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What Drives Sovereign Debt Maturity in European Countries?

Summary: The aim of this paper is to study the determinants of sovereign debt maturity for 23 European countries during the period between 1995 and 2013. For this purpose, we use quantile regressions with robust standard errors clustered by countries to consider the impact of the determinants in the entire distribution. The results indicate a positive relation between the level of debt of the country and sovereign debt maturity, particularly for countries with the lowest debt maturity. We also find evidence of a negative relationship between sovereign risk and debt maturity for the lowest and intermediate values of the debt maturity.

Key words: Sovereign debt maturity, Quantile regressions, Debt, Sovereign risk.

JEL: G12, G15, H63.

The outbreak of the recent financial crisis has very negatively affected all economic agents. Initially, this crisis affected the real economy, which suffered from the failure of large financial institutions such as Lehman Brothers in 2008. Nevertheless, these types of events, far from decreasing in number, have continued their expansion to influence state finances. In this regard, the financial crisis in Europe has recently transformed into a sovereign debt crisis, beginning in 2009, and has affected most members of the Economic and Monetary Union (EMU).

In this context, this paper aims to deepen the analysis of the determinants of sovereign debt maturity in Europe as sovereign debt crisis has had the greatest impact in this territory. Studies have generally focused on analyzing the determinants of sovereign risk. However, the maturity of sovereign debt has barely been analyzed, even when the expansion of maturity is essential to reducing the risk (Harold L. Cole and Timothy J. Kehoe 2000). Furthermore, the debt-to-GDP ratios, which have substantially increased during the recent financial crisis, are influenced by their maturity structure (Juan Equiza-Goñi 2016). The crucial role of debt maturity in smoothing the sovereign debt crisis is clearly shown if we observe the measures adopted in Greece that generated a sharp increase in average maturity and reduced pressure on sovereign debt. Therefore, the maturity structure of debt seems to be an important factor in the expansion and depth of the sovereign debt crisis. A better understanding of the determinants of the sovereign debt maturity structure would allow economic authorities to implement measures that smooth the impact of a crisis with similar characteristics. For this purpose, the focus of our paper is to empirically and exhaustively analyze the determinants of sovereign debt maturity for a set of 23 European countries for the period between 1995 and 2013 through quantile regressions with clustered standard errors (Paulo M. D. C. Parente and João M. C. Santos Silva 2015).

The results of our paper shed light on the main drivers of the maturity structure of sovereign debt. In this sense, we find some stylized facts on the determinants of sovereign debt maturity. Namely, two main variables appear to be the main forces that drive maturity. First, the indebtedness level exhibits a positive relationship with debt maturity, particularly for low values of debt maturity. Therefore, high levels of debt lead to an increase in maturity for those countries with a short maturity structure rather than for countries with longer average maturities. A similar phenomenon occurs with respect to sovereign risk. Regarding the latter, risk reduces maturity for low and medium values of average maturity.

The paper is structured as follows. The first section presents the theoretical framework and reviews the literature on which the study relies. The second section discusses and justifies the primary hypotheses of the study. Section 3 describes the data and methodology used in the analysis. In section 4, we analyze the results. Finally, Section 5 presents the conclusions.

1. Theoretical Framework and Review of the Literature

In this section, we present the main theories, according to the academic literature, related to the maturity structure of sovereign debt. Some authors have already warned about the importance of debt maturity structure in avoiding debt crisis. Cole and Kehoe (2000) argue that lengthening the maturity structure of sovereign debt significantly decreases the effects of a self-fulfilling debt crisis, which is confirmed by Satyajit Chatterjee and Burcu Eyigungor (2012) who affirm that in the presence of debt rollover crisis, long-term debt provides greater welfare than short-term debt.

From a theoretical point of view, there are several papers that have analyzed the optimal maturity structure of sovereign debt. Some examples are the papers of Georges-Marios Angeletos (2002) or Olivier Jeanne (2009) about the optimal maturity structure of public debt. In this sense, Guillermo A. Calvo and Pablo E. Guidotti (1992) analyze the role of sovereign debt maturity structure. They develop a model as an extension of Robert J. Barros's (1979) model in which they take into account tax smoothing theory and time inconsistency to study the maturity structure of nominal government debt obligations. They discover stylized facts about debt maturity and its relationship with other variables for a set of industrial countries. Namely, they conclude that a positive relation between public debt and maturity exists. Regarding government expenditure, this relationship is negative.

The relationship between the amounts of public debt and maturity is not a new concept. Jakob De Haan, Bernd Jan Sikken, and Andrew Hilder (1995) and Andriy Bodnaruk (1999) analyze the relationship between indebtedness level and maturity structure in sovereign states, yielding ambiguous results about the direction of the relationship. In the context of sovereign states, it must be considered that countries can inflate away their debt (Bodnaruk 1999). Indeed, highly indebted countries may have incentives to reduce their debt with inflation (Alberto Alesina et al. 1992). The benefits of debt reduction are greater with increasing leverage and maturity (Bodnaruk 1999). For this reason, markets request an inflation premium in long-term bonds. Alessandro Missale and Olivier J. Blanchard (1994) consider that states may mitigate the inflation premium by shortening the maturity structure to signal the markets that they will not resort to inflation to reduce debt. Therefore, in an environment with inflationary pressures, a higher level of debt reduces the maturity of sovereign debt. However, in the context of the EMU, where the European Central Bank (ECB) controls inflation, it would be difficult for the monetary authorities to enact this possibility, and the risk of devaluation is substantially reduced (Alesina et al. 1992).

Juan Carlos Hatchondo and Leonardo Martínez (2009) analyze how the issue of long-duration bonds affects spreads in emerging economies. Despite other studies, they assume that government issues one-quarter bonds but also long-duration bonds, which for emerging economies are bonds with an average duration of 4 years. The inclusion of bonds with higher duration significantly increases yields.

Cristina Arellano and Ananth Ramanarayanan (2012) present a dynamic model for sovereign default with long-duration bonds in emerging economies. According to these authors, default is more likely to occur in times of low income and high debt. In this respect, if income is high and debt is low, spreads decrease, as does default probability. They suggest that maturity structure reflects a trade-off between the incentive to repay short-term debt and the hedging that provides long-term debt. Namely, they find that there exists a co-movement between maturity and the term structure of spreads.

The effects of risk on the maturity structure of sovereign debt have also been studied by Dirk Niepelt (2014). According to Niepelt, high debt-to-GDP ratios influence maturity structure. In this respect, in times of low income, governments issue more debt and the maturity structure shortens. On the other hand, in times of high income, total debt issuance decreases and the maturity structure increases. Niepelt also finds that maturity smoothing should increase in response to risk, whereas it shortens in times of crisis or low output.

Another possible approach to the relationship between growth and debt maturity is proposed by Stefan Eichler and Dominik Maltritz (2013). These authors indicate that countries with reduced growth show an increased risk for all maturities of debt, both short- and long-term. In this situation and in the event that the term structure of interest rates is increasing, countries with lower growth can reduce their cost of financing by issuing short-term debt, which has lower costs. However, countries with high growth reduce risk across all maturities of debt and can borrow at longer terms without significantly increasing the cost of debt.

In this sense, the analysis of risk over maturity structure has also been widely analyzed in the literature. Along this line of research, Laura Alfaro and Fabio Kanczuk (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. Chul Woo 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. Hei Wai Lee, Yan Alice Xie, and Jot Yau (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). Fernando A. Broner et al. (2014) indicate that the average maturity of sovereign debt in peripheral countries 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, Guido Lorenzoni, and Sergio L. Schmukler (2013), who analyze the relationship between those two variables for a set of emerging countries for the 1990s and the first decade of the 21st 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, suggesting the presence of an inverse relationship between maturity and risk, as in Diego Perez (2013). The authors also obtain evidence that this trend intensifies in times of crisis because in this case, the risk premium that investors incorporate into long-term bonds is higher than that in times of financial stability.

Francesco Drudi and Raffaela 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 risk premium and average maturity only for countries with a high level of indebtedness.

Previous studies that have analyzed the determinants of debt maturity in sovereign states are shown in Table 1. Kees P. Goudswaard (1990) is one of the first to analyze this topic and includes a dummy variable for the economic cycle, inflation and real interest rates as determinants of maturity. Missale and Blanchard (1994), De Haan, Sikken, and Hilder (1995) and Bodnaruk (1999) analyze the effect of the indebtedness level on the maturity of sovereign debt with different results. Recently, studies have focused on analyzing the relationship between credit risk and the maturity of sovereign debt (Arellano and Ramanarayanan 2012; Broner, Lorenzoni, and Schmukler 2013; Perez 2013, among others). The results show the existence of an inverse relationship between the variables. As demonstrated, most of the papers focus their analysis on emerging economies, but there is no recent evidence for a set of industrialized countries. Therefore, we focus on the euro area context, taking into account recent events derived from the current financial crisis.

Table 1 Summary of Previous Works on the Determinants of Sovereign Debt Maturity

Authors	Sample	Dependent variable	Economic cycle (+)	Inflation (+/-)	Debt (+/-)	Risk (-)
Goudswaard (1990)	Netherlands	Average debt maturity	+ (not significant)	+ (not significant)		
Missale and Blanchard (1994)	Italy, Belgium and Ireland	Effective average debt maturity			-	
De Haan, Sikken, and Hilder (1995)	OCDE countries	Average debt maturity		- (not significant)	- + for EEUU and Canada	
Bodnaruk (1999)	Ukraine	Average debt maturity			+	
Hatchondo and Martínez (2009)	Emerging economies	Average duration				-
Perez (2013)	Emerging economies	Average debt maturity				-
Broner, Lorenzoni, and Schmukler (2013)	Emerging economies	Average debt maturity				-
Arellano and Ramanarayanan (2012)	Emerging economies	Average duration of issued debt	+			-
Yan Bai, Seon Tae Kim, and Gabriel P. Mihalache (2015)	Emerging economies	Average maturity of issued debt			+ (not significant)	-

Notes: The table shows several studies that have analyzed the determinants of the average maturity of sovereign debt and its relationship to the economic cycle, inflation, debt and credit risk. It also reflects, in parentheses, the expected sign of the relationship between the explanatory variables and the dependent variable.

Source: Own elaboration.

2. Hypotheses Formulation

This section presents the hypotheses to be tested in the study according to the arguments extracted from the theoretical framework and literature review. As stated, the objective of this paper is to analyze the determinants of the maturity of sovereign debt. According to the previous studies summarized in Table 1, it appears that there are three forces that drive sovereign debt maturity: business cycle, risk and debt level (previous studies also take into account inflation but in the context of a Monetary Union where inflation is supervised; as is the case for European countries, its effect should be residual. In any case, we also control for inflation in our estimations). Therefore, our hypotheses are in line with these arguments.

2.1 Maturity and Business Cycle

Eichler and Maltritz (2013) note countries that show low growth facing a higher default risk in all its debt maturities. Therefore, if the risk increases, regardless of the duration of operations, sovereign states with reduced growth will choose financing at a lower cost, i.e., debt with shorter maturities. This reasoning is supported by Niepelt (2014), who states that when a country's income is low, the maturity structure shortens. According to the foregoing argument, we propose the following hypothesis:

Hypothesis 1: The level of growth in the countries analyzed has a positive effect on the maturity of sovereign debt.

According to Eichler and Maltritz (2013), the growth of a country is inversely related to the credit risk for all maturities of sovereign debt. Therefore, a country with low growth suffers greater credit risk, which increases the cost of debt, especially at longer maturities. In this case, countries issue short-term debt to reduce their costs, and consequently, the maturity of sovereign debt shortens.

2.2 The Effects of Risk on Debt Maturity

The relationship between risk and sovereign debt maturity has been analyzed in several papers, whose authors find evidence of an inverse relationship between the variables (Xie et al. 2009; Lee, Xie, and Yau 2011; Broner, Lorenzoni, and Schmukler 2013; Perez 2013). Moreover, this effect is strengthened during recession periods and when sovereign credit ratings are worse (Broner, Lorenzoni, and Schmukler 2013), as confirmed by Bai, Kim, and Mihalache (2015), who find that governments are more prone to issue bonds with short duration during crises. Based on these arguments, we propose the following hypothesis:

Hypothesis 2: Sovereign credit risk is inversely related to the maturity of sovereign debt.

An increase in sovereign risk implies an increase in yields for longer maturities. In this case, governments shorten the maturity to reduce their financing costs. In addition, this inverse relationship is intensified in times of financial turmoil.

2.3 The Influence of Debt on Maturity

The relationship between debt maturity and indebtedness level in sovereign states is complex because governments can inflate away their debt. Missale and Blanchard (1994) suggest that highly indebted states can shorten the maturity structure as a signal to markets that are not using inflation to reduce debt, and therefore, they control inflation premiums in longer-term bonds. Thus, countries with higher levels of debt will resort to short-term debt. In this vein, Drudi and Giordano (2000) state that when the indebtedness level is very high, the yields of instruments of longer maturities are difficult to sustain and governments are forced to issue more short-term debt.

According to previous research, it is expected that an increase in the indebtedness level will reduce the maturity of sovereign debt because high indebtedness may increase premiums on long-term bonds, hindering the issuance of longer maturities because they imply higher financing costs. However, Eichler and Maltritz (2013), in a more recent analysis of the euro area, explain that the level of indebtedness in states only increases short-term risk. In this case, long-term bonds yields would remain stable, which would expand debt maturity or keep it constant. Therefore, we propose the following hypothesis:

Hypothesis 3: The indebtedness level of a country has a positive influence on the maturity of sovereign debt.

In addition, we control for the influence of inflation on the maturity of sovereign debt, although inflation in the euro area is currently controlled by the ECB. A high level of inflation introduces greater uncertainty about the future and the development of long-term bonds (Goudswaard 1990); therefore, an inflation premium is incorporated into those instruments.

We also take into account the effect of the public deficit/surplus on debt maturity. According to Niepelt (2014), government expenditure exhibits a negative relationship with maturity. Therefore, an increase in government expenditure can lead to a rise in government deficit. We thus expect that high public deficits reduce average maturity, and therefore, public surplus lengthens maturity.

3. Data and Methodology

This section describes the data and methodology used in the empirical analysis. The aim of this paper is to analyze the determinants of the maturity of sovereign debt in Europe. To this end, we have selected the following European countries: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia and Spain between 1995 and 2013. This provides us a data set for 23 European countries over 19 years, which includes unbalanced panel data comprising 437 observations. The countries and the rest of the variables included in the analysis were selected according to the availability of data.

3.1 Data

Specifically, we propose the following annually based variables.

Dependent variable. In the literature, many variables are used to approximate the average maturity. Goudswaard (1990), Broner, Lorenzoni, and Schmukler (2013) and Perez (2013) use the average maturity of debt as the dependent variable. In this paper, we use the average maturity of sovereign debt in years as a dependent variable. Annual data are obtained from the European Central Bank (ECB 2014)[1] Statistical Data Warehouse for the period between 1995 and 2013 inclusively. The data concerning the average maturity for Germany, Ireland, Slovakia and Spain are not available in the ECB Data Warehouse. Therefore, we have completed the data set with maturity data for these countries obtained from the Organisation for Economic Co-operation and Development (OECD 2014)[2] Central Government Debt Statistical Yearbook and the Spanish Treasury (2014)[3]. Unlike the OECD, to calculate average maturity, the ECB considers all government consolidated debt involving all sectors of the economy,

[1] **European Central Bank (ECB).** 2014. Statistical Data Warehouse. http://sdw.ecb.europa.eu/ (accessed October 11, 2014).

[2] **Organisation for Economic Co-operation and Development (OECD).** 2014. Central Government Debt Statistics. http://www.oecd.org/newsroom/centralgovernmentdebtstatistics.htm (accessed October 15, 2014).

[3] **Spanish Treasury.** 2014. Public Debt. http://www.tesoro.es/deuda-publica (accessed October 16, 2014).

taking into account local and regional debt and social security funds. Therefore, the difference between the two sources is the amount of local and regional debt and social security funds that is in most cases residual over total debt. Correlations between the values of maturity from the OECD and the ECB are very high, indicating that the differences between them are small.

We use GDP *per capita* growth as an indicator to approximate business cycle (Eichler and Maltritz 2013). The data were obtained from Eurostat (2014)[4]. It is expected that lower growth will lead to a lower maturity of sovereign debt because reduced growth increases the sovereign risk.

To approximate credit risk, we use the risk premium relative to the U.S. sovereign bond to include Germany in the study to have the greatest possible number of observations (Kerstin Bernoth, Jürgen von Hagen, and Ludger Schuknecht 2012). The data concerning the yields from the analyzed countries and from the U.S. were obtained from Eurostat (2014) and the Federal Reserve Bank of St. Louis (2014)[5], respectively. A high risk premium is indicative of high credit risk, and we expect an inverse relationship with the maturity of sovereign debt (Xie et al. 2009; Broner, Lorenzoni, and Schmukler 2013).

We use the debt-to-GDP ratio to approximate the indebtedness level (Missale and Blanchard 1994; De Haan, Sikken, and Hilder 1995; Bodnaruk 1999). These studies do not yield conclusive results on the relationship between the indebtedness level and the maturity of sovereign debt. The data are taken from the European Central Bank Statistical Data Warehouse. In addition, we incorporate inflation as a determinant of sovereign debt maturity (Goudswaard 1990; Missale and Blanchard 1994; De Haan, Sikken, and Hilder 1995). It is expected that the relationship is inverse because inflation increases uncertainty and an inflation premium is incorporated into long-term bonds (Missale and Blanchard 1994). However, in the euro area, this relationship may be conditioned by the ECB, whose main objective is to control inflation. The data are expressed as interannual variations and are obtained from the European Central Bank Data Warehouse. We also consider the variables relative to government expenditure (Niepelt 2014) and the public deficit/surplus (net borrowing/lending by the general government sector), both obtained from the European Central Bank Statistical Data Warehouse.

We include different control variables, including the debt held by non-residents and the real effective exchange rate (Bai, Kim, and Mihalache 2015). The real effective exchange rate (REER) was obtained from Eurostat and represents the changes in cost and price competitiveness taking into account price trends. It is calculated as the nominal effective exchange rate (NEER) deflated by nominal unit labor costs and consumer prices. Namely, we use the REER for 42 competitor countries, which include 28 countries from the EU plus other 14 industrialized countries. We also include the index of

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[4] **Eurostat.** 2014. Database. http://ec.europa.eu/eurostat/data/database (accessed October 19, 2014).

[5] **Federal Reserve Bank of St. Louis.** 2014. Economic Data. https://fred.stlouisfed.org/ (accessed October 21, 2014).

economic freedom from the Heritage Foundation (2014)[6] to control for the different characteristics of the countries analyzed.

To control for the investment and financial development of the countries in the sample, we incorporate indices of investment and financial freedom from the Heritage Foundation. We also control for the size of the debt market using the gross debt issues to GDP ratio. Data on the gross debt issues were obtained from the European Central Bank Statistical Data Warehouse.

In addition to these variables, we include a variable called Crisis that reflects the effect of the current financial crisis and the sovereign debt crisis. For the former, Crisis is a dummy variable that takes a value of 1 for years including and following 2007 and 0 in other cases, and for the latter, Sovereign Crisis takes a value of 1 for years including and following 2010 and 0 otherwise. We also include dummy variables for the euro's entry into force, which take a value of 1 when the currency is officially adopted in each country and 0 otherwise. We also take into when each of the countries entered the EU. To do so, we construct a dummy variable that takes a value of 1 following a country's entrance and 0 otherwise.

Table 2 Average Values of the Variables by Country

	Mat	*GDP*	*Spread*	*Debt*	*Exp*	*Net*	*HICP*	*Held*	*REER*	*Score*
Austria	7.03	0.028	-0.00098	0.70	0.51	-0.027	0.018	0.44	100.2	69.0
Belgium	5.83	0.027	0.00065	1.05	0.51	-0.019	0.019	0.44	99.8	68.0
Bulgaria	8.23	0.093	0.01570	0.30	0.37	-0.010	0.051	0.16	96.8	57.0
Czech R.	5.56	0.072	0.00386	0.26	0.42	-0.040	0.033	0.05	98.5	68.3
Denmark	6.15	0.029	-0.00045	0.48	0.54	0.002	0.020	0.19	98.8	73.2
Estonia	6.31	0.119	-	0.59	0.37	0.003	0.054	0.02	98.2	73.9
Finland	4.47	0.035	-0.00368	0.45	0.52	0.009	0.018	0.34	99.9	70.6
France	6.54	0.024	-0.00122	0.68	0.53	-0.036	0.017	0.35	98.7	61.3
Germany	5.81	0.019	-0.00385	0.65	0.46	-0.025	0.014	0.27	100.1	69.4
Greece	8.66	0.030	0.03982	1.41	0.22	-0.042	0.036	0.19	99.1	59.8
Hungary	4.50	0.065	0.03684	0.67	0.49	-0.055	0.075	0.25	90.9	63.1
Ireland	5.32	0.042	0.00870	0.57	0.38	-0.033	0.021	-	94.3	77.8
Italy	6.34	0.029	0.00934	1.09	0.48	-0.035	0.024	0.36	97.1	61.7
Lithuania	5.60	0.131	0.02050	0.14	0.38	-0.036	0.043	0.09	96.1	66.8
Luxemb.	4.86	0.037	-0.00339	0.12	0.41	0.019	0.022	-	98.9	75.6
Malta	6.20	0.049	0.00935	0.61	0.41	-0.048	0.023	-	96.8	63.1
Netherl.	6.48	0.031	-0.00232	0.57	0.45	-0.020	0.021	0.26	97.5	73.4
Poland	4.73	0.078	0.02377	0.46	0.44	-0.044	0.042	0.16	95.5	60.3
Portugal	4.58	0.033	0.01479	0.72	0.45	-0.052	0.025	0.43	97.0	64.2
Romania	4.47	0.106	0.03996	0.21	0.36	-0.036	0.025	0.11	90.3	55.2
Slovak R.	3.61	0.094	0.01093	0.38	0.43	-0.052	0.048	0.15	97.3	63.2
Slovenia	6.92	0.043	0.01476	0.31	0.46	-0.038	0.047	0.15	99.8	60.0
Spain	6.44	0.036	0.00775	0.57	0.41	-0.036	0.028	0.20	97.6	66.8
Average	**5.84**	**0.055**	**0.00937**	**0.53**	**0.44**	**-0.028**	**0.042**	**0.20**	**97.4**	**66.1**

[6] **Heritage Foundation.** 2014. Index of Economic Freedom. https://www.heritage.org/index/ (accessed October 29, 2014).

Notes: The table shows the mean values by country for the main variables included in the analysis. We include the average maturity of sovereign debt in years as our dependent variable (*Mat*). As explanatory variables, we present the following: *GDP* represents the growth of the GDP *per capita*; *Spread*, the spread between the 10 year sovereign bond yields of each country and U.S. sovereign bond yields of the same maturity; *Debt* is the debt-to-GDP ratio; *Exp* is the government expenditure; *Net* represents the net lending/borrowing; *HICP* is the harmonized consumer price index; *Held* represents the amount of debt held by non-residents relative to GDP; *REER* is the real effective exchange rate for 42 competitors countries; *Score* is the overall score of the Heritage Foundation Index.

Source: Own elaboration.

Tables 2 and 3 present the average values of the variables included in the analysis by country, and the correlation among those variables, respectively. No multicollinearity is observed between the explanatory variables according to the correlations.

Table 3 Correlations of the Explanatory Variables Included in the Analysis

	GDP	*Spread*	*Debt*	*Exp*	*Net*	*HICP*	*Held*	*REER*	*Score*
GDP	1,000								
Spread	-0,246	1,000							
Debt	-0,391	0,268	1,000						
Exp	-0,455	0,051	0,551	1,000					
Net	0,299	-0,481	-0,386	-0.300	1,000				
HICP	0,442	0.217	-0,262	-0.347	0.107	1,000			
Held	-0,258	-0.001	0,584	0.522	-0.159	-0.115	1,000		
REER	-0,039	0,159	-0.221	-0.160	-0.099	0.022	-0.100	1,000	
Score	-0,102	-0.274	-0,299	-0.139	0.252	-0.160	-0,208	0.035	1,000

Notes: The table shows the Pearson's correlations between the explanatory variables included in the analysis.

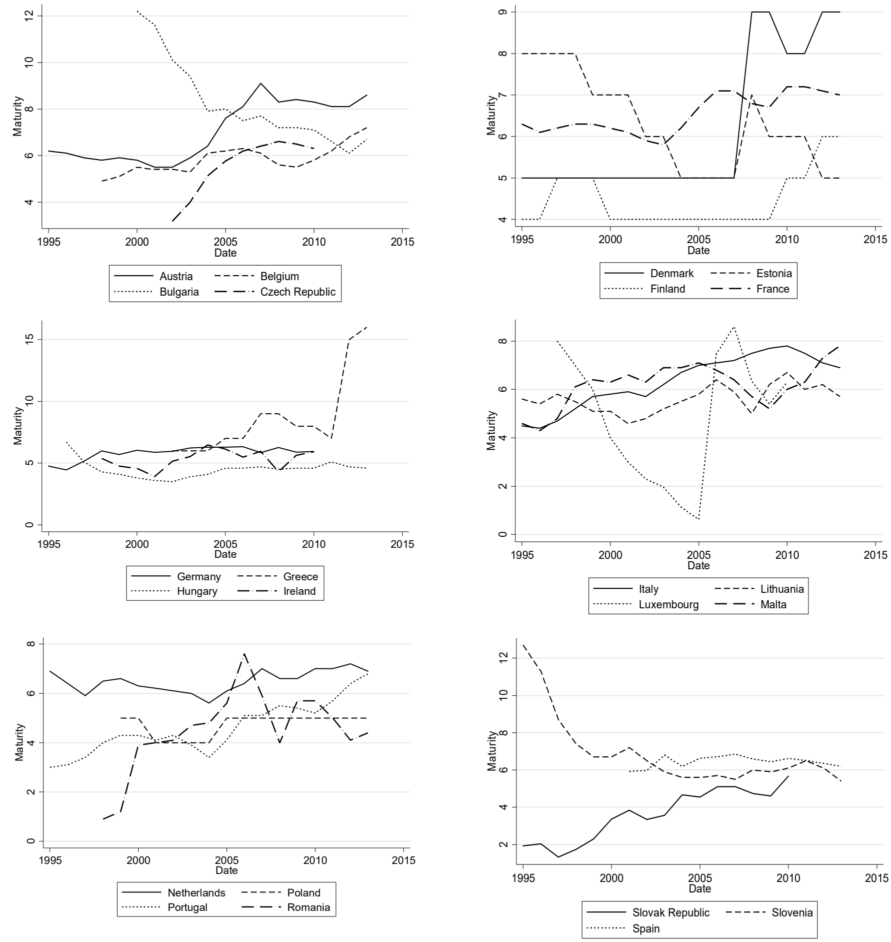
Source: Own elaboration.

3.2 Methodology

Figure 1, which illustrates the evolution of the dependent variable, shows different outliers in the data that could bias the results. We observe a sharp increase for Greece that occurred after the outbreak of the sovereign debt crisis and the implementation of rescue packages by the Eurozone. In addition, we observe irregular behavior for Denmark, Estonia, Finland, and Luxembourg. We will consider the difference in behavior in a subsequent analysis.

Thus, in the context of the aforementioned erratic behavior and outliers, the linear regression models assume that the relationship between average maturity and its determinants is linear. Nevertheless, if the sample is heterogeneous in terms of the distribution of the dependent variable, linear regressions provide misinformation on the estimation coefficients because they use the mean values of the sample.

Therefore, to test the hypotheses and to analyze the determinants of sovereign debt maturity, we use the quantile regression approach. The quantile regression method, which was developed by Roger Koenker and Gilbert Bassett (1978), involves estimating a range of marginal impacts for dependent variable distribution quantiles. Compared to the Ordinary Least Squares method (OLS), which assumes a constant marginal impact across an entire dependent variable distribution, quantile regression examining how covariates influence the location, scale, and shape of an entire response distribution (Koenker 2005). Consequently, the quantile regression approach offers a more complete account of the true effects of explanatory variables (Koenker and Kevin



Source: Own elaboration from European Central Bank database (ECB 2014).

Figure 1 Evolution of Average Debt Maturity (in Years) by Country

F. Hallock 2001). This methodology is advantageous in that it is more robust to non-normal errors and outliers and it is less sensitive to skewness and to heterogeneities of response variables, thus allowing us to consider effects of a variable along an entire dependent variable distribution (Christopher F. Baum 2013). This method assumes that the value of the error term ε_τ conditional on regressors in the τ-th quantile takes a value of zero. Then, the conditional quantile model of y_i given x_i is specified as follows:

$$Q_{y_i}(\tau \mid x) = \alpha(\tau) + x_i'\beta(\tau) + \varepsilon_\tau , \tag{1}$$

where $Q_{y_i}(\tau \mid x)$ denotes the τ-th conditional quantile of a random dependent variable y_i, $\alpha(\tau)$ presents the unobserved effect, x_i is the independent variable vector, $\beta(\tau)$ is the coefficient vector under the quantile τ-th, and ε_τ is the error term. When τ-th changes at (0, 1), this methodology solves the following minimization problem of the asymmetrically weighted absolute error criterion to obtain a different quantile parameter estimation:

$$\hat{\beta}(\tau) = \arg\min \sum_{i=1}^{n} \rho_\tau (y_i - x_i{}' \beta(\tau) - \alpha(\tau)), \tag{2}$$

where $\rho_\tau (y_i - x_i{}' \beta(\tau) - \alpha(\tau))$ is the check function, which is an absolute value function that generates the τ-th quantile as its solution. The estimator is robust because this method splits residuals into positives and negatives and gives weights of τ and 1 - τ.

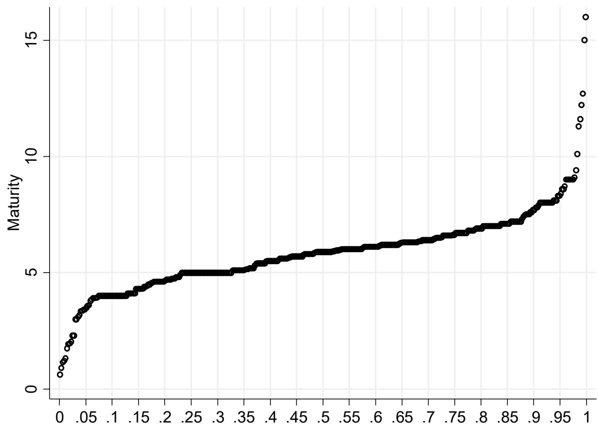
To study the different effects of the explanatory variables on average debt maturity we transform Equation (1) into the following model:

$$Q_{Mat_i}(\tau | x) = \alpha(\tau) + \beta_1(\tau) Cycle_i + \beta_2(\tau) Risk_i + \beta_3(\tau) Debt_i + \beta_4(\tau) X_i + \varepsilon_\tau, \tag{3}$$

where $Q_{Mat_i}(\tau | x)$ is the τ-th conditional quantile of the average maturity of sovereign debt, expressed in years (*Mat*). $Cycle_i$ variable represents the business cycle approximated by the growth of the GDP *per capita*; $Risk_i$ represents the credit risk; $Debt_i$ include the variables related to the debt structure of the country (debt-to-GDP ratio, government expenditure and net lending/borrowing); X_i is a vector of variables that include the rest of the control variables. Finally ε_τ is the error term. For the purpose of our paper, we estimate pooled quantile regression clustering standard errors by country (Parente and Santos Silva 2015). As the data represent a pool of observations that are time series observations (i.e., they are structured as a panel dataset), it is likely that observations for each country are correlated over time, although each is independent. Therefore, it is necessary to consider this structure to compute a valid covariance matrix, as the traditional quantile regression approach does not provide a valid one under this configuration of the dataset. To solve this problem, we use the quantile regression approach with standard errors clustered by countries. This technique approximates a quantile regression with robust standard errors that correct for intra-cluster correlation. According to Parente and Santos Silva (2015) it is increasingly common to use pooled quantile regressions and random effects quantile regressions to analyze panel data. Nevertheless, previous studies using quantile regressions do not seem to provide consistent estimators. To this end, Parente and Santos Silva (2015) follow the findings of Tae-Hwan Kim and Halbert White (2003) and find evidence that the traditional estimator in quantile regression is consistent and asymptotically normal if there exists within-cluster correlation of the error term and an estimator that is consistent with intra-cluster correlation. Therefore, this technique allows us to run quantile regressions when data are from different individuals as in a panel data set, with the consideration that observations for different groups are independent and intra-cluster correlation may be present (Parente and Santos Silva 2015). Because our data has a panel data structure and we want to test all the distributions of the dependent variable, we consider this technique to be a better fit for our sample.

4. Results and Discussion

In this section, we present the main results obtained regarding the relationship between average debt maturity and its determinants. Table 3 shows the quantile regressions for the dependent variable on the explanatory variables. Because our objective is to analyze and consider the entire distribution of the dependent variable, we decided to perform the quantile regressions for the quantiles *q*(0.05), *q*(0.25), *q*(0.5), *q*(0.75), and *q*(0.95) to obtain more abundant results and draw conclusions from the data set. The quantile selection method is based on the evolution of maturity, for which data are presented in Figure 2. According to the graph, it appears that for values falling below 0.05 and exceeding 0.95, a different behavior than of the rest of the distribution is found. Therefore, these quantiles have been selected for the analysis as distribution extremes to examine the entire distribution. Moreover, this selection is in line with previous studies that utilize quantile regression models (José A. F. Machado and José Mata 2005; Patrice Fontaine and Sujiao Zhao 2014; Massimo Molinari, Silvia Giannangeli, and Giorgio Fagiolo 2016).



Source: Own elaboration from European Central Bank database (ECB 2014).

Figure 2 Quantiles of Average Debt Maturity

As recommended by Baum's (2013) notes, Table 4 displays the results for the quantiles along with the OLS estimation. The table shows that in the median regression (i.e., quantile 0.50), the growth of GDP *per capita* negatively affects sovereign debt maturity for levels close to the median of average maturity, which is contrary to our hypothesis. Nevertheless, when we analyze the quantile (0.95), which represents the highest values of the dependent variable, this relationship becomes positive as expected. Therefore, at high levels of average maturity, the business cycle positively influences the dependent variable, but as this threshold decreases, this relationship disappears and even becomes negative.

Table 4 Quantile Regressions on Average Debt Maturity

Dependent variable: average maturity	Quantiles					OLS
	q(0.05)	*q*(0.25)	*q*(0.5)	*q*(0.75)	*q*(0.95)	
GDP	0.218 (3.130)	-2.698 (2.825)	-5.974* (3.321)	-2.334 (2.161)	12.36** (4.869)	0.073 (1.789)
Spread	10.50 (11.87)	-12.17 (10.55)	-16.55* (8.849)	-12.56 (8.802)	30.77*** (11.53)	8.017 (10.80)
Debt	1.560** (0.666)	2.389*** (0.919)	1.826*** (0.696)	1.771*** (0.583)	1.975 (2.469)	2.455*** (0.651)
Exp	-3.132 (4.269)	-1.738 (3.391)	-5.842** (2.652)	-1.357 (4.510)	13.55*** (3.710)	0.024 (2.093)
Net	6.557 (7.167)	0.882 (6.124)	-2.876 (3.782)	1.023 (5.038)	8.128 (6.685)	4.199 (2.925)
HICP	-11.40 (15.04)	-3.830 (6.477)	4.182 (12.53)	7.972 (6.440)	6.312 (22.59)	-5.413 (6.894)
Held	1.609 (1.288)	-1.224 (1.173)	-0.137 (1.170)	0.433 (1.168)	-0.199 (1.339)	-0.698 (1.040)
REER	0.0441** (0.0215)	0.0578** (0.0289)	0.0625*** (0.0189)	0.0566** (0.0235)	0.0484 (0.0611)	0.054*** (0.012)
Score	-0.0473 (0.0657)	-0.00962 (0.0434)	-0.0169 (0.0277)	0.00703 (0.0335)	0.0390 (0.0491)	0.00477 (0.0162)
Constant	3.092 (4.894)	-0.0281 (4.222)	2.577 (3.485)	-0.153 (5.336)	-7.406 (10.78)	-0.987 (2.296)
N	301	301	301	301	301	301
R-squared	0.149	0.151	0.097	0.116	0.087	0.211

Notes: The table shows the quantile regressions for the 0.05, 0.25, 0.5, 0.75 and 0.95 quantiles. Robust standard errors are shown in parentheses. Following the notes of Baum (2013), we also provide the results for the OLS estimation with robust standard errors clustered at the country level to compare with the results of the quantile regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Own elaboration.

A similar phenomenon is observed for the variable that approximates sovereign risk. The variable that approximates sovereign risk, which is the spread against the U.S. bond (we also used the long-term interest rates of the 10-year sovereign bond, and the results do not differ from those presented in Tables 4 and 5), shows a significant negative sign for median levels of average maturity. However, for the quantile (0.95), this relationship indicates a positive sign. This unexpected relationship may be caused by outlier values that bias the results, as in the case of Greece (see Figure 1).

For the debt-to-GDP ratio, the results are more robust than those obtained for the rest of the explanatory variables. According to Table 4, there is a significant positive relationship between debt and sovereign debt maturity along the entire distribution of the dependent variable, which is line with the proposed hypothesis.

Because the first table does not consider the effect of time variability, we include time dummies and a time trend in Table 5. We also include a dummy for Greece because the country appears to have a perturbation effect on the sample. The results indicate that the effect of the growth of the GDP *per capita* remains stable and the spread on the U.S. bond shows the expected negative sign for the low values of the dependent variable.

The results displayed in Table 5 shed light on the negative relationship between risk and maturity when the length of maturity is already low. After we account for time variability and Greece's unique situation, we find that countries that already have lower maturities are more prone to shortening the length of maturity by an even greater amount during a period of financial turmoil. This observation should alert authorities to implement measures that aim to increase the average maturity to values higher than the current average at the 0.5 quantile, which is approximately 6 years. For maturities lower than this average, the risk of facing a decrease in the maturity structure will be higher.

In short, Table 5 shows a negative and persistent relationship between average debt maturity and sovereign risk, as stated in H_2. Nevertheless, this relationship is only significant for medium and low values of the dependent variable. The presence of countries such as Greece, where renegotiations and bailout programs have been established to avoid default, biases the results because they artificially lengthen the average maturity (see Figure 1). Therefore, the importance of the quantile regression analysis is greater because it allows us to detect these perturbations in the results given that we do not regress the mean values of the variables but the whole distribution.

The debt-to-GDP ratio still shows the expected positive sign for reduced values of average maturity. In this sense, high values of debt have a positive effect on lengthening the maturity structure. This smooths and relieves the pressure that short average maturity structures have on a country's public finances. However, for higher values of maturity (quantile 0.95), the relationship becomes negative. This indicates that in countries with large maturity structures, higher levels of debt lead to a shortening of the maturity structure. Therefore, the results indicate a positive effect of the debt-to-GDP ratio, which confirms our H_3 but only for low values of average maturity. When countries are able to lengthen the maturity structure, the effect of debt on average maturity diminishes.

Table 5 Quantile Regression Including a Time Trend and Time Dummies and Controlling for the Effect of Greece

Dependent variable: average maturity	Quantiles					OLS
	q(0.05)	*q*(0.25)	*q*(0.5)	*q*(0.75)	*q*(0.95)	
GDP	-3.338* (1.882)	-3.491 (2.345)	-5.171** (2.492)	-1.894 (2.926)	-0.688 (2.513)	-0.287 (2.373)
Spread	-32.13*** (11.04)	-39.86*** (10.08)	-36.94** (18.62)	-6.856 (11.80)	-4.875 (5.566)	-10.07 (10.35)
Debt	1.997*** (0.726)	2.034*** (0.642)	1.267 (0.990)	1.694 (1.033)	-1.404* (0.826)	1.846** (0.662)
Exp	2.220 (4.927)	0.0367 (3.279)	-2.633 (4.522)	4.364 (4.722)	7.406** (2.965)	1.631 (3.401)
Net	0.461 (6.246)	-1.972 (4.111)	-0.231 (6.618)	11.42* (6.903)	10.73*** (3.601)	7.244 (5.032)

HICP	4.538 (10.33)	3.506 (10.67)	-0.765 (11.17)	3.609 (12.91)	0.337 (5.727)	-5.664 (10.07)
Held	-1.141 (1.170)	-1.666* (0.848)	-1.235 (2.039)	-2.410 (2.198)	-0.528 (0.871)	-1.962 (1.186)
REER	0.0232 (0.0152)	0.0438 (0.0365)	0.0370 (0.0232)	0.0203 (0.0271)	-0.0771*** (0.0166)	0.0173 (0.0157)
Score	-0.0949** (0.0367)	-0.0361 (0.0337)	-0.0258 (0.0337)	0.00982 (0.0353)	-0.0499* (0.0285)	-0.0316 (0.0336)
Greece dummy	1.449 (1.434)	2.448*** (0.542)	2.856** (1.262)	7.078** (3.098)	8.452*** (1.409)	3.604*** (0.747)
Constant	5.564* (3.146)	0.834 (4.430)	4.480 (5.052)	0.400 (5.900)	14.89*** (4.341)	3.784 (3.673)
Time trend	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
N	301	301	301	301	301	301
R-squared	0.192	0.261	0.236	0.350	0.195	0.409

Notes: The table shows the quantile regressions for the 0.05, 0.25, 0.5, 0.75 and 0.95 quantiles. The explanatory variables are the previous ones and a dummy for Greece. Robust standard errors are shown in parentheses. Following the notes of Baum (2013), we also display the results for the OLS estimation with robust standard errors clustered at the country level to compare with the results of the quantile regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Own elaboration.

Moreover, we find no evidence of a positive relationship between the business cycle and average maturity. The results show negative coefficients for low and moderate values of maturity. This inverse relationship contradicts our hypothesis of positive effects of GDP growth and maturity. According to the results, this direct correlation does not exist, and it is even significantly negative for some quantiles. This may be attributed to the fact that countries with lower growth tend to lengthen maturity structures to avoid debt payment problems in the short-term as they are not growing enough, and hence they do not generate the resources required to face such payments. Therefore, our results cannot support H_1.

The rest of the variables barely show statistically significant coefficients. Government expenditures, net lending/borrowing and the real effective exchange rate appear to have an impact on maturity but only for the highest values of average maturity. Moreover, the real effective exchange rate shows some significant values. The persistently positive and significant effect of Greece's dummy variable on the distribution of sovereign debt maturity is also notable.

4.1 Robustness Tests

To be exhaustive in our analysis, we perform different robustness tests on our regressions. First, we consider the size of the public debt market. We consider small countries such as Malta and the Baltic countries (Estonia and Lithuania) to have small debt markets that may influence the analysis. We thus control for this in our analysis by removing these countries from the estimation (Table 6). In addition to this fact, inferring from the results shown in Figure 1, there appear to be some countries that show erratic behaviors in the evolution of their average debt maturity trends. We thus proceed to estimate the models without these countries (Table 7) to determine whether the results remain stable and robust.

Table 6 presents the results of the estimations that do not consider countries with small debt markets. We maintain the same variables as those of the previous specifications to compare the results. The table shows that the coefficients remain similar to those listed in Table 5. The sovereign risk level keeps the expected negative sign in lower quantiles of the distribution, denoting an inverse relationship with maturity as expected. Regarding GDP growth, negative significant coefficients disappear and there is no relationship. Similarly, public expenditure and net lending/borrowing variables remain positive for higher values of maturity $q(0.95)$.

Table 6 Quantile Regression Controlling for the Size of the Public Debt Market

Dependent variable: average maturity	Quantiles					OLS
	q(0.05)	*q*(0.25)	*q*(0.5)	*q*(0.75)	*q*(0.95)	
GDP	-1.456 (2.430)	-2.814 (2.530)	-3.734 (3.384)	-2.104 (3.933)	3.855 (2.634)	-0.00927 (1.989)
Spread	-31.44*** (7.470)	-37.81* (20.79)	-34.86** (16.30)	-8.411 (23.86)	-6.160 (5.126)	-14.36 (10.58)
Debt	1.880*** (0.643)	1.842* (1.009)	1.146 (0.870)	1.440 (1.731)	-0.448 (0.609)	2.154*** (0.560)
Exp	1.529 (4.797)	0.341 (4.073)	-2.338 (3.949)	5.307 (6.266)	7.981*** (2.041)	2.131 (1.963)
Net	1.276 (4.858)	-0.870 (6.267)	0.150 (5.679)	13.08 (10.89)	11.31*** (2.998)	8.922*** (3.082)
HICP	4.328 (6.090)	2.538 (10.48)	-4.806 (10.75)	0.847 (12.06)	6.276 (5.611)	-3.957 (8.839)
Held	-0.365 (0.778)	-1.938 (2.010)	-0.731 (1.454)	-2.277 (4.866)	-0.149 (0.814)	-2.356** (1.083)
REER	0.0269*** (0.00959)	0.0307 (0.0387)	0.0273 (0.0278)	0.0363* (0.0209)	-0.0286 (0.0183)	0.0146 (0.0144)
Score	-0.0833* (0.0429)	-0.0301 (0.0396)	-0.0259 (0.0384)	0.00711 (0.0300)	-0.00438 (0.0184)	-0.0375** (0.0171)
Greece dummy	2.153*** (0.763)	2.613** (1.118)	2.630*** (0.925)	7.503 (8.027)	9.056*** (1.421)	3.720*** (0.842)
Constant	4.669* (2.745)	2.101 (4.508)	5.212 (5.615)	-0.948 (4.505)	5.854 (3.626)	4.097 (2.718)
Time trend	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
N	279	279	279	279	279	275
R-squared	0.199	0.273	0.230	0.339	0.222	0.424

Notes: The table shows quantile regressions for the 0.05, 0.25, 0.5, 0.75 and 0.95 quantiles (excluding Malta and Baltic countries - Estonia and Lithuania - from the analysis). Robust standard errors are shown in parentheses. Following the notes of Baum (2013), we also display the results for the OLS estimation with robust standard errors clustered at the country level to compare the results with the quantile regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Own elaboration.

Table 7 shows the results without data for Denmark and Finland, as data for these countries exhibit odd behaviors in terms of maturity evolution. From Figure 1, it seems that these countries maintain a constant evolution of average maturity with sudden jumps. We thus perform estimations without them. The results displayed are very similar to those shown in Table 5. The spread also presents a negative relationship in the lower quantiles although it loses its significance for the median regression. A similar trend is found for the debt-to-GDP ratio, which only remains significant and positive for the lower quantile. GDP growth shows a negative coefficient for the 0.05 quantile as listed in Table 5.

Table 7 Quantile Regression Controlling for Atypical Behaviors in the Evolution of Average Debt Maturity

Dependent variable: average maturity	**Quantiles**					**OLS**
	***q*(0.05)**	***q*(0.25)**	***q*(0.5)**	***q*(0.75)**	***q*(0.95)**	
GDP	-3.369* (1.886)	-2.069 (2.450)	-5.090 (3.530)	-1.674 (4.380)	-0.294 (2.608)	-0.363 (1.756)
Spread	-36.87*** (7.237)	-30.11* (17.46)	-24.66 (23.88)	-1.487 (21.03)	-4.112 (6.432)	-2.514 (8.655)
Debt	1.784*** (0.533)	0.838 (1.257)	0.674 (0.949)	1.328 (1.124)	-1.062 (0.832)	1.303** (0.506)
Exp	1.070 (4.669)	4.187 (5.035)	1.218 (7.743)	6.520 (8.084)	3.538 (4.869)	3.844 (2.755)
Net	3.403 (6.420)	8.986 (8.608)	7.415 (11.40)	15.39 (15.85)	6.247 (5.035)	13.75*** (4.084)
HICP	5.925 (8.405)	-3.635 (11.94)	-4.176 (11.67)	3.591 (14.04)	-2.975 (5.671)	-11.39* (6.843)
Held	-0.779 (0.821)	-0.874 (1.690)	-0.799 (2.241)	-2.087 (2.715)	0.811 (1.063)	-1.343 (0.957)
REER	0.0205 (0.0192)	0.0175 (0.0224)	0.0339 (0.0210)	0.0206 (0.0263)	-0.0601*** (0.0172)	0.0168 (0.0130)
Score	-0.0981*** (0.0334)	-0.0251 (0.0419)	-0.00971 (0.0435)	0.0155 (0.0447)	-0.0543** (0.0261)	-0.0320* (0.0193)
Greece dummy	2.539*** (0.860)	3.394*** (1.075)	3.134* (1.593)	6.759 (5.729)	8.621*** (1.643)	3.734*** (0.953)
Constant	6.793* (3.514)	1.866 (5.008)	2.486 (6.843)	-0.502 (7.731)	14.95*** (4.507)	3.535 (2.873)
Time trend	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
N	265	265	265	265	265	255
R-squared	0.190	0.293	0.296	0.387	0.251	0.450

Notes: The table shows quantile regressions for the 0.10, 0.25, 0.5, 0.75 and 0.95 quantiles (excluding Finland and Denmark from the analysis). Robust standard errors clustered at the country level are shown in parentheses. Following the notes of Baum (2013), we also display the results for the OLS estimation with robust standard errors clustered at the country level to compare the results with the quantile regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Own elaboration.

In short, the results that do not consider countries with small debt markets (Malta and the Baltic countries) or countries presenting odd trends such as Finland and Denmark do not differ considerably from those listed in the previous section.

For a more thorough analysis, we consider the importance of the Euro as a determining factor in the relationship between maturity and the explanatory variables. For this scenario, we perform an estimation that considers countries that have adopted the Euro and those that have not using a dummy that takes a value of one in the former case and a value of zero otherwise. The results are shown in Tables 8 and 9.

Table 8 Quantile Regression for Eurozone Countries

Dependent variable: average maturity	**Quantiles**					**OLS**
	***q*(0.05)**	***q*(0.25)**	***q*(0.5)**	***q*(0.75)**	***q*(0.95)**	
GDP	-5.564 (13.68)	-2.630 (19.24)	-3.225 (6.742)	6.220 (23.79)	18.85*** (3.079)	9.722* (5.410)
Spread	-49.91 (33.99)	-32.08* (18.49)	-18.46 (23.32)	9.520 (220.1)	8.690 (9.219)	2.449 (11.47)
Debt	2.768* (1.642)	2.017 (1.519)	1.459 (1.528)	1.232 (3.501)	1.454* (0.780)	2.217*** (0.632)
Exp	0.0793 (7.479)	-5.041 (8.006)	-5.208 (9.241)	-1.218 (18.66)	-0.856 (7.205)	-2.664 (3.104)
Net	1.565 (11.57)	-2.242 (8.413)	0.362 (12.39)	3.934 (15.72)	0.960 (6.111)	2.519 (3.335)
HICP	-18.58 (23.31)	-26.23 (37.40)	-17.90 (16.38)	-25.88 (41.07)	-19.44* (10.59)	-37.55** (17.42)
Held	-1.392 (2.232)	-0.523 (2.611)	-1.405 (3.408)	-0.574 (12.10)	1.026 (2.163)	-1.263 (1.059)
REER	0.0216 (0.0510)	-0.00542 (0.0364)	-0.0329 (0.0202)	-0.0603 (0.0482)	-0.0735*** (0.0115)	-0.0411** (0.0158)
Score	-0.0868 (0.0611)	-0.0430 (0.102)	-0.0526 (0.0371)	-0.00343 (0.148)	0.0474 (0.0434)	-0.0325 (0.0208)
Greece dummy	2.467 (1.621)	2.245 (1.777)	2.866 (1.926)	4.964 (38.53)	7.531*** (2.554)	2.796*** (0.830)
Constant	7.142 (8.464)	8.887 (11.31)	13.78** (6.401)	11.34 (15.60)	7.830 (6.535)	10.92*** (3.387)
Time trend	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
N	145	145	145	145	145	145
R-squared	0.251	0.369	0.443	0.465	0.371	0.542

Notes: The table shows quantile regressions for the 0.10, 0.25, 0.5, 0.75 and 0.95 quantiles for Eurozone countries. Robust standard errors are shown in parentheses. Following the notes of Baum (2013), we also display the results for the OLS estimation with robust standard errors clustered at the country level to compare the results with the quantile regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Own elaboration.

According to the results, effects of risk on maturity are only found for the 0.25 quantile, indicating that the negative relationship with risk is only significant for low values of maturity. Regarding the debt-to-GDP ratio, only the distribution extremes, quantiles 0.05 and 0.95, produce significant coefficients. This indicates that in countries that use the Euro, debt levels only affect maturity for low and high values of the latter. This is in line with our hypothesis and with the arguments of Eichler and Maltritz (2013) who argue that country indebtedness levels only increase short-term security risks. Therefore, countries presenting high levels of debt are more prone to issuing long-term debt. For GDP growth, the table shows positive relationships for only higher levels of maturity as anticipated in the hypothesis section. Nevertheless, this is the only evidence available for these results. Therefore, according to our estimations, this positive relationship only holds for Eurozone countries with long maturities.

Table 9 Quantile Regression for Non-Eurozone Countries

Dependent variable: average maturity	Quantiles					OLS
	q(0.05)	*q*(0.25)	*q*(0.5)	*q*(0.75)	*q*(0.95)	
GDP	-2.552 (3.223)	-2.843 (2.957)	-2.301 (5.082)	-1.561 (6.795)	-1.794 (1.239)	-1.386 (2.092)
Spread	-38.51*** (14.68)	-28.92* (15.70)	-41.63 (34.30)	-47.42* (26.48)	-24.18*** (9.183)	-35.78*** (11.01)
Debt	0.855 (1.280)	1.577 (1.423)	0.774 (1.236)	1.040 (1.186)	-0.998** (0.392)	0.841* (0.451)
Exp	7.461 (5.297)	4.152 (6.007)	-0.852 (8.864)	2.618 (5.631)	3.754 (2.600)	2.480 (2.699)
Net	-4.310 (7.431)	-1.434 (11.05)	-4.286 (18.39)	7.152 (19.23)	7.488 (9.249)	6.661 (5.886)
HICP	15.15 (10.12)	6.107 (10.68)	7.523 (21.37)	11.36 (9.835)	20.07** (8.596)	10.22 (7.821)
Held	-3.922 (3.183)	-3.893 (4.384)	-2.192 (5.238)	-4.197 (3.423)	-2.735*** (0.810)	-2.309 (1.669)
REER	0.0719*** (0.0203)	0.0657*** (0.0225)	0.0658* (0.0340)	0.0364 (0.0566)	-0.0454** (0.0225)	0.0474** (0.0197)
Score	-0.0649 (0.0402)	-0.0206 (0.0431)	0.00614 (0.0475)	-0.0176 (0.0488)	-0.0340 (0.0216)	-0.0306 (0.0261)
Constant	-3.325 (5.175)	-3.734 (4.744)	-1.375 (6.825)	1.997 (10.02)	12.10*** (3.907)	0.925 (3.851)
Time trend	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
N	156	156	156	156	156	145
R-squared	0.223	0.268	0.250	0.305	0.054	0.353

Notes: The table shows quantile regressions for the 0.10, 0.25, 0.5, 0.75 and 0.95 quantiles for non-Eurozone countries. Robust standard errors are shown in parentheses. Following the notes of Baum (2013), we also display the results for the OLS estimation with robust standard errors clustered at the country level to compare the results with the quantile regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Own elaboration.

The results for non-Eurozone countries are shown in Table 9. Our analysis of the results suggests that risk is the most important driver of maturity for this group of countries, as negative and significant coefficients are found along almost the entire distribution. Nevertheless, despite these Eurozone states, effects of debt levels and GDP growth on maturity disappears. Therefore, our analysis of Euro an non-Euro countries shows that the debt-to-GDP ratio affects countries that use the Euro more, although risk is also significant for low to medium values of maturity, and sovereign risk influences the maturity of states to a greater extent when the Euro is not used as a form of currency.

5. Conclusion and Policy Implications

This paper analyzes the determinants of sovereign debt maturity for a set of 23 European countries during the period from 1995 to 2013. The paper aims to empirically test which forces drives sovereign debt maturity in developing countries, taking into account the recent episode of sovereign debt crisis. For this purpose, we test the effect of business cycle, sovereign risk and indebtedness level, along with a set of control variables, on maturity because, according to the literature, these three variables appear to be the main determinants of sovereign debt maturity.

To this end, we use quantile regressions with robust standard errors clustered by countries to gain a more complete picture of how this set of variables affects the different quantiles of the conditional distribution of maturity. We have also considered the effects of debt size, of atypical behaviors in the evolution of maturity debt and of the Euro currency to determine whether the results remain stable.

According to the results, there is no evidence of a relationship between the business cycle and debt maturity, as those countries that face lower growth levels tend to increase maturity levels to avoid debt repayment problems in the short-term, as they do not generate enough income to meet their payments. These countries are thus prone to lengthening the maturity structure during a recession or low growth period. We also find evidence of a fairly robust positive relation between maturity and the indebtedness level of the country. This relationship is particularly significant for low values of maturity, which suggests that countries with lower maturities have more room to lengthen the maturity structure as they increase their debt level.

Regarding risk, the results confirm the existence of an inverse relationship between average maturity and sovereign risk for medium and low values of average maturity. According to this finding, countries that face higher risk and show a more reduced average maturity are more prone to shorten their maturity structure in the presence of sovereign risk than countries with longer maturities. Therefore, those countries are in a riskier situation in the case of a sovereign debt crisis because the crisis can quickly spread, forcing the countries to reduce their maturity and pushing them toward default or debt renegotiations. To avoid such a situation, countries should implement measures to lengthen the maturity structure to limit the effects of the crisis. This approach is in line with previous studies that state that a long and balanced maturity structure significantly reduces the effect of a sovereign debt crisis.

In addition, the analysis for Eurozone members and non-member countries provides some interesting insights. First, risk seems to have more significance as a determining factor in non-Eurozone countries, and the debt-to-GDP ratio appears to be one of the main determinants in Eurozone countries. Therefore, non-Eurozone countries face a higher risk of shortening their maturity structure during periods of financial turmoil.

These results provide a starting point in gaining a better understanding of the forces that drive sovereign debt maturity. This information allows public authorities to determine what mechanisms to use should they need to lengthen the maturity structure of sovereign debt to smooth the effects of a debt crisis. According to our results, countries that face higher spread risk and have lower maturities are more prone to shortening their maturity structure, which in turn will increase funding costs and the risk of default. This is particularly important for non-Eurozone members. Therefore, the implementation of measures designed to increase the average maturity will reduce such harmful effects on public debt. Furthermore, a balanced debt-to-GDP ratio will provide greater stability for the maturity structure of debt. Given the positive relationship between maturity and debt-to-GDP ratios, there should be equilibrium between the size of debt and the maturity structure.

References

Alesina, Alberto, Mark De Broeck, Allessandro Prati, and Guido Tabellini. 1992. "Default Risk on Government Debt in OECD Countries." *Economic Policy*, 15(15): 427-463. http://dx.doi.org/10.2307/1344548

Alfaro, Laura, and Fabio Kanczuk. 2009. "Debt Maturity: Is Long-Term Debt Optimal?" *Review of International Economics*, 17(5): 890-905. http://dx.doi.org/10.1111/j.1467-9396.2009.00851.x

Angeletos, Georges-Marios. 2002. "Fiscal Policy with Noncontingent Debt and the Optimal Maturity Structure." *The Quarterly Journal of Economics*, 117(3): 1105-1131. http://dx.doi.org/10.1162/003355302760193977

Arellano, Cristina, and Ananth Ramanarayanan. 2012. "Default and the Maturity Structure in Sovereign Bonds." *Journal of Political Economy*, 120(2): 187-232. http://dx.doi.org/10.1086/666589

Bai, Yan, Seon Tae Kim, and Gabriel P. Mihalache. 2015. "The Maturity and Payment Schedule of Sovereign Debt." National Bureau of Economic Research Working Paper 20896. http://dx.doi.org/10.3386/w20896

Barro, Robert J. 1979. *On the Determination of the Public Debt*. Chicago: University of Chicago Press.

Baum, Christopher F. 2013. "Quantile Regression." http://fmwww.bc.edu/EC-C/S2013/823/EC823.S2013.nn04.slides.pdf.

Bernoth, Kerstin, Jürgen von Hagen, and Ludger Schuknecht. 2012. "Sovereign Risk Premiums in the European Government Bond Market." *Journal of International Money and Finance*, 31(5): 975-995. http://dx.doi.org/10.1016/j.jimonfin.2011.12.006

Bodnaruk, Andriy. 1999. "Determinants of Sovereign Debt Term for Transition Countries." http://www.kse.org.ua/uploads/file/library/1999/Bodnaruk.pdf.

Broner, Fernando A., Guido Lorenzoni, and Sergio L. Schmukler. 2013. "Why Do Emerging Economies Borrow Short Term?" *Journal of the European Economic Association*, 11(S1): 67-100. http://dx.doi.org/10.1111/j.1542-4774.2012.01094.x

Broner, Fernando A., Aitor Erce, Alberto Martin, and Jaume Ventura. 2014. "Sovereign Debt Markets in Turbulent Times: Creditor Discrimination and Crowding-Out Effects." *Journal of Monetary Economics*, 61(C): 114-142. http://dx.doi.org/10.1016/j.jmoneco.2013.11.009

Calvo, Guillermo A., and Pablo E. Guidotti. 1992. "Optimal Maturity of Nominal Government Debt: An Infinite-Horizon Model." *International Economic Review*, 33(4): 895-919. http://dx.doi.org/10.2307/2527149

Chatterjee, Satyajit, and Burcu Eyigungor. 2012. "Maturity, Indebtedness, and Default Risk." *American Economic Review*, 102(6): 2674-2699. http://dx.doi.org/ 10.1257/aer.102.6.2674

Cole, Harold L., and Timothy J. Kehoe. 2000. "Self-Fulfilling Debt Crises." *The Review of Economic Studies*, 67(1): 91-116. http://dx.doi.org/10.1111/1467-937X.00123

De Haan, Jakob, Bernd Jan Sikken, and Andrew Hilder. 1995. "On the Relationship between the Debt Ratio and Debt Maturity." *Applied Economics Letters*, 2(12): 484-486. http://dx.doi.org/10.1080/135048595356934

Drudi, Francesco, and Raffaela Giordano. 2000. "Default Risk and Optimal Debt Management." *Journal of Banking & Finance*, 24(6): 861-891. http://dx.doi.org/10.1016/S0378-4266(99)00110-7

Eichler, Stefan, and Dominik Maltritz. 2013. "The Term Structure of Sovereign Default Risk in EMU Member Countries and Its Determinants." *Journal of Banking & Finance*, 37(6): 1810-1816. http://dx.doi.org/10.1016/j.jbankfin.2012.02.002

Equiza-Goñi, Juan. 2016. “Government Debt Maturity and Debt Dynamics in Euro Area Countries.” *Journal of Macroeconomics*, 49(C): 292-311. http://dx.doi.org/10.1016/j.jmacro.2016.01.005

Fontaine, Patrice, and Sujiao Zhao. 2014. “On Debt Maturities of Firms and Refinancing Risk: A Consideration of Heterogeneous Effects and Extreme Cases.” Cahier de Recherche Working Paper 2014-02.

Goudswaard, Kees P. 1990. “Determinants of Public Debt Maturities.” *De Economist*, 138(1): 33-46.

Hatchondo, Juan Carlos, and Leonardo Martínez. 2009. “Long-Duration Bonds and Sovereign Defaults.” *Journal of International Economics*, 79(1): 117-125. http://dx.doi.org/10.1016/j.jinteco.2009.07.002

Jeanne, Olivier. 2009. “Debt Maturity and the International Financial Architecture.” *American Economic Review*, 99(5): 2135-2148. http://dx.doi.org/10.1257/aer.99.5.2135

Kim, Tae-Hwan, and Halbert White. 2003. “Estimation, Inference and Specification Testing for Possibly Misspecified Quantile Regressions.” In *Maximum Likelihood Estimation of Misspecified Models: Twenty Years Later*, ed. Thomas B. Fomby and R. Carter Hill, 107-132. New York: Elsevier.

Koenker, Roger, and Gilbert Bassett Jr. 1978. “Regression Quantiles.” *Econometrica*, 46(1): 33-50. http://dx.doi.org/10.2307/1913643

Koenker, Roger, and Kevin F. Hallock. 2001. “Quantile Regression.” *Journal of Economic Perspectives*, 15(4): 143-156. http://dx.doi.org/10.1257/jep.15.4.143

Koenker, Roger. 2005. *Quantile Regression*. New York: Cambridge University Press.

Lee, Hei Wai, Yan Alice Xie, and Jot Yau. 2011. “The Impact of Sovereign Risk on Bond Duration: Evidence from Asian Sovereign Bond Markets.” *International Review of Economics & Finance*, 20(3): 441-451. http://dx.doi.org/10.1016/j.iref.2010.11.020

Machado, José A. F., and José Mata. 2005. “Counterfactual Decomposition of Changes in Wage Distributions Using Quantile Regression.” *Journal of Applied Econometrics*, 20(4): 445-465. http://dx.doi.org/10.1002/jae.788

Missale, Alessandro, and Olivier J. Blanchard. 1994. “The Debt Burden and Debt Maturity.” *The American Economic Review*, 84(1): 309-319.

Molinari, Massimo, Silvia Giannangeli, and Giorgio Fagiolo. 2016. “Financial Structure and Corporate Growth: Evidence from Italian Panel Date.” *Economic Notes*, 45(3): 303-325. http://dx.doi.org/10.1111/ecno.12059

Niepelt, Dirk. 2014. “Debt Maturity without Commitment.” *Journal of Monetary Economics*, 68(S): 37-54. http://dx.doi.org/10.1016/j.jmoneco.2014.08.006

Parente, Paulo M. D. C., and João M. C. Santos Silva. 2015. “Quantile Regression with Clustered Data.” *Journal of Econometric Methods*, 5(1): 1-15. http://dx.doi.org/10.1515/jem-2014-0011

Park, Chul Woo. 1999. “Maturity Structure of Public Debt and Expected Bond Returns.” *Journal of Banking & Finance*, 23(9): 1407-1435. http://dx.doi.org/10.1016/S0378-4266(99)00009-6

Perez, Diego. 2013. “Sovereign Debt Maturity Structure under Asymmetric Information.” Stanford Institute for Economic Policy Research Discussion Paper 12-020.

Xie, Yan Alice, Sheen Liu, Chunchi Wu, and Bing Anderson. 2009. “The Effects of Default and Call Risk on Bond Duration.” *Journal of Banking & Finance*, 33(9): 1700-1708. http://dx.doi.org/10.1016/j.jbankfin.2009.04.004

Appendix

Table 10 Variables Included in the Analysis

Variable	Description	Source
Maturity	Average maturity of sovereign debt in years.	European Central Bank Statistical Data Warehouse
Growth GDP *per capita*	Interannual growth of the GDP *per capita*.	Eurostat
Spread USA	Spread between the 10 year government bond yields of the countries analyzed and the U.S. government bond yield of the same maturity.	Own elaboration from data obtained from Eurostat and the Federal Reserve Bank of St. Louis
Long-term interest rate	Annual average of 10 year bonds sovereign yields.	Eurostat
Debt-to-GDP ratio	Gross government debt to GDP ratio.	European Central Bank Statistical Data Warehouse
Inflation	Harmonized index of consumer prices (HICP) calculated as the annual average rate of change.	European Central Bank Statistical Data Warehouse
Government expenditure	Government total expenditure as a % of GDP.	European Central Bank Statistical Data Warehouse
Deficit/surplus	Net lending/net borrowing by the general government sector.	European Central Bank Statistical Data Warehouse
Debt held by non-residents	Government debt held by non-residents as % of GDP.	European Central Bank Statistical Data Warehouse
Real effective exchange rate	Real effective exchange rate for 42 competitors countries (EU28 along with Australia, Brazil, Canada, China, Hong Kong, Japan, Norway, New Zealand, Mexico, Russia, South Korea, Switzerland, USA and Turkey).	Eurostat
Gross debt issues to GDP ratio	Total gross debt issues as a % of GDP.	European Central Bank Statistical Data Warehouse
Overall score	Overall score of the Heritage Foundation index.	Heritage Foundation
Investment freedom	Index of investment freedom.	Heritage Foundation
Financial freedom	Index of financial freedom.	Heritage Foundation
Crisis	Dummy variable that takes the value 1 from 2007 and 0 otherwise.	Own elaboration
Sovereign crisis	Dummy variable that takes the value 1 from 2010 and 0 otherwise.	Own elaboration
EU	Dummy variable that takes the value 1 since the year in which each country entered in the European Union and 0 otherwise.	Own elaboration
Euro	Dummy variable that takes the value 1 since the year in which each country adopted Euro as national currency in the European Union and 0 otherwise.	Own elaboration

Notes: The table shows the main variables included in the empirical analysis along with a brief definition and the source from which they have been obtained.

Source: Own elaboration.

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