"Bond Market Interdependencies: The Case of Italy, Portugal and Spain."

by

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Abstract

This paper examines the effects of both domestic and eurozone-wide factors on 5-year sovereign bond yields for Spain, Portugal and Italy. The distinguishing feature of this paper is the use of Target2 balances as a domestic factor. During the recent European sovereign debt crisis, bond yields have risen significantly due primarily to deteriorating public finances. The Johansen test for cointegration is employed to determine the existence of any cointegrating relation between yields and factors. Where such a relation exists, a Vector Error Correction Model (VECM) is estimated to further analyze it. Results provide a number of insights. For the combined country analysis, a long-run relation is found between the 3 bond markets, with iTraxx indices and VStoxx, a measure of eurozone volatility, being driving forces. Furthermore, for each individual country, bond yields are found to be cointegrated with a number of domestic factors. Driving forces influencing Spanish yields are the Spanish Economic Sentiment Indicator (ESI), inflation, Target2 balances and credit default swap spreads (CDS). For Portugal, these driving forces are PSI 20 (Portuguese stock market), inflation, Target2 balances and CDS spreads. In contrast, driving forces for Italian yields are ESI, Target2 balances and CDS spreads.

Table of Contents

1 - Introduction

It is well known that many investors diversify their portfolios by holding various assets (stocks, bonds, mutual funds, cash, etc.) in order to maximize their expected return for a given level of risk. In their classic papers, Markowitz (1952) and Grubel (1968) both show the benefits of portfolio diversification, and how holding such a diversified portfolio would result in less risk and smaller losses incurred by an investor.

In particular, portfolio diversification may apply well to sovereign bond markets. An investor may want to invest in a number of different countries, for instance, with the aim of reducing risks stemming from a particular country or region. Over the last few decades, financial market deregulation, combined with technological and financial innovation have led domestic financial markets to become more global in the sense that unexpected international developments (i.e. news shocks) can rapidly influence domestic markets. As a result, this could potentially suggest the existence of greater interdependence between markets.

Since the introduction of a common currency and monetary policy, European financial markets have increasingly been integrated. However, with the onset of the recent financial crisis and the European sovereign debt crisis, many European countries have become more vulnerable to external shocks. The effects of contagion and systemic risk have particularly been significant in peripheral countries, while at the same time public finances were deteriorating sharply. Countries like Italy, Spain, and especially Portugal have seen their bond yields and credit default swap spreads rise considerably in recent years. Target2 liabilities have also risen dramatically for a number of peripheral European countries, which has recently concerned the Bundesbank (Carrel, "Weidmann gains traction with policy pushback.").

The purpose of this paper is to determine whether a number of sovereign bond markets, namely those of Italy, Portugal and Spain are cointegrated. In particular, if they are found to be correlated in the long run, then diversification will not be as effective as in the case if these bond markets were uncorrelated and operated independently of each other. This paper would contribute to the literature by determining if the above bond markets are cointegrated by using the Johansen test for cointegration, and to see whether portfolio diversification extends to these sovereign bonds. In the event that evidence of a long-run relation exists, a Vector Error

Correction Model (VECM) will be estimated to better understand the relation. Moreover, it will seek to test whether domestic factors, such as CDS spreads and Target2 balances, help determine each country's bond yields. The remainder of the paper will proceed as follows. Section 2 will briefly review the related literature. Section 3 will describe the data and present some summary statistics, while Section 4 will discuss the methodology. Section 5 will present and discuss the empirical results, and lastly, Section 6 will conclude the paper.

2 - Literature Review

A number of studies have been undertaken in the past on the potential relations between various financial markets and, in particular, sovereign bond markets. The relevant literature has especially expanded in the last decade or so.

Some of the earlier works sought to test whether a number of sovereign bond markets moved together in the long run. Using daily data, Mills and Mills (1991) showed that 5-year bond yields for Japan, West Germany, the United Kingdom and the United States were not cointegrated, but appeared to be determined by their own domestic fundamentals over the period April 1986 to December 1989. In light of the fact that no long-run relation was found, the authors estimated a VAR model and analyzed impulse response functions. Similarly, a paper by Clare et al. (1995) found no cointegrating relationship between bond returns for the same countries. Their data consisted of monthly observations from January 1979 to April 1990.

A number of papers explored the possibility that various economic and financial factors might influence sovereign bond markets. Clare and Lekkos (2000) found evidence that American, British and German yield curves were influenced by domestic and international factors, with the latter being more important during times of financial instability. They used weekly 1-year and 10-year bond yields, for the period of August 1990 to August 1999. They estimated a Vector Autoregressive Model (VAR) in order to model the influence of these factors on the yield curves. On the other hand, Bernoth et al. (2004) investigated bond yield differentials of 13 European countries against Germany and the United States from 1991 to 2002. They estimated the effects of fiscal variables, such as debt, deficit and debt-service ratio, on those yields and found the yields to be positively affected by these factors. Moreover, they sought to estimate the effects of the creation of the monetary union and euro on the risk premia paid by these 13 countries. The authors found that the countries enjoyed a lower default risk after the creation of the monetary union. Another study by Christiansen (2007) examined volatility spillovers across the bond markets of the United States, an aggregate for Europe and 9 European countries using a Generalized Autoregressive Conditional Heteroskedasticity Model (GARCH). Using weekly data for the period of January 1988 to November 2002, they found evidence of strong volatility spillover effects from the aggregate Europe market into individual European countries. In contrast, the effects from the US were weaker.

Recent studies published by the Bank for International Settlements and the European Central Bank among others have explored linkages between sovereign bond markets and credit default swaps, especially since the advent of the 2008-2009 financial crisis and the European sovereign debt crisis. Fontana and Scheicher (2010) analyzed potential determinants of weekly CDS spreads and government bonds of 10 European countries from January 2006 to June 2010. They primarily found evidence of a repricing of sovereign credit risk in the CDS market, with CDS spreads exceeding bond spreads since September 2008. Additionally, the authors found market integration varied across countries. For some, price discovery took place in the bond market, while for others, it took place in the CDS market. Likewise, Gyntelberg et al. (2013) found similar results of a widening gap between CDS and bond spreads, by using intraday observations.

For their part, Palladina and Portes (2011) confirmed the existence of a cointegrating relation between bond and CDS markets for the period 2004 to 2011. They showed through their VECM analysis that the CDS market moved ahead of the bond market regarding price discovery for 6 European countries. Lastly, Delatte et al. (2012) investigated the potential influence of the CDS market on the borrowing costs for 10 European countries from 2008 to 2010. Making use of daily data, they found evidence of a cointegration relation between CDS spreads and bond spreads, although the equilibrium adjustment process depended on market characteristics and the level of market instability.

Some studies have looked more closely at the impact of the recent financial crisis on sovereign bonds. Attinasi et al. (2009) used a dynamic panel approach to study the determinants of numerous European bond yields vis-à-vis German bunds for the period 2007-2009. In particular, they looked at the effects of various fiscal variables and government announcements of banking rescue packages. Their results showed that higher budget deficits and/or government debt ratios relative to Germany led to higher yields. Moreover, they found that rescue package announcements resulted in a re-assessment of sovereign credit risk, with risk being transferred from the private sector to the government. A research note by Schuknecht et al. (2010) analyzed several European government bond spreads against German and US benchmarks for the period 1991-2009. Their main finding was the importance of economic principles in explaining yield spreads before and during the recent financial crisis. Furthermore, they found that markets penalize fiscal imbalances more strongly after September 2008.

On a final note, other research has investigated contagion and spillover effects emanating from the European sovereign debt crisis. Beirne and Fratzscher (2013) focused on analyzing the determinants of sovereign crisis of a number of European countries and several emerging economies from 1999-2011. Their results showed that domestic fundamentals mainly accounted for the rise in sovereign debt yields and CDS spreads, both in Europe and globally. On the other hand, regional spillovers and contagion have not been as important. De Santis (2012) found that several factors helped explain rising sovereign spreads during the period 2008-2011. Specifically, these factors were aggregate regional risk, country-specific credit ratings and a spillover effect from Greece, especially through the latter's rating downgrades.

3 - Data & Summary Statistics

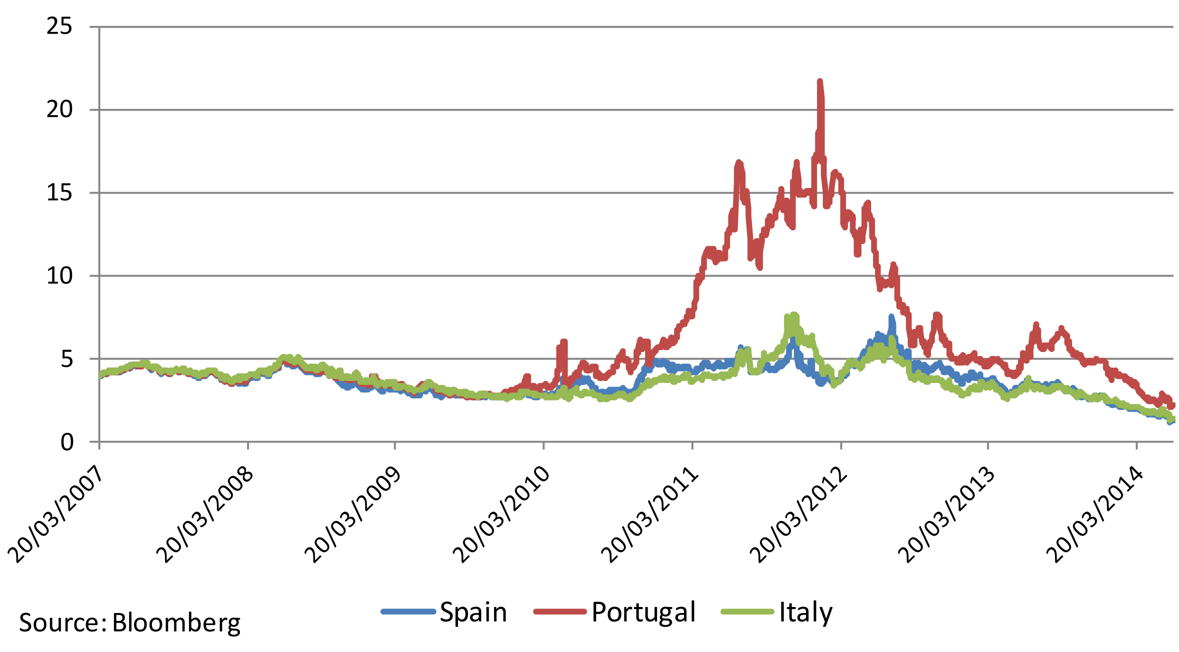
A number of datasets are used in this paper and all are fully detailed in Appendix A. In particular, the data that are of interest in this paper consist of 5-year sovereign bond yields for Italy, Portugal and Spain. The three series are plotted in **Figure 1** below.

For the combined country study, I use daily data for bond yields, iTraxx 5-year Senior Financial & iTraxx 5-year Main, Euro Stoxx 50 and VStoxx, with the latter being a measure of volatility in the eurozone. For individual country studies, I use monthly data for bond yields, 5-year CDS quotes, equity indices (IBEX 35, PSI 20 or FTSE MIB), inflation, Target2 balances and Economic Sentiment Indicator (a business climate index). The iTraxx indices can be viewed as proxies for risk aversion in Europe, with an increase reflecting a deterioration in the credit risk of a European company or financial institution. Target2 is an interbank payment system used by Eurosystem central banks for settling urgent, real-time transactions. Many peripheral countries have seen their Target2 liabilities sharply increase, especially with unlimited loans from the European Central Bank and the recent establishment of the European Stability Mechanism.

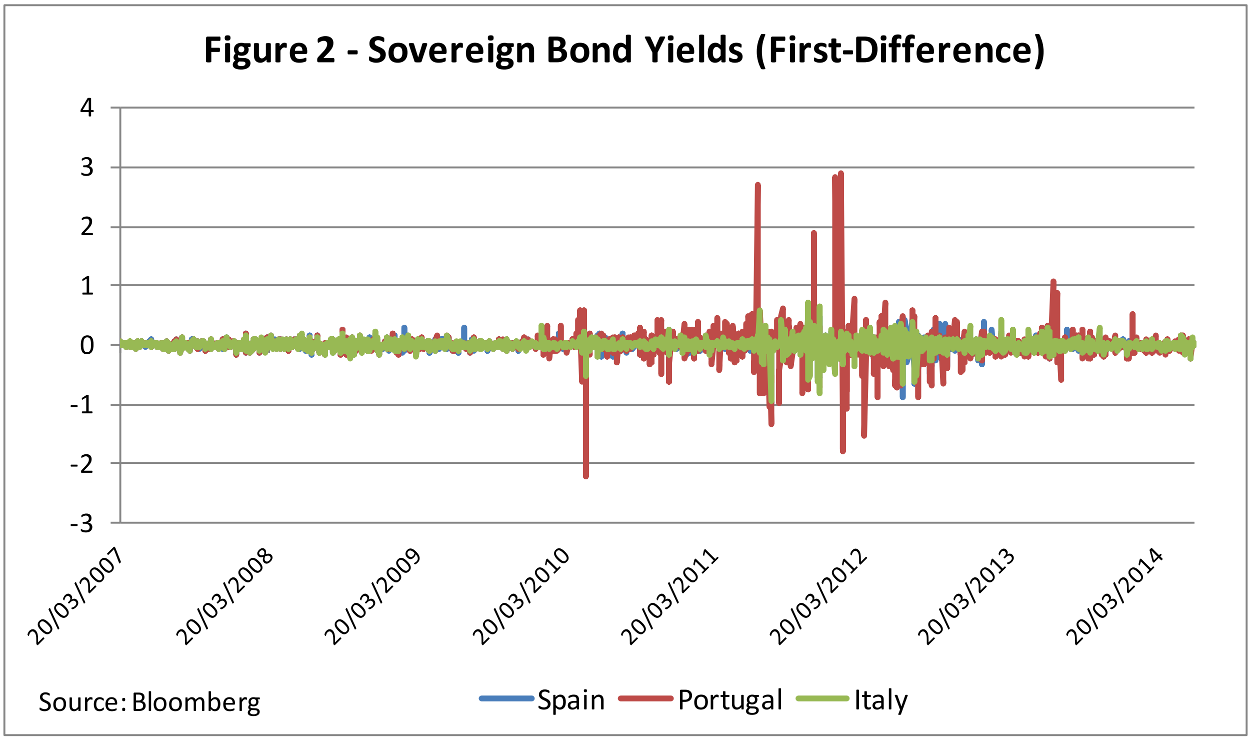
In total, there are 2,646 daily and 125 monthly observations for each country, collected for the period of January 2004 to May 2014. It should be noted that sovereign CDS data are only available from 2004 and onwards. The data are tested and modeled in Stata and figures & tables are constructed in either Excel or Stata.

Looking at **Figure 1**, the time series are clearly not stationary, a well-observed characteristic of financial data. The order of integration is not as clear, although it can be determined by performing unit root tests. For example, if a series contains a unit root, it is said to be integrated of order 1. In this case, for the data to become stationary, it must be differenced once. **Figure 2** below presents the first difference of each bond yield series and they appear to be stationary. Formally, testing for stationarity and the presence of unit roots will be further discussed in the methodology section, and the associated results will be presented in Section 4.

Figure 1 - Sovereign Bond Yields (5-year maturity, %)



Source: Bloomberg



Charts for other variables expressed in levels & first differences have been included in Appendix B. See **Figure 3 - Figure 16**. All variables appear non-stationary with stationary differences.

Table 1 & 2, which can be found in Appendix C, present various descriptive statistics for the combined country study variables, while similar statistics for individual country variables are given in Appendix D (**Tables 3-10**). Furthermore, Portmanteau tests and Bartlett's test were used to investigate the data for white noise, which was strongly rejected.

The daily mean yields range from 3.7% in Italy to 6.02% in Portugal, while the standard deviations range from 0.93 in Spain to 3.72 in Portugal. The latter indicates that the Portuguese 5-year bond market is the most volatile one during this time period. The bond yield range for Spain and Italy is very close, at about 6.3%, while Portugal's bond yields go from a low of 2.08% in June 2014 to a high of 21.75% in January 2012.

The values for skewness show that all series are positively skewed (skewed to the right). The kurtosis numbers give an idea as to the peakedness of the data's distribution. A normal distribution has a kurtosis of 3. Heavy tailed distributions (leptokurtic) will have a kurtosis greater than 3, while light tailed distributions (platykurtic) will have a kurtosis less than 3. A look at the numbers shows that Portuguese bond yields are more leptokurtic than the others. However, the null hypothesis of normality is rejected at the 1% significance level for most series. Lastly, the pairwise unconditional correlations are given in **Table 2**. In particular, the Italian bond market exhibits a stronger correlation with the Spanish market than the Portuguese one.

4 - Methodology

References consulted for this section include Davidson and MacKinnon (2004), Hamilton (1994), Juselius (2006) and Johansen (1995).

4.1 Stationarity and Units Roots

A time series is (weakly) stationary if it is characterized by a constant mean, a constant variance and constant autocovariances for each given lag. Using non-stationary data can lead to spurious regressions, and the standard assumptions for asymptotic analysis will not be valid in such regression models.

Consider the case of an autoregression model of order one, AR(1), with no drift and where u_t is a white noise disturbance term:

$$y_t = \phi\, y_{t-1} + u_t \qquad (1)$$

Lagging (1) one and then two periods, we obtain

$$y_{t-1} = \phi y_{t-2} + u_{t-1} \qquad (2)$$
$$y_{t-2} = \phi y_{t-3} + u_{t-2} \qquad (3)$$

Putting (2) into (1) yields

$$y_t = \phi^2 y_{t-2} + \phi u_{t-1} + u_t \qquad (4)$$

Now putting (3) into (4) yields

$$y_t = \phi^3 y_{t-3} + \phi^2 u_{t-2} + \phi u_{t-1} + u_t \qquad (5)$$

Iterating forward T times will thus yield

$$y_t = \phi^{T+1} y_{t-(T+1)} + \phi u_{t-1} + \phi^2 u_{t-2} + \phi^3 u_{t-3} + \cdots + \phi^T u_{t-T} + u_t \qquad (6)$$

The parameter ϕ can take on three possible values.

- $\phi < 1 \Rightarrow \phi^T \rightarrow 0$ as $T \rightarrow \infty$. Shocks will gradually die away. This is the stationary case.
- $\phi = 1 \Rightarrow \varphi T = 1 \; \forall \; T$. Shocks persist and do not die away. This is the unit root case, since the root of the characteristic equation would be equal to 1.

Equation (6) can then be written as $y_t = y_0 + \sum_{t=0}^{\infty} u_t \; as \; T \rightarrow \infty$.

- $\phi > 1$ is called the explosive case, where shocks become more influential with time.

The random walk model (1) can generally be rendered stationary by differencing the data, as follows.

Define $\Delta y_t = y_t - y_{t-1}$ and $Ly_t = y_{t-1}$, where L is the lag operator. Both of these imply that $\Delta y_t = y_t - y_{t-1} = (1 - L)y_t$. Therefore (1) can be written as

$$\Delta y_t = \mu + u_t \qquad (7)$$

Therefore, by differencing y_t once, the time series is now stationary.

In general, if a non-stationary time series, y_t must be differenced d times before it becomes stationary, then it is said to be integrated of order d. This is written as $y_t \sim I(d)$. By definition, if $y_t \sim I(d)$, then $\Delta^d y_t \sim I(0)$.

It should be noted that I(0) is a process with no unit roots (so it is stationary). On the other hand, I(1) is a process with one unit root and so would require differencing once to induce stationarity.

4.2 Testing for Unit Roots

Having introduced the concept of integration, the paper now turns to unit root testing. The pioneering work is due to Fuller (1976) and Dickey and Fuller (1979). Additionally, among many others, Phillips and Perron (1988), Sargan and Bhargava (1983) and Elliott, Rothenberg and Stock (1996) have contributed to this field.

4.2.1 Dickey-Fuller Test

Essentially, this test examines the null hypothesis that $\phi = 1$ in equation (7)

$y_t = \phi \, y_{t-1} + u_t$ against the one-sided alternative $\phi < 1$.

Thus the hypotheses of interest in the DF test are

H_0: the time series contains a unit root

vs

H_1: the time series is stationary.

Empirically, the DF test would be as follows:

$$\Delta y_t = (\phi - 1)y_{t-1} + u_t \Rightarrow \Delta y_t = \gamma y_{t-1} + u_t \qquad (8)$$

where $\gamma = (\phi - 1)$. Thus, a test of $\phi = 1$ is equivalent to a test of $\gamma = 0$.

If the null hypothesis of a unit root cannot be rejected, then the test should be performed on the first order differences. The null hypothesis of a unit root is rejected in favour of the stationary alternative if the test statistic is more negative than the critical value. It should be noted that the DF tests can be different depending upon whether the model has a constant and/or a time trend. Furthermore, the tests are valid only if u_t is white noise.

4.2.2 Augmented Dickey-Fuller Test

The disturbance term u_t in equation (8) is assumed not to be autocorrelated, but would be so if there was autocorrelation in the dependent variable, Δy_t. The solution here would be to augment the DF test by using *p* lags of the dependent variable. The model would thus be written as

$$\Delta y_t = \gamma y_{t-1} + \sum_{j=1}^{p} \phi_j \Delta y_{t-j} + u_t \qquad (9)$$

This test is known as an augmented Dickey-Fuller test (ADF) and is still conducted on γ.

By including lags of the order *p*, a problem arises in determining the optimal number of lags of the dependent variable. This means that the lag length *p* has to be determined prior to applying the ADF test.

A first approach may be to use the frequency of the data. For example, if the data are monthly, then 12 lags could be used. On the other hand, if the data are quarterly, then 4 lags could be used. However, it is not obvious how many lags should be included for higher frequency data (e.g. hourly, daily, weekly). One alternative approach is to start with a large *p*, and then test downward using standard normal test theory (F or t tests). A final approach is to use model selection criteria such as the Akaike information criteria (AIC) or the Bayesian information criteria (BIC). This latter approach will be used in the paper.

Lastly, a high number of lags should be avoided, since the number of parameters grows quickly with the lag length. Model selection criteria essentially attempt to balance the lag length with the number of parameters by minimizing a linear combination of the latter and the residual sum of squares (RSS).

4.2.3 Phillips-Perron Test

Phillips (1987) demonstrated that DF tests can be affected by autocorrelation in the errors. Phillips and Perron (1988) developed a test that is similar to ADF tests, but that allows for the possibility of autocorrelation and conditional heteroskedasticity. The conclusions are typically the same as those from the ADF tests.

4.2.4 KPSS Test

An important criticism of DF/ADF and PP tests is that their power is low if the process is stationary but with roots that are near unity. Standard asymptotic theory will still apply if $\phi < 1$, but will most likely provide a poor approximation close, but not quite equal to unity, especially in small samples. One way to get around this problem is to use a unit root test as well as a stationarity test, such as the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test due to Kwiatkowski et al. (1992). Unlike unit root tests (DF, ADF, PP), the null hypothesis of the KPSS test is stationarity. Thus, the data will appear stationary by default if there is little information in the sample.

The results of the KPSS test can be compared with the other unit root tests to see if the same conclusion is obtained. The null and alternative hypotheses under each test type are as follows.

Stationarity Test (KPSS)	**Unit Root Tests (DF, ADF, PP)**
$H_0 : y_t \sim I(0)$	$H_0 : y_t \sim I(1)$
$H_1 : y_t \sim I(1)$	$H_1 : y_t \sim I(0)$

Consequently, there are four possible scenarios.

	Stationarity Test (KPSS)	Unit Root Tests
Scenario 1	Do not reject H_0	Reject H_0
Scenario 2	Reject H_0	Do not Reject H_0
Scenario 3	Reject H_0	Reject H_0
Scenario 4	Do not reject H_0	Do not reject H_0

For the conclusions to be robust, the results should fall under scenarios 1 or 2, which would be the case when both tests concluded that the time series is stationary or non-stationary, respectively. Scenarios 3 or 4 imply conflicting results.

4.3 Cointegration

The origins of cointegration can be traced to Engle and Granger (1987). The idea behind cointegration essentially amounts to analyzing stationary and non-stationary variables in the same model, in order to describe possible long-run relations and short-term adjustments. This long-run equilibrium relation between a number of variables can be represented by the linear combination $\alpha^T x_t$, where x_t is a vector of variables and α, a vector of coefficients. By definition, the vector x_t is said to be in equilibrium when:

$$\alpha^T x_t = 0. \qquad (10)$$

It may be possible that x_t is not in equilibrium. Consequently, a variable z_t defined by

$$z_t = \alpha^T x_t \qquad (11)$$

is called the equilibrium error.

Lastly, it should be noted that a linear combination of I(1) variables that move together in the long-run must necessarily be I(0) or a stationary process. In the event that this is not true, then these I(1) variables would drift apart.

4.3.1 Johansen Test for Cointegration & Vector Error Correction Model (VECM)

In the case where there are only two variables in an equation, y_t and x_t, there can be at most only one linear combination of y_t and x_t that is stationary. That is, there can be at most one cointegrating relationship. An OLS-based approach, such as the Engle-Granger 2-step method, will be capable of finding this cointegrating relationship. However, suppose that there are k variables in a system (ignoring any constant term), denoted y_t , x_{2t} , . . . x_{kt} . In this case, there may be up to r linearly independent cointegrating relationships (where $r \leq k - 1$). The answer to this problem is to use a systems approach to cointegration, which will allow determination of all *r* cointegrating relationships. One such approach due to Johansen (1988, 1991) is the Johansen test for cointegration.

Suppose that a set of k I(1) variables ($k \geq 2$) are under consideration and which are thought to be cointegrated. A vector autoregression model (VAR) with m lags containing these variables could be set up as follows:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots + \beta_k y_{t-k} + u_t \qquad (12)$$

where u_t is independent mean zero with a constant covariance.

In order to use the Johansen test, the VAR in (12) may be written as a vector error correction model (VECM) of the form:

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{m-1} \Delta y_{t-(m-1)} + \Pi_m y_{t-m} + u_t \qquad (13)$$

where $\Pi_m = (\sum_{i=1}^{m} \beta_i) - I_k$ and $\Gamma_i = (\sum_{j=1}^{m} \beta_j) - I_k$.

This VECM contains k variables in first differenced form on the LHS, and m−1 lags of the dependent variables (first differenced) on the RHS, each with a Γ coefficient matrix attached to it. Π_m in equation (13) can be interpreted as a long-run coefficient matrix, since in equilibrium, all the Δy_{t-i} will be zero, and setting the error terms, u_t , to their expected value of zero will leave $\Pi_m y_{t-m} = 0$.

The intuition behind the test amounts to testing the rank of Π_m by looking at its eigenvalues. By definition, the rank of a matrix is equal to the number of its eigenvalues that are different from zero. The eigenvalues, denoted λ_i, are arranged in ascending order $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_k$. If the λs are roots, then they must be less than 1 in absolute value and positive. λ_1 will be the largest (the closest to 1), while λ_k will be the smallest (the closest to zero). If the variables are not cointegrated, the rank of Π_m will not be significantly different from zero, so that $\lambda_i \approx 0 \ \forall$ i.

The Johansen test is a likelihood ratio, also called the trace test, and is obtained as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{k} \ln(1 - \lambda_i) \qquad (14)$$

where r corresponds to the number of cointegrating vectors under the null hypothesis and λ_i is the estimated value for the i^{th} ordered eigenvalue from the Π_m matrix.

Each eigenvalue will have a corresponding cointegrating eigenvector. An eigenvalue that is statistically different from zero indicates a significant cointegrating vector.

λ_{trace} is a joint test where the null hypothesis corresponds to the number of cointegrating vectors that is less than or equal to r, against an alternative that there are more than r. The test starts with p eigenvalues, and then successively the largest one is removed. $\lambda_{trace} = 0$ when all the $\lambda_i = 0$, for $i = 1, . . . , k$.

Lastly, if the test statistic is greater than Johansen's critical value, then the null that there are *r* cointegrating vectors is rejected in favour of the alternative that there are *r* + 1. The value of r is continually increased until the null is no longer rejected as displayed below.

$$\begin{array}{ccc} H_0 : r = 0 & \text{vs} & H_1 : 0 < r \leq k \\ H_0 : r = 1 & \text{vs} & H_1 : 1 < r \leq k \\ \ldots & \ldots & \ldots \\ H_0 : r = k - 1 & \text{vs} & H_1 : r = k \end{array}$$

For example, the first test involves a null hypothesis of no cointegrating relationship, or equivalently, that the Π_m matrix has a rank of zero. If this null is not rejected, then this would mean all variables are I(1) and none are cointegrated.

4.4 Vector Autoregression Model (VAR)

A VAR is essentially an AR model with more than one dependent variable. Each dependent variable, y_t, has an equation explaining its evolution based on its own lags and the lags of the other dependent variables. It should be noted that all the variables in a VAR are endogenous. Consider the following p-th order VAR model specification that contains k variables:

$$y_t = \mu + \Gamma^1 y_{t-1} + \Gamma^2 y_{t-2} + \cdots + \Gamma^p y_{t-p} + u_t \tag{15}$$

where y_t and y_{t-i} (for i = 1, 2, ..., p) are k x 1 vectors of dependent variables, Γ^i is a k x k matrix of coefficients, μ is k x 1 vector of constants and u_t is a k x 1 vector of error terms.

It should be noted that the optimal lag length p will be determined by using model selection criteria, such as AIC and BIC, as previously discussed in section 4.2.2. Furthermore, since there are k equations, with p lags of each of the dependent variables in each equation, there will a total of $(k + pk^2)$ parameters to be estimated.

4.5 Granger Causality

When a VAR includes many lags of dependent variables, it will be difficult to see which sets of variables have significant effects on each dependent variable and which do not. Typically, the significance of the VAR variables occurs on the basis of joint tests on all of the lags of a particular variable in an equation, rather than by examining individual coefficient estimates. There is an economic sense in which one variable is said to "cause" another. This kind of causation is referred to as Granger causation, due to Granger (1969).

A set of variables z_t is said to be Granger caused by a set of variables x_t if the information in the past and present x_t helps improve the forecast of z_t. It follows that if a set of variables x_t causes z_t, then lags of x_t should be significant in the equation for z_t. On the other hand, if z_t causes x_t, lagged values of z_t should be significant in the equation for x_t. If both sets of lags are statistically significant, then there is feedback. Finally, if neither set of lagged values are statistically significant in the equation for the other variable, then x_t and z_t are said to be independent.

5 - Results & Discussion

5.1 Unit Root and Stationarity Tests

The Stata output for both level and first-order differences are given in numerous tables found in Appendix E. For each of the tests, the optimal lag length has been selected by information criteria, such as AIC and BIC (see section 4.2.2).

Looking at the unit root test results for the levels from ADF and PP, we cannot reject the null hypothesis that the time series contain a unit root for Spanish, Portuguese & Italian bond yields, Euro Stoxx 50, both iTraxx indices and VStoxx at the usual 1%, 5% and 10% levels. Now looking at the series in first differences, we reject the null that the series contains a unit root at all levels of significance for all countries.

On the other hand, the results from the KPSS stationarity test indicate that the null hypothesis of stationarity can be rejected at the usual levels of significance for all the series in level, while the results in first differences are not statistically significant at the usual levels.

After carefully analyzing each individual series, both unit root tests and the KPSS stationarity test match with Scenario 2 found in section 4.2.4 of this paper. We can thus conclude that all three bond yield series, the Euro Stoxx 50, the iTraxx and VStoxx indices are each integrated of order 1, that is I(1), meaning that they have a unit root.

Similar conclusions apply to the individual country analysis variables. All of them have roots on the unit circle, as confirmed by both unit root tests and the KPSS stationarity test.

5.2 Johansen Test &VECM

Combined Country Analysis

Since the series for the combined country analysis are I(1) processes, a Johansen test of cointegration is performed. It was optimally determined by selection-order criteria that the underlying VAR model should include 2 lags. It should also be noted that since there are 7 variables in the system, there can be at most 6 linearly independent cointegrating vectors.

From the output in Appendix F, we reject the null hypothesis of no cointegration and fail to reject the null hypothesis of at most one cointegrating equation at the 1% significance level. **Table 13** reports the trace statistics. Using all 7 series and a model with 2 lags, we find that there is one cointegrating relationship. In other words, there is strong evidence of a long run equilibrium between these variables. This is not a surprising result considering the developments in worldwide information systems, globalization and integration of financial markets, especially given these countries are all members of the eurozone. Consequently, since these three bond markets are cointegrated, investors may not benefit from portfolio diversification.

Given the finding of cointegration at the 1% level, the appropriate way to proceed would be to estimate a VECM model as described in section 4.3.1, and not a VAR (section 4.4).

The output from the VECM estimation is given in Appendix G. Overall, the results indicate that the model fits relatively well. **Table 17** contains the estimated adjustment coefficients and **Table 18** the long-run coefficients. From these tables we see the cointegrating relation as the first column. In this case a normalization on the variable *Spain_5yr* is performed. This will make it straightforward to interpret the cointegrating relation in terms of an error correction mechanism measuring some of the factors that influence Spanish bond yields.

Similar to equation (16), our model here is expressed as

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \Pi_1 y_{t-1} + u_t,$$

where $\Pi_1 = \alpha\beta^T$ and the y is the vector of variables.

Here, the corresponding $\alpha = (-.002416\ \ -.005338\ \ -.000294\ \ 1.1475\ \ -.000475\ \ .007716\ \ -.14914)$, while $\beta = (1\ \ .0003833\ \ -.93718\ \ .0003591\ \ .80903\ \ -.28509\ \ .20585)$.

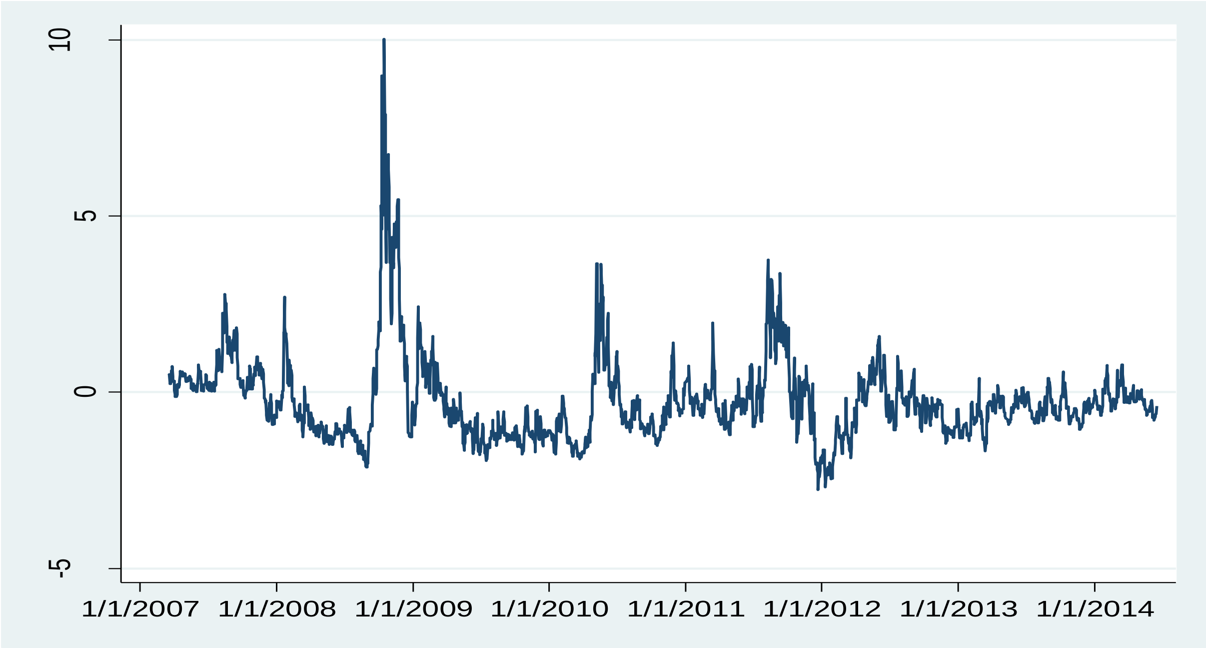
The coefficient α can be interpreted as the effect of a change in the disequilibrium error corrected for the lagged differences. Thus α corresponds to the speed of adjustment to equilibrium. A low coefficient indicates slow adjustment and a high coefficient is indicative of rapid adjustment.

In particular, the above long-run equilibrium relation is given by

Spain_5yr = -.0003833 ***Portugal_5yr*** + .93718 ***Italy_5yr*** -.0003591 ***EuroStoxx50*** -.80903 ***iTraxx_5yr_Main*** +.28509 ***iTraxx_5yr_Sen_Fin*** - .20585 ***VStoxx*** - 57.4.

The coefficients on *Italy_5yr, iTraxx_5yr_Main* and *VStoxx* are statistically different from 0 at the 1% level. The coefficient on *iTraxx_5yr_Sen_Fin* is significant at the 5% level. In contrast, the coefficients on *Portugal_5yr*, *EuroStoxx50* and the constant are not statistically significant at the usual levels. Moreover, a Wald test is performed on the cointegrating vector coefficient for *Spain_5yr* to test the hypothesis that it is equal to 0. The test statistic is given by 4.72, which is distributed as a Chi-Square with 1 degree of freedom, and the 5% critical value is 3.84. Consequently, the null hypothesis is rejected at the 5% level.

Additionally, inference on the parameters depends crucially on the stationarity of the cointegrating equation, so we should check the specification of the model. As a first check, the cointegrating equation is plotted in the figure below. The processes appear noticeably more stationary than the original variables.



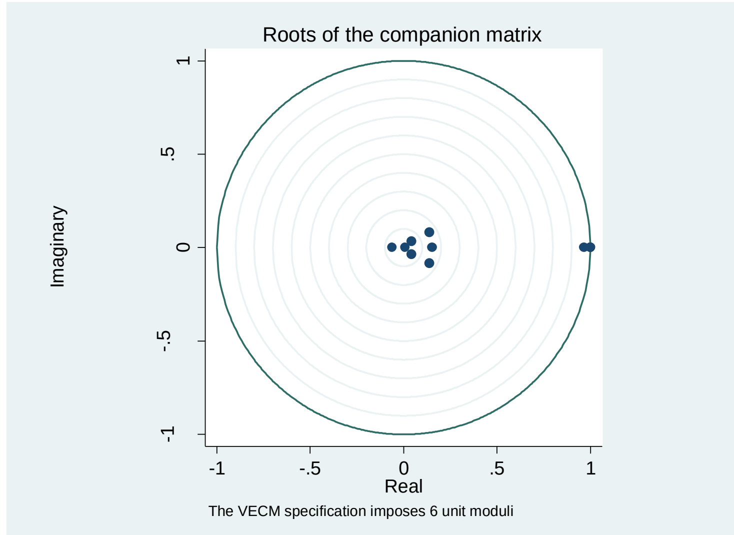
We can also check whether we have correctly specified the number of cointegrating equations. The coefficient matrix in companion form of a VECM with k endogenous variables and r cointegrating equations has k - 1 unit eigenvalues. If the process is stable, the moduli of the remaining r eigenvalues are strictly less than one. Here there are 7 endogenous variables, so there should be 6 unit eigenvalues. The remaining eigenvalue is strictly less than 1.

The results given in the "Eigenvalue stability condition" table below confirm this. There are altogether 7 real roots and 6 are on the unit circle. The graph to the right plots the companion matrix's eigenvalues with the real part on the x axis and the imaginary part on the y axis. Furthermore, there is no indication that the roots are close to any other value on the unit circle, which means that this type of non-stationarity can be removed by differencing.

Eigenvalue stability condition

Eigenvalue	Modulus
1	1
1	1
1	1
1	1
1	1
1	1
.9650839	.965084
.136885 + .08315258*i*	.160162
.136885 - .08315258*i*	.160162
.1504197	.15042
-.06190416	.061904
.04095034 + .03541446*i*	.05414
.04095034 - .03541446*i*	.05414
.0065804	.00658

The VECM specification imposes 6 unit moduli.



<u>Individual Country Analysis</u>

Similarly to the combined country analysis, it was found that individual country variables were I(1) processes. Consequently, the Johansen test for cointegration is performed for each country. The results are given in <u>Appendix F</u>.

<u>Spain</u>

First, looking at **Table 14** for Spain, we fail to reject the null hypothesis of at most one cointegrating equation at the 5% significance level. This makes intuitive sense that Spanish bond yields "co-move" with other Spanish economic variables. However, there is also another interesting result coming from the output. We would fail to reject the null hypothesis of no cointegration at the 1% level. Therefore, at this significance level, we cannot conclude that there is no cointegrating relationship between Spanish bond yields and other factors. At the 1% level, a VAR model would be estimated and not a VECM. All in all, the results suggest evidence of weak cointegration. It was optimally determined by selection-order criteria that the underlying VAR model should include 2 lags. The cointegrating equation for Spain has been plotted and is given in <u>Appendix F</u>. It almost appears to be stationary, but again it is suggestive of weak cointegration. In particular, the long-run equilibrium relation (recalling the 5% significance level) is given by

$$\boldsymbol{Spain\_5yr} = -.1557\ \boldsymbol{Spain\_ESI} + .000062\ \boldsymbol{IBEX35} + .8210\ \boldsymbol{Spain\_inflation} - .01936\ \boldsymbol{Spain\_T2} - .02627\ \boldsymbol{Spain\_CDS} + 16.1950.$$

All coefficients are statistically significant at the 1% level except for *IBEX35* and the constant, which are not significant at the usual levels. Moreover, a Wald test is performed on the cointegrating vector coefficient for *Spain_5yr* to test the hypothesis that it is equal to 0. The test statistic is given by 3.99, which is distributed as a Chi-Square with 1 degree of freedom, and the 5% critical value is 3.84. Consequently, the null hypothesis is rejected at the 5% level.

Portugal

Next, looking at **Table 15** for Portugal, we fail to reject the null hypothesis of at most one cointegrating equation at the 1% significance level. Again, this makes intuitive sense that Portuguese bond yields "co-move" with other Portuguese economic variables. It was optimally determined by selection-order criteria that the underlying VAR model should include 1 lag. The cointegrating equation for Portugal has been plotted and is given in Appendix F. It appears to be stationary. In particular, the equilibrium relation is given by

Portugal_5yr = .002806 ***Portugal_ESI*** + .0002101 ***PSI20*** + .2583 ***Portugal_inflation*** + .03654 ***Portugal_T2*** + .01218 ***Portugal_CDS*** + .9188.

All coefficients are statistically significant at the 1% level except for *Portugal_ESI* and the constant, which are not significant at the usual levels. A Wald test is performed on the cointegrating vector coefficient for *Portugal_5yr* to test the hypothesis that it is equal to 0. The test statistic is given by 9.49, which is distributed as a Chi-Square with 1 degree of freedom, and the 5% and 1% critical values are 3.84 and 5.02 respectively. Consequently, the null hypothesis is rejected at both these levels.

Italy

Finally, looking at **Table 16** for Italy, we fail to reject the null hypothesis of at most one cointegrating equation at the 1% significance level. Moreover, we fail to reject the null hypothesis of at most two cointegrating equations at the 5% significance level. Again, this makes intuitive sense that Italian bond yields "co-move" with other Italian economic variables. It was optimally determined by selection-order criteria that the underlying VAR model should include 1 lag. The cointegrating equation for Italy has been plotted and is given in Appendix F. It appears to be stationary as well. In particular, the long-run equilibrium relation is given by

Italy_5yr = - .1387 ***Italy_ESI*** + .000073 ***FTSEMIB*** + -.3579 ***Italy_inflation*** - .008054 ***Italy_T2*** - .00644 ***Italy_CDS*** + 16.03.

Italy_ESI, Italy_T2 and *Italy_CDS* are statistically significant at the 1% level, while the other variables are not significant at the usual levels. Lastly, a Wald test is performed on the cointegrating vector coefficient for *Italy_5yr* to test the hypothesis that it is equal to 0. The test statistic is given by 4.40, which is distributed as a Chi-Square with 1 degree of freedom, and the 5% critical value is 3.84. Consequently, the null hypothesis is rejected at the 5% level.

5.3 Granger Causality Tests

The results for the combined country analysis are given in **Table 19** in Appendix H. There are a few interesting points to mention. First, both Spanish and Italian bond yields Granger cause Portugal's yields at the 1% significance level, while Portugal's and Spain's Granger cause Italy's at the 10% level. As discussed in section 4.5, there is thus (weak) feedback between Portuguese and Italian bond yields. On the other hand, the variable EuroStoxx50 doesn't Granger cause any of the bond yields, while iTraxx 5yr Sen. Fin. Granger causes Portuguese yields at the 1% level.

The results for each individual country are given in **Tables 20-22** in Appendix H. There are a few things worth mentioning. There is (weak) feedback between Spanish bond yields and Target2 balances. In particular, Spanish yields Granger cause T2 balances at the 5% level, while T2 balances Granger cause yields at the 10% level. There is also feedback between Spanish bond yields and Spanish CDS spreads. In fact, Spanish yields Granger cause Spanish CDS spreads at the 1% level, while the reverse is significant at the 5% level. Lastly, Italian CDS spreads Granger cause Italian bond yields at the 1% level.

6 - Conclusion

This paper has sought to test for the existence of long-term relationships between Spanish, Portuguese and Italian 5-year bond markets over the period 2004-2014. Results from unit root and stationarity tests have shown that bond yields and a number of economic variables were I(1) processes. The Johansen test was used to assess the degree of integration of these sovereign bond markets. The results were divided into two parts. The first part was concerned with all three countries combined. The other part analyzed each country separately and sought to test whether domestic fundamentals influenced the country's bond yields.

For the combined country analysis, a cointegrating relation was found at the 1% significance level, so that in the long run these bond markets may not be strictly determined by their own domestic fundamentals. Variables that appear to influence these three sovereign markets include EuroStoxx 50, iTraxx indices and VStoxx, a measure of volatility in the eurozone. A VECM was estimated to determine the nature of this long-term relationship. What is more, from the Granger causality tests, there was feedback between Portuguese & Italian bond markets, and that Portuguese & Spanish bond yields Granger caused Italian yields.

Clearly, investors holding sovereign bonds from these countries would not benefit as much from diversification. In particular, diversification is effective whenever a portfolio's assets do not move in the same way, or produce the same returns for that matter. Ideally assets would be independent of each other. However, the inherent diversification of a portfolio can potentially change over time, and from the results in this paper, geography does have an influence on the risk of a portfolio. In addition to any other assets, investors could diversify their portfolio by choosing only one of the three 5-year bonds analyzed in this paper.

For individual country analyses, a long-run relation was found between each country's bond market and a number of domestic variables. First, a cointegrating relation was found to be significant at the 5% level for Spain, but not at the 1% level. In particular, the coefficients for inflation, Target2 balances, CDS spreads and the ESI in the cointegrating equation were statistically significant. Next, a long-run relation was found to be significant for Portugal, with the cointegrating equation coefficients for the national stock market, inflation, Target2 balances & CDS spreads being statistically significant. Similar results were found for Italy, with the coefficients for Target2 balances and CDS spreads being statistically significant. Moreover, there was feedback between Spain's bond yields & Target2 balances, and between Spain's yields and CDS spreads. For Italy, it was found that its CDS spreads Granger caused its bond yields. All in all, these results are in line with many previous studies, especially those of Delatte et al. (2012), Fontana and Scheicher (2010) and Palladina and Portes (2011). The distinguishing feature of this paper is the use of Target2 balances as a key domestic factor.

Naturally, a number of issues has limited the scope of this paper. First and foremost, it was difficult to obtain a large sample of observations for some of the variables. For example, CDS spreads, which are closely related to bond yields, only go back as far as 2004. The quality of the CDS data may not be the best as they could potentially be affected by liquidity problems in CDS markets.

More importantly, a number of variables that could potentially influence bond yields were not very useful for this paper since the countries publish them on an annual basis. These variables include government debt, fiscal balance (e.g. surplus/deficit levels), foreign debt and GDP growth, although the latter is published on a quarterly basis. Another interesting variable to be considered is a political risk score, published by the Economist Intelligence Unit. Unfortunately, these scores are only available quarterly and only go back several years.

Lastly, unit root tests are known to suffer from poor power properties. However, careful analysis of the data with 2 unit root tests along with a stationarity test have produced similar conclusions in this paper. Future research could extend these results by including more eurozone countries, looking at impulse response functions or even examining the possibility of a structural break in the data.

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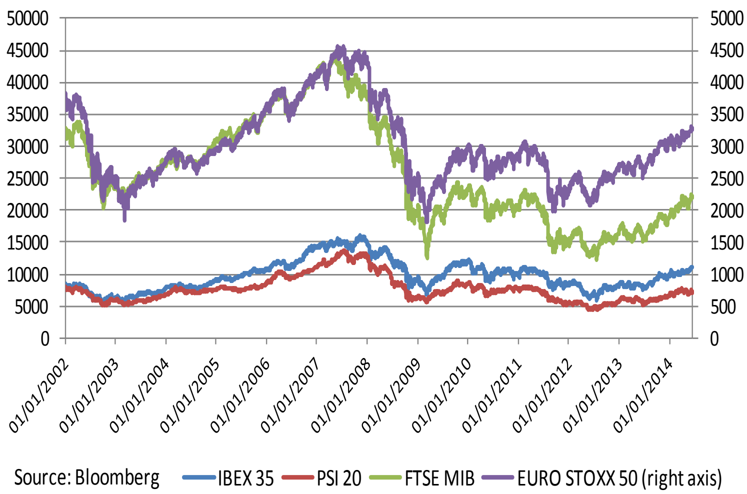
8 - Appendices

8.1 Appendix A - Data Sources

Variable	Description	Source	Frequency
5-year bond yields	Yield in % on a sovereign bond with a 5-year maturity	Bloomberg	Daily
VSTOXX	A measure of volatility in the Eurozone	Bloomberg	Daily
IBEX 35	Index consists of the 35 most liquid stocks traded on the Spanish Continuous Market	Bloomberg	Daily
PSI 20	Index consists of the top 20 stocks listed on the Lisbon Stock Exchange	Bloomberg	Daily
FTSE MIB	Index consists of the 40 most liquid and capitalized stocks listed on the Borsa Italiana	Bloomberg	Daily
Euro Stoxx 50	Index covers 50 stocks from 12 Eurozone countries, including Italy, Portugal and Spain	Bloomberg	Daily
5-year credit default swap (CDS)	A swap agreement whereby the seller of the CDS compensates the buyer in the event of a default or other credit event	CNBC	Daily
iTraxx EU 5-year Senior Financial	Index consists of 25 European senior subordinated financial entities with investment grade credit ratings that trade in the CDS market	Bloomberg	Daily
iTraxx Europe Main 5-year	Index consists of 125 most liquid European entities with investment grade credit ratings that trade in the CDS market.	Bloomberg	Daily
Economic Sentiment Indicator (ESI)	An indicator reflecting general economic activity. It combines assessments and expectations stemming from business and consumer surveys.	Eurostat	Monthly
Inflation	Inflation rate	Eurostat	Monthly
Target2 balances	Total claims & liabilities within the Eurosystem, in billions of euro	ECB	Monthly

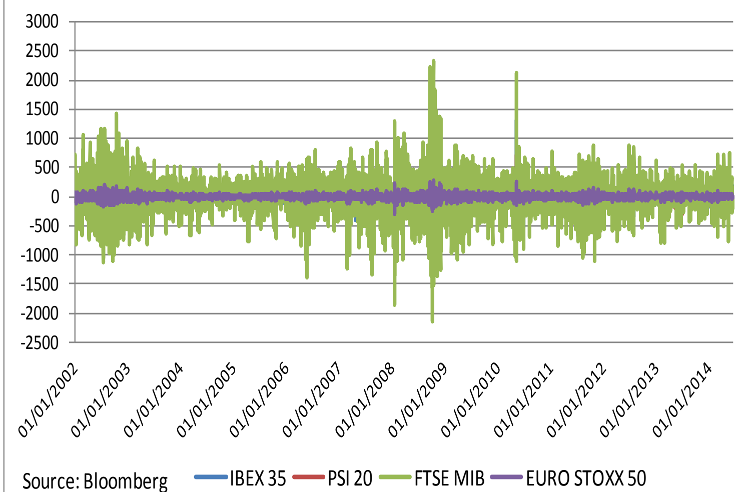
8.2 Appendix B

Figure 3 - Stock Markets



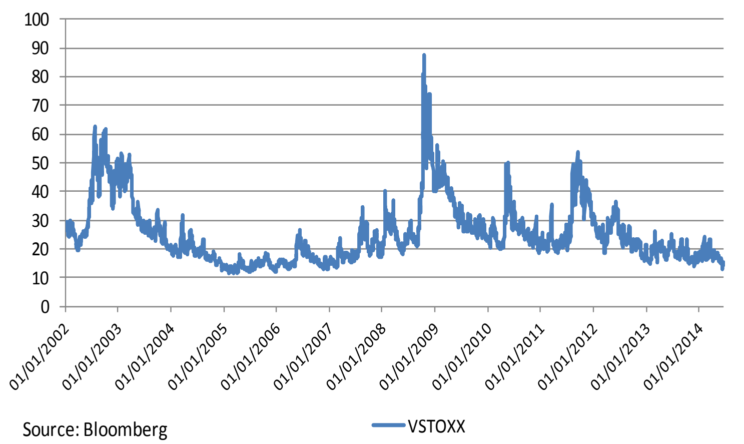
Source: Bloomberg

Figure 4 - Stock Markets (First-Difference)



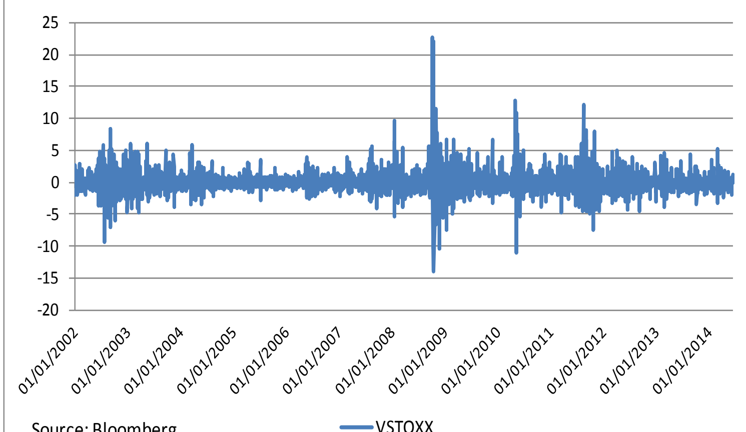
Source: Bloomberg

Figure 5 - VStoxx (volatility)



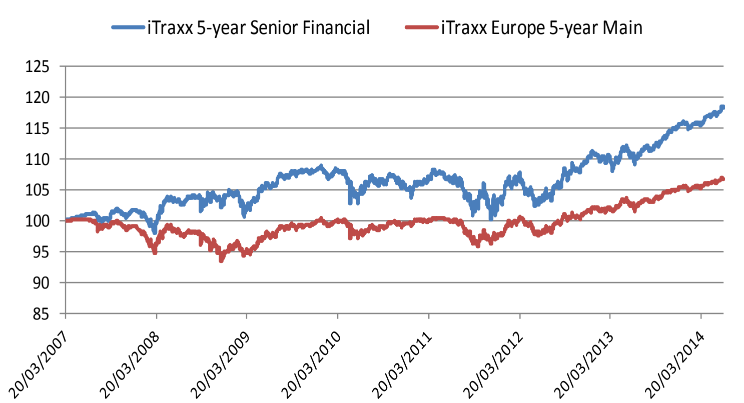
Source: Bloomberg

Figure 6 - VStoxx (First-Difference)



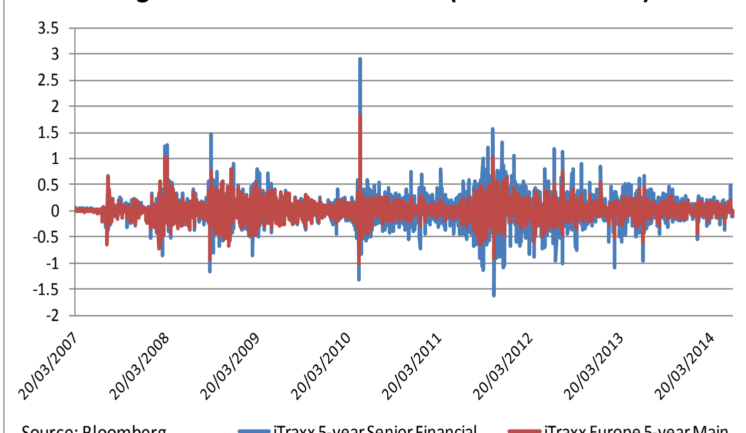
Source: Bloomberg

Figure 7 - iTraxx Credit Default Swap Indices



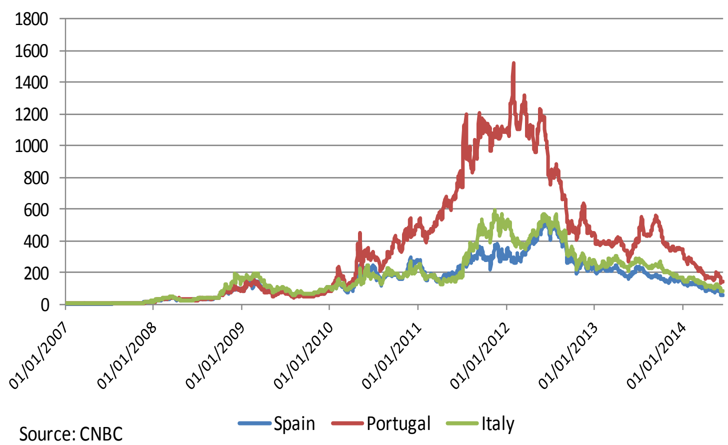
Source: Bloomberg

Figure 8 - iTraxx CDS Indices (First-Difference)



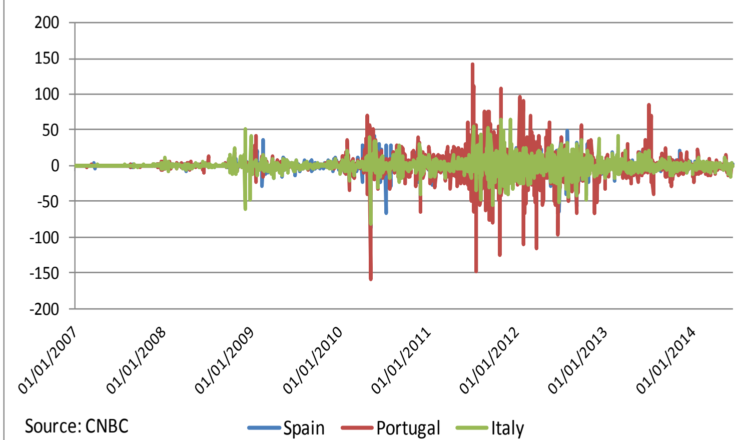
Source: Bloomberg

Figure 9 - 5-year CDS spreads (basis points)



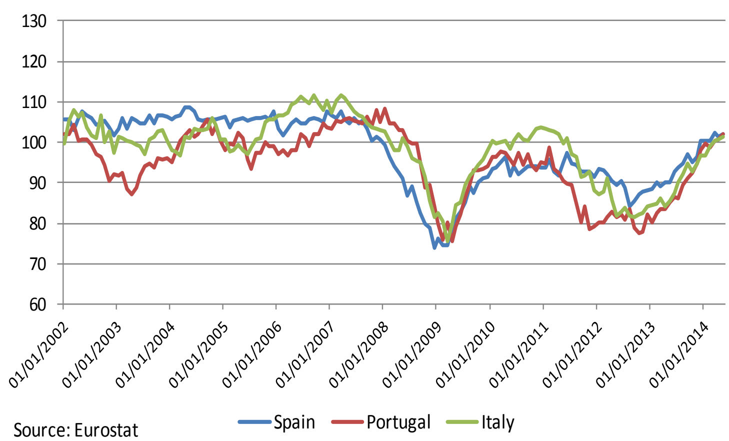
Source: CNBC

Figure 10 - 5-year CDS spreads (First-Difference)



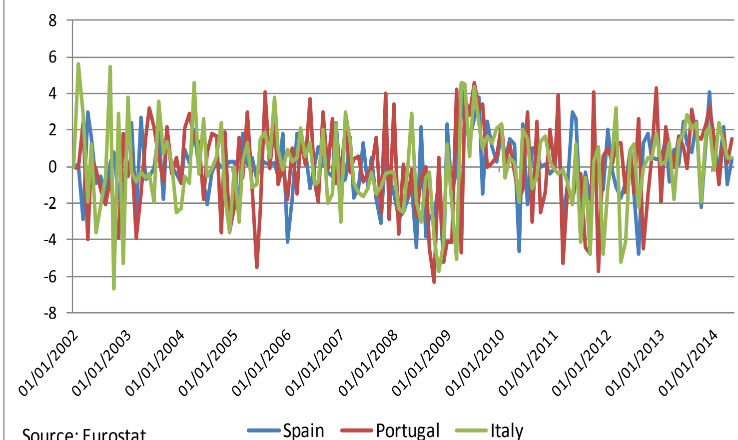
Source: CNBC

Figure11 - Economic Sentiment Indicator



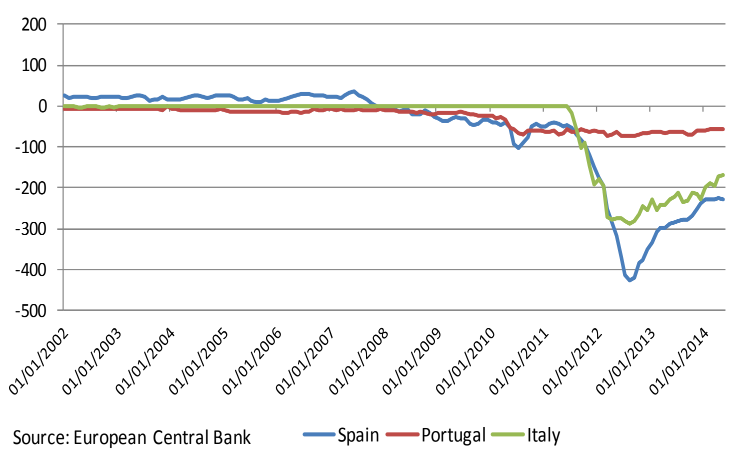
Source: Eurostat

Figure 12 - Economic Sentiment Indicator (First-Difference)



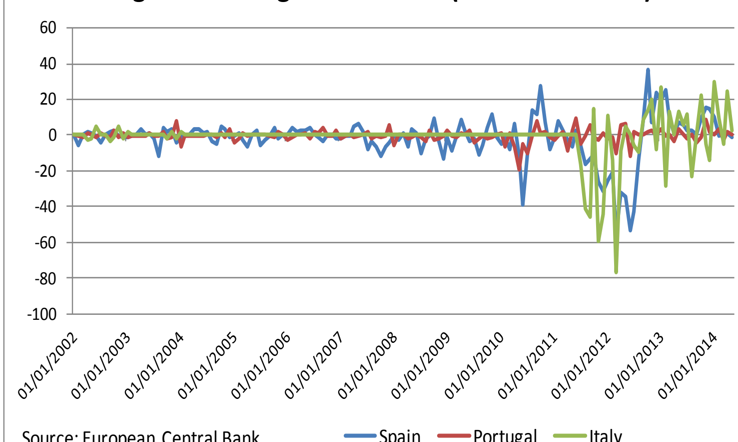
Source: Eurostat

Figure 13 - Target 2 balances (billions of euro)

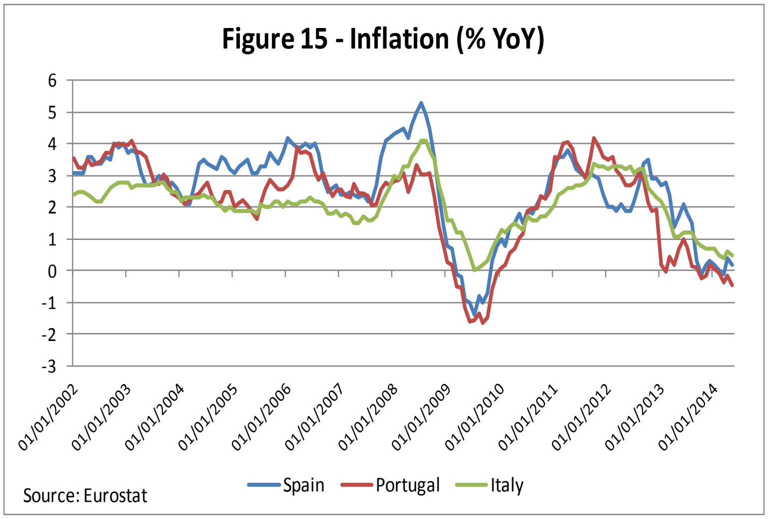


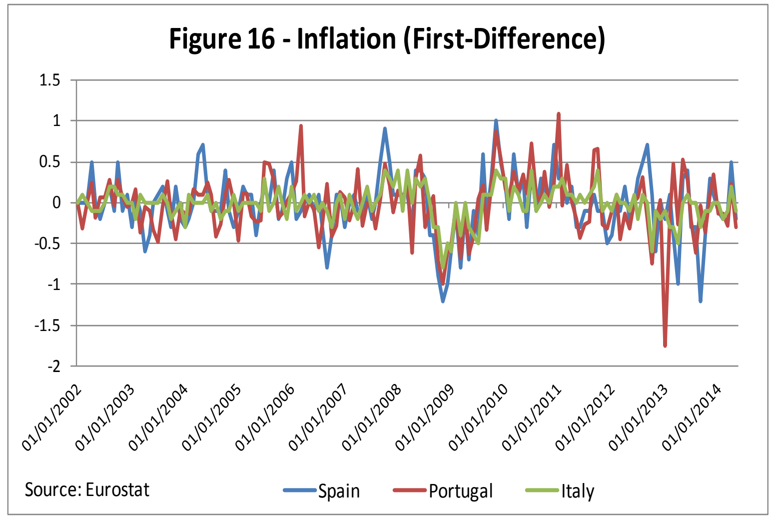
Source: European Central Bank

Figure 14 - Target 2 balances (First-Difference)



Source: European Central Bank





8.3 Appendix C

<u>Combined Country Analysis</u> (daily data)

Table 1 - Summary Statistics for Combined Country Analysis

	Spain_5yr	Portugal_5yr	Italy_5yr	EURO STOXX 50	iTraxx 5yr Main	iTraxx 5yr Sen Fin	VStoxx
Mean	3.75	6.02	3.70	2941.79	99.78	106.40	26.31
Standard deviation	0.93	3.72	0.98	635.85	2.64	4.31	9.99
Min	1.18	2.08	1.30	1809.98	93.57	98.05	13.04
Max	7.50	21.75	7.70	4557.57	107.03	118.60	87.51
Skewness	0.105**	1.569*	0.582*	1.098*	0.674*	0.748*	1.943*
Kurtosis	3.204**	4.312*	3.77*	3.422*	3.377*	3.14	8.115*

Jarque-Bera test for normality performed. The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level.

Table 2 - Unconditional Correlations for Combined Country Analysis

	Spain_5yr	Portugal_5yr	Italy_5yr	EURO STOXX 50	iTraxx 5yr Main	iTraxx 5yr Sen Fin	VStoxx
Spain_5yr	1						
Portugal_5yr	0.589	1					
Italy_5yr	0.871	0.643	1				
EURO STOXX 50	-0.029	-0.374	0.014	1			
iTraxx 5yr Main	-0.409	-0.121	-0.527	0.177	1		
iTraxx 5yr Sen Fin	-0.600	-0.146	-0.684	-0.262	0.848	1	
VStoxx	0.097	0.095	0.273	-0.447	-0.719	-0.429	1

8.4 Appendix D

Individual Country Analysis (monthly data)

Table 3 - Summary Statistics for Spain Analysis

	Spain_5yr	Spain_ESI	IBEX35	Spain_inflation	Spain_T2	Spain_CDS
Mean	3.61	96.43	10339.89	2.44	-77.76	111.28
Standard deviation	0.85	8.69	2237.91	1.45	128.31	122.06
Min	1.54	73.80	6089.80	-1.40	-428.62	2.78
Max	6.20	108.60	15890.50	5.30	34.80	507.76
Skewness	0.453**	-0.519**	0.671*	-0.67*	-1.265*	1.083*
Kurtosis	3.515	2.546	2.687	2.909	3.265	3.578

Jarque-Bera test for normality performed. The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level.

Table 4 - Unconditional Correlations for Spain Analysis

	Spain_5yr	Spain_ESI	IBEX35	Spain_inflation	Spain_T2	Spain_CDS
Spain_5yr	1					
Spain_ESI	-0.199	1				
IBEX35	0.025	0.348	1			
Spain_inflation	0.452	0.331	0.200	1		
Spain_T2	-0.168	0.423	0.527	0.303	1	
Spain_CDS	0.478	-0.536	-0.569	-0.215	-0.788	1

Table 5 - Summary Statistics for Portugal Analysis

	Portugal_5yr	Portugal_ESI	PSI20	Portugal_inflation	Portugal_T2	Portugal_CDS
Mean	5.23	94.37	7941.92	1.92	-33.15	250.31
Standard deviation	3.46	8.78	2121.88	1.44	24.99	338.61
Min	2.52	75.40	4513.38	-1.66	-74.54	4.13
Max	20.64	108.40	13434.20	4.20	-6.21	1217.35
Skewness	2.231*	-0.528*	0.926*	-0.778*	-0.420**	1.486*
Kurtosis	7.541*	2.076*	3.269	2.677	1.326	4.194**

Jarque-Bera test for normality performed. The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level.

Table 6 - Unconditional Correlations for Portugal Analysis

	Portugal_5yr	Portugal_ESI	PSI20	Portugal_inflation	Portugal_T2	Portugal_CDS
Portugal_5yr	1					
Portugal_ESI	-0.521	1				
PSI20	-0.388	0.770	1			
Portugal_inflation	0.439	0.214	0.220	1		
Portugal_T2	-0.603	0.604	0.652	0.047	1	
Portugal_CDS	0.919	-0.671	-0.604	0.231	-0.819	1

Table 7 - Summary Statistics for Italy Analysis

	Italy_5yr	Italy_ESI	FTSEMIB	Italy_inflation	Italy_T2	Italy_CDS
Mean	3.62	97.44	25827.41	2.02	-59.01	131.68
Standard deviation	0.88	8.68	8843.35	0.89	100.88	144.96
Min	1.68	75.40	12873.84	0.00	-289.32	5.90
Max	7.50	111.70	43755.00	4.10	0.00	540.27
Skewness	0.987*	-0.479**	0.433**	0.038	-1.238*	1.191*
Kurtosis	5.426*	2.355**	1.852*	2.729	2.728	3.603

Jarque-Bera test for normality performed. The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level.

Table 8 - Unconditional Correlations for Italy Analysis

	Italy_5yr	Italy_ESI	FTSEMIB	Italy_inflation	Italy_T2	Italy_CDS
Italy_5yr	1					
Italy_ESI	-0.090	1				
FTSEMIB	0.112	0.801	1			
Italy_inflation	0.713	-0.059	0.030	1		
Italy_T2	-0.092	0.599	0.616	-0.031	1	
Italy_CDS	0.418	-0.668	-0.804	0.237	-0.751	1

8.5 Appendix E

Table 9 - Unit Root & Stationarity Test Results for Combined Country Analysis

	Spain_5yr	Portugal_5yr	Italy_5yr	EURO STOXX 50	iTraxx 5yr Main	iTraxx 5yr Sen Fin	VStoxx
ADF Test							
Levels	-1.983	-1.468	-1.725	-2.066	-0.583	-0.745	-2.138
First Differences	-28.026*	-26.209*	-30.837*	-31.535*	-29.61*	-28.669*	-33.01
PP Test							
Levels	-1.853	-1.347	-1.701	-1.973	-0.542	-0.664	-2.012
First Differences	-44.934*	-42.67*	-46.098*	-52.6*	-47.591*	-47.786*	-50.9*
KPSS Test							
Levels	8.22*	21*	10.6*	33.1*	46.4*	55.5*	13.4*
First Differences	0.111	0.199	0.104	0.238	0.228	0.0959	0.0228

Note: The numbers in the table are the test statistic. All tests include a constant, but no trend. Results do not change when including a trend. The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level.

Table 10 - Unit Root & Stationarity Test Results for Spain Analysis

	Spain_5yr	Spain_ESI	IBEX35	Spain_inflation	Spain_T2	Spain_CDS
ADF Test						
Levels	-2.042	-1.511	-1.72	-2.223	-1.196	-1.661
First Differences	-7.287*	-4.561*	-5.78*	-5.319*	-3.593*	-6.653*
PP Test						
Levels	-2.169	-1.375	-1.735	-1.663	-0.617	-1.528
First Differences	-11.777*	-11.018*	-9.526*	-7.253*	-4.548*	-7.912*
KPSS Test						
Levels	0.358***	1.82*	0.982*	0.962*	3.11*	3.02*
First Differences	0.131	0.265	0.165	0.098	0.148	0.132

Note: The numbers in the table are the test statistic. All tests include a constant, but no trend. Results do not change when including a trend. The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level.

Table 11 - Unit Root & Stationarity Test Results for Portugal Analysis

	Portugal_5yr	Portugal_ESI	PSI20	Portugal_inflation	Portugal_T2	Portugal_CDS
ADF Test						
Levels	-1.344	-1.351	-1.421	-1.532	-0.841	-1.163
First Differences	-7.055*	-6.26*	-7.571*	-7.071*	-8.201*	-5.478*
PP Test						
Levels	-1.553	-1.418	-1.31	-1.284	-0.849	-1.096
First Differences	-14.377*	-11.963*	-8.926*	-8.79*	-10.931*	-9.481*
KPSS Test						
Levels	1.95*	2.72*	2.45*	0.844*	5.39*	3.57*
First Differences	0.157	0.169	0.176	0.132	0.128	0.274

Note: The numbers in the table are the test statistic. All tests include a constant, but no trend. Results do not change when including a trend. The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level.

Table 12 - Unit Root & Stationarity Test Results for Italy Analysis

	Italy_5yr	Italy_ESI	FTSEMIB	Italy_inflation	Italy_T2	Italy_CDS
ADF Test						
Levels	-2.443	-1.578	-0.975	-1.665	-0.585	-1.808
First Differences	-7.797*	-7.089*	-7.533*	-4.44*	-6.917*	-5.67*
PP Test						
Levels	-2.239	-1.441	-0.869	-1.142	-0.502	-1.454
First Differences	-10.043*	-9.301*	-9.317*	-7.266*	-9.604*	-7.232*
KPSS Test						
Levels	0.359***	2.33*	4.29*	0.607**	3.96*	4.26*
First Differences	0.104	0.139	0.223	0.171	0.239	0.138

Note: The numbers in the table are the test statistic. All tests include a constant, but no trend. Results do not change when including a trend. The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level.

8.6 Appendix F

Combined Country Analysis

Table 13 - Johansen Test for Cointegration

Maximum Rank	Eigenvalue	Trace Statistic	95%	99%
0		167.3918	124.24	133.57
1	0.02939	88.5235*	94.15	103.18
2	0.01381	51.7426	68.52	76.07
3	0.00939	26.8040	47.21	54.46

Individual Country Analysis

Table 14 - Johansen Test for Cointegration, Spain

Maximum Rank	Eigenvalue	Trace Statistic	95%	99%
0		70.975*	68.52	76.07
1	0.26355	33.3479**	47.21	54.46
2	0.1144	18.4051	29.68	35.65
3	0.08246	7.8197	15.41	20.04

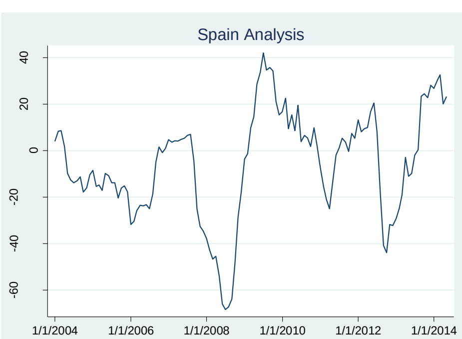
Table 15 - Johansen Test for Cointegration, Portugal

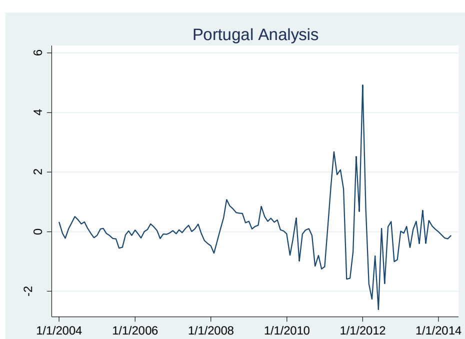
Maximum Rank	Eigenvalue	Trace Statistic	95%	99%
0		96.8227	68.52	76.07
1	0.38045	37.4564*	47.21	54.46
2	0.14288	18.3383	29.68	35.65
3	0.08952	6.7085	15.41	20.04

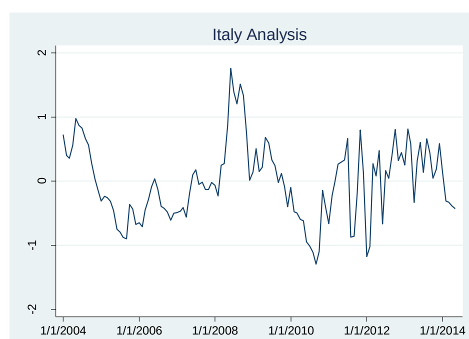
Table 16 - Johansen Test for Cointegration, Italy

Maximum Rank	Eigenvalue	Trace Statistic	95%	99%
0		114.247	68.52	76.07
1	0.3876	53.4404*	47.21	54.46
2	0.1824	28.4688**	29.68	35.65
3	0.10609	14.5616	15.41	20.04

Predicted Cointegrating Equations







8.7 Appendix G

Combined Country Analysis

Table 17 - Estimates of the Adjustment Parameters (α)

	α_1	α_2	α_3	α_4	α_5	α_6	α_7
ΔSpain_5yr_	.19421*	.003797	.044008	-17.6858	-.064348	-.13915	.34964
	(.0316)	(.0704)	(.0311)	(14.027)	(.0609)	(.0935)	(.659)
ΔPortugal_5yr	-.023944*	.14893*	-.025401*	5.84581	.035371*	.087847*	-.16216
	(.00915)	(.0204)	(.009)	(4.061)	(.0176)	(.0271)	(.191)
ΔItaly_5yr	-.070368**	.1297***	.084696*	-4.61652	-.004485	-.062428	.15677
	(.0322)	(.0716)	(.0317)	(14.281)	(.062)	(.0952)	(.671)
ΔEURO STOXX 50	-.000163**	-.000178	-.000171**	-.009088***	.000253***	.000314	-.001499
	(.0000781)	(.000174)	(.0000768)	(.0346)	(.00015)	(.000231)	(.00163)
ΔiTraxx 5yr Main	.039327***	.034561	.006772	17.6602	.0953**	.16789*	-.84073***
	(.0225)	(.0501)	(.0221)	(9.987)	(.0434)	(.0666)	(.469)
ΔiTraxx 5yr Sen Fin	-.021415	-.066133**	-.002555	-9.46125	-.029568	-.038399	.31339
	(.0139)	(.0310)	(.0137)	(6.176)	(.0268)	(.0412)	(.29)
ΔVStoxx	.000011	.000340	-.000892	.72718	.003325	.005376	-.024781
	(.00149)	(.00333)	(.00147)	(.663)	(.00288)	(.00442)	(.0311)

The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level. Standard errors in parentheses.

Table 18 - Estimates of the Long-Run Parameters (β)

	β_1	β_2	β_3	β_4	β_5	β_6	β_7
Spain_5yr	-.002416**	-.005338***	-.000294	1.1475**	-.000475	.007716**	-.14914
	(.00134)	(.00299)	(.00132)	(.597)	(.00259)	(.00398)	(.028)
Portugal_5yr	-9.26e-07**	-2.05e-06***	-1.13e-07	.00044**	-1.82e-07	2.96e-06**	-.000057
	(5.15e-07)	(1.15e-06)	(5.07e-07)	(.000229)	(9.93e-07)	(1.52e-06)	(.0000107)
Italy_5yr	.002264**	.005003***	.000276	-1.07541**	.000445	-.007231**	.13978
	(.00126)	(.0028)	(.00124)	(.559)	(.00243)	(.00373)	(.0263)
EURO STOXX 50	-8.98e-07**	-1.92e-06***	-1.06e-07	.000412**	-1.70e-07	2.77e-06**	-.0000536
	(4.83e-07)	(1.07e-06)	(4.75e-07)	(.000214)	(9.3e-07)	(1.43e-06)	(.0000101)
iTraxx 5yr Main	-.001955**	-.004319***	-.000238	.92836**	-.000384	.006242**	-.12066
	(.00109)	(.00242)	(.00107)	(.483)	(.0021)	(.00322)	(.0227)
iTraxx 5yr Sen Fin	.000689**	.001522***	.000084	-.32714**	.000135	-.0022**	.04252
	(.000383)	(.000853)	(.000377)	(.17)	(.000739)	(.00113)	(.00799)
VStoxx	-.000497**	-.001099***	-.000061	.23621**	-.000098	.001588**	-.030701
	(.000277)	(.000616)	(.000272)	(.123)	(.000533)	(.000819)	(.00577)

The asterisks indicate the statistical significance at 1% (*), 5% (**) and 10% (***) level. Standard errors in parentheses.

For brevity reasons, tables for individual countries have been omitted.

8.8 Appendix H

Table 19 - Granger Causality Wald Test Results for Combined Country Analysis

Equation	Excluded	chi2	df	Prob > chi2
Spain_5yr_FD	Portugal_5yr_FD	11.821	2	0.003
Spain_5yr_FD	Italy_5yr_FD	5.0686	2	0.079
Spain_5yr_FD	EUROSTOXX50_FD	5.3032	2	0.071
Spain_5yr_FD	iTraxx_main_FD	4.4323	2	0.109
Spain_5yr_FD	iTraxx_5yr_seni~D	3.7929	2	0.150
Spain_5yr_FD	VSTOXX_FD	2.0675	2	0.356
Spain_5yr_FD	ALL	31.287	12	0.002
Portugal_5yr_FD	Spain_5yr_FD	.0161	2	0.992
Portugal_5yr_FD	Italy_5yr_FD	5.0397	2	0.080
Portugal_5yr_FD	EUROSTOXX50_FD	.7682	2	0.681
Portugal_5yr_FD	iTraxx_main_FD	.51307	2	0.774
Portugal_5yr_FD	iTraxx_5yr_seni~D	5.1334	2	0.077
Portugal_5yr_FD	VSTOXX_FD	.25863	2	0.879
Portugal_5yr_FD	ALL	40.318	12	0.000
Italy_5yr_FD	Spain_5yr_FD	3.1965	2	0.202
Italy_5yr_FD	Portugal_5yr_FD	9.2077	2	0.010
Italy_5yr_FD	EUROSTOXX50_FD	4.9438	2	0.084
Italy_5yr_FD	iTraxx_main_FD	.76885	2	0.681
Italy_5yr_FD	iTraxx_5yr_seni~D	.78699	2	0.675
Italy_5yr_FD	VSTOXX_FD	.48326	2	0.785
Italy_5yr_FD	ALL	21.896	12	0.039
EUROSTOXX50_FD	Spain_5yr_FD	1.5698	2	0.456
EUROSTOXX50_FD	Portugal_5yr_FD	2.2834	2	0.319
EUROSTOXX50_FD	Italy_5yr_FD	1.0769	2	0.584
EUROSTOXX50_FD	iTraxx_main_FD	2.508	2	0.285
EUROSTOXX50_FD	iTraxx_5yr_seni~D	2.9132	2	0.233
EUROSTOXX50_FD	VSTOXX_FD	8.7935	2	0.012
EUROSTOXX50_FD	ALL	19.403	12	0.079
iTraxx_main_FD	Spain_5yr_FD	1.2175	2	0.544
iTraxx_main_FD	Portugal_5yr_FD	4.4209	2	0.110
iTraxx_main_FD	Italy_5yr_FD	.85425	2	0.652
iTraxx_main_FD	EUROSTOXX50_FD	4.7649	2	0.092
iTraxx_main_FD	iTraxx_5yr_seni~D	3.6435	2	0.162
iTraxx_main_FD	VSTOXX_FD	12.46	2	0.002
iTraxx_main_FD	ALL	24.42	12	0.018
iTraxx_5yr_seni~D	Spain_5yr_FD	2.1394	2	0.343
iTraxx_5yr_seni~D	Portugal_5yr_FD	10.953	2	0.004
iTraxx_5yr_seni~D	Italy_5yr_FD	.898	2	0.638
iTraxx_5yr_seni~D	EUROSTOXX50_FD	1.7849	2	0.410
iTraxx_5yr_seni~D	iTraxx_main_FD	6.8085	2	0.033
iTraxx_5yr_seni~D	VSTOXX_FD	8.2185	2	0.016
iTraxx_5yr_seni~D	ALL	35.535	12	0.000
VSTOXX_FD	Spain_5yr_FD	.46978	2	0.791
VSTOXX_FD	Portugal_5yr_FD	.9801	2	0.613
VSTOXX_FD	Italy_5yr_FD	1.1185	2	0.572
VSTOXX_FD	EUROSTOXX50_FD	4.3363	2	0.114
VSTOXX_FD	iTraxx_main_FD	4.0667	2	0.131
VSTOXX_FD	iTraxx_5yr_seni~D	.85534	2	0.652
VSTOXX_FD	ALL	19.656	12	0.074

Table 20 - Granger Causality Wald Test Results for Spain Analysis

Equation	Excluded	chi2	df	Prob > chi2
Spain_5yr_FD	Spain_ESI_FD	.04261	2	0.979
Spain_5yr_FD	IBEX35_FD	6.159	2	0.046
Spain_5yr_FD	Spain_inflation~D	2.5882	2	0.274
Spain_5yr_FD	Spain_T2_FD	7.3687	2	0.025
Spain_5yr_FD	Spain_CDS_FD	8.7298	2	0.013
Spain_5yr_FD	ALL	20.052	10	0.029
Spain_ESI_FD	Spain_5yr_FD	.63553	2	0.728
Spain_ESI_FD	IBEX35_FD	6.7275	2	0.035
Spain_ESI_FD	Spain_inflation~D	.09514	2	0.954
Spain_ESI_FD	Spain_T2_FD	5.3329	2	0.070
Spain_ESI_FD	Spain_CDS_FD	1.8514	2	0.396
Spain_ESI_FD	ALL	17.255	10	0.069
IBEX35_FD	Spain_5yr_FD	.60604	2	0.739
IBEX35_FD	Spain_ESI_FD	2.8105	2	0.245
IBEX35_FD	Spain_inflation~D	.48592	2	0.784
IBEX35_FD	Spain_T2_FD	1.6699	2	0.434
IBEX35_FD	Spain_CDS_FD	1.6364	2	0.441
IBEX35_FD	ALL	6.5843	10	0.764
Spain_inflation~D	Spain_5yr_FD	.62891	2	0.730
Spain_inflation~D	Spain_ESI_FD	.10922	2	0.947
Spain_inflation~D	IBEX35_FD	2.3968	2	0.302
Spain_inflation~D	Spain_T2_FD	2.4504	2	0.294
Spain_inflation~D	Spain_CDS_FD	.03615	2	0.982
Spain_inflation~D	ALL	6.594	10	0.763
Spain_T2_FD	Spain_5yr_FD	5.0291	2	0.081
Spain_T2_FD	Spain_ESI_FD	3.2776	2	0.194
Spain_T2_FD	IBEX35_FD	5.6955	2	0.058
Spain_T2_FD	Spain_inflation~D	.56462	2	0.754
Spain_T2_FD	Spain_CDS_FD	3.0769	2	0.215
Spain_T2_FD	ALL	34.733	10	0.000
Spain_CDS_FD	Spain_5yr_FD	5.9172	2	0.052
Spain_CDS_FD	Spain_ESI_FD	.15077	2	0.927
Spain_CDS_FD	IBEX35_FD	8.054	2	0.018
Spain_CDS_FD	Spain_inflation~D	1.5178	2	0.468
Spain_CDS_FD	Spain_T2_FD	1.6843	2	0.431
Spain_CDS_FD	ALL	21.673	10	0.017

Table 21 - Granger Causality Wald Test Results for Portugal Analysis

Equation	Excluded	chi2	df	Prob > chi2
Portugal_5yr_FD	Portugal_ESI_FD	.14444	1	0.704
Portugal_5yr_FD	PSI20_FD	.22111	1	0.638
Portugal_5yr_FD	Portugal_inflat~D	5.0467	1	0.025
Portugal_5yr_FD	Portugal_T2_FD	3.5149	1	0.061
Portugal_5yr_FD	Portugal_CDS_FD	.2255	1	0.635
Portugal_5yr_FD	ALL	8.1256	5	0.149
Portugal_ESI_FD	Portugal_5yr_FD	.0798	1	0.778
Portugal_ESI_FD	PSI20_FD	4.2603	1	0.039
Portugal_ESI_FD	Portugal_inflat~D	.86971	1	0.351
Portugal_ESI_FD	Portugal_T2_FD	1.6437	1	0.200
Portugal_ESI_FD	Portugal_CDS_FD	.34247	1	0.558
Portugal_ESI_FD	ALL	7.4648	5	0.188
PSI20_FD	Portugal_5yr_FD	1.3889	1	0.239
PSI20_FD	Portugal_ESI_FD	3.5432	1	0.060
PSI20_FD	Portugal_inflat~D	.0557	1	0.813
PSI20_FD	Portugal_T2_FD	.99971	1	0.317
PSI20_FD	Portugal_CDS_FD	.1511	1	0.697
PSI20_FD	ALL	5.6214	5	0.345
Portugal_inflat~D	Portugal_5yr_FD	.23064	1	0.631
Portugal_inflat~D	Portugal_ESI_FD	.21499	1	0.643
Portugal_inflat~D	PSI20_FD	.95962	1	0.327
Portugal_inflat~D	Portugal_T2_FD	.39516	1	0.530
Portugal_inflat~D	Portugal_CDS_FD	1.0405	1	0.308
Portugal_inflat~D	ALL	3.5329	5	0.618
Portugal_T2_FD	Portugal_5yr_FD	1.3648	1	0.243
Portugal_T2_FD	Portugal_ESI_FD	.21665	1	0.642
Portugal_T2_FD	PSI20_FD	1.2132	1	0.271
Portugal_T2_FD	Portugal_inflat~D	1.6475	1	0.199
Portugal_T2_FD	Portugal_CDS_FD	3.2334	1	0.072
Portugal_T2_FD	ALL	16.631	5	0.005
Portugal_CDS_FD	Portugal_5yr_FD	.03757	1	0.846
Portugal_CDS_FD	Portugal_ESI_FD	1.7003	1	0.192
Portugal_CDS_FD	PSI20_FD	1.0467	1	0.306
Portugal_CDS_FD	Portugal_inflat~D	.0267	1	0.870
Portugal_CDS_FD	Portugal_T2_FD	9.2328	1	0.002
Portugal_CDS_FD	ALL	13.584	5	0.018

Table 22 - Granger Causality Wald Test Results for Italy Analysis

Equation	Excluded	chi2	df	Prob > chi2
Italy_5yr_FD	Italy_ESI_FD	1.2041	1	0.273
Italy_5yr_FD	FTSEMIB_FD	1.8515	1	0.174
Italy_5yr_FD	Italy_inflation~D	5.5367	1	0.019
Italy_5yr_FD	Italy_T2_FD	1.3968	1	0.237
Italy_5yr_FD	Italy_CDS_FD	1.166	1	0.280
Italy_5yr_FD	ALL	10.889	5	0.054
Italy_ESI_FD	Italy_5yr_FD	.0006	1	0.980
Italy_ESI_FD	FTSEMIB_FD	13.814	1	0.000
Italy_ESI_FD	Italy_inflation~D	.06861	1	0.793
Italy_ESI_FD	Italy_T2_FD	8.0452	1	0.005
Italy_ESI_FD	Italy_CDS_FD	.22359	1	0.636
Italy_ESI_FD	ALL	32.716	5	0.000
FTSEMIB_FD	Italy_5yr_FD	1.3759	1	0.241
FTSEMIB_FD	Italy_ESI_FD	.41318	1	0.520
FTSEMIB_FD	Italy_inflation~D	1.943	1	0.163
FTSEMIB_FD	Italy_T2_FD	.02522	1	0.874
FTSEMIB_FD	Italy_CDS_FD	.83207	1	0.362
FTSEMIB_FD	ALL	4.2476	5	0.514
Italy_inflation~D	Italy_5yr_FD	.62943	1	0.428
Italy_inflation~D	Italy_ESI_FD	.29726	1	0.586
Italy_inflation~D	FTSEMIB_FD	4.6806	1	0.031
Italy_inflation~D	Italy_T2_FD	1.2248	1	0.268
Italy_inflation~D	Italy_CDS_FD	1.6495	1	0.199
Italy_inflation~D	ALL	9.0585	5	0.107
Italy_T2_FD	Italy_5yr_FD	.21236	1	0.645
Italy_T2_FD	Italy_ESI_FD	.12503	1	0.724
Italy_T2_FD	FTSEMIB_FD	.03827	1	0.845
Italy_T2_FD	Italy_inflation~D	3.5041	1	0.061
Italy_T2_FD	Italy_CDS_FD	1.1514	1	0.283
Italy_T2_FD	ALL	4.5083	5	0.479
Italy_CDS_FD	Italy_5yr_FD	4.9746	1	0.026
Italy_CDS_FD	Italy_ESI_FD	.03176	1	0.859
Italy_CDS_FD	FTSEMIB_FD	8.1774	1	0.004
Italy_CDS_FD	Italy_inflation~D	1.0033	1	0.317
Italy_CDS_FD	Italy_T2_FD	.05194	1	0.820
Italy_CDS_FD	ALL	15.878	5	0.007