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EMU GOVERNMENT BOND YIELD SPREADS AND DETERMINANTS OF RISK PREMIA

– the Sovereign Debt Crisis: PIIGS in EU

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ABSTRACT

Globalization and attributed financial markets integration are central themes and topics in today's international finance. Since the start of 1999 when the euro was introduced, the integration started to accelerate among European financial markets and especially on the European government bond markets. This is also widely acknowledged in the topic's previous literature. However things started to turn upside down since the beginning of the turmoil in financial markets caused by the US's subprime mortgage crisis. The spreads between the EMU government bond yields begun to widen and in late 2009 the solvency of some member states became questionable.

The aim of this thesis is to study how large have the EMU government bond yield spreads become during 2010. Moreover how well the country-specific EMU convergence criteria, international risk and liquidity premium explain these spreads.

In line with the previous literature the evidence suggests the wider spreads are caused by the credit quality factors driven by the current market situation. Thus despite the earlier integration some risk premiums have grown unbearable while the EMU government bonds have became relatively strong substitutes.

KEYWORDS: EMU government bond yield spreads, 2010 solvency crisis

1. INTRODUCTION

Globalization and attributed financial markets integration are central themes and topics in today's international finance. Interest on these themes grows on because of their benefits and other byproducts. The benefits of integration like economic growth via risk sharing, improved capital allocation and reductions in macroeconomic volatility and transaction costs are all well accepted matters (Kim, Moshirian & Wu 2005). These phenomena and most of the benefits are easily seen in Europe in a smaller scale under the influence of the European Economic and Monetary Union, EMU (see e.g. Baele, Ferrando, Hördahl, Krylova & Monnet 2004).

Same benefits were also behind the targets of the Delors report in 1989 named only then as less volatile economic growth, lower inflation and more efficient capital markets together with higher employment. The report was the first plan to implement EMU in three stages. Starting from complete liberalisation of capital movements in the European Economic Community *(EEC, later became EC)* and convergence criteria *(The Treaty of Maastricht)* via establishing the European Central Bank *(ECB)* finally leading to the single currency, euro. (Rossi 2001: 4).

Since the start of 1999 when the euro was introduced, the integration started to accelerate among European financial markets. The velocity of integration varied between different market sectors and some sectors obtained higher degree of integration much faster than others (Baele et al. 2004: 80). Those included government bond markets as can be seen on the following page in Figure 1. Since then the effects of EMU have motivated many researchers and a lot of evidence can be found related to integration and development of European government bond markets.

In the core of European government bond markets research has traditionally been German 10-yr government bond called "Bund". It has retained its place as the benchmark bond for two reasons, relative liquidity and credit quality. Both factors simply arise from the German government's economical status and history of having the most traded securities on European markets. Germany being solvent and the largest economy in Europe, its government bonds are the most liquid among euro nominated bonds. As a result based on the previous

facts and the financial theory of market efficiency in other words can be stated that the bund is the most correctly priced due to its liquidity and the most riskless security due to the solvency and low yield, when compared to other European bonds. (Ejsing & Sihvonen 2009: 14–15.)

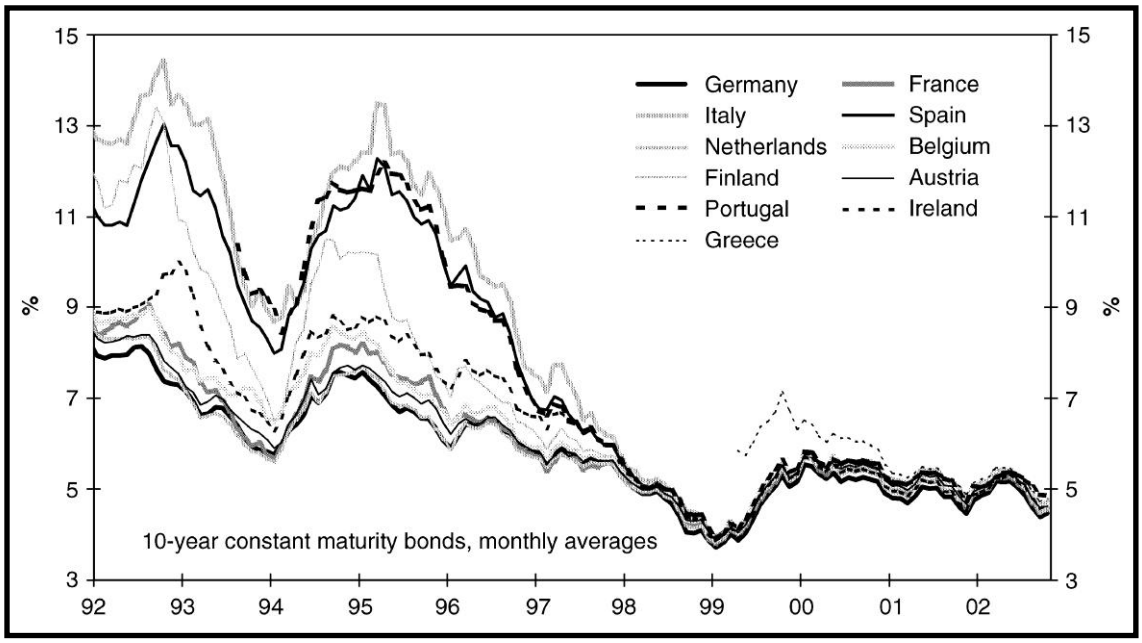


Figure 1. Government bond yields in the euro area (Codogno, Favero & Missale 2003: 507).

In many studies on euro area government bonds (e.g. Codogno et al. 2003, Baele et al. 2004, Pagano & von Thadden 2004, Kim et al. 2005) the findings have been similar in a sense that every euro-country's bond yield spreads with German bund have narrowed, even with quite a pace, after the introduction of euro. This is partly because the European intra-market of government bonds has lost the currency risk component. It is logical in terms of mutual inflation and expectations of the euro area carrying a lower risk together than its participants on their own. Considering sovereign bonds outside the euro area similar effect should be seen because no doubt the euro is a much more stable currency than national currencies of the participants and so the currency carries a lower risk when the exchange rate is less volatile. Although in sovereign bond context outside the euro area, inflation plays a more significant role than before. However, inside EMU the same financial instrument's risks can be assumed to reduce when issuing government changes to mutual currency. This explains some of the integration in euro area government bond markets.

The narrower spreads are not though necessarily resulting only from the elimination of currency risk. If the liquidity factor is considered to be remained more or less the same as well as the national aspects *(e.g. tax treatments),* the remaining part and perhaps the most significant part of the risk factor would be credit risk component. In this case the bond yields movement towards the bond yield of German bund suggests the mutual currency has also lowered the credit risk of other participant countries ceteris paribus. This gives an indication that on the markets EMU is thought to be more solvent than its participants on their own or that EMU is willing to sustain its in debt members no matter what the cost. Indication derives from the assumption that solvency and credit risk are positively correlated. And because of Germany's solvency and economic power, the other participants of EMU benefit most from joining the euro in terms of interest rates of government debt. This explains why the integration has moved toward the German bund yield.

The integration in EMU government yield spreads harmonized even more through the 2000s, when spreads larger than 1 % were quite rare. This is demonstrated in Figure 2. below which depicts interest rate spreads between all euro country bonds and benchmark bonds *(i.e. German bund and U.S. bond in case where bund data n/a)*, spread measured at the time of issuance of the bond (Schuknecht, von Hagen & Wolswijk 2009: 1).

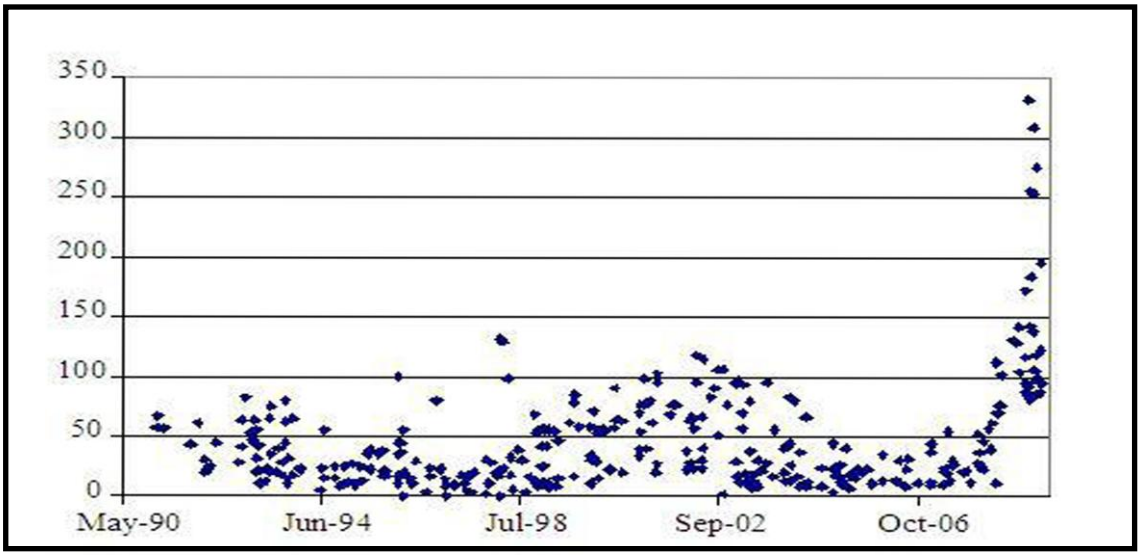


Figure 2. Interest rate spreads for EU15 *(in basis points)* between May 1990 and May 2009 (Schuknecht et al. 2009: 1).

Yet things have turned upside down starting slowly from the beginning of the subprime mortgage crisis of U.S. in 2007 (Berg 2010: 17). As the crisis started to accelerate in the U.S. and latest when the Lehmann brothers collapsed in September 2008, the credit risk awareness spread to European capital markets. In the Figure 2. this is easily seen as the jump of the large mass over the 100 basis points line. Continuation of this financial crisis finally cumulated to fears of a sovereign debt crisis in Europe.

In late 2009 the fears became true when the solvency of some members of the EU became questionable. Implications from this were ongoing widening in the bond yield spreads, downgrades of government credit ratings and weaker economic forecasts for the most in debt countries. This ongoing sovereign debt crisis in Europe concerns most notably Portugal, Ireland, Italy, Greece and Spain *(the PIIGS)*.

The first country with widening spread was Greece after it confessed a somewhat creative accounting in its government's accountancy. When the markets perceived other in debt countries, the spreads of Ireland and Portugal followed Greece's example. Lots of speculation swirled also around Spain and Italy and still continue. During the financial crisis these speculations have appeared in mass media as well whether this recession will develop to be the worst in the world history since the Great Depression. Therefore it is interesting to see if the determinants of risk premiums have remained stable within the whole crisis as them did during the Great Depression, according to Fisher (1959) who studied the topic with corporation bonds.

According to the very basic theory of finance, the risk-return trade-off with the effective market hypothesis, one should remember that if there is return there is risk as well. Consequently, and especially in the light of past events one should also bear in mind that even government bonds, often called risk-free or riskless assets, cannot be automatically taken as free from the credit risk even with developed countries. The case of default *(i.e. the borrower's failure to pay the timely debt and/or interest payments)* should be seen as the ultimate risk in all government debts as well, even though the history provides us few straight examples from this. One significant issue related to this in EMU context is that the member states have lost their ability to print money. Therefore the default probability of a participant in EMU actually may have risen along with joining

the monetary union. This is because of the in debt governments do not have anymore monetary tools to affect the relative size of the debt as they did before and because EMU countries were not obliged to bail out each others according to the Lisbon treaty. (Codogno et al. 2003: 509.)

However, since a default results from lost solvency, it should be a good idea to always introduce the market yields or prices of government bonds together with, at least one measurement referring to the credit risk, e.g. such as government debt ratios or budget deficit/surplus. The idea behind this is the simple risk-return trade-off where the creditor should be interested in the financial standing of the borrower since this is one of the key matters whilst defining the correct interest rate. For realization of this, a straight example is given below in Table 1. where are illustrated the average prices of 10-year zero-coupon bonds of EMU countries with debt-to-GDP ratios at the end of the years 2009 and 2010 together with their relative change.

Table 1. The average prices of EMU governments' 10-yr zero-coupon bonds with par value 1 000 euro in December 2009 and 2010, together with consolidated government gross debts as the percentage of Gross Domestic Product (*Maastricht criteria*) at the end of the years 2009 and 2010. The grey columns indicate yearly change in prices and ratios. (ECB and Eurostat, 2011.)

Country	12/2009 avg. price (€)	12/2010 avg. price (€)	1-yr price change	12/2009 Debt-to-GDP (%)	12/2009 Debt-to-GDP (%)	1-yr change in dtG
Germany	**734.06**	**750.63**	*(2.3 %)*	**73.5**	**83.2**	*(13.2 %)*
Netherlands	**713.04**	**732.63**	*(2.7 %)*	**60.8**	**62.7**	*(3.1 %)*
Finland	**711.66**	**730.51**	*(2.6 %)*	**43.8**	**48.4**	*(10.5 %)*
France	**710.29**	**719.97**	*(1.4 %)*	**78.3**	**81.7**	*(4.3 %)*
Austria	**701.43**	**713.73**	*(1.8 %)*	**69.6**	**72.3**	*(3.9 %)*
Belgium	**701.43**	**676.21**	*(-3.6 %)*	**96.2**	**96.8**	*(0.6 %)*
Spain	**688.03**	**592.13**	*(-13.9 %)*	**53.3**	**60.1**	*(12.8 %)*
Portugal	**681.44**	**531.23**	*(-22.0 %)*	**83.3**	**93.0**	*(12.0 %)*
Italy	**674.91**	**637.80**	*(-5.5 %)*	**116.1**	**119.0**	*(2.5 %)*
Ireland	**620.97**	**444.33**	*(-28.4 %)*	**65.6**	**96.2**	*(46.6 %)*
Greece	**585.99**	**321.69**	*(-45.1 %)*	**127.1**	**142.8**	*(12.4 %)*

1.1. Purpose of the study

The aim of this thesis is to study how large have the EMU government bond yield spreads become during 2010. Moreover how well the EMU convergence criteria among other credit quality factors explain these spreads. Therefore the study is to show how influential country-specific features can eventually grow during a crisis time, even in properly integrated common market area such as EMU is. The influence is measured with the risk premiums observed in market yields. The thesis aims in determination of the risk premium to find support on the assumption that the country-specific features are indeed behind the observed changes in the premiums and thus to question market pricing. The assumption is made in terms of the structure of EMU and efficiently functioning EMU government bond markets expectation. The study is motivated by the recent news and market movements which suggest that even the bonds of western developed governments are exposed to default risk nowadays. This aspect is exceedingly interesting in a context where these government bonds are, at least once were, generally considered as risk-free or riskless and therefore may have been led to market mispricing.

The study concentrates on the yield spreads between EMU government bonds and the German bund just before and during the latter financial crisis in Europe. These spreads are understood as the risk premiums since the bund is concerned the less risky asset in Europe. Moreover the study tries to figure out how much of the risk premium could be explained by solvency, liquidity and international risk since the market movements after 2009 might indicate mispricing in government bond prices of the PIIGS countries.

First the risk premiums are analyzed so that the development, variation and level of integration during the financial crisis can be observed. Target of this analysis is to define how the euro area government bonds' yields are related to each other 10 years after the introduction of euro. According to previous studies related to the subject (e.g. Codogno et al. 2003, Baele et al. 2004, Pagano & von Thadden 2004) the risk premiums among the monetary union members have been coherent and increasingly integrated despite the remaining structural differences between the members. Analyzing is accomplished by measuring the risk premiums from the government bond market yields between EMU member states and Germany which are then compared to each others before

and during the 2010 started crisis. More specific details about the methods are presented later in the study (in Ch. 4).

Based on the risk premia analysis the grounds for the thesis are set when the effect of the financial crisis is considered. Ignoring the previously noticed integration it is now expected that the 2010 crisis has strongly increased EMU government bond yield spreads with respect to the previous financial crisis. Thus the first hypothesis is the following:

H1: The 2010 started financial crisis in Europe has strongly increased the spreads of EMU government bond yields

Secondly more evidence is sought to support the assumption that the addressed financial crisis effect is because of the country-specific features. This will be done by presenting and testing an econometric model where are included a few economic indicators in addition to two other variables, all acknowledged credit quality factors in previous literature (see Ch. 3). Hence the model's factors are solvency, liquidity and international risk measured with independent variables such as debt-to-GDP ratio and public deficit figure, trading volume and change in market yields of the United States 10-year government bond. These variables are used as explanatory variables in a linear regression where the risk premium of government bond yield is the explained variable.

The regression aims at estimating the risk premium while used to test the second and the third hypothesis. Based on theory and previous studies (e.g. Bernhardsen 2000, Codogno et al. 2003 and Barrios, Iversen, Lewandowska & Setzer 2009) it is expected that solvency positively correlates with the risk premium whereas liquidity and international risk factors have negative coefficients. Furthermore, in similar studies (e.g. Fisher 1959, Lemmen & Goodhart 1999, Barrios et al. 2009) the model validation and significance have been relatively high. Thus it is expected the model would provide the evidence to support the assumption about country-specific features if those factors have statistically significant expected signs and are developing as can be assumed in the current financial crisis. Moreover, as already mentioned, the evidence from regressions is also used to test whether the pricing of EMU government bonds has been correct and rational over the recent years.

The second and the third hypothesis are:

H2: Changes in the credit quality factors explain the observed changes in EMU government bond yield spreads during 2007–2010

H3: The market pricing of EMU government bonds is consistent regardless of the explaining factors' information frequency

The primary gain of this thesis is the evidence from side effects of critical and large crises among countries which share the same currency risk. The gain should not be underestimated in possible future cases where EMU or another economic and monetary union is going through a crisis time or planning to expand further. In addition, the goal of this analysis is to identify the determinants of yield spreads whereas to see how depending they are on the credit quality factors and especially on the Stability and Growth Pact *(SGP)* criterias. In other words, the thesis tries to suggest that the fiscal stance should explain a significant amount of the yield spread. This idea works as the motivation also since the SGP being a mutually agreed contract which has not been honored by member states of EMU and thus these states should have been "punished" with higher interest rates by the markets.

Furthermore this thesis can be expected to serve some institutional investors who have significant positions in government bonds and face similar crisis in low risk areas as seen in the 2010 sovereign debt crisis in Europe. The benefit for market participants may arise from the findings of how much investors are influenced by various aspects of bond quality and especially the fiscal policy factors. As a whole, the purpose of the study is to produce additional information about behavior of bond yields in a single currency area for the use of investment management.

1.2. Structure of the study

The rest of the paper is organized as following. Next section (2) discusses about the theory related to bond valuation and European government bond market together with the basic terminology and short description how the 2010

financial crisis was evolved. A review of the previous studies concerning the topic is presented in section three. In the end of the third section one can find a summary of the previous studies. Fourth section presents and analyzes more closely the yield spreads and the studied risk premium factors with summary from the results of the analysis. In section five, the econometric models are constructed and results presented. Section six concludes.

2. BOND MARKET AND EMU

This section discusses about the theory and the context related to both bond valuation and government bond markets in EMU. In the beginning bond characteristics are shortly described together with the basic terminology. The section ends in a brief review of how the financial crisis culminated into the 2010 sovereign debt crisis in Europe.

2.1. Bond characteristics

Bond is a type of debt security which is used by public authorities, credit institutions and companies to finance their long-term investments or current expenditures, as typically is the case with sovereign (*government*) bonds. Bonds are usually issued in underwritings on primary markets where investment banks buy the whole debt from the borrower and re-sell it in fractions to investors on financial markets (*in this context known as secondary markets*). An alternative way to issue a bond is to arrange an auction, called a public sale, where investors may bid for the bond.

Bonds differ by their defined term, i.e. maturities which are ranging up to 30 years. The maturity can be any length of time but debt securities with maturities less than one year are generally designated as money market instruments. During their maturity bonds usually provide fixed income, coupon, why the bonds are often called fixed-income securities. This is mainly the case of government bonds where the coupon is a regular interest payment of the debt and is determined as some percentage from bond's par value. The par value, or *principal*, is the amount of money which is paid back at the redemption *(maturity)* of a bond. In some cases (*floating rate notes*) the coupon can be tight to a money market reference rate or a bond can lack the interest payments totally (*zero-coupon bonds*). Zero-coupon bonds tend to be more common on secondary markets. (Bodie, Kane & Marcus 2011: 439–440.)

The most famous bond is no doubt the U.S. government's Treasury note, also known as the "T-note" whereas in Europe similar status is enjoyed by the

"Bund", a bond issued by the government of Germany. Both of these benchmark bonds have 10-year maturities starting from their issuance.

2.2. Bond valuation and term structure of interest rates

Bond valuation means the determination of the fair price of a bond and is calculated as in Equation 1. below. As with any security or capital investment, the theoretical fair value of a bond is the present value of the stream of cash flows it is expected to generate. Valuation is always inevitable since the possible return of an investment, measured with yield to maturity *(YTM)* in context to bonds, cannot be defined without the fair price. To determinate the fair value of a bond, all of its future cash flows, i.e. coupons and/or par value, need to be discounted to the present. Therefore it is essential to know the discount rate (*the interest rate*, *r*) which can be derived from an analysis called the term structure of interest rates. Though the yield of a bond and the discount rate appear to be synonyms they have a meaningful difference in theory that is to come. When time until each coupon is paid is denoted with t and T is the maturity period, the bond value can be written as

$$\text{(1)} \qquad Bond\ value = \sum_{t=1}^{T} \frac{Coupon}{(1+r)^t} + \frac{Par\ value}{(1+r)^T}$$

The basic idea behind the term structure of interest rates is that the yields to maturity of longer maturity bonds consist of yields for shorter maturity bonds. To help perceive this, an example of action called "stripping" follows. Stripping means the separation of the coupons of a whole Treasury bond (i.e. a fixed-income security) to their own independent zero-coupon bonds. When each of the coupons is stripped and valued as an individual security, a zero-coupon bond, the sum of their market value plus the market value of the par value of the whole bond discounted with the same yield to maturity as the last coupon payment, should be equal to the value of the whole bond where the zeros were origin stripped from, even the yields may vary. This assumption rests on the Law of One Price which is defined by Bodie et al. (2011: 1001) as "the rule stipulating that equivalent securities or bundles of securities must sell at equal prices to preclude arbitrage opportunities". However the stripping needs to be done to define spot rates and consequently short rates. (Bodie et al. 2011: 481−482.)

The spot rate, y_n, is the yield to maturity on zero-coupon bonds meaning that annualized interest rate what an investor will have on her zero-coupon investment if bought now and held until the maturity *(n, years)*. Hence the spot rate is the interest rate which was used in stripping to determine the fair value of each zero. If the spot rate is known the market value, i.e. the present value of a zero-coupon bond can be calculated with slight change from Equation 1. as

$$(2) \qquad Bond\ value = \frac{Par\ value}{(1+r)^T}$$

Based on the Law of One Price the price difference now, and hereby the expected returns for different maturity bonds, needs to lead equal results regardless of which investment strategy is used by investors. For example, there should be no difference in terms of returns whether an investor buys now a 2-year zero-coupon bond or invests in a 1-year zero-coupon bond on consecutive years. This in turn gives an indication what might be the interest rate for a 1-year zero-coupon bond one year from now. This future interest rate, needed also for the discounting, is called the short rate, r_n, and its relation to spot rates is defined below in Equation 3. where it comes clear that the yields of longer maturity bonds consist of the yields of shorter maturity bonds, as

$$(3) \qquad (1+y_n)^n = (1+r_1)\times(1+r_2)\times(1+r_3)\times\ldots\times(1+r_n)$$

where n denotes the period in question and y_n is the yield to maturity of a zero-coupon bond with an n-period maturity. Thus y_1 always equals r_1. This relation, illustrated also in Figure 3. on the next page, can be shortened by using the previous time spot rate leading to Equation 4.,

$$(4) \qquad (1+y_n)^n = (1+y_{n-1})^{n-1}\times(1+r_n)\,.$$

Afterwards it is possible to define any period's short rate based on the yields of zero-coupon payments by transforming Equation 4 to Equation 5.

$$(5) \qquad (1+f_n) = \frac{(1+y_n)^n}{(1+y_{n-1})^{n-1}}\,.$$

Since the actual future's short rates, r_n, are always uncertain as is the nature of future, the name and the notation used in theory for the expected or defined short rate is the forward interest rate, f_n.

Here was the basic idea behind the bond valuation and the interest rate derivation. However since the real world is uncertain, the actual short rate that will prevail in the future rarely equals the forward rate, which is calculated from today's data. Because of this issue few theories about the term structure are developed and those are shortly presented next. (Bodie et al. 2011: 482–487.)

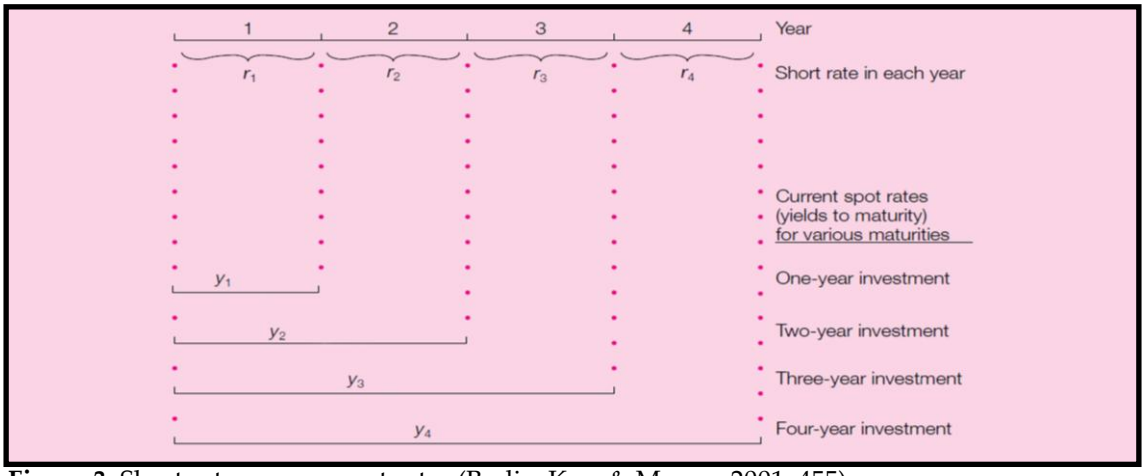


Figure 3. Short rates versus spot rates (Bodie, Kane& Marcus 2001: 455).

2.2.1 Theories of the term structure

Above an example was used where it was assumed in name of market efficiency (*no free lunches*) that there should be no difference in terms of returns regardless what maturity bond and which strategy the investor will choose. However, since the future interest rates are uncertain in the real world the investor cannot be sure whether the 2-year zero-coupon bond will yield the same, more, or less after the first year, than the 1-year zero-coupon bond bought one year from now. Thus there is more risk in investing in longer maturity bonds than in shorter maturity bonds. It can be that the interest rates of the 1-year zero-coupon bonds will rise and then the fair value of the 2-year zero-coupon bond is not worth as much after the first year as previously expected. Therefore at the redemption the investor will have the yield that was

locked in the beginning whereas another investor who rolled over the 1-year zero-coupon bonds on two consecutive years will have larger returns. Obviously if this would be the case the investors willing to invest in longer maturity bonds would certainly demand a higher return from the interest rate risk they are carrying. Thus there needs to be difference between forward rate and expected short rate, $E(r_n)$. This difference is named liquidity premium, which refers to the ability to sell an asset easily with predictable price. Since longer maturity bonds carry greater price risk (interest rate risk), they are considered less liquid in this context and therefore need to offer a premium.

Consequently the forward rate may be considered as the sum of two components, the expected short rate and the liquidity premia. In respect to this view it is relatively easy to present the theories of the term structure. There are three main economic theories attempting to explain how yields vary with maturity. Two of the theories are extreme positions, while the third attempts to find a middle ground between the former two. The first and simplest theory is the expectations hypothesis where a common version of it argues that liquidity premiums are zero. Hence the name of the theory since it states the forward rate equals the market consensus expectation of the future short interest rate. So the forward rates derived from today's long-term spot rates (YTM) can be used to infer market expectations of future short rates (Bodie et al. 2011: 490–491). Accordingly the hypothesis assumes that the various maturities are perfect substitutes and thus neglects the risks inherent in investing in bonds; the previously mentioned interest rate risk and reinvestment risk.

The second theory named liquidity preference assumes that while long-term interest rates reflect market expectations about future short interest rates, investors also have investment horizons and therefore follow their investment strategies. This creates preferences for different maturity bonds and is then contrary with the perfect substitute assumption of the previous hypothesis. The liquidity preference theory also asserts that short-term investors dominate the market and thus a liquidity premium is demanded for holding long-term bonds. Therefore the premium, the excess of f_n over $E(r_n)$ is predicted to be positive (Bodie et al. 2011: 491). In theory this premium needs to compensate investors not only for the interest rate and the reinvestment risk but also for the higher risk of credit loss from holding a security for a longer period. Therefore

questions arise when long-term rates fall below short-term and the expected short rate exceeds the forward rate leading to a negative liquidity premia.

Because of the shortcomings of the previous theories there is a third one, the segmented market hypothesis. According to this theory the various maturities are not substitutable and as a result there exists independent markets for both shorter and longer maturity bonds. On these markets the supply and demand is based solely on the investors' decisions on whether they prefer more liquid portfolios or longer-term investments. Although the market segmentation theory succeeds in explaining the usual market situation where short-term yields are lower than long-term yields, this theory fails to explain the observed fact that yields tend to move together whereas the first two theories explains it perfectly.

In practice one does not need to rely on these theories and determine by self the correct discount rates used in bond valuation since spot rates are reported together with bond prices in financial press. However, while weighing which investment strategy would profit the most, an investor needs to consider what direction the interest rates are expected to move and what will the future short rates be. For the support of decision making a potentially powerful tool called yield curve is useful. Yield curve depicts the spot rates, i.e. current yields to maturities, of bonds with different maturity dates and interpolates the intervals where no maturity date exists. The most famous curve is no doubt the yield curve of U.S. government debt securities, jointly called the Treasuries. It is illustrated on the next page together with the yield curve of U.K. gilts (the debt securities issued by the Bank of England) in Figure 4. on two different days, the first and the last day of the observation period of the thesis.

Figure 4. The yield curves of U.S. Treasuries and U.K. Gilts. The inverted and flat curves are on January 1, 2007 whereas the upward rising curves are on December 27, 2010 (YieldCurve.com 2011).

The word potentially was used while first mentioning the yield curve because the curves live along with the interest rates' fluctuation and thus is not stable. Actually the changes in the shape of the yield curves can be quite substantial as is seen during the four years in Figure 4. Here the outcome of active trading from shorter towards longer maturity bonds may have been much more profitable than investing only in long term since the short interest rates have fell relatively more. This outcome is simply inferential from Equation 1. in bond valuation where it is easily seen that a change in the discount rate causes an adverse change in the bond price. In fact this property of bond prices is progressive because a decrease in the interest rate results in a price gain which is larger than the price decline resulting from an increase of equal magnitude in interest rates. This relationship between bond prices and yields is called convexity because of the convex shape of the bond price curve and is demonstrated next in Figure 5. (Bodie et al. 2011: 448.)

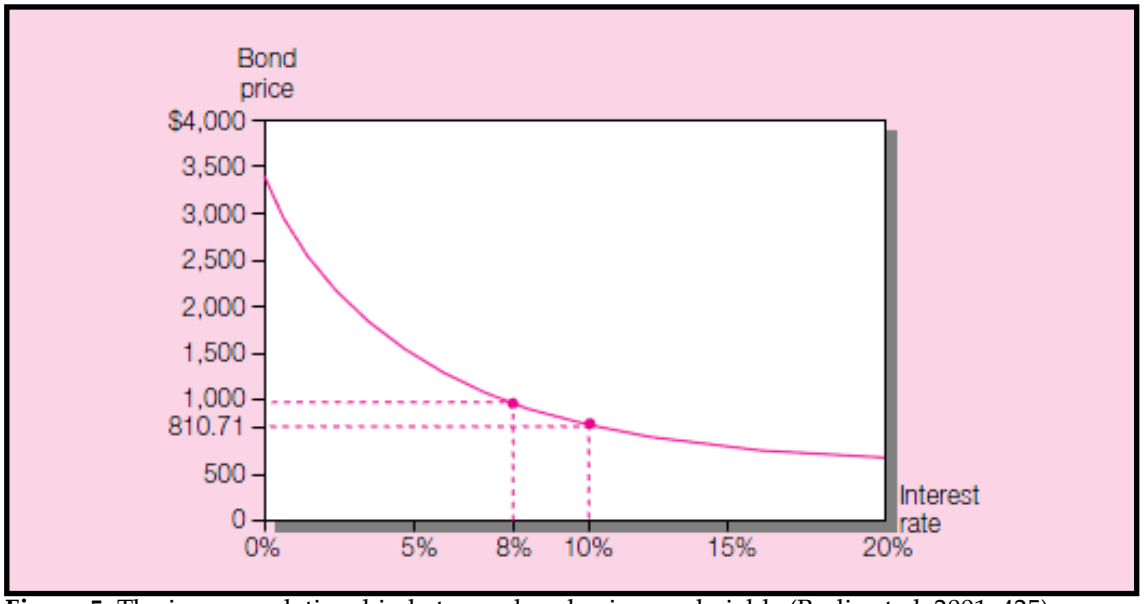


Figure 5. The inverse relationship between bond prices and yields (Bodie et al. 2001: 425).

However, while the yield curve reflects the current market expectations of future interest rates it can also reflect other factors. Recalling to the expectations hypothesis the current yields reflects only the expected future short rates but then for an example when upward rising yield curve it means always higher and higher future short rates. The liquidity preference had also the premium to explain this and thus next will be taken a closer look at premiums.

2.3. Risk premiums

Definition of the risk premium in theory is that it is the difference between an expected return and a certain return since by excess return is meant the difference between the realized rate of return on a risky asset and the actual risk-free rate. Therefore risk premium is the expected value of an excessive return. In practice by risk premium is meant the additional return demanded from a riskier asset compared to that of a less risky asset. In context to bonds the risk premium is often named yield spread, or *yield differential*, since it is calculated as the difference in yields between two bonds. The popular less risky asset used here is usually a so-called *benchmark bond* such as the T-note or Bund. (Bodie et al. 2011: 129.)

While the fixed-income securities are generally considered as less risky in comparison to for example shares or derivatives, the bond market is no exception to the risk-return trade-off. Also with government issued bonds, sometimes called risk-free assets, the credit quality and a specific bond's risk level varies. Thus with a similar principle as on private capital markets where some enterprises are better borrowers than others, also governments differ in terms of bond quality. Because a better bond quality leads to a lower yield, risk premiums i.e. yield differentials arise and the amount of these are defined based on risk factors. Below are listed and explained most of the risk factors related to government bonds (Knüpfer & Puttonen 2009: 82−88; SIFMA 2011):

Systematic risks

- *Interest rate risk (price risk)* is the inverse relation shortly discussed in the previous chapter. The longer the bond's maturity the greater its interest rate risk since the higher its price sensitivity. Thus the long-term bonds tend to have a higher yield as well. The interest rate risk derives from the fluctuation of the expected return of investors. A measure for the price sensitivity is called *the modified duration*.
- *Inflation risk* decreases the real yield since inflation causes depreciation of the future cash flows i.e. the future interest payments and principal. Thus the purchasing powers of the cash flows are less than at the time of investing. In addition, and especially at a time of economic growth, inflation usually leads to higher interest rates, which in turn lead to lower bond prices.

- *Currency risk* derives from the possible currency fluctuation which affects the bond's price during the maturity as well as it may depreciate the future cash flows
- *Reinvestment risk* arises from a possibility of lower future interest rates than at the time when purchasing the bond. This means investors have to reinvest the received cash flows with lower expected returns.
- *Market risk* is the risk that the whole bond market declines and drags the values of individual securities down with it regardless of their fundamental characteristics.
- *Timing risk* refers to the risk that the bond's price plummets after its purchase or peaks after its sale.

Unsystematic risks

- *Credit risk (default risk)* is defined by Standard & Poor's (2010) generally as "the failure to meet a principal or interest payment on the due date contained in the original terms of a debt issue." In addition "Standard & Poor's considers a sovereign to be in default under any of the following circumstances: (1) For local- and foreign-currency bonds – – issued by the central government – – a sovereign default occurs when the central government either fails to pay scheduled debt service on the due date or tenders an exchange offer of new debt with less-favorable terms than the original issue."
- *Liquidity risk* means such a lack of demand that it results in wide bid–ask spreads causing a liquidity premium when an investor wants to sell bonds. Typically the most liquid periods for bonds are right after issuance when the typical bond has the highest trading volume and when bonds are deliverable into the nearest-to-expiry derivatives.
- *Transaction risk* is the risk of changes between subscription and payment which may lead to unexpectedly higher fees or excessive costs.
- *Selection risk* is similar to timing risk but here the security underperforms for reasons caused by its issuer risk and could not have been anticipated.
- *Call risk* is a risk existing only with callable bonds. Sometimes bonds may have a call provision entitling their issuers to redeem them at a specified price on a date prior to maturity. These bonds are usually more likely to be called when declining interest rates.

All of these risks do not necessarily relate to EMU government bonds. For example when a European investor invests in euro-denominated EMU bonds in euros there is no currency risk. Other possibly absent risks are transaction risk and call risk since the first is more common among business-to-business operations and obviously the second does not exist if the bond is not callable.

The most certain risks when investing in bonds and actually the ones that cannot be avoided are credit risk and reinvestment risk. Though regardless of the USA's ever-growing liability of debt the U.S. government bonds are generally treated as free of default risk (Bodie et al. 2011: 461). However, avoidance of all the other risks demands that the investor purchases the bond straight from its issuance and holds it until the maturity. In addition the bond needs to be a U.S. Treasury Inflation-Protected Security (*TIPS*) to avoid the inflation risk.

Because it is a surprisingly complex process to define risk premiums, especially in such a way that the outcome would represent the fair value of a bond, and there are every market participants willing to learn this the demand for the help of independent credit rating agencies is obvious. These companies, namely Fitch, Moody's and Standard & Poor's, compiles ratings about governments and companies based on their risks and thus the uncertainty of their actual payments. The actual payments should be concerned uncertain as they always depend on some ultimate level on the borrower's financial status. This uncertainty is analyzed in the light of today's financial status and tomorrow's outlook by the credit rating agencies and after a credit quality rating is awarded. The poorer the rating the higher the demanded interest rate on the markets usually is, and thus the larger the risk premium. The need for the credit rating agencies may had grown a somewhat unbearable since. To avoid conflict of interests these companies should stay independent from other market participants and the markets functionality sometimes may depend too much on the agencies' faultless actions. Questions whether this has been the situation have been staged particularly after the subprime crisis in the US. This topic is shortly discussed in the end of this section when a review to current crisis is presented.

2.4. EMU context

EMU government bonds differ from the normal sovereign bond context largely because of the main feature of monetary union. A member in EMU is engaged to transfer the monetary authority in its entity to the European Central Bank, ECB. For a sovereign state this can be considered as having some positive implications as well as negative ones. The clearest positive implication coming along the mutual monetary policy is the common currency which eliminates the intra-market currency risk and is more stable than the sovereign's own currency thus reducing the currency volatility outside the market area. A clear negative implication is that all the EMU governments are now exposed to liquidity crisis also and not only solvency crisis thanks to the mutual monetary policy. In liquidity crisis bond prices decline and thus the interest rates increase leading to higher interest expenses. A member state still has fiscal policy means though

(e.g. taxation and government borrowing) to guide its economy but since losing its ability to print money the member is also dependent on the actions of central bank. This layout creates a possible threat of systemic bank failures and/or credit defaults because governments are more likely to turn on additional borrowing in times of budget stress since their tools are limited. A prevention of mentioned situations should be in the interests of other members too since these could cause depreciation of common currency or a liquidity overspill onto other bond markets. (Lemmen & Goodhart 1999: 77–81.)

To prevent situations like solvency crises and create creditability on the financial markets few actions were taken. First of all in the Maastricht Treaty, the Treaty on European Union, in 1992 was included a convergence criteria known as the Maastricht criteria. The criteria includes four main criteria presented in Table 2. which are the criteria for EU member states to enter the third stage of EMU and adopt the euro. To ensure the members keep respecting the Maastricht criteria, an agreement among the member states of EU taking part in Eurozone was made. This agreement is called the Stability and Growth Pact, SGP, and it consists of the public deficit and debt to GDP criteria from the Maastricht Treaty. Yet in addition an article 125 was included in the Treaty on the Functioning of the European Union, the Lisbon Treaty in 2007 and in the Treaty on European Union since Maastricht. The article 125 commonly known as the bail out clause clearly rules out the possibility of direct financial assistance from EU and thus from an EMU member to another. It is as important to note that since the Maastricht Treaty neither ECB is obliged to rescue any troubled members and thus not expected to inject liquidity into the system in cases of solvency crisis.

Table 2. The Maastricht Criteria (Article 121(1), 1992).

1.	**Price stability:**	the inflation rate of a given Member state must not exceed by more than 1.5 % that of the three best performing Member states in terms of price stability.
2.	**Government finance** **a)** *Annual government deficit:* **b)** *Government debt:*	the annual government deficit must not exceed 3 % of GDP. government debt must not exceed 60 % of GDP.
3.	**Exchange rate:**	the Member state must have participated in the exchange-rate mechanism (ERM II) under the European Monetary System (EMS) for two consecutive years before the examination and should not have devalued its currency during the period.
4.	**Long-term interest rate:**	the nominal long-term interest rate must not be more than 2 % higher than those of the three best performing Member states in terms of price stability

With the yield spread in context to EMU government bonds is generally meant the difference in market yields between country i's and Germany's bonds. All in all these spreads can be caused by three main factors though the spreads vary cross-country and cross-time. The first factor is country-specific risk of default which is strongly related to the country's fiscal vulnerability. Second is liquidity and it is also a country-specific factor even though it may be affected also by external matters such as liquidity overspills or crisis. Third factor is more a systematic one that changes with time and it is investors' preferences and the markets' reprising of the risk. (Barrios et al. 2009:2, Pagano & von Thadden 2004: 546–548.)

2.5. The sovereign debt crisis in the EU

Grounds for the current 2010 crisis were casted as early as when the euro was taken in use in 2002. By that time right after the bursting of the tech bubble and as was seen in the introduction in Figure 1., the yield spreads between all the euro countries integrated and converged with the yield of German Bund. This

enabled the Border States, mainly southern European governments, to start raising capital for much lower interest rates than they were used to despite the borrower's credit qualities. This of course led to higher indebtedness, especially in southern Europe.

Nevertheless the global economy was growing and as the financial markets priced the risks among the euro countries more or less the same - in terms of market yields - the financial integration in the euro area enhanced (e.g. Codogno et al. 2003). At the same time in the United States a housing bubble was accelerating thanks to new credit derivatives that enabled banks to transfer the default risk of mortgages onward to investors. This created unprecedented liquidity on home loan markets since every savings and loan bank was cashing because they could award mortgages practically for everyone and then pass the default risks onward to financial markets. On the markets investment banks securitized these subprime mortgages to collateralized debt obligation (CDO) derivatives, obtained quality ratings from the credit rating agencies for them and passed on to investors. Obviously this scheme led to increasing house prices while the interest rates were at a relatively low level. London Interbank Offer Rate (LIBOR) being below 2 % in 2004 with the spread between T-bill rate (i.e. TED spread) near 0 % indicating healthy banking sector. (Bodie et al. 2011: 14–19.)

However, the interest rates began to rise in 2005 which started to brake the ever-growing housing prices. This of course lifted also the interest expenses of homeowners and thus delinquency rates in subprime mortgages started to accelerate in 2006. But the banking and insurance industry had also created another credit derivative called credit default swap (CDS) to hedge against the default risks and thus the markets remained calm. This did not last long since the whole system was suddenly short of collaterals when it emerged that the ratings of the CDOs had not taken into account the possible collapse of the whole housing markets of the U.S. In addition among the initial loaners was a large mass of insolvent homeowners who needed to default the whole mortgage at the same time with half-the-price house (collateral). In 2007 banks and hedge funds all over the world were found to be vulnerable because of the subprime loans. (Bodie et al. 2011: 18–21.)

As the financial crisis peaked in September 2008, the U.S. government needed to bail out the federal mortgage agencies Fannie Mae and Freddie Mac, and private insurance company AIG while the large investment bank Lehmann Brothers filed for bankruptcy. Within days the U.S. government was pumping hundreds and hundreds of billions onto the markets and at the same time investors worldwide suffered losses not only because of the plummeting share prices but also because AAA-rated (the best possible credit rating) debt securities turned out to be worth nothing. Oldest and largest Wall Street investment banks, such as Merrill Lynch, were sold to each others in attempts to prevent the worst possible consequences. The capital markets froze up and companies could not raise even short-term funds since banks were either insolvent or unable to raise funds themselves. The recession was officially declared and because of the global capital markets its effects reflected on Europe as well. (Bodie et al. 2011:19–23.)

In Europe the stock exchanges crashed likewise and in the aftershocks of the global financial crisis banks were forced to writedowns also in Europe suffering heavy credit losses. This created the need of excess borrowing for European governments since several banks needed to be bailed out to cut the further freezing on the capital markets and economies were stimulated in an attempt to prevent the recession. For a while it looked like the markets were correctly pricing the risks since the government bond yield spreads increased substantially (this is demonstrated later in section 4. in Figure 7.) in early 2009. The governments' aid packages after all calmed down the markets and the spreads converged again. (Barrios et al. 2009: 2–5, Vits & Anstey, (2010)2010.)

However, the increased borrowing of governments and especially in the case of southern Europe, started to develop fears of a sovereign debt crisis in Europe in late 2009. Because of the global financial crisis the gross domestic products (GDPs) were dropped at the same time when indebtedness had increased. Therefore ratios such as the debt-to-GDP (dtG) describing the solvency of governments were far from what was mutually agreed among the EMU members in the SGP. To top of the situation, the new government of Greece publishes on 21 October 2009 that its last year's public deficit is twice the figure what was originally reported. Consequently the credit rating agencies downgrades the ratings of Greece.

In early 2010 volatility starts to stick the interest rates of the other euro countries also as the fears grow further. Greece announces its strict means of fiscal policy in fighting against the growing indebtedness. A month later it is revealed that Greece had paid hundreds of millions of dollars for different banks for hiding its actual level of borrowing from EU. Regardless as the general situation does not change, Greece is forced to ask help from the EMU. Shortly after its bonds are dropped to 'junk' grade and it is bailed out by EU and IMF. At the same time Portugal's rating is downgraded and in the end of 2010 Ireland is granted a bail out package. It became slowly certain that the countries could not have survived from their massive debt burdens alone but yet they enjoyed from very modest interest expenses in terms of market yields only a year before.

3. PREVIOUS LITERATURE

Most of the studies on the integration of financial markets have concerned equity markets. Although thanks to EMU's influence, the credit markets have also gained growing attention especially over the past years. On these markets the European government bonds have been undoubtedly the most popular target of integration measurement. Still the difference is that research on integration on bond markets is modest compared to integration studies on stock markets.

In this chapter will be discussed relevant previous studies related to the subject. Discussion starts from general view to research area related to bonds proceeding more specific area and different aspects concerning the integration on financial markets and in EMU context. Towards the end of the chapter the weight goes naturally on government bond markets integration in EMU.

3.1. Seminal bond research

To begin with here is a shortly reviewed study which can be perceived as one of the seminal papers since many studies afterwards have based on this. It is Lawrence Fisher's paper which was published in 1959. He tested a hypothesis about the determinants of risk premiums on corporate bonds. The risk premium was measured as the market yield spread between "riskless" U.S. treasury bonds. As explanatory determinants was used firms earnings variability, period of solvency, equity/debt ratio and the market value of all the bonds outstanding (i.e. publicly traded). The feature what made it seminal was the same sort of what this master thesis is aiming to determine and it was described by Fisher (1959: 218) as follows: "this is the first time they (i.e. the explanatory variables) have been used together in an attempt to discover how much investors are influenced by various aspects of bond quality". Thus the actual tested model was a linear regression and it was intended for estimating the average risk premium on a firm's bond by the four variables mentioned.

Fisher used cross-sectional data with five different time sections between 1927 and 1953. The data consisted of only industrial corporations' bonds in the U.S. because public utilities and governments were not considered to be exposed to default risk that time due to regulatory reasons. The regional restriction was to exclude the currency risk.

As results Fisher was able to explain more than 70 % of each cross-sections' risk premium with the model. The correlations of coefficients were as expected and agreed by economists, so that the earnings variation was the only determinant that was positively correlated with the risk premium. As the main conclusions Fisher noticed that economic and statistical methods are appropriate to security analysis. Moreover it was proven even the methods could not indicate rational investor behaviour that, at least in the bond market, the coefficients in respect to the risk premium are relatively steady over time. Worth noticing here is that the data's time sections comprehended sections before, during and after the Great Depression.

3.2. Government bond and integration research

Bernhardsen (2000) studied European government's interest rate differentials relationships to macroeconomic variables in the context of European Exchange Rate Mechanism (ERM). Consequently the time period was from 1979–1995. His panel data consisted of macroeconomic variables (the rate of unemployment, the real income growth differential, the relative labor costs, the inflation differential, the current account and the public deficit) from nine European countries. The countries used were France, Belgium, Denmark, Italy, the Netherlands, Austria, Great Britain, Norway and Sweden. The macro factors were regressed against the interest rate differential and as the interest rate differential was used the 12 months interest rate spread between Germany. The regressions were done twice calculating for slightly different interest rates, the yearly average and the last observation of the year. Other data was with yearly frequency because of the data availability and "overlapping data problem" (Bernhardsen 2000: 290–291).

As his methodology Bernhardsen analyzed the panel data using linear regression models. In the regressions country specific "fixed effects" (dummies) were used and they were run twice again. First having all the countries in the same group and later having two groups where the ERM membership was the separating factor. Stationarity of the factors was tested with panel data suitable Dickey-Fuller and Lewin & Lin tests.

Bernhardsen wanted to find more relevant evidence from the relationship between interest rates and macroeconomical factors. As his hypothesis was that interest rate differential depends on domestic macroeconomic variables. This suggests governments may affect the domestic interest rates by conducting the appropriate policy. If this does not hold and there is no relationship, a government's chances to influence the interest rate are small.

The results of Bernhardsen's study argued that all the macroeconomical factors have statistically significant effects to the interest rate differential. The most important explanatory variables with a clear effect were the real income growth differential, the relative labor cost, the inflation differential and the current account whereas the current account was the only variable with negative sign. Moreover based on all tested models the real income growth and the inflation had statistically strongest evidence. Almost as strong evidence was founded for the current account to have negative effect on the interest rate differential. All in all the results were roughly the same for all the models with an exception concerning the public deficit. The debt-to-GDP had a positive significant effect only for the countries outside ERM. This indicates that compared to non-members, ERM countries can handle larger public deficits without facing an increase of depreciation expectations and the interest rate differential. This may have given ERM countries more flexibility in fiscal stabilization policy compared to the outsiders (Bernhardsen 2000: 303). In addition the study contained speculation about exchange rate policy creditability which was based on the dummy factors. However there were unclear results whether or not the ERM was sufficient system to produce such creditability.

The findings were more promising than results in previous studies where as the measures for interest rate differential were used short-term rates. It can be that the macroeconomical factors explain long-term interest rate differentials better than short-term differentials. For example, in case of inflation, it can be

considered that if inflation today influences expected inflation in the future, inflation today may have a stronger effect on long term interest rates than on short term interest rates. Hence the effect of the inflation differential on the interest rate differential will be stronger for interest rates at 12 months maturity than for interest rates at 1 month and 3 months maturity (Bernhardsen 2000: 302).

As the contribution Bernhardsen found strong evidence for the hypothesis that a government's policy affects the interest rates. The explanation was that all the studied macroeconomic variables may influence depreciation expectations and consequently the domestic interest rates. Because Bernhardsen's findings were stronger and more promising than in previous studies there is a clear indication that macroeconomic variables explain long-term interest rate differentials better than short-term differentials.

Ejsing and Sihvonen (2009) were motivated by the "on-the-run liquidity phenomenon". The name is to describe a pattern identified in previous studies. According to this phenomenon there are pronounced liquidity differences across government securities so that the most recently issued bond of a particular maturity tend to be much more liquid than the earlier issued ones. Because liquidity being a valuable factor for market participants, especially during market stress, the better liquidity results in liquidity premia *(i.e. premium)* thus having an important implication for bond pricing. Previous studies based mainly on evidence from the U.S. treasury market.

In contrast Ejsing and Sihvonen concentrated on the liquidity of German government bonds as a purpose to provide new insights to the topic. These securities were considered especially interesting for two reasons. At first the German government bonds are gained the benchmark status among euro interest rates as are U.S. government securities in dollar rates (Ejsing & Sihvonen 2009: 14–19). But second, the market structures between the securities of these two issuers differ considerably. The most notably difference is the relative size of futures market to cash market, that is in U.S. 56 % and 985 % in Germany. This implicates a possibility to liquidity spillovers in terms that bonds which can be deliverable into the futures contracts undergo a significant peak in their liquidity when the bonds become deliverable. Studying this feature Ejsing and Sihvonen formed following two hypotheses. The German

futures market gives rise to significant liquidity spillovers to the bond market and these liquidity effects are reflected in the prices of German government bonds as the liquidity premia. Moreover they assessed whether the determinants of liquidity premia changed during the financial crisis.

The study was actualized with liquidity data collected from two different sources. From an electronic trading venue, MTS, bond trade data was obtained at intra-day frequency between January 2006 and September 2008. This included approximately ten million quotes (depth of daily quotes and quoted bid-ask spreads) and sixty thousand trades on German government bonds. Furthermore traded volumes were obtained from Datastream because the MTS transactions represent only a fraction of the overall trades. Trading volume covered the period from January 2002 to February 2009.

The liquidity was measured all in all with four different meters: traded volumes, quoted depths, quoted bid-ask spreads and a liquidity index. To assess the determinants of liquidity a panel regression model was used with seven different regressors. These included besides time to maturity, seasonedness and issue size four dummies for: time, deliverability, cheapest-to-deliver and on-the-run status. Identical analyzes was also conducted for a control country (France) to ensure findings. Strongest evidence was found when explaining the traded volumes despite the high validity *(over 73 %)* of every model. The results suggested the liquidity of German bonds which became deliverable into the futures contracts rose higher than those of not-deliverable. Moreover this impact was consistently higher for German bonds than for the control country which lacks a future market and the positive relation between deliverability and liquidity increased in the crisis sample.

Ejsing and Sihvonen also compared German bonds yields to those of France due to similar fiscal fundaments and lack of a bond futures market to find out the possible spillover reflection. They calculated yield spreads between the two countries and pooled their data to a panel which included observations during the shorter time period so after splitting that it was possible to compare the results in pre-crisis and post-crisis periods. The spread was then tried to explain by credit risk, liquidity measure, average issue size and deliverability to futures contract in a regression. In pre-crisis period the liquidity was found not to be statistically significant and overall validity of the model remained below 70 %.

However in post-crisis period subsample all the coefficients were strongly statistically significant and had the expected sign. Liquidity and credit risk were positively correlated with the yield spread and so were the deliverability coefficients *(which were dummies based on the maturity of the bond)*. The issue size was negatively correlated and three times larger than in pre-crisis sample indicating that large float grew importance in times of market stress. What was perhaps the most notable in post-crisis sample, where the model explained 75 % of the spread, was that the convenience yield for the 10-year bond was as high as 6 basis points. Together with the future deliverability premium the total convenience yield for long-term deliverable bond could well be 8.2 basis points. This indicates relatively strong liquidity premia in German government bond yield in crisis time.

As their conclusions Ejsing and Sihvonen noted that the "on-the-run liquidity phenomenon" did not appear in the German government bond market. Instead they found strong evidence about yields of German government bonds being closely related to their eligibility for futures contract although they could not fully explain the liquidity premia with their variables. Also the economic importance of liquidity and deliverability emphasized clearly under severe market stress, here the 2007 financial crisis.

Björkstén (2000) documented integration in the EU, the US and Canada. His approach was to analyze real convergence in mentioned economic zones and to produce benchmark estimates for integration in EMU for upcoming 10–30 years. As EMU is a specific system for convergence and a true part of integration on European markets aiming coherent productivity, income and price levels, Björkstén's target was to estimate the concrete speed for the European convergence process.

Real convergence was measured with GDP per capita and price levels in Europe during 1970–1997, with regional income per capita and gross state product in the United States during 1950–1998 and with provincial income and output per capita in Canada during 1961–1998. The data of Björkstén's study is collected from the OECD, the Bureau of Economic Analysis (US Department of Commerce) and the Statistics Canada. As used methodology were linear panel regressions where the dependent factor was the annual change in the productivity gap between a country/region/province and average. Regression

methods were seemingly unrelated regression (SUR), and generalized least squares (GLS) when serial correlation caused biases. From Europe the data included EU15 countries (EU members in 2000) added with Norway, Switzerland and Iceland.

First Björkstén examined real convergence and the mechanism for it in 2000. Afterwards the study proceeded to comparisons of the development of integration based on the above mentioned measurements and run the regressions to estimate the speed of real convergence for each economic zone in turn. Because of closer economic integration, increased trade, a diffusion of technology and best practices (namely in Europe) and especially migration (namely in the US and Canada) it is clear on every zone that the poorest and the richest areas (country/region/province) converges. This phenomenon creates, besides growth, inflation as well for the poorer areas. Based on the earlier results where the real convergence speed was determined to be around 2 % Björkstén conducted a simple simulation concerning EMU involving the faster-growing Spain, Portugal and Greece. He expected these countries to achieve higher growth rate than the rest of the EU countries and still the countries' real per capita would be 85 per cent of the euro area average by 2040. However based on the results the strengthening growth and inflation may cause inflation pressures for the whole euro zone.

In the end Björkstén after all did not believe that real convergence in Spain, Portugal and Greece could cause problems for EMU since convergence in these countries has started already before 1990s. Though in his another simulation where he considered 13 candidates (e.g. Turkey, Romania and Balkan countries) for accession to the EU the convergence speed could substantially differ from the first simulation. This simulation takes its place during 2020–2030 and estimates the range of convergence speed in Europe to be from 2 % per year to over 10 %. During this process trend inflation will be higher in the "catching-up" countries starting to diminish from 5 % yearly inflation and temporary these countries may cause inflation pressures and shocks to the whole euro zone. While measuring integration with per capita GDP Björkstén believes the catching-up process nears completion by 2030, after which the related inflation differential is assumed to disappear. His simulation did not take into account any eventual changes to relative positions on the business cycle.

Goetzmann, Li and Rouwenhorst (2001) carried out a study where they examined the correlation structure of the world equity markets over 150 years. Because of such a long data period Goetzmann et al. starts from primary theories as well. Much of credit is given for Henry Lowenfeld's 1909 published study and book which may well contain the first documentations of the co-movement of securities from various countries and the first strategies to use in international diversification. As the purpose of the study was to examine how international diversification has actually fared over the world market history when modern academic research on topic has begun circa 40 years ago. In addition they wanted to study how well Lowenfeld's and his predecessors' strategies actually served investors over the last century and half i.e. how beneficial global diversification had been. Last Goetzmann et al. were considering whether there could be useful lessons for future found in capital market history.

The data of the study was enormous as one can imagine when the studied time period is over 150 years and comprehending all the major world equity markets. The data was collected from four different sources; Global Financial Data, the Jorion and Goetzmann sample of equity markets, The Ibbotson Associates database of international markets and the IFC database of emerging markets. Their combined sample included more than 80 markets that appear to have existed at some time currently or in the past in Eastern and Western Europe, North and South America, South and East Asia, Africa and Australasia. The data was cross-sectional time series of returns from equity markets mentioned above. Self-evidently the used information had notable holes in it since very few markets had have proper indexes continuously for such a long time (say more than 100 years), or there have existed investable markets without record at all and vice-versa.

In this massive documentary Goetzmann et al. had three contributions. First they wanted to document the correlation structure of world equity markets since 1850 to 2000, and this was driven by the lack of such data. The second contribution was to provide a decomposition of the benefits of international diversification. Thirdly they wanted to develop an econometric framework to test hypotheses about changes in correlation among different markets through time. After documenting all the returns and calculating the correlations they tested for constancy with a test based on the asymptotic distribution of

correlation matrix from previous studies. Final tests were accomplished with the data from four "core" countries: US, UK, France and Germany. Later the decomposition of the benefits of international diversification was made with three different scenarios to separate the effects of average correlation from the effects of increasing numbers of markets. The decomposition was calculated from the diversification ratio of the variance of an equally-weighted portfolio to average variance of a single market. This was needed because when analyzing the past benefits of diversification it is clear that more the markets one ads in his portfolio the more one benefits whereas this case could not continue to perpetuity since investment possibilities were limited for investors. So it was necessary to take into account how many markets there were available for example investors in the mentioned core countries. After this it was possible to calculate the decomposition of benefits in the past. The three scenarios included a portfolio where the investor hold an equal-weighted portfolio of four core countries and had limited diversification possibilities to only these markets; a portfolio with relaxed constraints so that there are diversification benefits of the "average" portfolio of four whatever countries over time (in this sense there are an unlimited number of country indices available so that all idiosyncratic risk can be diversified away); a portfolio assuming an investor that holds an equal-weighted portfolio across all countries in the sample at any given point in time.

During the whole time period the average correlation for all available markets with a rolling window of 60 months was never over 0.5. Closest to this correlation the world equity markets came during the Great Depression while the other peaks (~0 and ~0.4) occurring in the end of the centuries. All in all the average correlation changed through time quite dramatically. Other findings were that the benefits of international diversification are not constant and as mentioned earlier the benefits were highest when new markets became available for portfolios. When the opportunity set expanded, the diversification benefits of cross-border investing relied increasingly on investment in emerging markets. Based on the calculated diversification ratio the relatively greatest benefits were gained when the number of markets in portfolio was added from one to six, this applied for all the examined time intervals. In the end it was concluded that roughly half the benefits of diversification available today to the international investor are due to the increasing number of world markets and half is due lower average correlation among the available markets (Goetzmann et al. 2001: 20–21).

Bowe and Mylonidis (1999) investigated the level of integration which prevailed on the Ecu-denominated international bond market before the last third phase *(i.e. the single currency)* of EMU. They were motivated by the lack of a single benchmark yield curve which could have become a foundation for the pricing of debt securities in the single European capital market after the introduction of euro, where Ecu was converted into euro at an exchange rate of one-to-one. This kind of a benchmark yield curve is usually derived from the yields of government bonds as e.g. in U.S. However because of the unique character that European capital markets do not have Federal European government institution, whose debt links the yields and maturities on euro-nominated bonds, constitution of such benchmark curve was left to market participants to decide. Consistently this eventually selected benchmark curve's usefulness in pricing bonds is depending on how well the European government bond markets can be said to exhibit the characteristics of a single, co-ordinated and integrated capital market system.

As said the study of Bowe & Mylonidis was carried out before the introduction of euro, more closely with data from March 1992 through January 1996. This time period was chosen because following the Maastricht Treaty the Ecu's composition was frozen that time. The weekly data was obtained from the database of Bloomberg, consisting of yields of seven European countries: Denmark, Spain, Belgium, Norway, Italy, France and the United Kingdom. Tested time series were long-term nominal yields of government bonds with time to maturities of 3-, 5-, 7- and 10-years.

Since considerable empirical evidence was found in previous studies that yields to maturity behave like integrated stochastic processes, Bowe & Mylonidis derived two definitions based on expectations theory to test for market integration. At first the Ecu capital markets were defined to be partially integrated if the yields moved together in the long-run. This cointegration of the yields were measured in two sets forming a defined Ecu benchmark term structure (UK, Belgium and France) and subsets of benchmark Ecu issues whose constituent securities possessed the same residual maturity. By using Johansen's procedure of multivariate cointegration analysis they tested the definitions. Hence the first condition of fully integrated markets demanded a unique stochastic trend to be common for all Ecu bond yields. The second

condition for complete integration tested zero-sum restriction on the cointegrated vectors.

The results of the cointegration analysis suggested that the various Ecu-denominated government bonds yields were partially integrated in terms the yields being cointegrated. Among yield series with the same residual maturities a unique stochastic trend was found with the exception of the 3- and 10-year maturities indicating evidence of full integration for 5- and 7-year maturities and only partial integration for the formers. However the second condition for complete integration was rejected implying non-stationarity between the yield spreads. Possibly the rejection could have been explained by the failure of the expectations hypothesis or biases from free-floating currencies. Since the UK and Italy left the ERM in September 1992 and Norway never was a member. Anyhow the study simply did not contain enough evidence to support the complete integration hypothesis during that time period.

3.3. Government bond yields integration in EMU research

Lemmen and Goodhart (1999) studied the default risk of EU member countries on the eve of euro. They were motivated for their research the need to investigate how much effect the fiscal stance of governments has on the default risk. This was crucial that time since government bonds in EMU were thought to come subject to only default risk *(instead of default and currency risk)* along the introduction of euro. This was due to expectations that intra-EMU exchange risk will be zero and inflation risk would be the same for every country in the eurozone. As their contribution was to compare the government bond yields to the respective credit risk and define what amount of the yield can be explained by the default risk. For this factors likely affecting default risk were identified though they could not distinguish between credit risk and liquidity risk because of the lack of data on the volume of government bond issues.

After a simple theoretical model for default risk a one-way and two-way fixed effects regression models were estimated. Relevant data was available from 13 countries belonging to European Union (EU15 excluding Greece and Luxembourg) during 1987−1996. The explained default risk was measured in a

synthetic way by the spreads between 10-yr government bond yields over the corresponding interest rate swap offer rates of the same 10-yr maturity denominated in the same currency defined as the annualized redemption yields. The 10-yr bond yields were particularly chosen because European governments increasingly financed their debt at longer maturities and at 10-yr horizon. As explanatory variables were government's tax raising capability, ability to control spending and debt management policies together with the degree of federal (EU) support, the capacity of the political system to produce coherent governments and the government's socioeconomic environment.

Because the default risk was measured in a synthetic way, Lemmen and Goodhart needed to have a key assumption that (1999: 82): "the credit risk of prime banks or corporations does not vary greatly from currency to currency so that fluctuations in the differential between the public sector debt rate and the fixed swap rate are assumed primarily reflects shifts in the credit risks of the former". This was essential also in terms to be able to compare the default risks between the countries. Another major assumption was that liquidity variations are negligible and was made because the model could not distinguish between credit risk and liquidity risk as mentioned earlier.

As a part of their results of analysis and comparisons of long-term government bond interest rates, Lemmen and Goodhart noted among the member states of EU, the interest rates have strongly converged to German long-term interest rates already in the first half of 1998. From their paper was also found a statement made by IMF that the noted convergence was a result from fundaments created by EMU rather than other reasons such as excess liquidity. Their comparisons were made with EMU countries in addition to parallel sample of countries not belonging to EMU *(i.e. Denmark, Sweden and UK)*.

The results of econometric analysis were somewhat expected. Government default risk was found to depend positively on changes in gross debt and lagged variability of inflation. Negatively the default risk was related to lagged inflation and tax margin increases. Since government expenditure was too strongly positively correlated with government debt ratios it was left out from the final model as well the federal support which size is relatively modest in EU. The null hypothesis about the equality of country-specific fixed effects was clearly rejected. In the end the tests were ran in two samples to test robustness

since observations showed Italy being an outlier. The goodness-of-fit of the model also dropped significantly when Italy was not included but otherwise it was relatively high around 70 %. Lemmen and Goodhart concluded that the bond yield differentials are likely to continue within EMU despite the earlier mentioned evidence of narrowed yield spreads with Germany. This was thought to be because fade out of these spreads would require accepting a "joint liability" of the EMU member states for each other's debt. (Lemmen & Goodhart 1999: 91–92.)

Codogno, Favero and Missale (2003) implemented their study in the same context. The disappearance of currency risk and integration of government debt markets in EMU. Their contribution was to search deeper for the determinants of the government bond yield spreads in an attempt to define these not yet fully converged spreads. Codogno et al. started their study from rationalizing the reasons for the eurozone yield spreads and by analyzing the actualized yield spreads since 1990s until December 2002 which also served as their timeline in the study.

As the European bonds are perceived as imperfect substitutes the goal of creation of a mutual euro-bond market was seeing frustrated. Also an appropriate cost-minimizing debt management that could lead to narrower spreads via more efficient transactions was seen as a policy task. Therefore the study suggests that in addition to the belief of market participants about liquidity premia, default risk is a relatively important component of the spreads especially because due to EMU exchange rate factors and controls on capital movement were eliminated. Consequently the goal of the study was to identify the importance of the mentioned two factors in pre-EMU and post-EMU samples by using macroeconomic fiscal fundaments, international risk factors and liquidity factors as variables.

The findings of Codogno et al. argued that fluctuations in the euro area bond spreads were mostly explained by changes in international risk factors such as US swap and corporate bond spreads relative to US Treasury yields. Also the importance of debt-to-GDP ratio was clear with three countries when used as in relation to the dtG of Germany. Substantial significant of default risk was perceived in case of Italy and Spain. Liquidity was found to have an effect when measured with trading volumes rather than with bid-ask spreads and France

was the only country to have the liquidity factor more important than the international risk. As a result the common currency was found as the cause for increased correlation among the euro countries. However the risk of default remained as a small important factor suggesting more structural integration in indebtedness is needed for further convergence of the yield spreads. Therefore Codogno et al. (2003: 527) believed that this risk component would continue to work as a deterrent for irresponsible fiscal policies.

Barrios, Iversen, Lewandowska and Setzer (2009) provided an empirical analysis in the exact same context as this thesis. Only they focused on the government bond yield spreads and their developments during the previous financial crisis. The data reached from March 2003 until April 2009 with weekly data and from Q1'2003 until Q2'2009 with quarterly data. Eventually the following seven countries were included in the analysis: Austria, Belgium, Spain, France, Greece, Italy and Portugal while Germany also but as a benchmark.

The factors used in the study of Barrios et al. were liquidity risk, credit risk, risk aversion on financial markets and a dummy representing crisis time. To measure the risk aversion an indicator was calculated where credit ratings of corporate bonds, stock market volatility and exchange rate volatility of the euro-yen were taken into account. To assess the liquidity risk bid-ask spreads were used and for the credit risk changes in 5-yr CDS contracts were measured. In addition with quarterly data few more factors were included in OLS regressions and these were fiscal balance, debt level and current account balances, all as a percentage of GDP. The fiscal data was from the Economist Intelligence Unit and was converted into weekly frequency by interpolation.

The findings of Barrios et al. suggested that EMU government bond yields are strongly influenced by the international risk aversion on financial markets. The domestic factors, such as liquidity and credit risk, only became important during the crisis. Especially the role of fiscal factors was shown to grow importance with the level of general risk aversion, leading to discrimination between the EMU sovereign bonds when intense financial market turbulence. The researchers also noted that despite the easing conditions on the global financial markets towards the end of 2009 it seemed unlikely the integration in EMU yield spreads will revert to pre-crisis level in the future. This was mainly

because the integration of spreads was seen on an abnormal level before the crisis and because government debt levels had increased significantly in many countries when compared to pre-crisis period.

All in all the econometric evidence provided by Barrios et al. yielded high (>0.7) goodness-of-fits with quarterly data while the weekly data produced much lower R^2s. Also a clear difference between the significances was obvious since most of the coefficients were significant at 1 % level in quarterly results while none in weekly results. Hence the data frequency played undisputed role in the study.

On the next page a summary from previous literature is presented. The Table 3. draws main points, such as data, methodology and determinants, from each study discussed in this section.

3.4. Summary of the previous studies

Table 3. Synopsis of the main points of the previous studies.

Study	Data	Methodology	Determinants	Findings / Other
Determinants of risk premiums on corporate bonds **(Fisher 1959)**	cross-sections (5) between 1929–1953 with industrial corporation bonds	a linear regression with least squares method	earnings variability, period of solvency, equity/debt ratio, bonds outstanding	coefficients relatively steady over time despite the Great Depression
The relationship between interest rate differentials and macroeconomic variables **Bernhardsen (2000)**	1979–1995, 1-yr yields of 9 European countries	linear regressions	6 macroeconomic variable	all variables significant, dtG affected positive only to non-ERM countries
Liquidity premia in German government bonds **Ejsing & Sihvonen (2009)**	liquidity data between Jan 2002 – Feb 2009 (German, France, US)	panel regressions	maturity, seasonedness, issue size and 4 dummies (time, deliverability, price, status)	no 'on-the-run' effect, but strong liquidity spillover related to Bund futures contracts
Real convergence in the enlarged euro area **Björkstén (2000)**	1950–1998, EU15 countries w/ Norway, Switzerland, Iceland	SUR and GLS	GDP and CPI of US, Canada and Europe	convergence of East-Europe to EU more problematic than Spain's, Greece's or Portugal's
Long term global market correlations **Goetzmann, Li & Rouwenhorst (2001)**	cross-sectional equity returns between 1850–2000	correlation test, scenario analyses, diversification ratio	equity markets all around the world	avg. correlation for available markets never over 0.5 with a rolling 60 mos.
Is the European Capital Market Ready for the Single Currency? **Bowe & Mylonidis (1999)**	Mar 1992 – Jan 1996 yields of 7 European countries' government bonds with maturities of 3-, 5-, 7- and 10-yrs	Johansen's multivariate cointegration analysis	benchmark yields (based on issuance and credit ratings), matrices of cointegrated vectors	partial integration based on cointegration, full integration based on unique stochastic trend in yields, no 1-to-1 relationship between yields
Credit Risks and European Government Bond Markets **Lemmen & Goodhart (1999)**	1987–1996 10-yr bond yields & swaps of EU15 (w/o Greece and Luxembourg)	one-way and two-way fixed effects regressions	taxable capacity, government expenditure, gross debt, EU grants, inflation	strong convergence to Germany, country-specific features clearly matters
Yield spreads on EMU government bonds **Codogno, Favero & Missale (2003)**	Jun 1991 – Dec 2002 10-yr bond yields of 10 EMU governments	SURE with daily and monthly data	debt-to-GDP ratio, spreads of US government bonds and US interest rate swaps & US corporate bonds	EMU yield spreads mainly explained by international risk factors, increasing integration, default a small factor
Determinants of intra-euro area government bond spreads during the financial crisis **Barrios, Iversen, Lewandowska & Setzer (2009)**	Mar 2003 – Jun 2009 10-yr bond yields of 7 EMU governments	OLS with weekly and quarter data	liquidity risk, credit risk, risk aversion, crisis time dummy	international risk aversion a main determinant, others grow importance during crisis

4. DESCRIPTIVE ANALYSIS

This section presents and documents the data. After presentation all the risk factors studied in the thesis are described and analysed carefully. Later the factors and observations are compared to each other and results reported. The aim of the section is to document the studied factors and give the reader a better understanding for upcoming chapters.

4.1. The data of the thesis

As related to the 2010 sovereign debt crisis, time period for the data used in this study is from January 2007 to January 2011. This time period alone allows the study to concentrate on the yield spreads during the financial crisis. This analysis of government bonds yield spreads bases on the long-term interest rate of selected EMU countries. More closely the market based yield on the 10-year government bond. The yields are analyzed as daily, monthly and quarter frequency. Later in the study where econometric methods are used the variables are calculated from monthly average and end of quarter figures.

The selected countries represent the largest economies *(GDP over 100 billion euros in 2009)* in EMU and are illustrated in the Figure 6. The economy restriction is used because the bonds issued by smaller countries tend to have such a poor liquidity that it may well cause biases. After restricting Cyprus, Estonia, Luxembourg, Malta, Slovakia and Slovenia the selected countries are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain and the Netherlands. During the thesis shortenings OE/AUS, BE/BEL, FI/FIN, FR/FRA, GE/GER, GR/GRE, IR/IRE, IT/ITA, PT/POR, ES/SPA and NL are used respectively.

The data consists of market yields on the US 10-year T-notes and the monthly traded volumes of 10-year government bonds of the selected countries. These two variables represent systematic and international as well liquidity risk and are essential in the later econometric model when explaining the yield spreads. Also end of quarter values of debt-related factors, debt-to-GDP ratio and public

deficit figures, are included in the data. All the data is obtained from the databases of Datastream International, Eurostat and European Central Bank's Eurosystem statistical data warehouse except the trading volumes which are also from Datastream, but eventually from International Capital Markets Association's (ICMA) launched TRAX system.

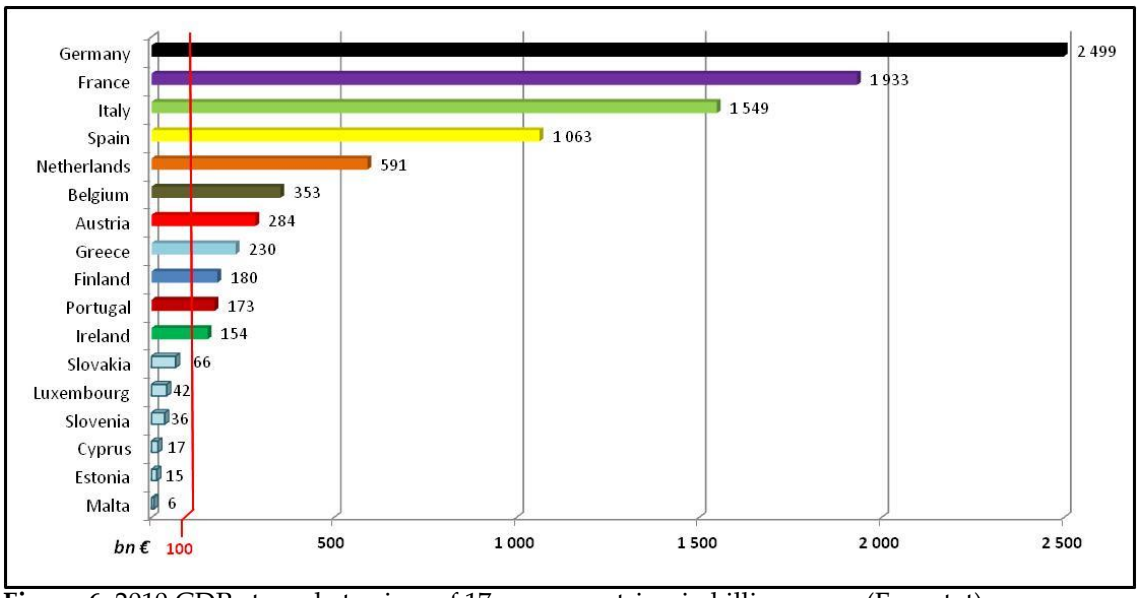


Figure 6. 2010 GDP at market prices of 17 euro countries, in billion euros (Eurostat).

4.2. Yield spreads

In the context of EMU government bonds by yield spread is meant the risk premium which is the difference in bond yields between a euro country and Germany. The yields studied in this thesis are the yields to maturity of government bonds with a remaining maturity close to ten years. The interest rates are harmonised secondary market yields with the data consisting of daily and monthly observations. The daily yields are end-of-day rates whereas the monthly yields are the averages from these. In all analyses and tests basis points are used as the measured units.

The actual spreads are depicted in Figure 7. on the next page where it is easily seen how integrated the yields were in the beginning of the time series. Also a shock in 2008–2009 and general broadening after 2009 can easily be observed.

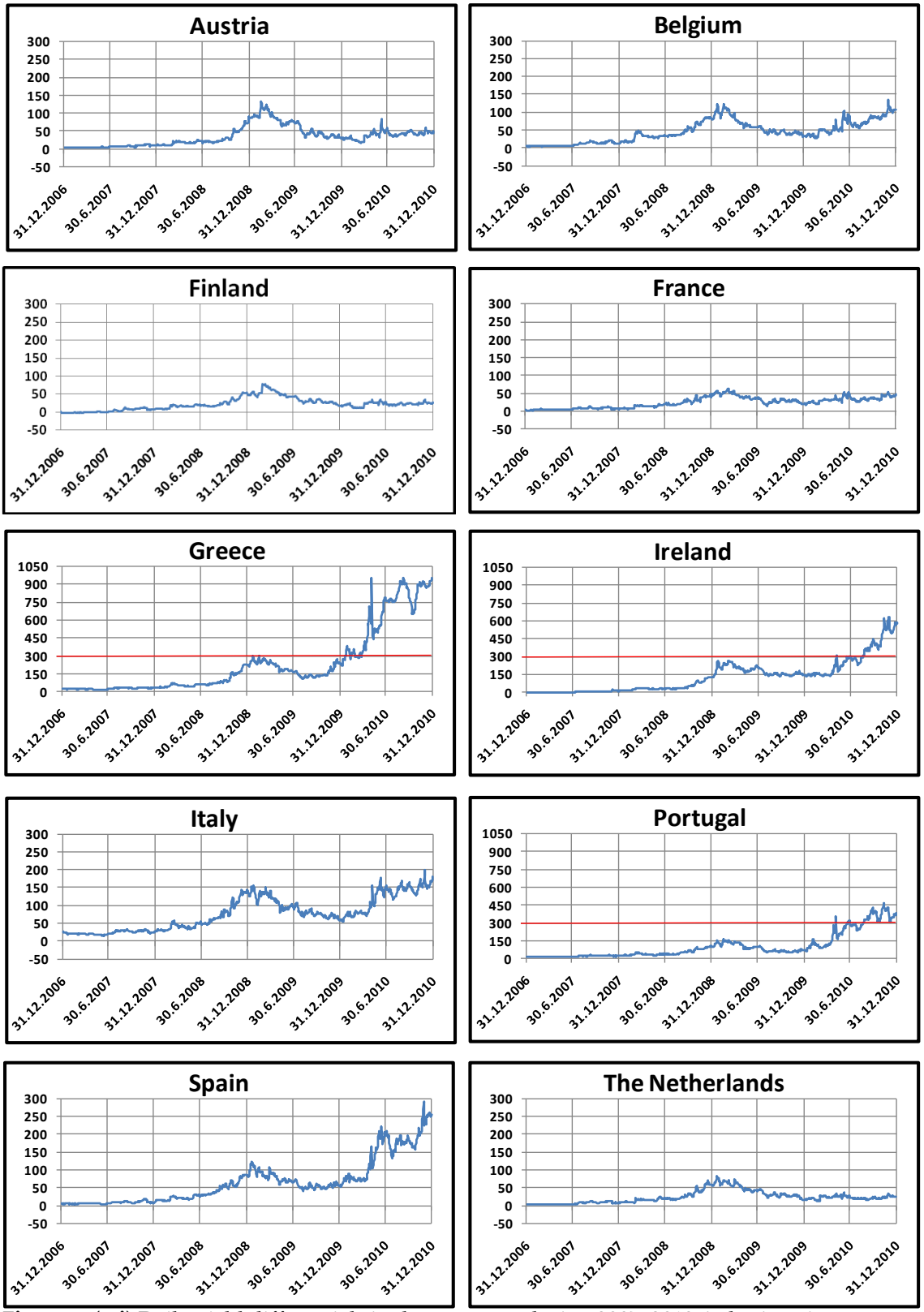


Figure 7. (a-j) Daily yield differentials in the euro area during 2007–2010, in basis points (Datastream).

These spreads varied between -4 basis points and 300 bp with all the largest EMU countries after 2006 until the beginning of 2010. Then on 22 January the spread pipe broke when the 10-yr market yield on the Greece's government bond hit 6.2328 % and so the spread with Germany (3.2069 %) grew to 303 bp. This is demonstrated in Figure 7. (e) where the spread first time crosses the 300 points' red line. For other than PIG countries the whole scale is up to 300 bp.

Below in Table 4. are reported the descriptive statistics of yield spreads calculated from monthly averages. The statistics clearly brings forth the PIIGS countries since all the other EMU members have a maximum of around 1 % spread with Germany. While presenting the maximums between 2007−2009 and 2007−2010 it is obvious that the spreads of the PIIGS have torn since the year 2010 is included in the data. For Greece the adding of 2010 means 625 bp wider spread and for Ireland, Portugal and Spain 295, 272 and 137 basis points respectively. Also the maximum of Italy has risen a bit in 2010 while the spreads of all the other countries have not hit a new maximum. In addition for the first mentioned countries the difference between the two maximum is larger than the country's mean during the whole period. Thus it is clear that the widening spreads must have affected to volatility as well and indeed standard deviation is doubled for Greece, Ireland, Portugal and Spain when the observations of 2010 are included in the data. In fact the standard deviation of these countries had increased so much that it is on the level of the countries' mean, or even above as for Greece and Portugal. For other countries except Belgium and Italy, the standard deviation decreased when 2010 was included.

Table 4. Descriptive statistics of yield spreads.

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	POR	SPA	NL
Mean	41	49	29	29	235	141	84	110	68	26
Median	43	47	28	32	133	148	84	66	57	23
Maximum	114	111	80	63	910	569	169	438	247	69
Max. '07 - '09	114	111	80	63	285	274	155	166	110	69
Minimum	4	4	3	5	23	2	21	14	5	2
STD	28	31	20	16	271	140	47	112	63	18
STD '07 - '09	32	30	23	17	82	88	41	40	32	20
Skewness	0.69	0.35	0.98	0.13	1.45	1.24	0.24	1.51	1.17	0.93
Kurtosis	2.99	2.20	3.44	2.08	3.83	4.39	1.76	4.22	3.55	3.22
Observations	48	48	48	48	48	48	48	48	48	48

The distributions of yield spreads are right-skewed meaning the majority of observations lies to the right of the mean *(more higher values than lower when compared to the mean)* except in case of Italy whose distribution is symmetric. In kurtosis more variation is observed since depending on the country a negative and positive excess kurtosis *(differing from the statistical value 3)* exists. The distributions of France and Italy are the most platykurtic (*flatter than normal distribution)* ones whereas Ireland and Portugal have the most leptokurtic *(peaked)* distributions.

In the upcoming empirical section the yield spreads are determined besides with monthly frequency also with quarter frequency. Therefore mean values for each quarter are computed from monthly observations. Obviously this modification smoothers the data and based on the Jarque-Bera test the null hypothesis of a normal distribution cannot be rejected at the 1 % significance level with all the countries. A significance level of 5 % could have been used but then the hypothesis of the normal distribution must have been rejected in the case of Portugal. The yields after the modifications are presented below in Figure 8.

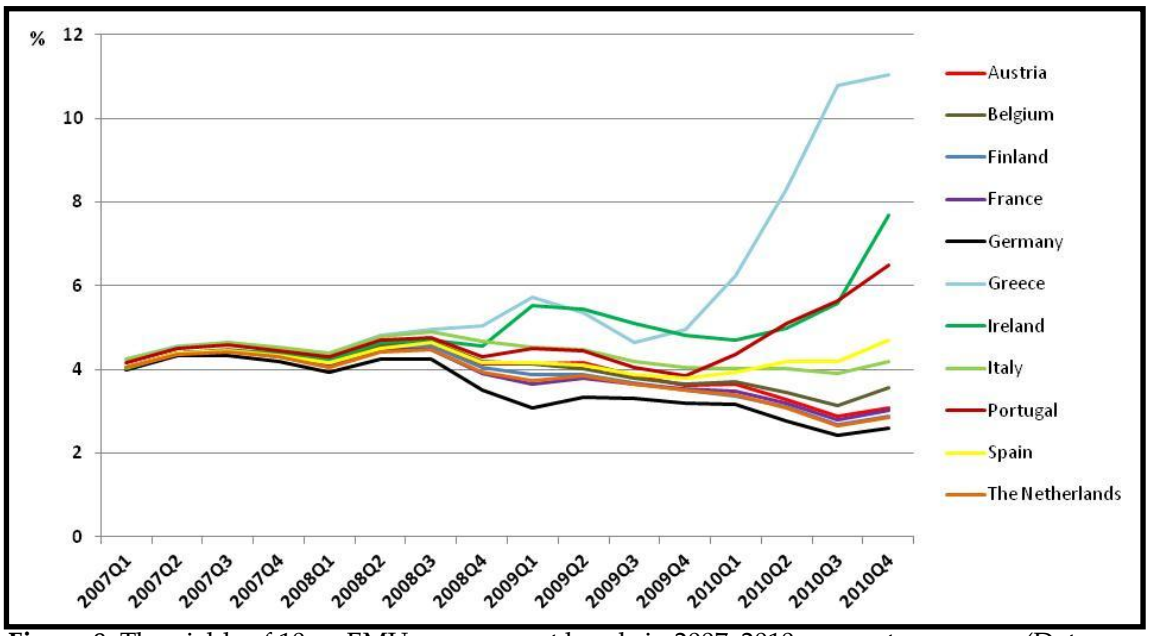


Figure 8. The yields of 10-yr EMU government bonds in 2007–2010 as quarter average (Data from Datastream).

4.3. Determinants of risk premia

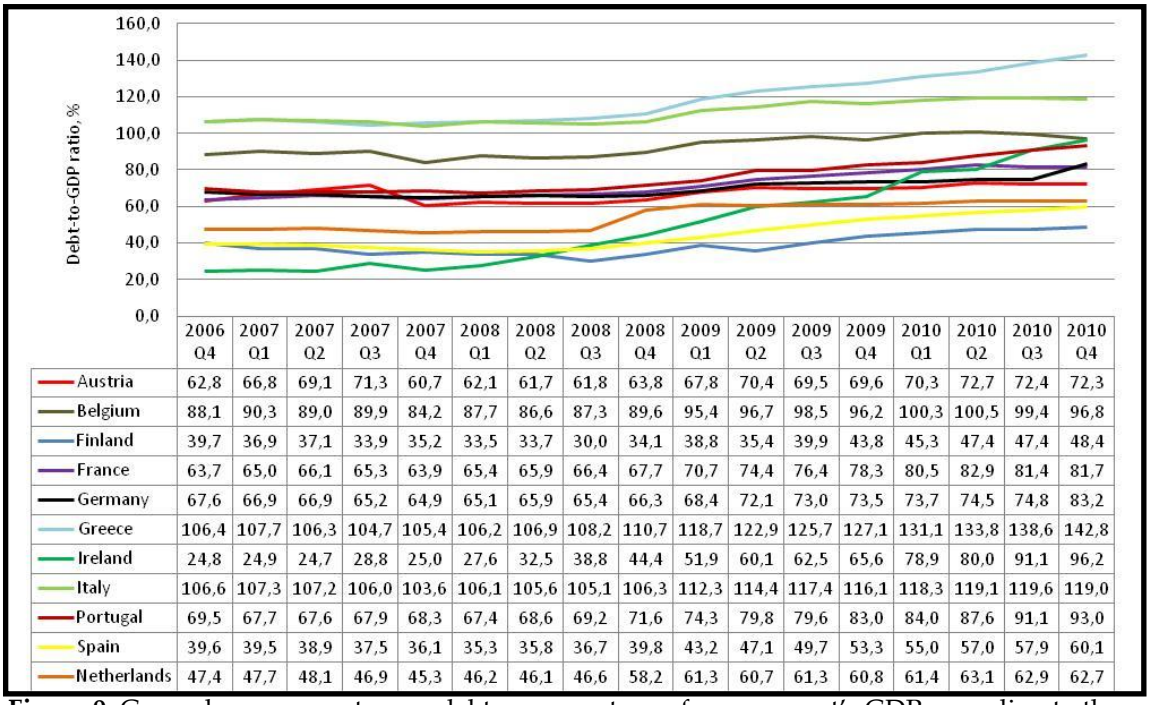
The studied risk premium factors are country *i*'s solvency, liquidity and international risk. These factors are measured with independent variables such as the published debt-to-GDP ratio and public deficit/surplus figure, trading volume and the change in the yield of the US T-note yield. These determinants are presented and analyzed more closely below.

4.3.1. Solvency

First is analyzed the solvency factor which is measured by debt-to-GDP (*dtG*) ratio and public deficit figure. Based on previous literature (e.g. Lemmen & Goodhart 1999; Codogno et al. 2003) these two variables are important factors in defining government risk premiums. Despite the low-frequency feature of these factors the total debt and government budget deficit are anyhow possibly the best factors describing the current and near future solvency of a government.

Quarterly debt-to-GDP is defined as the total gross debt at nominal value outstanding at the end of each quarter between and within the sectors of general government as required by the Maastricht criteria. Classification of the data is in accordance with the European System of Accounts (ESA 1995) and it is transmitted by national authorities (national statistical institutes, national central banks or Ministries of Finance) for Eurostat within three months of the end of the quarter to which the data refer to. Thereafter data are validated before publication. The public deficit figure represents a government's deficit/surplus which is the net borrowing/net lending of general government as defined in the ESA95. It is the difference between the revenue and the expenditure of the general government sector. Thus a government budget surpass is likely to create deficit and vice versa.

On the next page in Figure 9. are depicted with earlier used colors all the quarterly dtG ratios of selected countries between Q4'2006 and Q4'2010 as published by Eurostat. Below the chart is also reported the actual data. As it becomes obvious the governments' debts have grown during the observation period and all in all the whole range of dtGs has jumped around 20 % higher.



	2006 Q4	2007 Q1	2007 Q2	2007 Q3	2007 Q4	2008 Q1	2008 Q2	2008 Q3	2008 Q4	2009 Q1	2009 Q2	2009 Q3	2009 Q4	2010 Q1	2010 Q2	2010 Q3	2010 Q4
Austria	62,8	66,8	69,1	71,3	60,7	62,1	61,7	61,8	63,8	67,8	70,4	69,5	69,6	70,3	72,7	72,4	72,3
Belgium	88,1	90,3	89,0	89,9	84,2	87,7	86,6	87,3	89,6	95,4	96,7	98,5	96,2	100,3	100,5	99,4	96,8
Finland	39,7	36,9	37,1	33,9	35,2	33,5	33,7	30,0	34,1	38,8	35,4	39,9	43,8	45,3	47,4	47,4	48,4
France	63,7	65,0	66,1	65,3	63,9	65,4	65,9	66,4	67,7	70,7	74,4	76,4	78,3	80,5	82,9	81,4	81,7
Germany	67,6	66,9	66,9	65,2	64,9	65,1	65,9	65,4	66,3	68,4	72,1	73,0	73,5	73,7	74,5	74,8	83,2
Greece	106,4	107,7	106,3	104,7	105,4	106,2	106,9	108,2	110,7	118,7	122,9	125,7	127,1	131,1	133,8	138,6	142,8
Ireland	24,8	24,9	24,7	28,8	25,0	27,6	32,5	38,8	44,4	51,9	60,1	62,5	65,6	78,9	80,0	91,1	96,2
Italy	106,6	107,3	107,2	106,0	103,6	106,1	105,6	105,1	106,3	112,3	114,4	117,4	116,1	118,3	119,1	119,6	119,0
Portugal	69,5	67,7	67,6	67,9	68,3	67,4	68,6	69,2	71,6	74,3	79,8	79,6	83,0	84,0	87,6	91,1	93,0
Spain	39,6	39,5	38,9	37,5	36,1	35,3	35,8	36,7	39,8	43,2	47,1	49,7	53,3	55,0	57,0	57,9	60,1
Netherlands	47,4	47,7	48,1	46,9	45,3	46,2	46,1	46,6	58,2	61,3	60,7	61,3	60,8	61,4	63,1	62,9	62,7

Figure 9. General government gross debt as percentage of government's GDP according to the convergence criteria set out in the Maastricht Treaty (Eurostat).

Hence the late rising trend is seen in Figure 9. but moving averages of the dtG ratios highlight it even more while also clearly depicting the turning point. As can be observed below from Figure 10., after the Q4'2008 the rather steady development suddenly jumps when averages increase near 10 % in one quarter. This is a natural consequence following the increased government borrowing.

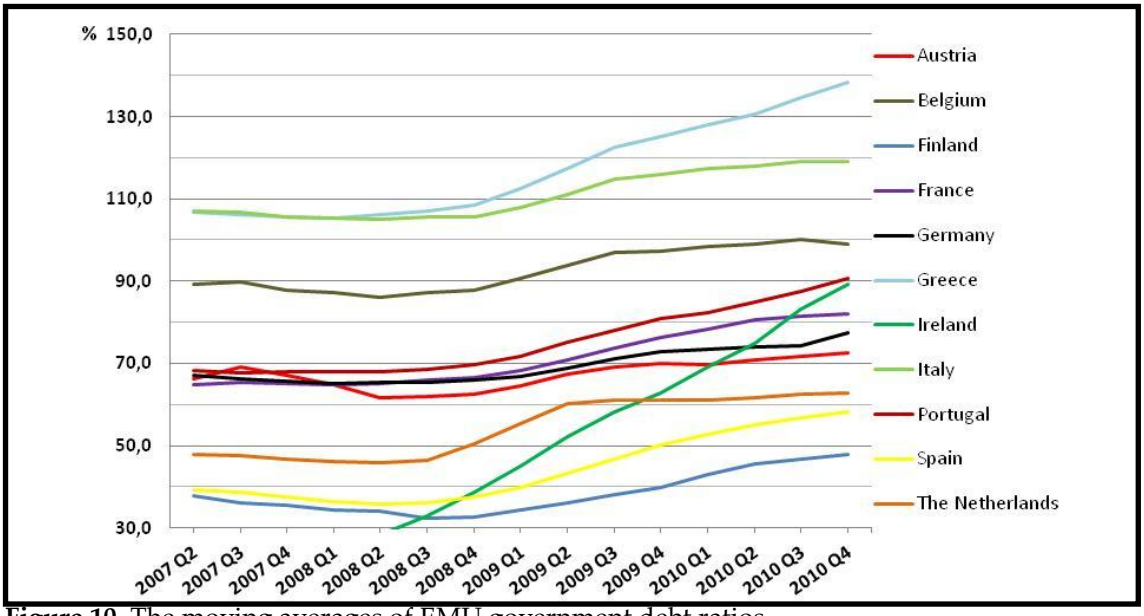


Figure 10. The moving averages of EMU government debt ratios.

The increased borrowing in turn can be demonstrated with the public deficit figures presented in Table 5. Every quarter there is a country whose deficit is more than the -3.00 % agreed in the SGP (though the limit is at yearly level). Usually there are several but it is not before the Q1'2008 when most of the countries cannot keep their deficit below the 3 % limit. However the consequences of this overdraft are barely seen in the dtG ratios except for Belgium and Ireland. The second time when most of the countries have deficits more than -3.00 % is during the Q1'2009 and this time the effects are much serious. In fact the level of deficits increases further the two following quarters and this time it really reflects to the dtG ratios as well. This is the turning point seen in the moving averages and as discussed in previous chapter the peak in the yield spreads as well. At the end of 2009 Finland and Germany are the only countries who do not overdraft the SGP limit. And as the situation does not change a lot during 2010, similar or worse outcome can be expected to be in the end of the year. For this Figure 9. already provided some evidence.

Table 5. The public deficit figures of selected countries in percentages of GDP (ECB 2011).

	2006Q4	2007Q1	2007Q2	2007Q3	2007Q4	2008Q1	2008Q2	2008Q3	2008Q4	2009Q1	2009Q2	2009Q3	2009Q4	2010Q1	2010Q2	2010Q3
Austria	0,18	-3,00	0,88	-3,06	1,04	-4,02	-0,11	-0,66	0,66	-7,22	-4,68	-4,77	-0,24	-10,77	-2,90	-4,88
Belgium	7,48	-8,93	5,15	-3,95	5,55	-8,05	4,78	-4,69	2,24	-13,83	-1,32	-8,58	-0,83	-10,54	0,57	-7,93
Finland	-0,11	4,75	11,34	3,53	1,36	4,87	10,56	3,01	-1,79	-1,05	3,58	-4,69	-8,90	-2,64	2,39	-4,46
France	2,32	-6,84	-0,62	-5,01	1,20	-6,51	-0,76	-5,24	-0,97	-11,67	-6,56	-9,76	-2,54	-11,90	-6,19	-7,28
Germany	-0,44	-1,16	2,10	-0,51	0,61	-0,56	1,91	-0,39	-0,51	-1,80	-1,40	-4,72	-4,06	-5,16	-1,12	-5,31
Greece	-4,64	-8,11	-12,07	-3,24	-3,79	-10,94	-15,28	-6,26	-7,34	-16,51	-17,65	-14,07	-14,10	-15,67	-9,38	-8,11
Ireland	10,12	1,07	-1,88	-6,16	6,73	-5,40	-8,57	-11,18	-4,36	-13,43	-18,54	-15,87	-8,46	-39,09	-15,47	-36,90
Italy	-6,09	-5,47	2,36	-0,31	-2,63	-5,64	-1,33	-1,48	-2,39	-9,47	-3,59	-4,22	-4,11	-8,53	-2,49	-3,36
Portugal	-6,76	-5,02	-0,53	-1,97	-5,35	-4,28	1,33	-5,74	-5,80	-10,80	-8,41	-8,07	-13,13	-9,51	-10,64	-7,19
Spain	-6,66	8,86	1,26	7,85	-9,23	6,48	-3,40	-1,33	-17,59	-0,45	-14,73	-6,96	-21,50	-2,03	-11,32	-4,51
The Netherlands	2,76	1,07	-2,60	-2,13	4,07	1,39	-0,27	-1,68	2,60	-2,56	-6,00	-8,89	-4,60	-3,67	-7,88	-8,30

4.3.2. International risk

The only determinant of risk premia describing the systematic risk in this thesis is international risk. This can be explained similarly as in the study of Codogno et al. (2003: 514) that: "This specification is not motivated by a theoretical model, but by empirical evidence that risk tends to affect bond yields proportionally rather than additively. As international risk increases, all yield differentials generally widen. In particular, the empirical literature on sovereign bond spreads in emerging markets shows that the yield on US government bonds and/or the slope of the US yield curve are main determinants of sovereign

spreads. Blanco (2001) also uses yields on US corporate bonds as a proxy for global credit risk in modeling yields on euro zone government securities."

The idea behind using yields of US T-notes as a proxy for international risk derives from a financial phenomenon called flight-to-safety *(flight-to-quality).* This means an effect on markets that usually appears during financial stress when investors flee from riskier assets into investments that are considered as very safe or the safest possible. Consistently investors have long perceived the T-notes as one of the best safe havens among securities during market stress, because of their real interest, liquidity and relatively small risk. Therefore also in this thesis the change in yields of US T-note is used as the measure for global financial markets' stress.

As a consequence of flight-to-safety yields of less risky assets decreases since the increased demand for these raises their asset prices. This can be seen on the next page in Figure 11. where the yield of US T-note starts slowly to decrease in 2007 and shortly after the eurozone sovereign (here without German Bund) bond yields start to increase together with falling share prices, here denoted by the Eurostoxx50 index. The latter is the cause of market stress when the values of risky assets depreciate most since investors are getting rid of them. Particularly well the phenomenon is seen in the end of the 2008 when after the collapse of the Lehman Brothers the yield of US T-note drops sharply and at the same time especially the bond yields of the PIIGS countries sharply jumps. After couple of months the European share market rocks the bottom. During the end of the 2009 an inverse effect of the phenomenon is seen when markets try to calm down while again it is seen starting on the spring 2010 now with all the PIIGS countries. Since the German Bund enjoys similar benchmark status to T-note it is expected that an increased international risk widens the eurozone yield spreads in terms of either price increase of Bund or price decrease of other EMU bonds or these both.

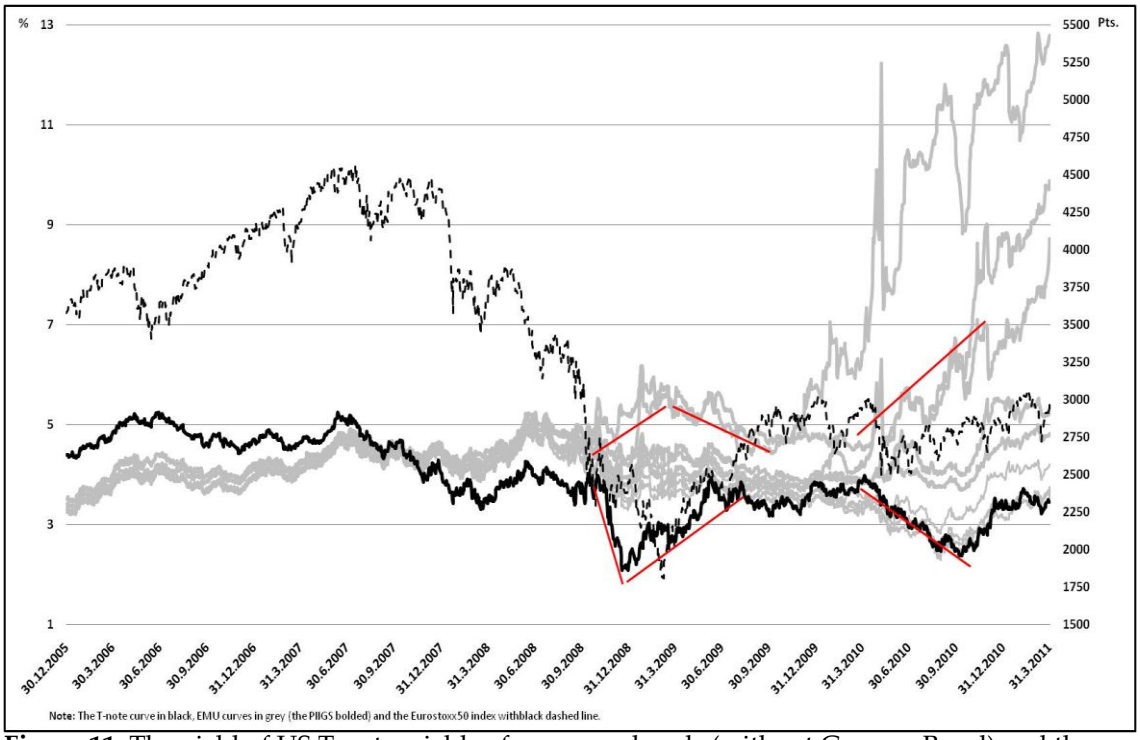


Figure 11. The yield of US T-note, yields of eurozone bonds (without German Bund) and the Eurostoxx50 price index, from Jan 2006 to Mar 2011 (Datastream).

4.3.3. Liquidity

Two possible data sets of liquidity were available. Since the studied yields are secondary market yields of government bonds with a remaining maturity close to 10-yrs would be logical to use the traded volumes of those exact bonds. Also this would be the only optional case if one were to study particularly these nominal bonds. However as this thesis concentrates on the risk premias of euro countries we may choose the better fitting set because another data set is the traded volumes of so-called benchmark bonds. By the benchmark bond is meant the most demanded and thus also the most traded bond series among all the bond series issued by the same government. The demand in turn can be measured with absolute trading volume or with bid-ask spread, called the market breadth and the market depth respectively. Usually the benchmark bonds have maturity near to 10-yrs but sometimes governments may have issued another series of bonds whose maturity is nearer to 10-yrs but still they have not gained the benchmark status for some reason. In this kind of situations the difference in maturities of the two series rarely is significant and especially here since the chosen benchmark bonds have anyway maturity ranging

between 8 to 12 years. The differences in trading volumes instead were much more significant (as seen in Figure 12. on the next page) and after running regressions twice with both series the results show that despite the yields having been calculated from another series the government's 10-yr bonds' risk premium was more depending on the volumes of the particular benchmark bonds.

The observations are end-of-month figures for average daily trading volumes in absolute numbers of bonds traded for that particular month. The data is collected from Datastream but eventually from TRAX system which is a trade matching and reporting system for the OTC markets owned by the Euroclear group. TRAX processed over 847 million transactions in 2010 in a range of capital market instruments (Xtrakter 2011). The described two volume series for each country are illustrated in the next page's charts in Figure 12. (a–k), where can also be noted the differences between these series. The darker shade always represents the trading volumes of benchmark bonds also used later in regressions.

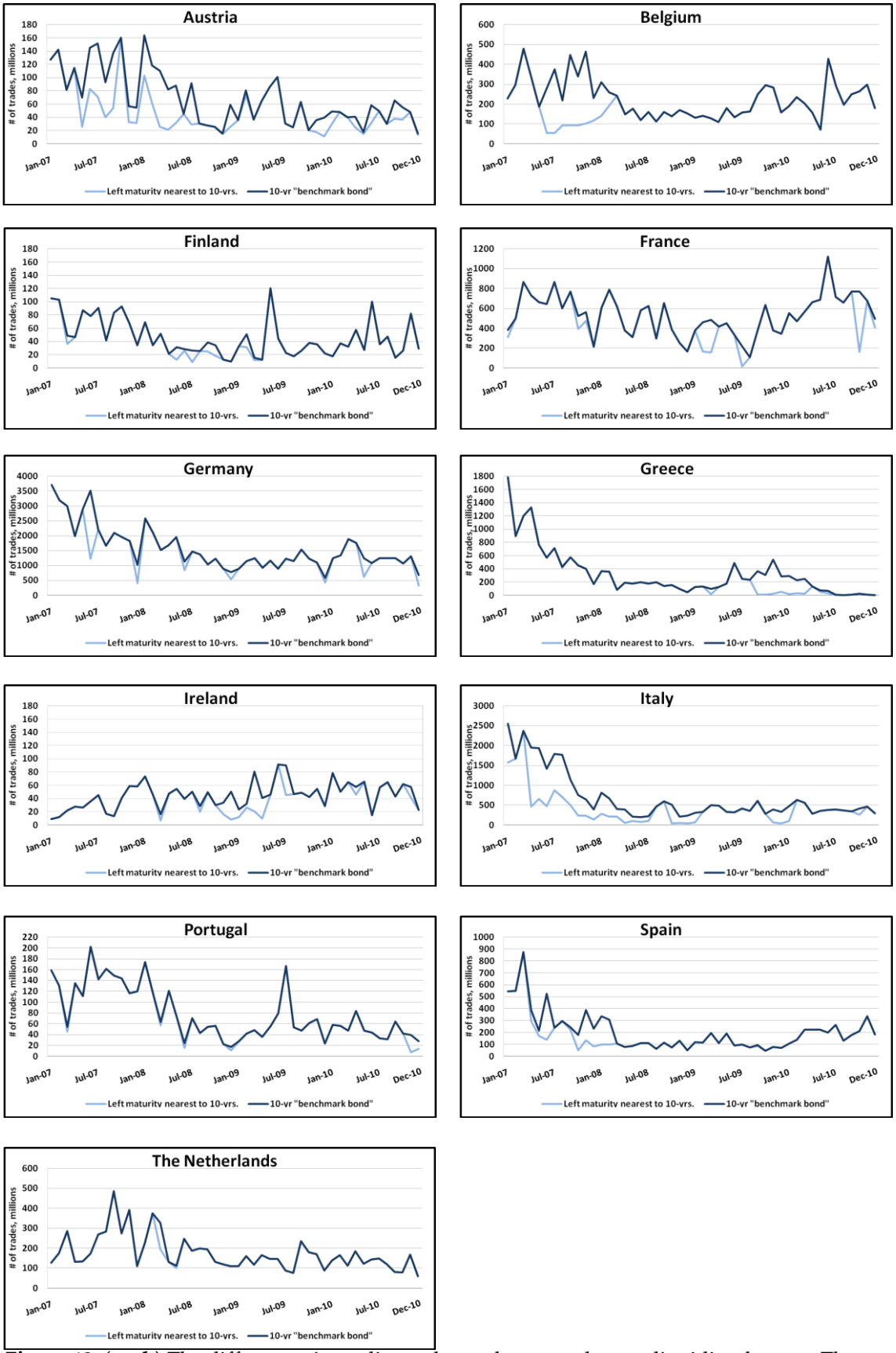


Figure 12. (a – k) The differences in trading volumes between the two liquidity data set. The selected benchmark bond data is indicated with the darker shade (Datastream).

The motivation to use liquidity as one explaining factor bases on findings in the previous literature. Many papers (e.g. Beber, Brandt & Kavajez 2006; Barrios et al. 2009; Ejsing & Sihvonen 2009) suggest the importance of liquidity escalates to a considerable price premium in times of market stress. Also the studied data here reveals significant changes in liquidity after the market stress, caused by the global financial turmoil, started to accumulate. Generally the number of trades rocked bottom in 2008 when it at least halved with the benchmark bonds of Finland, Greece, Italy, Portugal and Spain. In 2009 in this list joined Austria, Belgium, Germany and the Netherlands while for France the change in the number of trades was not so shocking. Strangely with Ireland the liquidity has increased during the whole studied period. In 2010 there was recoil in the liquidities of most of the countries however France being the only one whose benchmark bonds were traded more than at the starting level in 2007. Greece and Italy have clearly lost most of their liquidity since 9.3 billion trades decreased to 1.1 billion and 18.4 billion decreased to 5 billion during the observation period respectively. Other countries that lost more from their liquidity than Germany includes Austria, Portugal and Spain. The only countries whose liquidity decreased in 2010 were Austria, Greece, Portugal and the Netherlands.

The liquidity is also analyzed based on its volatility. To observe the volatility in the number of trades a specific indicator of relative volatility is used and it is named Volatility-%. This ratio defines how significant the volatility has been with respect to total liquidity at yearly basis. Thus the ratio especially reveals extreme movements in liquidity at monthly level as well significant changes in the level of total liquidity. To interpret correctly the Volatility-% it is also needed to consider the average and standard deviation of liquidity together with the total liquidity, as all of them are presented in Table 6.

Important notice arising from the use of Volatility-% is the substantially increased volatility of Finland and Greece, the ratio being 5.1 % and 9.6 % at the end of the 2010 respectively. In addition with Austria, Ireland and Portugal the average ratio during the observation period rose higher than at the starting level in 2007.

By means of the ratio it is also possible to notice the benchmark status of German Bund. Even its absolute liquidity crashed and halved in the financial

crisis since 2008 along the other euro countries, the Volatility-% of Germany has solely stayed below 3 % every year and the last two years it remained as the least while being the most traded bond the whole time. In other words despite the freezing of the markets the liquidity of German 10-yr bonds has even stabled since the beginning of market stress.

Table 6. The liquidity stats (data from Datastream).

		2007	2008	2009	2010
Austria	mthly avg.	111 207 160	71 627 308	51 468 805	43 179 443
	mthly std (mil.)	38	45	26	15
	total	1 334 485 920	859 527 690	617 625 660	518 153 320
	Volatility-%	2,88 %	5,27 %	4,28 %	2,95 %
Belgium	mthly avg.	323 162 267	179 194 350	177 706 325	229 838 958
	mthly std (mil.)	101	60	63	88
	total	3 877 947 200	2 150 332 200	2 132 475 900	2 758 067 500
	Volatility-%	2,62 %	2,78 %	2,96 %	3,20 %
Finland	mthly avg.	73 454 560	32 048 879	36 624 175	42 409 317
	mthly std (mil.)	25	16	29	26
	total	881 454 720	384 586 548	439 490 100	508 911 800
	Volatility-%	2,82 %	4,20 %	6,60 %	5,09 %
France	mthly avg.	609 723 950	472 091 517	383 805 067	679 004 175
	mthly std (mil.)	192	196	132	171
	total	7 316 687 400	5 665 098 200	4 605 660 800	8 148 050 100
	Volatility-%	2,63 %	3,46 %	2,87 %	2,10 %
Germany	mthly avg.	2 421 408 417	1 479 544 525	1 090 026 117	1 279 212 467
	mthly std (mil.)	823	530	238	309
	total	29 056 901 000	17 754 534 300	13 080 313 400	15 350 549 600
	Volatility-%	2,83 %	2,98 %	1,82 %	2,01 %
Greece	mthly avg.	772 883 867	181 806 596	260 421 638	93 131 637
	mthly std (mil.)	460	96	144	108
	total	9 274 606 400	2 181 679 150	3 125 059 660	1 117 579 648
	Volatility-%	4,96 %	4,42 %	4,60 %	9,63 %
Ireland	mthly avg.	30 614 396	43 119 042	52 034 067	53 214 763
	mthly std (mil.)	17	15	23	18
	total	367 372 754	517 428 500	624 408 800	638 577 160
	Volatility-%	4,71 %	2,89 %	3,69 %	2,87 %
Italy	mthly avg.	1 532 968 075	409 362 342	390 524 225	413 033 333
	mthly std (mil.)	681	205	100	104
	total	18 395 616 900	4 912 348 100	4 686 290 700	4 956 400 000
	Volatility-%	3,70 %	4,17 %	2,12 %	2,10 %
Portugal	mthly avg.	135 402 121	69 740 456	59 034 297	47 775 401
	mthly std (mil.)	35	47	37	16
	total	1 624 825 450	836 885 470	708 411 560	573 304 810
	Volatility-%	2,18 %	5,58 %	5,29 %	2,75 %
Spain	mthly avg.	389 224 200	130 573 772	106 988 942	201 256 967
	mthly std (mil.)	204	92	45	62
	total	4 670 690 400	1 566 885 260	1 283 867 300	2 415 083 600
	Volatility-%	4,37 %	5,88 %	3,50 %	2,56 %
The Netherlands	mthly avg.	236 431 708	196 679 217	140 038 095	126 441 058
	mthly std (mil.)	117	86	46	39
	total	2 837 180 500	2 360 150 600	1 680 457 140	1 517 292 700
	Volatility-%	4,14 %	3,63 %	2,77 %	2,57 %

4.4. Results

In this section became clear that there has been an upward rising trend in the yield spreads during 2007−2010 (see Figure 7.). However, it is not a straightforward trend since the global financial crisis caused a peak in the spreads in 2009 and then they reverted shortly after. This reversion anyway was only a temporary one since in the beginning of 2010 the spreads started to widen again. This time the observed widening was more discriminating since now especially the yields of the PIIGS countries rose more than before while the quarter averages of the yields of other selected countries remained below 4 %.

Hence the analysis produces clear evidence with all data frequency that during market stress the yield spreads definitely differ. The evidence is supported even more if the data is being compared to earlier documented strong integration in times without similar market turbulence. The conclusion is also in line with the previous literature (e.g. Barrios et al. 2009). Whether the reason for wider yield spreads is entirely because of the crisis time cannot be conducted here. Although the trends in all credit quality factors during 2007−2010 support the expectations about the relations between the yield spreads and factors.

The debt-to-GDP ratios were somewhat steadily increasing during the whole observation period supporting the parallel trend in yield spreads. More obvious however were the two peaks in indebtedness based on the public deficit figure. These peaks happened the exact same time as the differentiations in yield spreads, in beginning of 2009 and 2010, thus the differentiation concerned most notably the PIIGS countries and Belgium. The correlation between the international risk factor and the PIIGS countries was notable. Figure 11. fully captures the idea of negative relation while also strongly supporting the flight-to-safety phenomenon. In terms of liquidity Greece and Italy lost clearly when compared the trading volumes of 2010 to the starting levels in 2007. Additionally Austria, Portugal and Spain lost more liquidity than Germany during the period. In 2010 only Austria, Greece, Portugal and the Netherlands had decreased liquidity which does not fully support the expectation about the liquidity factor if concentrated on the yield spreads only in 2010. The volatility in liquidity increased the most for Finland and Greece, while increasing also with Austria, Belgium and Portugal. Ireland, Finland and Austria had the poorest liquidity respectively.

As the conclusion from the descriptive analysis it is clear the financial crisis time increases the EMU government bond yields in general. However while concentrating on the 2010 crisis in Europe the following hypothesis cannot be fully approved:

H1: The 2010 started financial crisis in Europe has strongly increased the spreads of EMU government bond yields

The yield spreads have increased with all the selected countries during the 2010 but strongly only with Belgium, Greece, Ireland, Italy, Portugal and Spain. With all of these countries the observed spreads were higher than in previous crisis suggesting highest ever spreads since the strong integration after the introduction of the euro. It is logical as the earlier studies (Pagano & von Thadden 2004, Barrios et al. 2009) have concluded that EMU bonds are substitutes (yet not perfect), and since the country-specific features become important during the times of market stress, the crisis leads to discrimination between EMU bonds. Consequently the first hypothesis can only be accepted behalf of Belgium and the PIIGS countries.

5. EVIDENCE AT THE COUNTRY-LEVEL

In this section is developed an econometric approach, a model, to determine the risk premium. The model aims to separation of systematic risk, country-specific credit risk and liquidity risk. First is shortly explained the data used here and then the methodology. This is followed by the presentation of the model and afterwards the empirical results of country-level analyses.

5.1. Data

The same data as in previous section is used but here with one notable challenge. The static feature of debt-related economic indicators lays a restrictive factor in the form of data mismatch. Where yields, liquidity and systematic risk variables can be observed at high-frequency the debt-to-GDP ratios and public deficit figures designating the country-specific credit risk are only available at quarter level. This makes a basic regression analysis with the raw data difficult but has also been a general challenge in previous studies (see e.g. Codogno et al. 2003, Barrios et al. 2009). This challenge is first dealt with by focusing on the variables at the quarter level and using arithmetic means for the high-frequency variables.

As a proxy for systematic risk the relative change in the yield of U.S. T-note is used. The empirical literature on government bond spread research shows that the yields of the US government bonds are one of the main determinants of sovereign spreads. Also in previous studies yields on US bonds have been used as an indicator for international risk when modeling yields on euro zone government securities (Codogno et al. 2003: 514). This was more closely discussed earlier in Ch. 4.

To measure country-specific credit risk, the debt-to-GDP ratio and public deficit figure presented in previous section are used. As mentioned these variables cause the challenge of data mismatch but at least they are relevant and true indicators of solvency and gearing. In their places one could also use alternatives, as for example prices of credit default swaps (CDS), but these

derivatives signals also the speculative positions of market participants and thus may cause bias.

When assessing liquidity risk market depth is observed. As in some previous studies (e.g. Ejsing & Sihvonen 2009, Sgherri & Zoli 2009) the market depth is measured by the trading volumes, which were also presented more closely in the previous section. From these two data sets the liquidity of benchmark bonds is chosen since it consists of more normally distributed observations. The market depth may not be as good indicator as market width, i.e. bid-ask spreads which has also been a popular indicator for liquidity. However the monthly trading volumes were the only data set available.

5.2. Econometric methodology

The process to build a valid regression model for the analysis is started from arranging the independent variables in order by their causal relationship with the dependent variable. The studied independent variables are the previously mentioned yield of U.S. T-note, public deficit, debt-to-GDP and liquidity. First approach used here is a simple linear regression and after as in the paper of Kim et al. (2006: 1523−1524), a test of the Granger causality. In simple regressions each variable of country *i*, is regressed alone against the spread between the yields of country *i*'s and Germany's bonds. When the yield spread is denoted as *YS*, and the yield of a 10-yr government bond as *r*, the spread is defined as

(6) $$YS_{i,t} = r_{i,t} - r_{GER,t}$$

at the time t.

Since the same time point variables do not have much of an explanatory power the lagged values of regressors, i.e. one-period-prior values *(t-1)*, are used. Therefore the simple regression is written as

(7) $$YS_{i,t} = \alpha + \beta x_{i,t-1} + \varepsilon_t$$

where α is the constant, β is the coefficient of the independent variable x_{t-1}, and ε_t is the error term.

Granger (1969) causality test is a regression-type approach which figures out how much of the current *y* can be explained by past values of *y* and then to see whether adding lagged values of *x* improves the explanation. If *x* has some explanatory power in *y*, or the coefficients on the lagged *x*'s are statistically significant, the *x* is said to Granger-cause *y*. Granger causality does not imply that *y* is the result of *x* but rather if *x* possess information content concerning *y* and in case of many explaining variables what is the precedence between them. The theory relies on the use of all past information of variables that is believed to help predict the other and thus with *l* lags forms the following equation:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + ... + \alpha_l y_{t-l} + \beta_1 x_{t-1} + ... + \beta_l x_{t-l} + \varepsilon_t \quad (8)$$

for all possible pairs of (*x, y*) series in the observation group. However suitable number of lags here is considered to be only one since the regression analysis focuses on the effects of the latest information available from the studied variables. Therefore the used Granger approach can be written as

$$YS_{i,t} = \alpha_0 + \alpha_1 YS_{i,t-1} + \beta_1 x_{i,t-1} + \varepsilon_t \quad (9)$$

Besides these two methods (eq. 7 and 9) help build the valid model by exposing the relevance of variables, the additional benefit from using the Granger approach is that it can also reveal indication from the possible later problem of multicollinearity. The causal relationships between the yield spreads and the lagged variables of; yield spread, change in the US yield, public deficit, debt-to-GDP and liquidity are reported on the next page in Table 3.

As is the case with usually less volatile interest rates, the previous time point's effect is dominant and hence it is included in simple regressions yielding to high validation when measured by R^2 statistic. From Table 7. can be seen that the R^2 for one-period-prior spread is very high ranging from 0.603 to 0.880 when regressed alone. This is good base for the model since the dominance will likely reduce serial correlation in the residuals in later regressions.

Table 7. The causal relationships of variables with YS_i.

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	POR	SPA	NL
$ys_{(t-1)}$	*** (0.647)	*** (0.649)	*** (0.603)	*** (0.706)	*** (0.880)	*** (0.804)	*** (0.776)	*** (0.880)	*** (0.859)	*** (0.636)
$us_{(t-1)}$	_ / ** (0.089)	* / ** (0.224)	_ / * (0.079)	_ / ** (0.103)	_ / _ (0.131)	_ / *** (0.142)	_ / * (0.153)	_ / _ (0.162)	_ / _ (0.155)	_ / * (0.052)
$pd_{(t-1)}$	_ / _ (0.024)	_ / _ (0.019)	_ / _ (0.079)	_ / _ (0.140)	_ / _ (0.018)	*** / _ (0.566)	_ / _ (0.080)	* / _ (0.241)	_ / _ (0.159)	_ / _ (0.000)
$dtG_{(t-1)}$	_ / * (0.004)	* / _ (0.195)	_ / _ (0.035)	* / _ (0.262)	*** / _ (0.757)	*** / _ (0.795)	** / _ (0.365)	*** / _ (0.744)	*** / _ (0.664)	* / _ (0.206)
$liq_{(t-1)}$	*** / * (0.541)	** / _ (0.390)	*** / ** (0.511)	_ / _ (0.134)	* / _ (0.261)	* / _ (0.238)	*** / _ (0.510)	** / _ (0.375)	_ / _ (0.148)	* / _ (0.228)

Notes: The R2 statistics of single regressions in parentheses
** significant at 10%; ** significant at 5%; *** significant at 1%*

Among the studied variables, liquidity and debt-to-GDP factors show strongest evidence of causality having both eight statistically significant coefficients out of ten, in simple regressions. Debt-to-GDP yields for higher R^2 statistics, especially under the PIGS countries, whereas liquidity has more Granger causes, two against one. However the change in the yield of U.S. T-notes has the most Granger causes, seven in ten cases. The results suggest the public deficit factor has the poorest causality although in case of Ireland its coefficient is strongly significant. Other interpretations arising particularly from the Granger approach were causalities between public deficit and other variables, and between liquidity and debt-to-GDP. These interpretations may be signs of multicollinearity which needs to be taken into account in actual regressions.

5.2.1. The regression model

The first multiple linear regressions with quarter data contain relatively short time series because the observation period starts from the beginning of the 2007. The static feature of debt-related variables in turn requires arithmetic means to be used for yield spreads, T-note yields and trading volumes since the sparsest frequencies of these data sets are by monthly. These monthly data sets are averages from daily observations in that particular month. Certainly the used averages in the model are calculated from the monthly observations of that particular quarter.

The regressions are first run with all the four studied variables in a similar way as in the paper of Barrios et al. (2009). Estimations are conducted with level-log

regressions using ordinary least squares method (OLS) separately for each country. The model is written as

$$(10) \qquad YS_{i,t} = \alpha + \beta_1 YS_{i,t-1} + \beta_2 US_{t-1} + \beta_3 PD_{i,t-1} + \beta_4 dtG_{i,t-1} + \beta_5 LIQ_{i,t-1} + \varepsilon_{i,t}$$

where YS_i is the 10-year government bond spread versus Germany, US is the logged percentage change in the yield of the U.S. T-note and PD_i is the public deficit figure, dtG_i is the debt-to-GDP ratio and LIQ_i is the trading volume of country i. All the independent variables are lagged one time point designating the previous quarter. Thus the data matches such a way that the model should be able to estimate the next quarter's average yield spread from the static values of the independent variables in this quarter.

Since the first results seem to suffer from some characteristic problems of regression analysis, such as a high-degree of multicollinearity, the tests are run second time. The possible problem with the multicollinearity is concerned in terms of goodness-of-fit since the adjusted R^2 statistics are relatively high (the lowest figure is 0.7218) but only 17 from the 40 independent variables are statistically significant with 10 % significance. As the solution for this problem the public deficit factor is dropped off. This is easily arguable since the coefficient of that variable was statistically significant in only one regression from ten. In addition the earlier used Granger test showed no evidence of causality with the yield spreads (see Table 3.) but instead with other variables it did. Consequently the improved model is expressed as

$$(11) \qquad YS_{i,t} = \alpha + \beta_1 YS_{i,t-1} + \beta_2 US_{t-1} + \beta_3 dtG_{i,t-1} + \beta_4 LIQ_{i,t-1} + \varepsilon_{i,t}$$

After the second regressions with quarter data, the results look much better. With five countries the adjusted R^2 statistic improved further and with three it remained almost the same. This is in line with the empirical literature since in similar studies (e.g. Fisher 1959, Lemmen & Goodhart 1999, Barrios et al. 2009) the goodness-of-fit has achieved relatively high levels, for example levels around 0.7. The number of statistically significant coefficients rose to 23 from 30 (and all in all to 38 when accounted with constants and lagged yield spreads). In addition when replacing the debt-to-GDP factor with the public deficit factor in the estimation, the sums of squared residuals (SSR) were higher and R^2 statistics lower. For possible remained multicollinearity supporting regressions

are ran with the debt-to-GDP and liquidity factors which show no cases of a larger R^2 statistic than in the actual regressions.

However while the multicollinearity looks lowered to an approvable level, also the other characteristic problems (heteroskedasticity and serial correlation) of regression analysis needs to be taken into account. This is essential when pursuing optimal estimates for the coefficients of independent variables. In theory the estimates are optimal and called the best linear unbiased estimators (BLUE) if under the classical assumptions (see Figure 13.) the OLS method minimizes the SSR. This is called the Gauss-Markov theorem. Here the sums of squared residuals and variances of regressions are the least in most of the cases when compared to running the regressions with alternative data sets.
(Davidson & MacKinnon 1999: 107.)

1. Minimum SSR:	$\mathbf{E[u_i] = 0}$, for all i (zero average error).
2. Homoscedasticity:	$\mathbf{Var[u_i] = \sigma^2}$, for all i.
3. No serial correlation:	$\mathbf{Cov[u_i, u_j] = 0}$, for all $i \neq j$.
4. Positive variance:	$\mathbf{\Sigma^n_{i=1}(x_i - x)^2 > 0}$.
5. No multicollinearity:	$\mathbf{Cov[x_i, z_j] = 0}$, for all $i \neq j$.

Figure 13. The classical assumptions of OLS method and qualifications for BLUE (Davidson & MacKinnon 1999:88).

To ensure valid results the regressions are ran by using Newey-West method (1987) which disposes the effects of both heteroskedasticity and serial correlation of unknown form. The results with quarter data are presented on the next page in Table 8.

Because of the short observation period there is a possibility of somewhat biased results from the regressions with quarter data. To improve the accuracy and reduce the observed characteristic problems a second set of regressions are ran but with monthly data. Since now there exists a restrictive factor caused by the low frequency variables, a method of simple interpolation is used. Importantly an attempt is made towards keeping consistency between the two specifications. The results with monthly data are presented in chapter 5.4. after the following quarter results.

5.3. Econometric evidence at the country-level from quarter data

The model with quarter data resulted in relatively strong evidence which is reported below in Table 8.

T able 8. Summary of country-level results from the regressions with quarter data.

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	POR	SPA	NL
α	147.34**	-32.70	72.27***	3.84	-1076.94*	-56.30***	-81.66	-331.68*	-77.88	79.06*
	(62.493)	(36.522)	(17.280)	(18.560)	(552.668)	(15.389)	(141.724)	(171.109)	(50.663)	(36.085)
$ys_{(t-1)}$	0.67***	0.16	0.56***	0.67***	0.61**	0.71***	0.58**	0.70***	0.67***	0.93***
	(0.055)	(0.204)	(0.074)	(0.119)	(0.241)	(0.149)	(0.204)	(0.173)	(0.204)	(0.156)
$us_{(t-1)}$	-0.59**	-1.43***	-0.44**	-0.41***	-4.23*	-3.48***	-0.95**	-1.92**	-1.17**	-0.52**
	(0.230)	(0.223)	(0.167)	(0.127)	(2.080)	(0.751)	(0.394)	(0.829)	(0.487)	(0.220)
$dtG_{(t-1)}$	-1.73*	1.32**	-1.11**	0.21	10.18*	2.59***	1.20	5.12*	2.57*	-1.14*
	(0.879)	(0.535)	(0.436)	(0.277)	(5.126)	(0.702)	(1.315)	(2.405)	(1.309)	(0.594)
$liq_{(t-1)}$	-0.23**	-0.23***	-0.37***	-0.02	0.00	-0.36	-0.02*	-0.10	-0.03	-0.09**
	(0.074)	(0.062)	(0.094)	(0.010)	(0.052)	(0.548)	(0.010)	(0.186)	(0.033)	(0.038)
adj. R^2	0.857	0.863	0.832	0.765	0.890	0.922	0.802	0.903	0.889	0.752
SE	10.21	10.73	8.21	7.11	92.17	39.25	20.41	35.08	20.65	8.57
Prob. (F)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Standard errors in parentheses.
** significant at 10%; ** significant at 5%; *** significant at 1%*

The adjusted R^2 which ranges from 0.752 to 0.922 is used to measure the model's goodness of fit since it penalizes for the addition of debilitating explanatory variables into the regression. The level of goodness of fit was expected to be high in the light of the previous studies but yet the overall level is surprisingly high. This can be expected to be because of the dominant effect of the previous time point yield spread. The standard errors of the regressions divide the countries clearly into two separate groups, the PIIGS and the rest. For the PIIGS the standard errors are quite high ranging from 0.2 % up to 0.4 %, except for Greece whose standard error of estimation is almost 1 %. Among the rest of the countries standard errors are tolerable and at highest 0.1 %.

The signs of the coefficients are mainly as expected in the quarter evidence. The change in the yield of US T-notes has negative correlation with all of the yield spreads and thus proves the flight-to-safety phenomenon. Another point supporting the phenomenon is the multiple counter effect of US T-note yield's change on the yields of countries with the deepest crisis, namely Portugal, Ireland and Greece. The coefficients of this international risk factor are all statistically significant and its impact is notable among the factors. For France

the international risk has lowest effect when a change of -25 % in US T-Note yield (e.g. the interest rate decreases from 4 % to 3% in a quartal) means 0.1 % effect to the yield spread. Yet with the PIIGS countries and Belgium such a change has an effect ranging from 0.2 % to even 1.1 % and this kind of volatility has not been rare especially after the second quarter in 2007.

All the coefficients of the liquidity factor have also negative correlation with the yield spread. Though with Greece the coefficient is zero but also not statistically significant. All in all liquidity is statistically significant with half of the countries and it seems the more significant role it plays the more it affects. Consequently its role is largest with Finland and Belgium, 10 million added trades decreases the yield spread by 3.7 basis points and 2.3 basis points respectively. Thus for Finland the liquidity effect is relatively negligible as well for Belgium but with Belgium's most demanded bonds which are traded 300 – 500 million times in the data the effect may be as large as 0.7 – 1.1 %. The standard errors of liquidity factors were smallest within all the variables so the estimates remain quite constant through the observation period.

Unexpected signs appeared only with the solvency factor. With Austria, Finland and the Netherlands debt-to-GDP ratio looks to correlate negatively, meaning that with additional debt the country's yield spread with Germany narrows. Since the development of Germany's debt ratio does not differ substantially from correspondents of these countries is this an interesting finding. The explanation may be some kind of a risk downgrade internally in EMU or then it might be hidden in the national aspects of these countries and cannot be explained in this thesis. However the counter effect for these countries remains small since even 10 % addition in debt ratio leads only to a decrease smaller than 0.2 % in the spread. With the crisis countries, namely Greece and Portugal the solvency is more important factor. For both of these countries the coefficient is also statistically significant and the mentioned change in the debt ratio means approx. 0.5 – 1.0 % larger spread. All in all the solvency factor was not statistically significant with France and Italy but with all the other countries.

The results show strong evidence that these variables holds information content regarding the yield spread. Even after all the adjustments the model retained its explaining power which was as earlier mentioned largely because of the

previous time point yield spread. This additional factor was strongly significant with all the other countries except with Belgium. Another interesting founding which suggests that regardless of the less volatile nature of interest rates the previous time period spread between the relatively stable interest rates of Belgium and Germany does not affect the next period's spread and thus can be taken that in case of Belgium the country is more sensitive for the variables determining the risk premium.

With the strong evidence from the quarter data the following null hypotheses:

- **H0: Solvency has zero coefficient while explaining EMU governments' yield spreads with liquidity and international risk**
- **H0: Liquidity has zero coefficient while explaining EMU governments' yield spreads with solvency and international risk**
- **H0: International risk has zero coefficient while explaining EMU governments' yield spreads with solvency and liquidity**
- **H0: The regression model formed from these three factors does not explain any variation of the EMU governments' yield spreads (adj. $R^2 = 0.00$)**

are all rejected since there was no single country that would not have any statistically significant coefficients among the tested credit quality factors. Therefore together with the perceived high levels of goodness of fit the quarter results support the second hypothesis:

H2: Changes in the credit quality factors explain the observed changes in EMU government bond yield spreads during 2007–2010

5.4. Econometric evidence at the country-level from monthly data

Generally the evidence from monthly data is not as strong as it was from quarter data even though the consistency was kept between these two approaches. Whereas in quarter data 23 coefficients from total 30 of the three credit quality factors were statistically significant, in regressions with monthly data only 3 out of 30 are statistically significant with at least 5 % significance

level when tested with two-way t-statistic. The summary of the results is shown below in Table 9.

T able 9. Summary of country-level results from the regressions with monthly data.

	AUS	BEL	FIN	FRA	GRE	IRE	ITA	POR	SPA	NL
α	57.44**	17.86	17.63**	-0.71	-228.84	-10.98	0.23	-98.37	-24.04	11.84
	(26.072)	(32.595)	(6.755)	(11.148)	(171.099)	(17.946)	(58.917)	(75.776)	(22.831)	(9.737)
$ys_{(t-1)}$	0.89***	0.93***	0.90***	0.88***	0.95***	0.96***	0.95***	0.90***	0.98***	0.98***
	(0.068)	(0.112)	(0.063)	(0.100)	(0.094)	(0.092)	(0.076)	(0.085)	(0.102)	(0.082)
$us_{(t-1)}$	-0.02	-0.10	-0.09	-0.06	-0.39	-0.08	-0.28	-0.41*	-0.12	-0.18
	(0.152)	(0.126)	(0.083)	(0.070)	(0.663)	(0.524)	(0.181)	(0.240)	(0.284)	(0.112)
$dtG_{(t-1)}$	-0.70*	-0.06	-0.30	0.10	2.24	0.80	0.09	1.62	0.66	-0.18
	(0.382)	(0.424)	(0.183)	(0.194)	(1.666)	(0.553)	(0.580)	(1.111)	(0.628)	(0.176)
$liq_{(t-1)}$	-0.07**	-0.03	-0.06	-0.00	-0.01	-0.25	-0.00	-0.08	0.00	-0.01
	(0.032)	(0.030)	(0.037)	(0.006)	(0.012)	(0.310)	(0.002)	(0.060)	(0.013)	(0.009)
adj. R^2	0.890	0.885	0.910	0.849	0.958	0.942	0.932	0.939	0.925	0.899
SE	9.24	10.19	6.08	6.01	55.42	33.61	12.22	27.59	17.13	5.60
Prob. (F)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Standard errors in parentheses.
** significant at 10%; ** significant at 5%; *** significant at 1%*

The overall results from the regressions look to suffer again from the typical problem of multicollinearity. This might derive from grown importance of the previous time point yield spread. With denser data set or longer time period of observations the significance of the one-period-prior yield spread may seize significance from the other explaining factors especially while it is arguable that with more observations the clearer should be seen its parallel correlation with the other factors. Hence despite the high levels of goodness of fit ranging from 0.849 to 0.958 only three statistically significant factors are found. However the margins of standard errors are smaller with all the countries than in the quarter data results.

Surprisingly all the three statistically significant coefficients represent each a different factor. Two of these coefficients, the solvency and liquidity factors, are significant with Austria and the third the international risk factor is significant with Portugal. From these the coefficient of debt-to-GDP is the only one to have unexpected sign meaning negative correlation with the yield spread. Anyhow the effect is smaller than in the quarter results, -0.70 vs. -1.73, thus this unexplained notice is not as heavy as it was with the looser data. Eventhough the liquidity factor has the right sign this time its role is even more negligible than in quarter observations. The change in the US's yield has also the right

sign and its effect is again largest among the explanatory variables though its role is now approximately ten times smaller than it was with quarter data.

All the standard errors are now smaller than they were in quarter regressions and roughly half of that in case of coefficients. However one problematic consequence arises from the used factors. As already mentioned the previous time point yield spread has now grown even more important while also having very strong significance for all of its coefficients. These ranges from 0.88 with France to 0.98 with the Netherlands leaving on average only 5–15 %'s part from the spread explaining for other sudden factors. This part is calculated as the average relative difference between the yield spread and only the previous time point yield spread's explaining part *(note: Austria and Finland are left out because they have also significant constant which together with the* YS_{t-1} *factor explains on average more than 100 % of the perceived yield spreads since all the other explaining factors together are expected to affect negatively to the yield spread)*. The part of other factors is called sudden because one can expect that at any rate the static variables of studied risk premium factors are at least partially considered already in form of YS_{t-1} when explaining the YS_t (and thus may have also caused some degree of multicollinearity). Therefore the left outs of the studied variables does not have changes radical enough in denser data to emerge as statistically significant. This problem suggests that either must be paid attention towards the possibilities of a biased model despite the high adjusted R^2 or the markets' inefficient functioning since the highest unexplained parts of the model are with Portugal, Ireland, Greece and Belgium. And especially with these countries should be reasonable to expect the studied risk premium factors to have statistical significance in the light of recent information and based on literature and the results from the previous section.

Although also a third possible interpretation of the problematic results might remain which is sudden changes in market conditions caused by some external intervention or another unexpected single event. For example the activities of the ECB or EMU governments to stable market conditions may be these kinds of random effects. If this is the case it is completely impossible to build a model to estimate the risk premiums or interest rates of EMU members and it is unfortunate also in terms that this kind of a random event or intervention was not even possibility in the first place according to the article 125 in the Lisbon

treaty, the amendment of the principle treaty of the EU, the Treaty on the Functioning of the European Union.

Regardless of the proposed interpretations the same null hypotheses as presented with quarter data are still rejected based on the evidence from monthly data. Only this time the evidence is very weak since the results show statistical significance for each risk premium factor only once and with Austria and Finland. Thus the second hypothesis:

H2: Changes in the credit quality factors explain the observed changes in EMU government bond yield spreads during 2007–2010

may be partially accepted because no evidence from significance was found with all the countries.

When comparing the evidences between the two regressions it is obvious the data frequency has notable significance. This is in line with the previous literature as for example in the study of Barrios et al. (2009) quarterly data produced much more statistically significant results than weekly data. In this thesis the difference is even more distinct as mentioned already that based on the monthly data only one coefficient per factor was found statistically significant. Although this may be because of the data mismatch or the constitution of used factors there is no other option than rejection of the following third hypothesis:

H3: The market pricing of EMU government bonds is consistent regardless of the explaining factors' information frequency

6. CONCLUSIONS

Based on the descriptive analysis it is clear the EMU government bond yield spreads contained an upward rising trend during the years 2007−2010. Especially during the crisis years 2009 and 2010 the spreads increased notably. These observations support findings from earlier studies though in the latter crisis the differentiation of yield spreads concerned only Belgium and the PIIGS countries. The findings suggest that investors started to concern EMU government bonds more as substitutes after the global financial crisis in 2009. This discrimination between countries partially derives from the country-specific features but especially from solvency since it is the most important country-level factor and correlated negatively with Austria, Finland and the Netherlands, the less indebted countries. As argued by Barrios et al. (2009) the country-specific features grow importance during market turbulence thus supporting the observed discrimination effect.

The international risk also played major role affecting most negatively again to Belgium and the PIIGS countries. This is logical since the factor was measured with the change in yields of US T-note, considered as the safest investment on the financial markets. In addition liquidity premia was found in regressions with quarter data having a straightforward relation to yields, the better the liquidity the lower the interest rate and hence the spread. Its significance however was minor and highlighted only in cases of countries with poor liquidity, such as Austria, Belgium and Finland.

To specify empirically the determinants of government bond yield spreads is a challenging task. And this task is not eased by the fact that probably the best determinants of financial stance, such as the solvency factors, are relatively static. Nevertheless the results of this thesis have important implications. Although statistically significant and strong evidence was found while using quarterly data this was completely opposite while using denser data. Similar results have been reported in previous studies (e.g. Barrios et al. 2009) thus suggesting the market does not value EMU government bonds correctly in short-term. The lack of evidence may be for various reasons but the possible market mispricing raises concerns and should draw attention further ahead. Though if the market structures are unexpectedly changed as recently in EMU, the task may become even more challenging.

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