



**LISBOA
SCHOOL OF
ECONOMICS &
MANAGEMENT**

MASTER IN FINANCE

MASTER FINAL WORK

DISSERTATION

**HOW DID THE PUBLIC DEBT RISK OF THE PIIGS (PORTUGUESE, IRELAND,
ITALY, GREECE AND SPAIN) PROGRESSED COMPARED TO GERMANY FOR
DIFFERENT YIELDS, BETWEEN 2000 AND 2013?**

LILIANA MARTINS MIROTO

LISBON, SEPTEMBER 30TH OF 2013



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Acronyms and Abbreviations:

EC – European Commission

EMU- European Monetary Union

GDP- Gross Domestic Product

HS- Historical Simulation

iid- independent and identically distributed

YTM- Yield to Maturity

Y- years

PIIGS – Portugal, Ireland, Italy, Greece and Spain

SWEAP- South West Eurozone Periphery

VaR- Value at Risk

Abstract

In recent years, we have observed an increase in sovereign debt on countries such as the PIIGS (Portugal, Greece, Ireland, Italy and Spain). This led investors to, gradually start to refuge their investments in safer countries like Germany. That is why, this is a hot topic in economic policy debate since the beginning of the crisis and represents an important issue for those who invest in these countries.

In this work we intend to study how did the public debt risk for PIIGS progressed, comparatively with Germany in different yields (2, 5 and 10 years), between 2000 and 2013. To measure this risk we used a well know measure, called Value at Risk. But, is VaR an appropriated valuation method of sovereign debt risks? In that sense, this work is innovative. Despite being a very relevant subject, no evidence was found on studies done of the use of VaR to measure this type of risk faced by European investors.

From the point of view of the investor an important issue is performed, what was the risk perception, between 2000 and 2002 (period of entry into force of the Euro) and between 2002 and 2008 (period pre-crisis)? And after 2008 (financial crisis and sovereign debt crisis)? And ultimately, what can explain the debt sovereign crisis in terms of credit risks?

The main conclusions of this work are that PIIGS, present higher volatility, which means they are riskier countries, also present higher VaR and low correlation, in contrast to what is observed in Germany. Another conclusion reached is that, the results are different depending on the period and country. Between 2000 and 2012, for Germany was more favourable the longer terms to invest, while for PIIGS was more favourable short terms to invest. However, we verify a different trend between 2012 and 2013. Since the potential loss is higher on long term, is more favourable to invest in shorter terms, also for PIIGS and Germany.

KEY WORDS: Risk, Value at Risk, Sovereign Risk, Public Debt, PIIGS, Germany

Resumo

Nos recentes anos temos vindo a observar um aumento da dívida soberana nos países como os PIIGS (Portugal, Grécia, Irlanda, Itália e Espanha). Isto fez com que os investidores, gradualmente começassem a refugiar os seus investimentos em países seguros como a Alemanha. É por isso, que este é um tema de extrema importância no debate da política económica desde o início da crise e representa um importante ponto para os investidores que investem nestes países.

Neste trabalho, queremos perceber como progrediu o risco da dívida pública para os PIIGS, comparativamente com a Alemanha para as diferentes *yields* (2, 5 e 10 anos), entre 2000 e 2013. Para medir este risco usamos uma medida bastante conhecida, chamada *Value at Risk (VaR)*. Mas, será este VaR um método de avaliação apropriado do risco de dívida soberana? Nesse sentido, este trabalho é inovador. Embora sendo um tema muito relevante, nos estudos já realizados não há evidências do uso do VaR para medir este tipo de risco sentido pelos investidores Europeus.

Do ponto de vista do investidor, uma questão importante surge, qual foi a percepção do risco, entre 2000 e 2002 (período em que o EURO entrou em vigor), e entre 2002 e 2008 (período antes da crise)? E depois de 2008 (crise financeira e crise da dívida soberana)? E por fim, o que é que pode explicar a crise da dívida soberana em termos de risco de crédito?

As principais conclusões deste trabalho são que os PIIGS, apresentam uma volatilidade elevada, o que significa que são países com maior risco, o que implica um elevado VaR e uma baixa correlação em contraste com o que é observado na Alemanha. Outra conclusão obtida foi a de que os resultados do VaR são diferentes dependendo do país e do período em questão. Entre 2000 e 2012, para a Alemanha era mais favorável investir no longo prazo enquanto que para os PIIGS era mais favorável investir no curto prazo. Contudo, verificámos uma tendência diferente entre 2012 e 2013. Tendo em conta que a perda potencial é maior no longo prazo, é mais favorável investir no curto prazo, tanto para os PIIGS como para a Alemanha.

PALAVRAS CHAVE: Risco, Value at Risk, Risco Soberano, Dívida Publica, PIIGS e Alemanha.

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I. Introduction

The public debt sustainability of finances refers to the ability and willingness of a country to repay its debt. Since the financial crisis, and more recent, the Europe sovereign crisis this has been a frequently discusses and relevant topic. In recent years, we have observed an increase in sovereign debt in countries such as PIIGS¹. We see that investors gradually began to refuge their investments in safer countries such as Germany. For this reason, this topic represents an important issue for those who invest in these countries, because it allows us to reach some conclusions, observing the risk that public debt is really facing, which is consistent with performance presented by each country.

The main purpose of this work is to answer an important question: how the public debt risk of the PIIGS progressed comparatively with Germany for different yields, between 2000 and 2013? To answer this main question, is necessary to understand some current European issues. From the point of view of the investor an important issue is performed: what was the risk perception, between 2000 and 2002 (period of entry into force of the Euro) and between 2002 and 2008 (period pre-crisis)? And after 2008 (financial crisis and sovereign debt crisis)? And, what can explain the debt sovereign crisis in terms of credit risks? And finally, is VaR an appropriated valuation method of sovereign debt risks?

For this objective, the following countries chosen, were the PIIGS, because they are facing serious fiscal constraints, which are reflected by the high yield, demanded from the government bonds of these countries. Germany was also chosen due to opposite role, since it works as a refuge of those investors.

Until the recent financial crisis of 2008, yields between the PIIGS and Germany remain much closed. Yet, in the last years, particularly with the sovereign debt crisis

¹ To have a better perception of the increase in each country, see figure 3 in appendix.

since 2010, PIIGS yields in secondary market have significantly increased, while at the same time, investors refuge in German Bonds. Why has the market perception of risk changed so abruptly?

In financial mathematics and risk management, VaR emerged as one of the most intuitive, comprehensive and commonly used risk measures of potential loss on a portfolio of financial instruments. It measures the worst expected loss of a portfolio over a given time horizon at a given level of confidence. Every assessment of public finance sustainability contains uncertainty; the use of VaR framework for sustainability takes into consideration uncertainty, when forecasting future values of relevant variables such as public debt.

The main conclusions of this work are that PIIGS, present higher volatility, which means they are riskier countries, also present higher VaR and low correlation, in contrast to what is observed in Germany. Another conclusion reached is that, the results are different depending on the period and country. For instance, between 2000 and 2012, for Germany was more favourable the longer terms to invest, while for PIIGS was more favourable shorter terms to invest. However, we verify a different trend between 2012 and 2013. Since the potential loss is higher on long term, is more favourable to invest in shorter terms, also for PIIGS and Germany.

The remainder of the paper is organized as follows. Section 2 is about literature review on sovereign risk. In Section 3 the methodology is developed and a descriptive analysis of the data is performed. Section 4 is related to the analysis and the discussion of main results and the last Section 5 relates to the findings achieved.

II. Literature Review

2.1 What is Risk?

“Although in modern parlance the term risk has come to mean “danger of loss”, finance theory defines risks as the dispersion of unexpected outcomes due to movements in financial variables.” (Jorion, 2001)

Jorion (2001) also defined *Risk*, as the uncertainty of outcomes and it is the best measure in terms of probability distribution function. On Reuters Glossary², Risk is defined as *the possibility that an investment or venture will make a loss or not make the returns expected.*

Knight (1921)³ wrote a statement which is a very famous definition of risk: *“To preserve the distinction ... between the measurable uncertainty and an unmeasurable one we may use the term “risk” to designate the former and the term “uncertainty” for the latter.”* He also said that, *“The word “risk” is ordinarily used in a loose way to refer to any sort of uncertainty viewed from the standpoint of the unfavourable contingency...”*

Damodaran (2003) said that those who are exposed to *risk*, can have negative consequences, but, those who use it to advantage, risk is the reason for higher returns. *“Risk can be both a threat to a firm’s financial health and an opportunity to get ahead of the competition”* (Damodaran, 2003).

Financial risks can be defined as the possibility of losses in financial market, due to interest rate movements or defaults on financial obligations. Giesecke (2002) added that, *financial risks refer to unexpected adverse changes in the market value of some financial position, for example a single bond, stock, option, or other derivative, or a portfolio of various securities.*

² <http://glossary.reuters.com/index.php?title=Risk>

³ See Holton G. (2004)

Risk in finance can also be viewed as the variance in actual returns around the expected return (Damodaran, 2008). It measures an investment's variability of returns, that is, its volatility in relation to its average return. In academic terms, a high volatility implies a high degree of risk.

According to Jorion (2001), there are five categories of financial risks, which are: market risks, liquidity risks, operational risks, legal risks and credit risks.

Market risk is due to variations movements in level or volatility of market prices (Jorion, 2001). Giesecke (2002) said, for a bond for example, that market risk arises from the variability of interest rates. Others risks associated to market risk are currency risk, equity risk, commodity risk and volatility risk.

Liquidity risk refers to the inability to adjust positions at current market rates or increased funding costs (Giesecke, 2002). Jorion (2001), added that it can take two different but related forms: asset liquidity risk (or market/product liquidity risk) that arises when a transaction cannot be conducted at prevailing market prices due to the size of the position relative to normal trading lots. And funding liquidity risk (or cash flow risk) that refers to the inability to meet payments obligations, which may force early liquidation.

Operational risk corresponds to the possibility of mistakes, like human and technical errors or accidents (such as fraud, management failure and inadequate procedures and controls) as referred by Jorion (2001). Operational risks also can lead to credit risk with sources other than inadequate funding and market risk with a change in market factors.

Jorion (2001) stated that Legal risk arises when a transaction proves to be not applicable in law. It is related to credit risk since counterparties that lose money on a transaction may try to find legal grounds for invalidating the transaction.

Finally, Credit risk is the risk that counterparties may be unwilling or unable to

fulfil in their contractual obligations. Credit risk includes the sovereign risk, which is the risk associated to the sovereign debt. It refers to country-specific, while default risk is normally company-specific as mentioned by Jorion (2001). Therefore, it is necessary to understand the concept of sovereign risk. The next subchapter address that issue.

2.2 What is Sovereign Risk?

Most of sovereign debt takes the form of bonds, and as in this analysis are used government bond yields, the concept of Sovereign debt is therefore quite relevant.

Financial Times⁴ defines *Sovereign debt* as the debt that is issued by a national government; the government can employ different measures to guarantee repayment e.g. increase taxes or print money, so theoretically it's consider risk-free. Oxford Dictionaries⁵ defines *Sovereign debt* as “*the amount of money that a country's government has borrowed, typically issued as bonds denominated in a reserve currency*”. Or, according to Das et al (2012a) refers to debt issued or guaranteed by the government of a sovereign state.

As stated before, credit risk includes the sovereign risk, that is the risk associated to the sovereign debt.

Firstly, according to Reuters Glossary⁶, *credit risk* is the possibility that a bond issuer or other borrower will default and fail to pay the principal and interest when due. For a bond, the creditworthiness of its issuer, for example a (sovereign) government or a corporation, affects the bond price, since it is uncertain whether the issuer will be able to fulfil his obligations (coupon, principal repayment) or not (Giesecke, 2002). According to Manganeli and Engle (2001), *credit risk* refers to the potential loss through the incapacity of a counterpart to comply its obligations, which can be because of credit exposure, probability of default or loss in the event of default.

⁴ <http://lexicon.ft.com/Term?term=sovereign-debt>

⁵ <http://oxforddictionaries.com/definition/english/sovereign-debt>

⁶ http://glossary.reuters.com/index.php?title=Credit_Risk

Secondly, Reuters Glossary defines that “*Sovereign risk* refers to the risk that a government or an agency backed by a government will not pay the interest according to the terms of a loan agreement and instead will default”.

2.3 Literature on sovereign risk

Literature on sovereign risk is scarce, despite the relevance of the theme. However, some authors like Bruder et al (2011), Gapen et al (2008), Sgherri and Zoli (2009), Afonso et al (2012a), Afonso and Nunes (2012b), Baldacci and Kumar (2010) and Aizenman et al (2011), wrote about sovereign risk assessment, that it is described later. In this section is described some literature on sovereign risk.

Das et al (2012b) argued that the key legacy of Global financial crisis is that sovereign risk is more than just a pure fiscal risk. They define Sovereign risk as a complex combination of risks that feed a number of channels into the sovereign balance sheet in a non-monotonic fashion⁷. They propose expanding the concepts developed in the macro-fiscal and macro-prudential literature to incorporate the macro-financial risks that sovereigns face. For instance, credit risk from systemic financial institutions will lead through the contingent liabilities component of the sovereign balance sheet, while market risk will affect the fiscal revenue and international reserves components.

Castillo (2004) defined sovereign risk as the risk that the government will not service its debt in full and on time and its analysis is related to the ability, flexibility and willingness that the government has to take appropriate policy measures to ease its debt servicing.

As stated by Gapen et al (2008), the most important type of risk in sovereign risk is the risk of default, so they considered that sovereign default is a result of accumulated distress and the risk of sovereign default is determined by the interaction of value of

⁷ See Figure 4, Das U. et al (2012), “Sovereign Risk: A Macro-Financial Perspective”. ADBI Working Paper Series, paper no. 383

sovereign assets, asset volatility and leverage.

2.4 Sovereign Risk Assessment

There are different types of studies according the different approaches used, using different inputs for the assessment of sovereign risk. However, there are not studies done on this subject using VaR.

The major studies available on this subject typically, have the same data used on this thesis, some countries of European Monetary Union are the same, and the period in analysis is the same (before, during and after the global financial crisis), but were done with different factors, namely Government bond yields spreads, Credit Default Swaps, ratings and were measured by econometric tests. The main objective of these studies is to assess if some fundamentals (macro, fiscal, liquidity risk, international risk) explained well the Government bond yields spreads and the other factors.

There is a substantial amount of literature on this subject, but the results are uneven, since there are many factors that may influence the sovereign spreads. On the appendix are listed some of the studies on a conceptual framework (table IV), that contributed to literature exploring alternative methodologies to measure and analyse sovereign risk.

For instance, Bruder et al (2011), present a useful framework to measure and analyse the sovereign risk of a bond portfolio. They define credit risk of a bond portfolio as the volatility of the CDS basket, that perfectly hedge the sovereign risk of the portfolio, which allows to compute the sovereign risk contribution of each country and monitor it across time. They concluded that indexation based on risk budgeting techniques is an efficient alternative compared to the traditional capitalisation-based approach to indexation. Also concluded that it is not enough and must be complemented by risk-based methods.

Gapen et al (2008) developed a new framework based on contingent claims that allows to measure and to analyse risk arising from the public sector (government and monetary authorities) balance sheet. The contingent claims are used to construct a marked to market balance sheet (that provides a structural framework that identifies balance sheet risks, incorporates uncertainty, and yields quantifiable risk indicators) and derive a set of forward-looking credit risk indicators that serve as a barometer of sovereign risk. They developed a set of risk indicators, like, distance to distress, risk-neutral probability of default, sovereign risk neutral credit spreads and value of senior foreign currency debt to measure sovereign balance sheet risk. Another step used by them is the Monte Carlo simulations and it is used to yield probability distributions and confidence intervals for the set of sovereign credit risk indicators. Sovereign bond spreads, spreads on sovereign CDS and implied probabilities from CDS markets.

The risk indicators when applied to a sample of emerging market economies shows to be robust and significant when compared with market observed credit spreads on foreign currency debt, even though the spreads were not used as inputs. This means that the level and variation of forward exchange rates and other market variables contain valuable information for analysing sovereign credit risk, which gives a stand for the approach used. The main results of this study include sovereign credit risk indicators (forward-looking market prices and nonlinear changes in values) and should have greater predictive power in estimating sovereign credit risk than would traditional macroeconomic vulnerability indicators or accounting-based ratios, sensitivity measures, and sovereign VaR.

Sgherri and Zoli (2009) used the spreads on yield on 10Y government bonds over Bunds, for some euro area members, together with by downgrades of sovereign debt ratings for three countries, Greece, Spain and Portugal and an alert for Ireland. This study is concerned about fiscal policies, default risk and global risk. These authors

concluded that fiscal policies through the use of public balance sheet are an important support in order to strengthen the financial system. The need to higher sovereign default risk premiums, for most countries, means that financial markets have answered to the significant deterioration in fiscal positions. Also concluded that global risks also played a significant role in explaining movements in euro area sovereign interest rate differentials.

According to Afonso et al (2012a), there are some studies on EMU government bond yields or their spread against Germany, that identified three main determinants of sovereign risk that are: first, the international risk factor, that captures the level of financial risk and unit prices, second is credit risk reflecting the probability of default normally used indicators of past or future fiscal performance, and third government bond yields are linked to liquidity risk. These authors used a set of fundamentals that are relevant for EMU members, as, macroeconomic and expected fiscal fundamentals, international risk, liquidity conditions and the risk of the crisis' transmission among EMU member states. They analyse three distinct time periods: first, the period preceding the global credit crunch (1999.01 – 2007.07); second, the period during which the global credit crunch had not yet mutated into a sovereign debt crisis (2007.08 – 2009.02); and third, the period during which the global financial crisis mutated into a sovereign debt crisis (2009.03 – 2010.12).

The conclusions of this study are different according to the periods defined previously, namely, during the pre-crisis period macro and fiscal fundamentals are usually not significant in explaining spreads. On the other hand, since summer 2007 the previous fundamentals explained spread movements well and were consistent with theoretical expectations. Additionally, the menu of fundamentals that are statistically significant in explaining spreads is supplemented since spring 2009, suggesting that markets are now pricing risks (risk of crisis transmission among the countries of the

European periphery, as well as from the periphery countries to the countries of the European core) which they did not consider previously, even within the crisis period. In contrast to the pre-crisis period, markets are now pricing the size, liquidity and maturity of debt issuances. Finally, sovereign credit ratings are statistically significant in explaining spreads, yet relative to macro- and fiscal fundamentals, their role has been rather limited.

Afonso and Nunes (2012b) performed an econometric analysis of the linkages between different economic forecasts and sovereign yield spreads, using 10-year government bond yields and considering as determinants the GDP real growth rate, the public debt-to-GDP ratio, the budget balance ratio, the inflation rate, given by the harmonised index of consumer prices (HICP), the real effective exchange rate, the current account balance, also as a percentage of GDP, the international risk, and monetary policy. The main conclusion is that corrections (particularly the corrections in fiscal variables- public debt and budget balance) in the European Commission forecasts do impinge on the 10-year sovereign bond yield spreads. This impact is different across countries, being more evident in countries with less favourable economic conditions. Higher credibility means yields will react less to changes in forecasts.

Baldacci and Kumar (2010), with data from 31 developed and in developing countries, between 1980 and 2008, examine the impact of fiscal deficits and public debt on long-term interest rates. The main result obtained is that the impact of fiscal deterioration on long-term interest rates is significant and robust but nonlinear. Basically, higher deficits and levels of public debt lead to a significant increase in long-term interest rates, and that the magnitude of such increase depends on the initial fiscal, institutional and structural conditions, and on the spillovers of the global financial markets.

Aizenman et al (2011) pricing sovereign risk for sixty countries based on fiscal

space (debt/tax and deficits/tax) and other economic fundamentals since 2005 to 2010. Their objective is to determine if the perception of relatively high sovereign default risk of the Euro area countries as seen in market pricing of CDS spreads focusing in particular on the five countries in the South-West Eurozone Periphery (Greece, Ireland, Italy, Portugal, and Spain), may be explained by existing past or current fundamentals of debt and deficits relative to tax revenue.

They find evidences that market-priced risk of sovereign debt as measured by CDS spreads is partly explained by fiscal space and other economic determinants. In addition to validating that fiscal space is an important determinant of market-based sovereign risk, find evidence of mispricing in SWEAP given current fiscal space and other current fundamentals: unpredicted low CDS in a quite period and unpredicted high during global crisis period, especially 2010 when sovereign debt crisis swept over Euro area.

They also found that SWEAP default risk is priced much higher than the “matched” (5 middle- income countries outside Europe, the ones close in terms of fiscal space (debt/tax)) countries in 2010, even allowing for differentials in fiscal space and other fundamentals. Their interpretation for the results is that market-priced risk of sovereign default follows waves of contagion, overreacting and mispricing risk of sovereign default over a period of several years. The extremely high CDS spreads in SWEAP in 2010, largely unpredicted by the model, can be explained by excessive pessimism and an overreaction to the fiscal deterioration. Other possible interpretation is that, CDS market is pricing default risk not primarily on current fundamentals but future fundamentals, expecting the SWEAP fiscal space to deteriorate markedly. The adjustment challenges of the SWEAP may be viewed as economically and politically more difficult due to exchange rate inflexibility associated with participation in the Euro area that is not a constraint in the matched group of the middle income countries.

2.5 Main Findings

The main findings can be summarised in the following steps: 1) Indexation based on risk budgeting techniques is an efficient alternative compared to the traditional capitalisation-based approach to indexation, but must be complemented by risk-based methods; 2) The sovereign credit risk indicators like forward-looking market prices and nonlinear changes in values should have greater predictive power in estimating sovereign credit risk than would traditional macroeconomic vulnerability indicators or accounting-based ratios, sensitivity measures, and sovereign VaR; 3) Fiscal policies through the use of public balance sheet help to reinforce the financial system. The higher sovereign default risk premiums means that financial markets have answered to the significant deterioration in fiscal positions. And global risks also played a significant role in explaining movements in euro area sovereign interest rate differentials; 4) During the pre-crisis period macro and fiscal fundamentals are not significant in explaining spreads, on the other hand, since 2007 that fundamentals explain very well spread movements and in 2009 fundamentals are supplemented, suggesting that markets are now pricing risks. In contrast to the pre-crisis period, in 2009 markets price the size, liquidity and maturity of debt issuances and sovereign credit ratings are statistically significant in explaining spreads, yet relative to macro- and fiscal fundamentals, their role has been rather limited; 5) The corrections in fiscal variables- public debt and budget balance in the EC's forecasts do impinge on the 10-year sovereign bond yield spreads, this impact is more evident in countries with less favourable economic conditions, it was also concluded that higher credibility means that yields will react less to changes in forecasts; 6) Market-priced risk of sovereign debt as measured by CDS spreads is partly explained by fiscal space and other economic determinants, SWEAP default risk is priced much higher than the five middle- income countries outside Europe, the ones close in terms of fiscal space (debt/tax)) countries in

2010, even allowing for differentials in fiscal space and other fundamentals. This can mean that market-priced risk of sovereign default follows waves of contagion, overreacting and mispricing risk of sovereign default over a period of several years. The CDS market is priced the default risk, not primarily on current fundamentals but on future fundamentals, expecting the SWEAP fiscal space to deteriorate markedly.

III. Methodology and Data

3.1 Methodology

The research methodology will be based on VaR framework using Yield to Maturity and benchmark prices for six countries (Portugal, Ireland, Italy, Greece, Spain and Germany) using three different maturities (two, five and ten years). The purpose of this study is to find out what is the degree of public sovereign risk. Or better, what was the risk perception, from the investor perspective, between 2000 and 2002 (period of entry into force of the Euro), between 2002 and 2008 (period pre-crisis) and after 2008 (financial crisis and sovereign debt crisis)? But, is VaR an appropriated valuation method of sovereign debt risks? What can explain the debt sovereign crisis in terms of credit risks? For this purpose were collected the YTM and the benchmark prices since 2000 until now. So as to measure that risk was employed VaR.

3.2 Statistical Analysis Methodology

This study will be complemented with some statistical measures, using yields data from 2000 to 2012. This will allow us to better understand the behaviour of each individual country during this period.

3.2.1 Statistics Measures

The first statistics measures that will be computed are, mean, standard error, median, mode, standard deviation, sample variance, kurtosis, asymmetry, interval, maximum and minimum value, sum, count and confidence level.

3.2.2 Covariance and Correlation Matrices

The second measures that will be computed are the covariance and correlation matrices. By define two variables X and Y, being the average respectively $E(X)$ and $E(Y)$ and variance $Var(X)$ and $Var(Y)$, the covariance and correlation can be algebraically represented as:

$$\text{Eq. 1} \quad \mathbf{Cov}(X, Y) = [E(X) - E(X^2)][E(Y) - E(Y^2)] = E(XY) - E(X)E(Y)$$

$$\text{Eq. 2} \quad \mathbf{Corr}(X, Y) = \frac{\mathbf{Cov}(X, Y)}{\mathbf{std}(X) * \mathbf{std}(Y)}$$

3.2.2.1 Covariance Matrix

Covariance is a statistical measure of the variance of two random variables that are observed or measured in the same time period. Or, can be defined as a non-standardized measure of the degree of relationship between two variables.

According to Hull (2011), in a covariance matrix the entry in the i^{th} row and j^{th} column is the covariance between variable i and j . The covariance between a variable and itself is its variance, thus, the diagonal matrix are variances, like the correlation matrix, it is symmetric.

A positive covariance indicates that the two variables move in the same direction; a negative covariance indicates that the variables move in the opposite direction. A covariance equal to zero means that the two variables are independent (unrelated).

3.2.2.2 Correlation Matrix

According to Hull (2011) the correlation matrix give us the correlation ρ_{ij} between a variable that entries in the i^{th} row and j^{th} column. The diagonal of the matrix is always 1 since a variable is always perfectly correlated with itself. Since the $\rho_{ij} = \rho_{ji}$ the correlation matrix is symmetric.

Figure 1- An example of a Correlation Matrix

$$\text{Corr}(X, Y) = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 \end{bmatrix}$$

Source: Hull, 2011.

The idea behind correlation is to measure the relationship between two or more variables, in this case between all six countries studied. If two countries are correlated, it means that they move together. On one hand, positive correlation means that high (low) YTM on one country is associated with high (low) YTM on the other country. On the other hand, negative correlation means that high (low) YTM on the first country is associated with low (high) YTM on the second. It is a standardized measure of the relationship between two variables and can be computed through the covariance.

3.3 Value at Risk Methodology

Historically⁸, financial companies introduced VaR in the late 80's. Since then, this method has become an essential/popular element in the toolkit among specialists, the academic community and central banks, because it provides a quantitative measure of

⁸ For more details about historical development of VaR see Holton G. (2002), Duffie and Pan [1997] and Linsmeier and Pearson [2000].

downside measure. According to Jorion (2001) it is a method of assessing risk that uses standard statistic techniques routinely used in other technical fields.

Based on literature, we can define VaR as a risk measure, it is a technique used to estimate the probability of a portfolio losses based on the statistical analysis of historical price (or yield) trends and volatilities.

For investors, risk is related to the probability of losing money, and VaR is based on that common-sense fact. Assuming investors care about the probability of a really big loss, institutional investors use VaR to evaluate portfolio risk.

As stated by Manganelli and Engle (2001), the reputation that this measure achieved is essentially due to its conceptual simplicity. VaR reduces the risk associated with any portfolio to just one number that is the loss associated to a given probability, for this reason it has become a widely accepted standard.

For some authors, VaR has become a standard measure used by financial analysts to quantify market risk, although some of them, namely Duffie and Pan (1997) considered that credit risk should be included on market risk. Jorion (2001), adds that, although in the beginning VaR was considered a method to measure financial market risk, now it is being used to control and manage risk actively, both credit and operational risk. VaR happens to control financial risks.

A definition of VaR given by Jorion (2001) is: *“VaR summarizes the worst loss over a target horizon with a given confidence level”*.

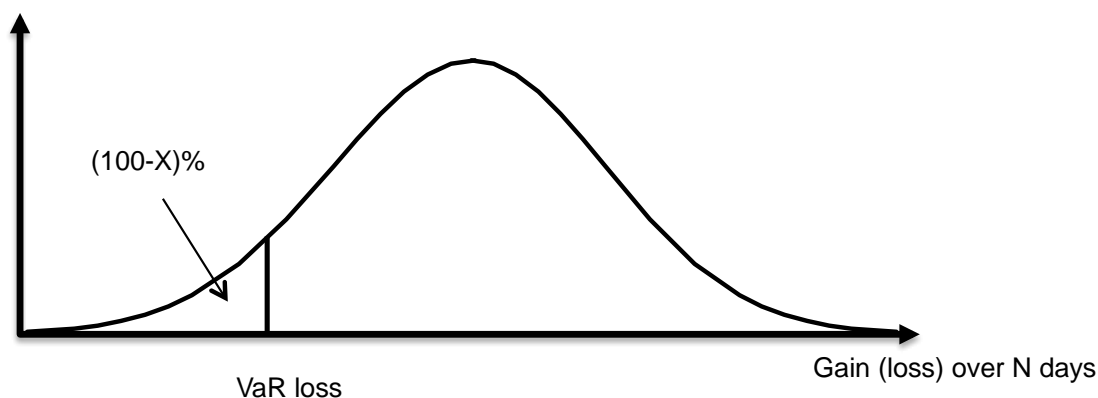
“VaR is defined as the maximum potential change in value of a portfolio of financial instruments with a given probability over a certain horizon” (Manganelli and Engle, 2001).

Pearson and Linsmeier (1996) defines VaR as: *“Using a probability of $x\%$ and a holding period of t days, an entity’s value at risk is the loss that is expected to be exceeded with a probability of only $x\%$ during the next t day holding period”*.

A VaR statistics is composed by three components: a time period (day, month or year), a confidence level (usually 95% or 99%) and a loss amount (expressed either in euros or in percentages). As mentioned by Hull (2011) the variable V is the VaR of the portfolio and it is a function of two parameters, the *time horizon* (N days) and the *confidence level* ($X\%$). When VaR is computed, it is intended to make a statement in the following form: “We are $X\%$ certain that we will not lose more than Y euros or percentage in the next N days”.

In practice and to realize better each measure, Hull (2011) stated that for N days horizon and $X\%$ of confidence level, VaR is the loss corresponding to the $(100-X)^{\text{th}}$ percentile of the distribution of the change in the value of the portfolio over the next N days. For instance, if we want to know how much our portfolio can lose with a confidence level of 95%, we examine the $(100-95)\%$ VaR value, as we can see in figure 2. Below are described the HS Method used to compute VaR and Volatility.

Figure 2- VaR curve



Source: Hull, 2011.

3.3.1 Estimating VaR through Historical Simulation Methodology

The Historical Simulation approach development by Hull (2011) is a procedure to predict the VaR by building the HS of YTM and price changes. This model does not

require any distributional assumption. This is a non-parametric method because, unlike other approaches, the VaR's calculation does not implicate to have an estimation of the parameters of a theoretical distribution, such as normal.

The main statement under this method is to look back at the past performance of our portfolio and make the supposition that the past observations are a good indicator of the near-future prices, this means, that the recent past will reproduce itself in the near-future.

The main steps to apply this method are to measure daily percentage changes in the price, after applying these changes to the portfolio and measure the corresponding profits and losses. Third, organize actual historical returns, putting them in order from worst to best and after ordering all the resulting data, set the level of VaR at the 5% and 1% quantile of worst outcomes.

For this valuation was used a set of complete elements, such as YTM and benchmark prices. Defining v_i as the value of a market variable on day i and suppose that today is day n , the hypothetical i^{th} scenario futures prices are obtained from applying historical changes in prices (or yields) to the current level of prices (or yields) like:

$$\text{Eq. 3} \quad \text{Value under } i^{\text{th}} \text{ scenario} = v_n \frac{v_i}{v_{i-1}}$$

There are no 100% perfect models and HS is not an exception. The advantages are actually easy calculation, easy implementation and execution, low operating cost and stability results. This method allows the use of actual data for the creation of distribution of returns for the next N days and it does not does not assume any distribution on the asset returns. The fat tails of the distribution and other extreme events (outliers) are captured as long as they are contained in the dataset.

However, also present disadvantages, namely the fact that there are some deficiencies. First of all, it imposes a restriction on the estimation assuming asset returns are independent and identically distributed (*iid*). Therefore it can be unrealistic to assume *iid* asset returns. Second restriction is related to time, because HS is indifferent to the time, it applies equal weight to all returns of the complete period, this means, that an observation of yesterday accounts the same as an observation of two or three years ago. This is incompatible with the nature of the decrease in forecast data that are further away from the present.

3.4 Estimating Volatility (using Historical Simulation Methodology)

We can define volatility as a measure of risk based on standard deviation of the asset. It is a statistical measure of the dispersion of return for a particular security or market index. Normally, a higher volatility implies a riskier security.

As asset prices are volatile, volatility measures that change of price over time. Were used historical prices to measure the historical volatility and is easily calculated using rudimentary statistical software.

After, it is described the standard method to estimate volatility from historical data according to Hull (2011). Defining σ_n as the volatility of a market variable on day n , as estimated at the end of day $n-1$. The variance rate is the squared of the volatility σ_n^2 on day n . Defining S_i as the value of the market variable at the end of day i , we can obtain the continuously compounded daily returns on a financial asset (between the end of day $i-1$ and end of day i) that is represented by $\mathbf{u}_i = \ln \frac{S_i}{S_{i-1}}$.

Defining \bar{u} as the average of daily returns (expected return). The sum of the differences gives us the return:

Eq. 4
$$\mathbf{R} = \sum_{i=1}^n (\mathbf{u}_i - \bar{u})^2$$

The historical standard deviation over the last n days is equal to (there are many other ways to represent the following expression):

$$\text{Eq. 5} \quad \sigma_n = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (u_i - \bar{u})^2}$$

The last step is to compute the estimated annualized volatility by:

$$\text{Eq. 6} \quad \hat{\sigma} = \text{Std} \times \sqrt{252}$$

3.5 Data in Analysis

The dataset consists of daily data of government bond yields and benchmark prices for maturities of 2, 5 and 10 years for PIIGS and Germany.

The data for government bond yields were collected from Bloomberg and refers to the period from 2000:01- 2013:12. This time frame allows to study the period of entry into force of the Euro, the pre-crisis period and financial crisis period. Later the sample is divided into three sub-periods [Jan2000- 31December of 2001] and [1Jan2002- 31Dec2007] and the last one [1Jan2008-31Dec2012] in order to see if conclusions change from one period to the other.

The benchmark prices were collected from Reuters and the period in analysis was shorter (from September 2012 till May 2013) because has limited information available, but it is enough for the second analysis done on this work.

IV. Analysis and Discussion of Results

4.1 Statistic Analysis

4.1.1 Principal Statistics

In this work we performed some statistics that allow us to confirm some empirical results and understand better some values about the data used in this dissertation. This

statistics measures were applied to each country (see appendix, table V). The main results are described below.

First, from short (2Y YTM) to long maturity (10Y YTM), we found that the means of YTM for all countries increases, except in Greece; we also verify that the higher sample variance is related to Greece for all maturities. This is related to the fact that, with the Greek crisis the level of uncertainty in short term has become higher.

Also from short to long maturity, the standard deviation decreases for all countries, which means that uncertainty is higher in short term. And thence, presumably be more favourable for investors to invest in long term.

In Kurtosis terms, we can conclude that there are no normal distributions (Mesokurtic distribution, that means Kurtosis is equal to three) of YTM results, which is consistent with the assumptions of the model. The YTM more close to normal distributions are the 10Y of Portugal and Ireland. We can also observe that there are three countries (Portugal, Ireland and Greece) that show a Kurtosis higher than three, which is a Leptokurtic distribution, with values concentrated around the means and thicker tails. This means that there is a high probability for the occurrence of extreme values. The other three countries (Germany, Italy and Spain) show a Kurtosis lower than three, which implies a Platykurtic distribution (flatter than normal distribution with a wider peak). The probability of extreme values is less than for a normal distribution, and the values are wider spread around the mean.

The difference between the minimum and the maximum for YTM is higher for all maturities in Greece, which confirms the final results achieved for this country. The confidence level at 95% is low for Germany, Italy and Spain and higher for Portugal, Ireland and Greece.

In terms of sum of all YTM for 2Y, Greece shows the higher sum, which proves the evidence of higher sovereign debt.

4.1.2 Covariance Matrix Results

Looking for the covariance matrix there are several results that are important to refer, namely the numbers with higher and lower covariance.

Table I - Covariance matrix (2000- 2012)

| Covariance | | Portugal | | | Ireland | | | Italy | | | Greece | | | Spain | | | Germany | | | |
|------------|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--|
| | | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | |
| Portugal | 2y | 10.8151 | | | | | | | | | | | | | | | | | | |
| | 5y | 9.995006 | 10.07611 | | | | | | | | | | | | | | | | | |
| | 10y | 7.028912 | 7.32222 | 5.583137 | | | | | | | | | | | | | | | | |
| Ireland | 2y | 7.750795 | 6.926414 | 4.642419 | 6.351061 | | | | | | | | | | | | | | | |
| | 5y | 4.805099 | 4.487747 | 3.144173 | 5.114752 | 3.473557 | | | | | | | | | | | | | | |
| | 10y | 4.349146 | 4.647904 | 3.689671 | 3.903007 | 2.664226 | 3.23502 | | | | | | | | | | | | | |
| Italy | 2y | 1.569098 | 1.071104 | 0.614917 | 1.193899 | 0.774062 | 0.172584 | 1.172217 | | | | | | | | | | | | |
| | 5y | 1.74476 | 1.509568 | 1.072511 | 1.227402 | 0.900406 | 0.598051 | 0.870127 | 0.768415 | | | | | | | | | | | |
| | 10y | 1.493714 | 1.453146 | 1.120001 | 0.989219 | 0.783336 | 0.719534 | 0.53834 | 0.566094 | 0.486987 | | | | | | | | | | |
| Greece | 2y | 101.3416 | 125.6218 | 105.4045 | 27.22647 | 27.66209 | 62.12311 | 0.946305 | 14.27293 | 18.11126 | 3456.71 | | | | | | | | | |
| | 5y | 31.56799 | 37.29276 | 30.83448 | 12.33779 | 10.32039 | 19.2854 | 0.627858 | 4.325925 | 5.354348 | 907.9029 | 245.029 | | | | | | | | |
| | 10y | 17.94883 | 19.23286 | 14.96047 | 9.903276 | 6.890366 | 9.39601 | 0.894803 | 2.371435 | 2.71062 | 327.0745 | 93.7343 | 44.67277 | | | | | | | |
| Spain | 2y | 1.314779 | 0.987656 | 0.656451 | 1.088961 | 0.744011 | 0.36952 | 1.027431 | 0.781431 | 0.494869 | 6.719367 | 2.077128 | 1.054782 | 1.018929 | | | | | | |
| | 5y | 1.491862 | 1.402356 | 1.084404 | 1.215942 | 0.906039 | 0.804983 | 0.733747 | 0.675483 | 0.514341 | 18.00999 | 5.311448 | 2.385938 | 0.77076 | 0.713745 | | | | | |
| | 10y | 1.513857 | 1.604254 | 1.327291 | 1.136554 | 0.90454 | 1.026846 | 0.462351 | 0.544036 | 0.495214 | 25.59018 | 7.397896 | 3.220908 | 0.526909 | 0.602161 | 0.611808 | | | | |
| Germany | 2y | -1.28876 | -1.86804 | -1.67714 | -0.47126 | -0.29943 | -1.2914 | 0.999313 | 0.477154 | 0.111698 | -48.75 | -13.8917 | -5.97887 | 0.865029 | 0.361058 | -0.02912 | 2.053666 | | | |
| | 5y | -1.44106 | -1.89396 | -1.63641 | -0.54939 | -0.31743 | -1.17268 | 0.730278 | 0.332096 | 0.067472 | -49.1848 | -13.8145 | -5.75092 | 0.609632 | 0.228597 | -0.06252 | 1.740136 | 1.549464 | | |
| | 10y | -1.29731 | -1.60539 | -1.33838 | -0.51599 | -0.27998 | -0.9222 | 0.501199 | 0.230272 | 0.061931 | -41.599 | -11.5403 | -4.72584 | 0.406934 | 0.149532 | -0.03844 | 1.335877 | 1.237551 | 1.028984 | |

Source: Own computations.

Legend: Green: higher values of Covariance, Yellow: Covariance near to 0, Red: lower values of Covariance.

All covariance's are dependent (covariance different to zero), which means that all of the six countries are not independent from each other, in other words, each country affects the others countries. However, there is a low covariance (approximately zero) between 2Y YTM of Germany and 10Y YTM of Spain (-0,029) and also between 10Y YTM of Germany and 10Y YTM of Spain (-0,038).

All numbers with higher covariance have in common the same country, Greece. For example, the higher covariance is presented between 5Y and 2Y YTM of Greece (907,90). Also between 5Y and 5Y YTM of Greece (245,02) and between 10Y and 2Y YTM of Greece (327,07). Between Greece and Portugal, there are also higher values for covariance, 2Y YTM of Greece and 5Y and 10Y YTM of Portugal (125,62; 105,40). Which means that there is a contagion effect between the maturities in Greece, for instance, the increases in spreads on shorter terms, implied increases in spreads on longer terms and vice versa. And also for the YTM between Greece and Portugal, for instance, when 2Y YTM of Greece gets worse, investors assume that 5Y YTM of Portugal will also get worse and vice versa.

HOW DID THE PUBLIC DEBT RISK OF THE PIIGS (PORTUGUESE, IRELAND, ITALY, GREECE AND SPAIN) PROGRESSED COMPARED TO GERMANY FOR DIFFERENT YIELDS, BETWEEN 2000 AND 2013?

Relatively to the negative covariance, the higher negative values are between 2Y, 5Y and 10Y YTM of Germany and 2Y of Greece. And the other ones are between 2Y, 5Y YTM of Germany and 5Y of Greece. In this case, the negative values mean that when YTM of Germany goes down, the YTM of Greece goes rise, they move in opposite directions. Which is not a surprise, this confirms the opposite situation of each country where Germany presents low YTM and Greece high YTM.

Looking in more detail for the period of financial crisis and sovereign debt crisis (2008-2012), the covariance matrix (see appendix, table VII) allows us to conclude that results consistently support the previous.

4.1.3 Correlation Matrix Results

Looking for matrix of correlation were analysed the values closest to the following cases: negatively correlated (-1), positively correlated (+1) and the uncorrelated (0).

Table II - Correlation Matrix (2000- 2012)

| Correlation | Portugal | | | Ireland | | | Italy | | | Greece | | | Spain | | | Germany | | | |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---|
| | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | |
| Portugal | 2y | 1 | | | | | | | | | | | | | | | | | |
| | 5y | 0.952433 | 1 | | | | | | | | | | | | | | | | |
| | 10y | 0.904552 | 0.976241 | 1 | | | | | | | | | | | | | | | |
| Ireland | 2y | 0.798207 | 0.739042 | 0.663938 | 1 | | | | | | | | | | | | | | |
| | 5y | 0.783971 | 0.758568 | 0.71397 | 0.939744 | 1 | | | | | | | | | | | | | |
| | 10y | 0.735276 | 0.81409 | 0.868181 | 0.737479 | 0.794777 | 1 | | | | | | | | | | | | |
| Italy | 2y | 0.440688 | 0.31166 | 0.240366 | 0.46543 | 0.383605 | 0.088625 | 1 | | | | | | | | | | | |
| | 5y | 0.605233 | 0.542511 | 0.517803 | 0.591379 | 0.551129 | 0.379316 | 0.916813 | 1 | | | | | | | | | | |
| | 10y | 0.650869 | 0.656 | 0.679236 | 0.572617 | 0.602285 | 0.573263 | 0.712515 | 0.925406 | 1 | | | | | | | | | |
| Greece | 2y | 0.524133 | 0.673112 | 0.758732 | 0.157996 | 0.252445 | 0.587467 | 0.014866 | 0.276939 | 0.441427 | 1 | | | | | | | | |
| | 5y | 0.61324 | 0.750545 | 0.833674 | 0.270162 | 0.353759 | 0.684998 | 0.037047 | 0.315268 | 0.49017 | 0.26733 | 1 | | | | | | | |
| | 10y | 0.816582 | 0.906517 | 0.947294 | 0.508083 | 0.553138 | 0.781598 | 0.123652 | 0.404755 | 0.58115 | 0.832327 | 0.895934 | 1 | | | | | | |
| Spain | 2y | 0.396064 | 0.308239 | 0.275227 | 0.469124 | 0.395476 | 0.203529 | 0.940106 | 0.883122 | 0.702521 | 0.11322 | 0.131459 | 0.15634 | 1 | | | | | |
| | 5y | 0.53696 | 0.522926 | 0.543226 | 0.608245 | 0.575424 | 0.529757 | 0.802178 | 0.912105 | 0.87241 | 0.362586 | 0.401643 | 0.422538 | 0.903807 | 1 | | | | |
| | 10y | 0.588521 | 0.646129 | 0.718157 | 0.561815 | 0.620487 | 0.729893 | 0.545959 | 0.793455 | 0.907249 | 0.55646 | 0.604226 | 0.616097 | 0.667354 | 0.911241 | 1 | | | |
| Germany | 2y | -0.27346 | -0.41065 | -0.4953 | -0.14015 | -0.11211 | -0.50102 | 0.644069 | 0.379836 | 0.111692 | -0.5786 | -0.61928 | -0.62421 | 0.59799 | 0.298223 | -0.02598 | 1 | | |
| | 5y | -0.35203 | -0.47933 | -0.55637 | -0.1925 | -0.13683 | -0.52378 | 0.541868 | 0.304352 | 0.077673 | -0.67206 | -0.70899 | -0.69123 | 0.485182 | 0.217375 | -0.06421 | 0.975501 | 1 | |
| | 10y | -0.38889 | -0.49857 | -0.55839 | -0.23589 | -0.14809 | -0.50545 | 0.456354 | 0.258964 | 0.087488 | -0.69348 | -0.72679 | -0.69703 | 0.397419 | 0.174485 | -0.04845 | 0.918961 | 0.980105 | 1 |

Source: Own computations.

Legend: Green: higher values of Covariance, Yellow: Covariance near to 0, Red: lower values of Covariance.

Starting by negative correlated values, the values close to -1 are all linked to Germany and Greece. Which denotes exactly the different reality experienced by each country, these mean that the YTM of Germany does not move together to the YTM of Greece, when YTM of Greece increases, the YTM of Germany decreases. For instance, the 5Y YTM of Germany is negative correlated with 5Y YTM of Greece (-0,70899).

Also the 10Y YTM of Germany is negative correlated with all YTM of Greece (2, 5 and 10 years), by order, -0,69348, -0,72679 and -0,69703.

These results lead us to the refuge effect. The crisis in Greece led to the flight of investors, who refuge their investments in Germany, because of low YTM, and not in other countries within the PIIGS.

On the other hand, the more positive correlated values are between 10Y YTM and 5Y YTM in Germany (0,98) and also in Portugal (0,976). There is another combination of positive correlated values between 5Y and 2Y YTM for three countries, Germany (0,975), Portugal (0,957) and Greece (0,986). This positive correlation means that values of YTM move together.

This lead us to the contagion effect on PIIGS and in Germany. For PIIGS, the trend shows that with the crisis, the increases in spreads on shorter terms, implied increases in spreads on longer terms. On the contrary, the trend in Germany shows that the decreases in spreads on shorter terms, implied decreases in spreads on longer terms.

Analysing further the results of the correlation matrix, we find that across countries there is also the contagion effect, particularly between Portugal and Greece and between Spain and Italy. Which means, for instance, when Greece gets worse economically, investors assume that Portugal will also get worse and vice versa. The same happens between Italy and Spain.

The low correlation values (close to 0) are linked to Germany in all of cases. The values closest to zero are 2Y, 5Y and 10Y YTM of Germany with 10Y YTM of Spain (-0,025; -0,064; -0,048). The 5Y and 10Y YTM of Germany are less correlated with 10Y YTM of Italy (0,077; 0,087). This means that investors are only afraid of Spain and Italy in shorter terms.

Looking in more detail for the period of financial crisis and sovereign debt crisis (2008-2012), the correlation matrix (see appendix, table IX) allows us to conclude that results consistently support the previous.

4.2 Value at Risk

4.2.1 VaR results using yields

Data used in this work was divided in three different periods (2000 to 2002, 2002 to 2008 and 2008 to 2012) for the six countries (PIIGS and Germany). The first period refers to the period of entry into force of the Euro, the second refers to the period pre-crisis and the last refers to the period of financial crisis and sovereign debt crisis.

In order to evaluate the behaviour of these countries were defined two different portfolios, one of PIIGS and another one of Germany and was computed the 95% VaR and 99% VaR.

Table I show us that Germany presents a smaller values of VaR for all cases compared to PIIGS, so, the possible loss in Germany is lower, for this period of time.

For the three different periods analysed, almost always, VaR increased among these periods both for PIIGS and Germany, except between 2002 and 2008 but this may be related to the fact that the period in question be greater, which decreases the VaR.

As we said previously, the period prior to the beginning of the crisis, the VaR decrease a little, but not significantly to change the low risk associated with this sovereign debt. From 2008 to 2012, as expected, presents a higher VaR, since the possible loss is higher during this period of crisis, compared with previous periods.

This means that the best period to invest was in 2000, in YTM with shorter terms for PIIGS and YTM with longer terms for Germany.

Table III- VaR results using yields (2000- 2012)

| | 2Y | | 5Y | | 10Y | |
|------------------|--------------|----------------|--------------|----------------|--------------|----------------|
| VaR 95% | PIIGS | Germany | PIIGS | Germany | PIIGS | Germany |
| 2000-2002 | 0.278 | 0.076 | 0.341 | 0.072 | 0.300 | 0.057 |
| 2002-2008 | 0.265 | 0.063 | 0.317 | 0.066 | 0.287 | 0.059 |
| 2008-2012 | 1.202 | 0.084 | 0.901 | 0.102 | 0.752 | 0.092 |

| | 2Y | | 5Y | | 10Y | |
|------------------|--------------|----------------|--------------|----------------|--------------|----------------|
| VaR 99% | PIIGS | Germany | PIIGS | Germany | PIIGS | Germany |
| 2000-2002 | 0,368 | 0,112 | 0,499 | 0,114 | 0,484 | 0,102 |
| 2002-2008 | 0,398 | 0,093 | 0,464 | 0,096 | 0,394 | 0,084 |
| 2008-2012 | 7,663 | 0,153 | 2,310 | 0,148 | 1,678 | 0,138 |

Source: Own computations.

4.2.2 VaR results using yields versus benchmark prices

In order to better understand what happens to the countries in analysis after 2012 using the same approach used before, it was computed again the VaR between 2012 and 2013, also using benchmark. Using the same approach and different information, we can compare if results are similar or not.

First, looking for the last period on table I and for table II, also for 95% VaR and 99% VaR, we conclude that all values of VaR start to decrease after the critical period of crisis. This is related to the fact that markets are recovering their performance and therefore the potential loss is lower than in the period of crisis.

Second, looking for tables I and for table II, we also conclude that now both for PIIGS and Germany are better to invest in shorter term. Since financial crisis, Germany keeps its strategy and the PIIGS start to change it to reverse theirs performance.

Comparing the different data using the same approach, table II and III, indicate that Germany always presents less VaR and also 95% VaR is lower than 99% VaR, because as the number of observations increase, VaR decrease. These two facts are consistent with observed in table I.

As predicted the results are not the same, however, they give us the same conclusions.

Table IV- VaR results using yields (2012- 2013)

| 2012-2013 | 2Y | | 5Y | | 10Y | |
|----------------|-------|---------|-------|---------|-------|---------|
| | PIIGS | Germany | PIIGS | Germany | PIIGS | Germany |
| VaR 95% | 0,525 | 0,032 | 0,740 | 0,059 | 0,467 | 0,061 |
| VaR 99% | 0,947 | 0,050 | 1,495 | 0,085 | 1,034 | 0,104 |

Source: Own computations.

Table V- VaR results using benchmark prices (2012- 2013)

| 2012-2013 | 2Y | | 5Y | | 10Y | |
|----------------|-------|---------|-------|---------|-------|---------|
| | PIIGS | Germany | PIIGS | Germany | PIIGS | Germany |
| VaR 95% | 0,008 | 0,000 | 0,013 | 0,000 | 0,045 | 0,003 |
| VaR 99% | 0,014 | 0,001 | 0,021 | 0,006 | 0,079 | 0,008 |

Source: Own computations.

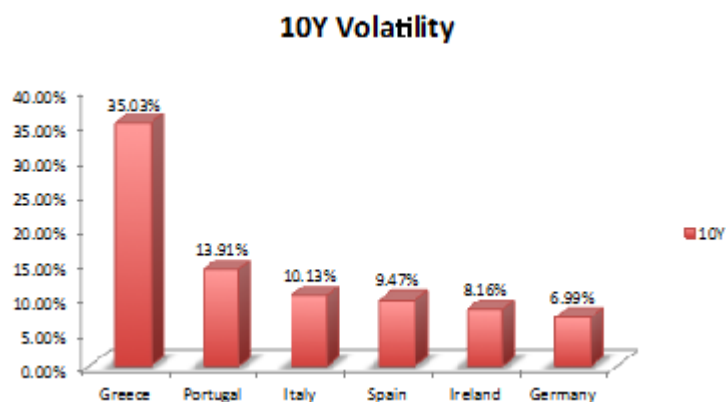
4.3 Volatility

From the computations through the HS we obtained the Volatility for all countries and all maturities, except the Greece 2Y and 5Y that there are no information. In order to construct the Volatility we must have between 90 and 180 days, and the data available of benchmark prices that fulfils this requisite is the 10Y data. The range data used to compute volatility was between 2012:12 and 2013:05.

Figure 2 shows us the distribution of 10Y of volatility and as we expected, Greece presents the higher volatility, approximately 35%, followed by Portugal and Italy. In the opposite side we have Germany with approximately 7%. A higher (less) volatility means that the country is riskier (less risky) and this confirms that PIIGS are riskier countries.

According to the theory, figure 4 in appendix is not complete because of the lack of information essentially for 2Y and 5Y of Greece. However, analysing the volatility for all maturities, we can have an idea of how countries volatility behave. In general for all countries, the volatility increases as the maturity increases. Which is in according with was observed in the VaR, since for long term the higher volatility imply higher VaR. As it was expectable Germany presents the lower volatility among all maturities.

Figure 2- 10 years Volatility for PIIGS and Germany



Source: Own computations.

V. Conclusion

The aim of this thesis is to assess how did the sovereign risk among PIIGS and Germany progressed since the beginning of this crisis. Or better, what was the risk perception, from the investor perspective, between 2000 and 2002 (period of entry into force of the Euro) and between 2002 and 2008 (period pre-crisis)? And after 2008 (financial crisis and sovereign debt crisis)? For this purpose were collected the 2, 5 and 10 Y of YTM and benchmark prices since 2000 until now and tried to understand if the method used is an appropriated valuation method of sovereign debt risks. A statistical analysis was performed in order to evaluate how these yields behave during those periods. In order to measure the risk, it was employed VaR, a risk tool based on historical information, that measure the risk associated to a confidence interval in a certain period of time.

Regarding the statistic analysis, the main results show that with Greek crisis the level of uncertainty in short term has become higher, so presumably be more favourable for investors to invest in long term that is less risky.

Concerning to covariance, by one hand, we verify that, the different YTM of Greece and the YTM between Greece and Portugal, tend to move in the same direction, as we expect. This means that there is a contagion effect between the maturities in Greece, for instance, the increases in spreads on shorter terms, implied increases in spreads on longer terms. And also for the YTM between Greece and Portugal, when 2Y YTM of Greece gets worse, investors assume that 5Y YTM of Portugal will also get worse and vice versa. By other hand, the YTM of Germany and Greece move in the opposite direction, which is not a surprise, this confirms the opposite situation of each country where Germany presents low YTM and Greece high YTM. Finally, we also verify that all covariance's are dependent, which means that all six countries are not independent from each other, in other words, each country affects the others countries.

Relatively to correlation, the results show two different effects. First, the refuge effect, which means that crisis in Greece, led to the flight of investors, who refuge their investments in Germany, because of lower YTM, and not in other countries within the PIIGS. Second, is the contagion effect on PIIGS and Germany. For PIIGS, the trend shows that with the crisis, the increases in spreads on shorter terms, implied increases in spreads on longer terms. On the contrary, the trend in Germany shows that the decreases in spreads on shorter terms, implied decreases in spreads on longer terms. There is also the contagion effect across countries, particularly between Portugal and Greece and between Spain and Italy. Which means, for instance, when Greece gets worse economically, investors assume that Portugal will also get worse and vice versa. The same happens between Italy and Spain.

Relatively to the results of the VaR, there are two facts that are consistent in both approaches and over the period under review. First, Germany, always presents less VaR. Second, 95% VaR is lower than 99% VaR, because as the number of observations increase, VaR decrease.

For the three different periods analysed, almost always, VaR increased among these periods both for PIIGS and Germany. In 2000 to 2002, since the introduction of EURO, VaR presents the lower value. Between 2002 and 2008, the period prior to the beginning of the crisis, the VaR decreased a little, but not significantly to change the low risk associated with this sovereign debt. The period of 2008 to 2012, as expected, presents higher values of VaR. This means that the best period to invest was in 2000 in shorter terms for PIIGS and longer terms for Germany. Analysing the values of VaR after 2012, we can concluded that VaR after the critical period of crisis starts to decrease. This reflects the recovering performance done by markets and therefore the potential loss now is lower than in the period of crisis. Between 2008 and 2012, for PIIGS was more favourable to invest in longer terms and for Germany in shorter terms. After 2012, we concluded that Germany keeps its strategy, investing in shorter terms and PIIGS start to change it, investing in shorter terms also, to reverse theirs performance.

In terms of volatility, we concluded that this increases as the maturity increases. Therefore for long term the higher volatility imply higher VaR, which means that investors now prefer to invest in shorter terms, which is according with was observed in the VaR. As it was expectable Germany presents the lower volatility among all maturities.

The main conclusions of this work are that PIIGS, present higher volatility, which means they are riskier countries, also present higher VaR and low correlation, in contrast to what is observed in Germany. Another conclusion reached is that the, the results are different depending on the period and country. Between 2000 and 2012, for Germany was more favourable the longer terms to invest, while for PIIGS was more favourable short terms to invest. However, we verify a different trend between 2012 and

2013. Since the potential loss is higher on long term, is more favourable to invest in shorter terms, also for PIIGS and Germany.

5.1 Limitations

Some limitations in the beginning of this work were the lack of studies done on this subject using the VaR method. Once there is a lot of data for Bonds, in the beginning was difficulty to understand exactly which data would be better to use and consequently collecting the data from the different sources.

5.2 Future investigation

Since this study allows understand what is the risk perception between 2000 to 2013, it would also be interesting to remake the same study using other models of VaR, like Monte Carlo Simulation and compare if results are similar or not to those achieved with this work. Or, it would also be interesting to remake the same study using other model and other type of data.

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Databases Consulted:

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- Reuters (Access in: 06/05/2013)

VII. Appendix

Table VI- Conceptual Framework

| Authors/ Year | Model | Country | Period under analysis | Type of maturities considered | Variables |
|--|---|---|-----------------------|-------------------------------|--|
| Gapen M., Gray D., Lim C., and Xiao Y. (2008) | Black-Scholes, VaR (Monte Carlos simulation) and econometric model | Emerging countries | | | Sovereign bond spreads, spreads on sovereign credit default swaps (CDS) and implied probabilities from CDS markets. |
| Benjamin Bruder, Pierre Hereil, Thierry Roncalli (2011) | SABR model | Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. | 2008-2011 | | Measure sovereign credit risk in a fixed income portfolio, |
| Silvia Sgherri and Edda Zoli (2009) | Econometric model | Germany- EU countries | 2003-2009 | 10-year sovereign bonds; | Spreads between yields |
| António Afonso, Michael G. Arghyrou and Alexandros Kontonikas (2012) | Econometric model | Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain. | 1999.01- 2010.12. | | Are assessed the role of a set of potential spread's determinants of European government bond yield spreads against Germany. Before, during and after the onset of debt crisis. |

HOW DID THE PUBLIC DEBT RISK OF THE PIIGS (PORTUGUESE, IRELAND, ITALY, GREECE AND SPAIN) PROGRESSED COMPARED TO GERMANY FOR DIFFERENT YIELDS, BETWEEN 2000 AND 2013?

| | | | | | |
|---|-------------------|--|---------------|--------------------------------|--|
| António Afonso & Ana Sofia Nunes (2012) | Econometric model | Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Sweden. | 1999:1-2012:1 | 10-year sovereign bond yields | |
| Emanuele Baldacci and Manmohan S. Kumar (2010) | Econometric model | Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Colombia, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Norway, Philippines, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, United States, Venezuela and Bolivarian Rep. | 1980-2008 | Long-term sovereign bond yield | Emanuele Baldacci and Manmohan S. Kumar (2010) |
| Joshua Aizenman, Michael Hutchison, Yothin Jinjark (2011) | | Greece, Ireland, Italy, Portugal, and Spain | 2005-2010 | 3, 5 and 10-year CDS spreads | Sovereign credit default swap (CDS) spreads |

HOW DID THE PUBLIC DEBT RISK OF THE PIIGS (PORTUGUESE, IRELAND, ITALY, GREECE AND SPAIN) PROGRESSED COMPARED TO GERMANY FOR DIFFERENT YIELDS, BETWEEN 2000 AND 2013?

Table VII - Descriptive Statistics (2000-2012)

| Portugal | | | |
|--------------------------|----------|----------|----------|
| | 2y | 5y | 10y |
| Mean | 4,40544 | 5,082548 | 5,437058 |
| Standard Error | 0,056483 | 0,054519 | 0,040583 |
| Median | 3,662 | 4,057 | 4,575 |
| Mode | 2,831 | 3,195 | 3,529 |
| Standard Deviation | 3,289117 | 3,174757 | 2,363215 |
| Sample variance | 10,81829 | 10,07908 | 5,584784 |
| Kurtosis | 7,155131 | 5,482208 | 3,626249 |
| Asymmetry | 2,66859 | 2,465612 | 2,080682 |
| Interval | 19,77 | 20,357 | 14,233 |
| Minimum | 1,238 | 2,517 | 3,16 |
| Maximum | 21,008 | 22,874 | 17,393 |
| Sum | 14938,85 | 17234,92 | 18437,06 |
| Count | 3391 | 3391 | 3391 |
| Confidence level (95.0%) | 0,110744 | 0,106893 | 0,079569 |

| Germany | | | |
|--------------------------|----------|----------|----------|
| | 2y | 5y | 10y |
| Mean | 2,626 | 3,162113 | 3,745492 |
| Standard Error | 0,024613 | 0,021379 | 0,017422 |
| Median | 2,604 | 3,358 | 3,919 |
| Mode | 1,324 | 3,74 | 5,202 |
| Standard Deviation | 1,433273 | 1,244958 | 1,014538 |
| Sample variance | 2,054272 | 1,549921 | 1,029287 |
| Kurtosis | -1,02244 | -0,42658 | -0,14869 |
| Asymmetry | -0,20942 | -0,52512 | -0,57349 |
| Interval | 5,391 | 5,038 | 4,477 |
| Minimum | -0,091 | 0,24 | 1,167 |
| Maximum | 5,3 | 5,278 | 5,644 |
| Sum | 8906,435 | 10722,73 | 12700,96 |
| Count | 3391 | 3391 | 3391 |
| Confidence level (95.0%) | 0,048258 | 0,041917 | 0,034159 |

| Ireland | | | |
|--------------------------|----------|----------|----------|
| | 2y | 5y | 10y |
| Mean | 3,951 | 4,327922 | 5,244082 |
| Standard Error | 0,051582 | 0,03201 | 0,030891 |
| Median | 3,4965 | 3,724 | 4,728 |
| Mode | 4,041 | 3,724 | 8,207 |
| Standard Deviation | 2,520659 | 1,864023 | 1,798881 |
| Sample variance | 6,353721 | 3,474582 | 3,235974 |
| Kurtosis | 11,0797 | 10,57603 | 2,439327 |
| Asymmetry | 2,839624 | 2,91619 | 1,639286 |
| Interval | 21,631 | 15,018 | 11,022 |
| Minimum | 1,591 | 2,328 | 3,057 |
| Maximum | 23,222 | 17,346 | 14,079 |
| Sum | 9435,946 | 14675,98 | 17782,68 |
| Count | 2388 | 3391 | 3391 |
| Confidence level (95.0%) | 0,10115 | 0,062761 | 0,060568 |

| Greece | | | |
|--------------------------|----------|----------|----------|
| | 2y | 5y | 10y |
| Mean | 23,892 | 10,33255 | 7,613419 |
| Standard Error | 1,009791 | 0,268845 | 0,114795 |
| Median | 4,005 | 4,434 | 4,953 |
| Mode | 225,116 | 61,185 | 5,446 |
| Standard Deviation | 58,80246 | 15,65544 | 6,684755 |
| Sample variance | 3457,73 | 245,0927 | 44,68595 |
| Kurtosis | 6,8907 | 5,439331 | 5,750207 |
| Asymmetry | 2,920988 | 2,632761 | 2,503433 |
| Interval | 258,451 | 63,402 | 33,871 |
| Minimum | 1,271 | 2,588 | 3,23 |
| Maximum | 259,722 | 65,99 | 37,101 |
| Sum | 81018,99 | 35037,67 | 25817,1 |
| Count | 3391 | 3391 | 3391 |
| Confidence level (95.0%) | 1,979861 | 0,527114 | 0,225074 |

| Italy | | | |
|--------------------------|----------|----------|----------|
| | 2y | 5y | 10y |
| Mean | 3,246 | 3,956922 | 4,633386 |
| Standard Error | 0,018595 | 0,015056 | 0,011986 |
| Median | 3,135 | 3,846 | 4,504 |
| Mode | 2,329 | 3,863 | 4,426 |
| Standard Deviation | 1,082849 | 0,876722 | 0,697948 |
| Sample variance | 1,172563 | 0,768642 | 0,487131 |
| Kurtosis | -0,60441 | 0,053948 | 0,302845 |
| Asymmetry | 0,293362 | 0,584312 | 0,60523 |
| Interval | 6,39 | 5,178 | 4,044 |
| Minimum | 1,274 | 2,562 | 3,217 |
| Maximum | 7,664 | 7,74 | 7,261 |
| Sum | 11007,94 | 13417,92 | 15711,81 |
| Count | 3391 | 3391 | 3391 |
| Confidence level (95.0%) | 0,036459 | 0,029519 | 0,0235 |

| Spain | | | |
|--------------------------|----------|----------|----------|
| | 2y | 5y | 10y |
| Mean | 3,248 | 3,924811 | 4,562643 |
| Standard Error | 0,017337 | 0,01451 | 0,013434 |
| Median | 3,261 | 3,835 | 4,359 |
| Mode | 2,559 | 3,746 | 5,487 |
| Standard Deviation | 1,009569 | 0,844959 | 0,782297 |
| Sample variance | 1,01923 | 0,713956 | 0,611989 |
| Kurtosis | -0,84669 | -0,4929 | -0,146 |
| Asymmetry | 0,167194 | 0,404367 | 0,524481 |
| Interval | 5,373 | 5,157 | 4,616 |
| Minimum | 1,269 | 2,435 | 3,005 |
| Maximum | 6,642 | 7,592 | 7,621 |
| Sum | 11013,57 | 13309,04 | 15471,92 |
| Count | 3391 | 3391 | 3391 |
| Confidence level (95.0%) | 0,033992 | 0,02845 | 0,02634 |

Source: Own computations.

HOW DID THE PUBLIC DEBT RISK OF THE PIIGS (PORTUGUESE, IRELAND, ITALY, GREECE AND SPAIN) PROGRESSED COMPARED TO GERMANY FOR DIFFERENT YIELDS, BETWEEN 2000 AND 2013?

Table VII- Covariance Matrix (2008- 2012)

| Covariance | | Portugal | | | Ireland | | | Italy | | | Greece | | | Spain | | | Germany | | | |
|------------|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--|
| | | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | |
| Portugal | 2y | 27,70559 | | | | | | | | | | | | | | | | | | |
| | 5y | 23,97079 | 22,5389 | | | | | | | | | | | | | | | | | |
| | 10y | 15,77002 | 15,12767 | 10,5825 | | | | | | | | | | | | | | | | |
| Ireland | 2y | 14,14952 | 11,75908 | 7,210061 | 12,25067 | | | | | | | | | | | | | | | |
| | 5y | 11,27258 | 9,607131 | 5,962457 | 9,581032 | 8,362995 | | | | | | | | | | | | | | |
| | 10y | 7,779882 | 7,269452 | 5,148697 | 5,865031 | 4,716992 | 4,214313 | | | | | | | | | | | | | |
| Italy | 2y | 5,018594 | 4,286577 | 2,906994 | 2,58677 | 2,015774 | 1,373342 | 1,27637 | | | | | | | | | | | | |
| | 5y | 4,537261 | 4,080505 | 2,842018 | 2,166123 | 1,797583 | 1,314478 | 1,14903 | 1,102665 | | | | | | | | | | | |
| | 10y | 3,352045 | 3,132892 | 2,215505 | 1,436038 | 1,242166 | 0,981082 | 0,825571 | 0,82268 | 0,641898 | | | | | | | | | | |
| Greece | 2y | 199,665 | 244,1344 | 201,7191 | 2,475712 | 21,42986 | 75,40803 | 43,51811 | 53,84275 | 47,21017 | 8228,323 | | | | | | | | | |
| | 5y | 61,85207 | 70,00615 | 56,27162 | 9,295345 | 11,556 | 23,11927 | 13,39606 | 15,37384 | 13,04272 | 2031,199 | 514,0808 | | | | | | | | |
| | 10y | 38,44316 | 37,6045 | 27,17192 | 13,31865 | 11,35715 | 11,16705 | 7,884666 | 7,843124 | 6,2567 | 625,9738 | 169,9285 | 80,41979 | | | | | | | |
| Spain | 2y | 3,747346 | 3,448637 | 2,548395 | 2,153772 | 1,684973 | 1,568924 | 0,970574 | 0,903914 | 0,654049 | 51,73245 | 14,89231 | 6,885394 | 1,045549 | | | | | | |
| | 5y | 3,318491 | 3,215828 | 2,434549 | 1,968597 | 1,61151 | 1,585142 | 0,865151 | 0,850611 | 0,631344 | 56,2547 | 15,61407 | 6,490285 | 0,980392 | 0,974145 | | | | | |
| | 10y | 2,877804 | 2,934215 | 2,266413 | 1,517815 | 1,311335 | 1,41631 | 0,713511 | 0,738393 | 0,571742 | 59,6893 | 16,02462 | 6,142148 | 0,838633 | 0,855476 | 0,788791 | | | | |
| Germany | 2y | -0,97795 | -1,12626 | -1,00124 | 0,347324 | 0,290723 | -0,18715 | -0,23158 | -0,26403 | -0,23352 | -43,3934 | -10,866 | -3,49349 | -0,26965 | -0,26093 | -0,2797 | 0,32337 | | | |
| | 5y | -1,77294 | -1,9147 | -1,62648 | 0,01839 | 0,0255 | -0,52502 | -0,40232 | -0,43215 | -0,36386 | -61,8459 | -15,7316 | -5,22783 | -0,4597 | -0,44829 | -0,45729 | 0,422833 | 0,593392 | | |
| | 10y | -1,82344 | -1,91301 | -1,59658 | -0,16225 | -0,13209 | -0,58124 | -0,40833 | -0,43142 | -0,35516 | -57,8972 | -14,7875 | -4,9798 | -0,45849 | -0,44818 | -0,44863 | 0,376949 | 0,546092 | 0,513174 | |

Source: Own computations.

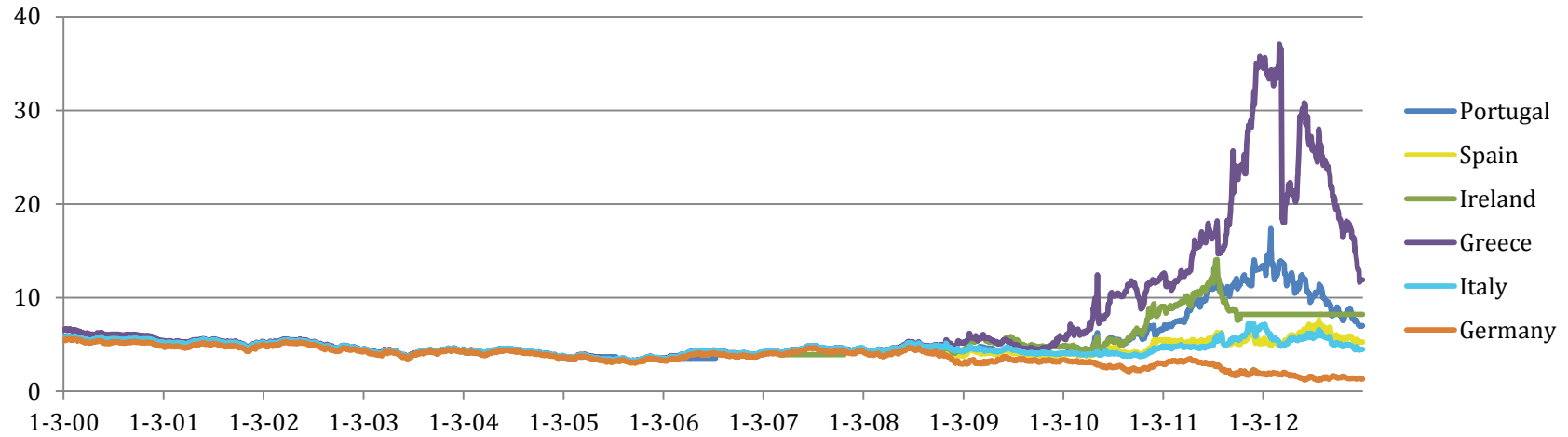
Table VIII- Correlation Matrix (2008- 2012)

| Correlation | | Portugal | | | Ireland | | | Italy | | | Greece | | | Spain | | | Germany | | | |
|-------------|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----|--|
| | | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | 2y | 5y | 10y | |
| Portugal | 2y | 1 | | | | | | | | | | | | | | | | | | |
| | 5y | 0,959251 | 1 | | | | | | | | | | | | | | | | | |
| | 10y | 0,920989 | 0,979516 | 1 | | | | | | | | | | | | | | | | |
| Ireland | 2y | 0,76803 | 0,707664 | 0,633235 | 1 | | | | | | | | | | | | | | | |
| | 5y | 0,740558 | 0,699756 | 0,633797 | 0,946567 | 1 | | | | | | | | | | | | | | |
| | 10y | 0,719989 | 0,745885 | 0,770974 | 0,816257 | 0,794549 | 1 | | | | | | | | | | | | | |
| Italy | 2y | 0,843937 | 0,799201 | 0,790973 | 0,654168 | 0,616982 | 0,592144 | 1 | | | | | | | | | | | | |
| | 5y | 0,820896 | 0,818513 | 0,831976 | 0,589361 | 0,591952 | 0,609773 | 0,968548 | 1 | | | | | | | | | | | |
| | 10y | 0,794865 | 0,823656 | 0,850052 | 0,512098 | 0,536125 | 0,596498 | 0,912081 | 0,977859 | 1 | | | | | | | | | | |
| Greece | 2y | 0,418179 | 0,566901 | 0,683593 | 0,007798 | 0,081693 | 0,404947 | 0,424645 | 0,565262 | 0,649601 | 1 | | | | | | | | | |
| | 5y | 0,518268 | 0,65036 | 0,762921 | 0,11713 | 0,176243 | 0,496701 | 0,522966 | 0,645721 | 0,717992 | 0,9876 | 1 | | | | | | | | |
| | 10y | 0,81443 | 0,883267 | 0,931418 | 0,424325 | 0,437932 | 0,606588 | 0,77824 | 0,832886 | 0,870825 | 0,769518 | 0,835736 | 1 | | | | | | | |
| Spain | 2y | 0,696254 | 0,71041 | 0,766126 | 0,601794 | 0,569823 | 0,747423 | 0,840172 | 0,841847 | 0,798372 | 0,557744 | 0,642354 | 0,750888 | 1 | | | | | | |
| | 5y | 0,638771 | 0,686301 | 0,75825 | 0,569856 | 0,564599 | 0,782335 | 0,775875 | 0,820724 | 0,798401 | 0,628335 | 0,697732 | 0,733281 | 0,971439 | 1 | | | | | |
| | 10y | 0,615597 | 0,695896 | 0,784448 | 0,488268 | 0,510566 | 0,776809 | 0,711101 | 0,791744 | 0,803501 | 0,740901 | 0,795776 | 0,771184 | 0,923461 | 0,975922 | 1 | | | | |
| Germany | 2y | -0,32673 | -0,41718 | -0,54125 | 0,174504 | 0,176787 | -0,16032 | -0,36047 | -0,44217 | -0,51256 | -0,84124 | -0,84276 | -0,68506 | -0,46375 | -0,4649 | -0,55382 | 1 | | | |
| | 5y | -0,43726 | -0,52356 | -0,64906 | 0,006821 | 0,011447 | -0,33201 | -0,46229 | -0,53424 | -0,58956 | -0,88508 | -0,90071 | -0,75678 | -0,58363 | -0,58962 | -0,6684 | 0,965269 | 1 | | |
| | 10y | -0,48359 | -0,5625 | -0,68511 | -0,06471 | -0,06376 | -0,39524 | -0,50454 | -0,57352 | -0,61881 | -0,89098 | -0,91043 | -0,77517 | -0,62593 | -0,63387 | -0,70514 | 0,925338 | 0,989607 | 1 | |

Source: Own computations.

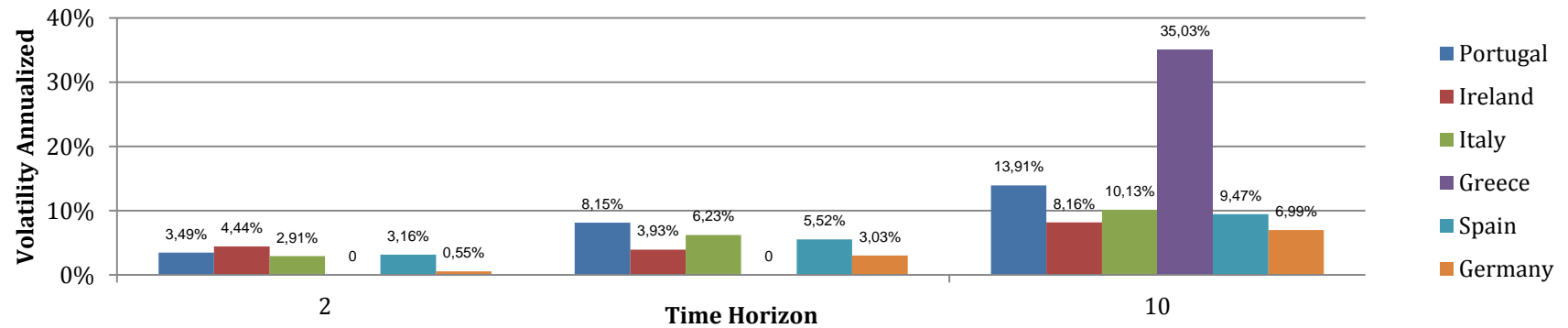
HOW DID THE PUBLIC DEBT RISK OF THE PIIGS (PORTUGUESE, IRELAND, ITALY, GREECE AND SPAIN) PROGRESSED COMPARED TO GERMANY FOR DIFFERENT YIELDS, BETWEEN 2000 AND 2013?

Figure 3- Sovereign Yield Spreads 10Y evolution



Source: Own computations.

Figure 4- Volatility of all maturities (2Y, 5Y and 10Y) for all countries



Source: Own computations.