source: own elaboration with data from the ECB.

Figure 5. Evolution of short-term and long-term debt volumes



Source: own elaboration with data from the ECB**.**

Figure 6. Evolution of risk premium for perifherical and core countries

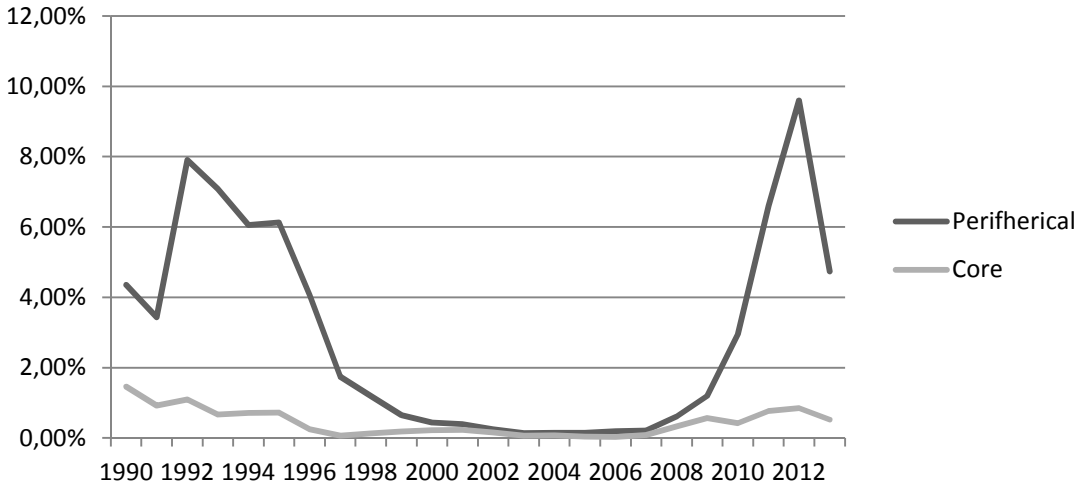
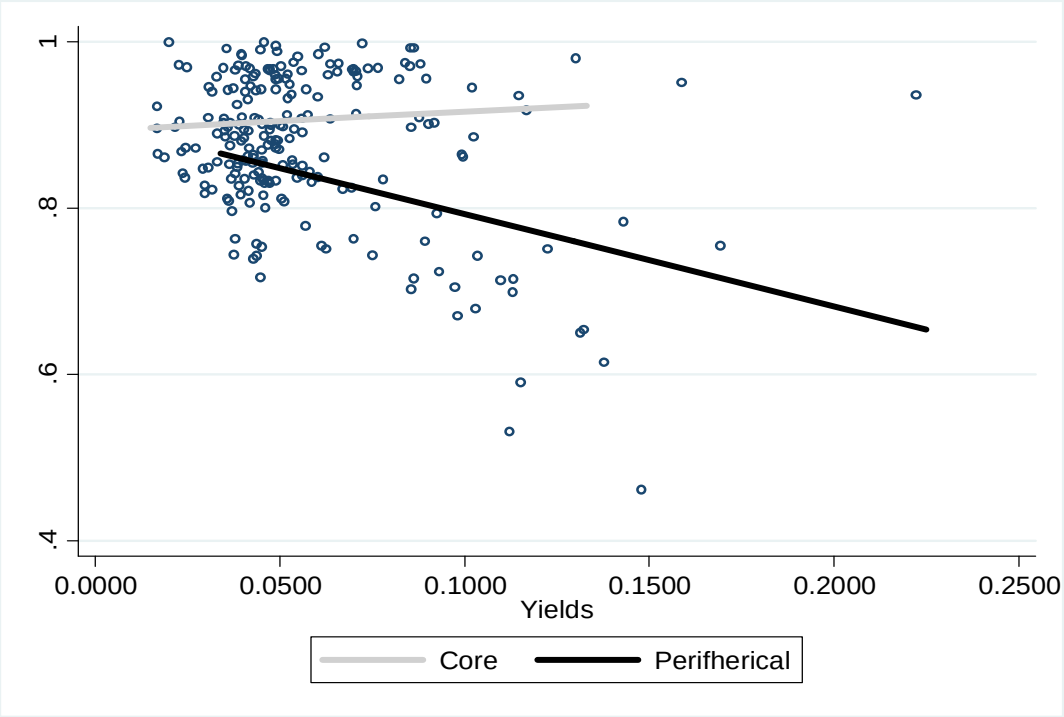
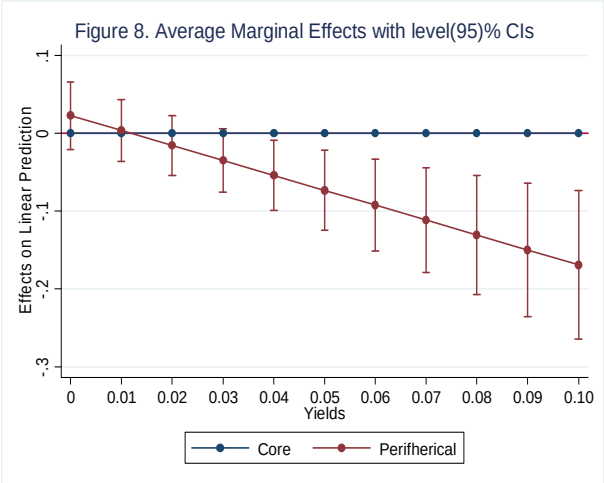
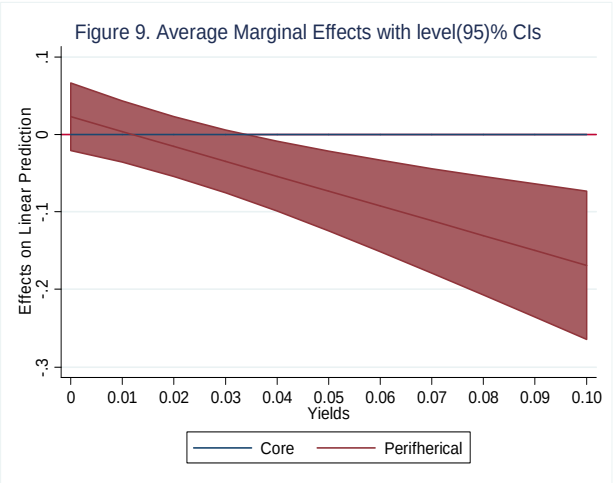


Figure 7. Maturity structure and sovereign bond yields in perifherical and core countries







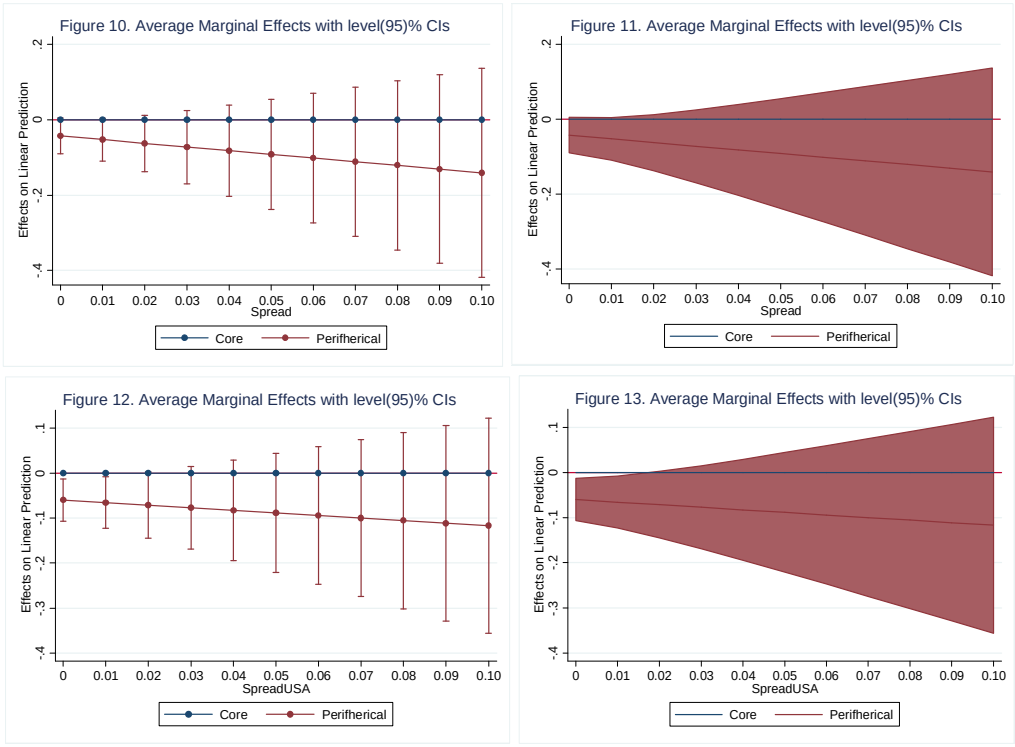


Figure 14. Simple slopes for the interaction between debt/GDP ratio and Yields