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The Determinants of Eurozone Bond Yields during the Sovereign Debt Crisis

An Investigation of the Role of Fundamentals, Contagion and the ECB's Asset Purchase Programmes

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"There has been, a clear crisis of confidence that has seriously aggravated the situation. Measures need to be taken to ensure that this vicious circle is broken"[1]

[1] Quote by IMF Managing Director Christine Lagarde on the Eurozone Sovereign Debt Crisis (Spiegel, 2011)

Preface and Acknowledgements

The topic of public debt and its relation with sovereign yields is a continuous thread throughout my studies. The bachelor courses made me familiar with the subject of public economics, while the *international financial markets* seminar was composed of more in-depth analysis of the deteriorating public finances in the Eurozone.

Last year, I obtained my International Economics master degree by defending my thesis regarding the influence of public debt on the economic growth. The main result reported the substantial influence of sovereign yields on the sustainability of debt. However, the analysis surpassed on the factors which caused these sovereign yields to surge and indirectly affected the sustainability so substantially. In particular, the recent Sovereign Debt Crisis has instigated my interest in conducting future research, as the crisis is characterised by both rising debt levels, as increased sovereign yields. More specifically, it sparked my interest whether the deteriorating country-specific fundamentals could solely explain the surged sovereign yields or whether alternative factors were of influence. To this end, I wrote my Financial Economics thesis on the determinants of Eurozone bond yields during the Sovereign Debt Crisis.

I want to express my gratitude to M.A. Pieterse-Bloem for the moments of reflection on my work. Especially, her theoretical and empirical expertise and experience have improved my insights into the required analysis that had to be conducted. Moreover, the exposure to the study material of the *Fixed Income Securities and Portfolio Management* course has improved my understandings on the topic. Finally, I would like to acknowledge my parents, friends, and girlfriend for the support and stimulations, which encouraged me in successfully writing my master thesis.

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Abstract

This paper examined the determinants of sovereign yields during the Sovereign Debt Crisis. In particular, it is identified to what degree the surge in sovereign yields can be attributed to the macro-fundamentals, liquidity, contagion and the ECB policies. The study examined the explicit influence of these potential yield components for the initial twelve Eurozone members for the January 2000-December 2017 period. The identification strategy of the paper is based upon a monthly Panel Data Fixed Effects regression model in which the 10-year to maturity sovereign yields depends on the macro-economic fundamentals, liquidity, and the ECB policies. Subsequently, contagion is addressed in a comprehensive set of analysis.

The analysis report substantial unexplained proportions of the actual yields, clustering of the residuals, surges in the time-fixed effects and heterogeneous pricing of the fundamentals during the Sovereign Debt Crisis which all can be attributed to the substantial presence of contagion. In the all-encompassing regression specification, the significant influence of regional contagion spill-overs and increased sensitivity to fundamental pricing is found. The quantification of contagion reports more substantial influence of contagion for the PIIGS countries. On the contrary, the study indicates neglection of the yield determinants in the times before to the crisis. The pre-crisis mispricing manifests itself in the presence of significant crisis dummy interaction terms, which implies the incorporation of specific variables that were previously neglected. More specifically, public debt, fiscal balance, trade openness, and liquidity have significant influence during times of the crisis, while the Security Market Programme achieved its aim by reducing the PIIGS yields. Thereby, the financial markets solely incorporate credit-risk and liquidity risk during the height of the Sovereign Debt Crisis, while relative homogeneous pricing characterises the pre-crisis period. The estimation and resulting conclusion are robust to the inclusion of an alternative set of control variables, specification and two-stage-least-squares corrections for endogeneity.

Keywords: Sovereign Debt Crisis, yield determinants, contagion, panel data fixed effect regression model and principal component analysis.

JEL Classification: F30, G01, G12, and G15.

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1. Introduction

Since the Financial Crisis of 2007, and the resulting Sovereign Debt Crisis in particular, sovereign debt yields have increased substantially in the Eurozone (Figure 1.1). This substantial rise in the sovereign interest rates is commonly ascribed to the economic demise, the issue of enormous amounts of sovereign debt, downward pressure on governmental revenues and the need for fiscal stimulation (Roman & Bilan, 2012). The sovereign debt yields of these financially distressed countries rose, as investors required further compensation for bearing increased credit-risk (Deutsche Bundesbank, 2011). In particular, the probability of sovereign default surged, as sovereign debt-to-GDP ratios rose, fiscal balance deteriorated and the solvency and sustainability of the confronted nations were directly jeopardized (Campello, Graham, & Campbell, 2010). Besides, demanded public yields further rose, as investors became more risk averse and liquidity risk increased due to stagnating activity in the public debt market (Coeure, 2012);(Chtourou, 2015).

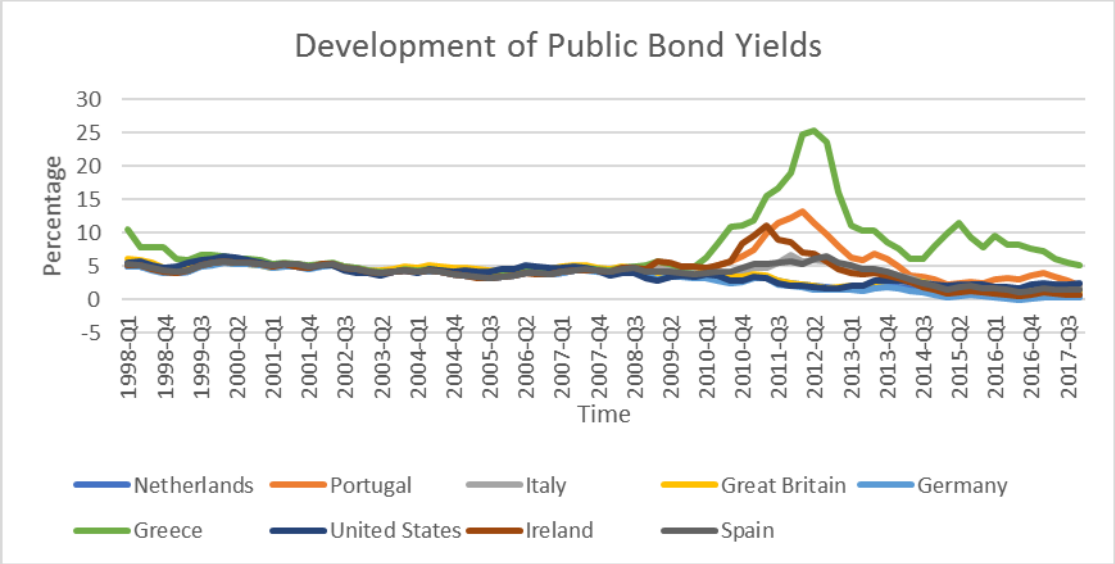

Figure 1.1: Development of Advanced Economies Public Bond Yields

Notes: Interest rates on 10-year government bonds; (2) source: OECD

The paper aims to quantify the impact of the, so-called, macro-economic fundamentals, such as the debt-to-GDP ratio and the fiscal balance, as determinants of the sovereign debt yields. The scope of the paper is primarily directed on the influence of the fundamentals on sovereign yields, as increased risk aversion and demanded compensation for liquidity risk was minimal and was mostly of temporary influence (Deutsche Bundesbank, 2011).

Moreover, the study aims at quantifying the influence of market sentiment and contagion that characterised the financial markets during the Sovereign Debt Crisis, as bond yields potentially became unrelated of the fundamentals and cross-country spill-overs occurred (de Grauwe, Ji &Macchiarelli, 2017). The presence of market sentiment, for instance, materisalises in Moody's downgrade of Portuguese sovereign debt due to the rise of the problematic Greek public finances, while no direct

deterioration of the Portuguese macro-fundamentals occurred (Constancio, 2011). Additionally, the study corrects for the substantial purchases on the secondary bond market under the ECB's Asset Purchase Programmes (henceforth: APP). Primarily, the yield-influence of the Security Market Programme is of interest (henceforth: SMP). As the aim of the SMP was to reduce the sovereign yields by acquisitions of sovereign bonds on the secondary bond markets. Consequently, the following research question is examined:

To what degree can the deteriorating fundamentals, contagion, and the ECB policies explain the rise in Eurozone debt yields during the 2010 Sovereign Debt Crisis?

The central research question of the study is addressed by estimating a panel data fixed effects regression equation with the 10-year public bond yield as the dependent variable and the macro fundamental variables, several measures of contagion and the ECB's purchasing programs as main independent variables. The econometric analysis is based upon the January 2000-December 2017 period for a sample of the initial twelve Eurozone members. Thereby, the paper analyses whether the development in sovereign debt yields should be contributed to worsening fundamentals, the APP, or whether contagion and market sentiment represent a substantial component of the yield rise.

In the past, several studies on the topic of yield determinants are conducted. However, further examination of the topic is required. First of all, previous studies concentrated at segregated factors, such as contagion, ECB policies, and the more traditional macro-economic fundamentals, while this study presents a complete examination of the general yield determinants and their explicit role in the Sovereign Debt Crisis. Moreover, the current study is based on an alternative set of countries and the most recent available data, thereby extending the understanding of yield determinants in the light of an alternative scope.

The answer to the research question is of utmost importance to provide the accurate policy recommendations concerning the correct approach to mitigate the negative consequences of rising sovereign debt yields in the future. Especially, as public debt-to-GDP ratios are still at potentially unsustainable levels, future ECB interventions are expected, and future yield rises are probable (Reuters, 2016).

The paper is structured in the following manner: the theoretical framework is outlined in the second chapter. The second chapter consists of the underlying theoretical model on the pricing of sovereign risk, and the related literature is described. In the third chapter, the applied methodology to determine the primary determinants of the sovereign bond yields is presented. The data of the study is defined in the fourth chapter. Furthermore, the data adjustments, performed tests and preliminary evidence, are outlined. The fifth chapter presents the results based on the methodology of the third chapter, which purpose is to unravel the yield determinants. The final chapter consists of the conclusion, policy recommendations and suggestions for future research.

2. Theoretical Framework

In this chapter, the existing literature reflecting the current stance regarding the determinants of sovereign yields is outlined. First, a theoretical model that states that sovereign yield is a function of credit-risk, liquidity-risk, and risk attitude is described. Secondly, the empirical studies concerned with determining the effect of macro-fundamentals, contagion and ECB policies on sovereign debt yields are discussed.

2.1 Theoretical Model

Theoretical studies and conventional theory state that sovereign debt yields are established from four sources of risk premia, which need to compensate investors for bearing risk relative to the risk-free bond investments. The required compensation is based upon credit-, liquidity, and exchange rate risk, as country-specific risk factors, while an international risk component indicates the level of risk adversity (Gomez-Puig, 2006). As a consequence, the public debt yields are described by the following components and Equation (Beirne & Fratzscher, 2013):

$$r_t = (1 - p) * (1 - \alpha_t) + \gamma_t + \delta_t + \mu_t \quad (2.1)$$

where r_t is the public debt yield,$(1 - p)$ is the chance that a county defaults and $(1 - \alpha_t)$ reflects the expected financial losses conditional on default, thereby capturing the credit-risk premium, while $\gamma_t$indicates the risk adversity, δ_t, the liquidity risk and μ_t reflects the exchange rate risk.

The credit-risk premium is compensation for expected losses which involves the expected financial loss conditional on public default and the probability of default on the sovereign bond. The risk adversity premium is required as investors demand an additional return for bearing uncertainty relating to unexpected financial costs and risk adversity in general. Moreover, the liquidity risk originates from the risk related to the potential problems with the selling the bonds at reasonable prices relative to a safe and fully liquid bond (Deutsche Bundesbank, 2011). The final component of Equation (2.1) consists of the compensation for exchange rate risk, as the foreign investors' pay-off depends on the state of the exchange rate. The latter component is discarded, as the exchange-rate risk is no longer present for the analysed set of EMU members.

2.2 Related Literature

The yield determinants during the Sovereign Debt Crisis

Several studies report the time-varying nature of the international risk factors and the fluctuating desire of risk-taking on the financial markets. The study of Bernoth and Erdogan (2010) reports the presence of risk aversion as a significant yield component in the early years of the EMU, while the influence became insignificant from 2001 to late 2006. On the contrary, during the Great Financial Crisis and the

Sovereign Debt Crisis, investors risk aversion enhanced, which materialized in larger demand for the, relatively safe and liquid, German Bund (De Santis, 2012).

The study of Haugh, Ollivaud, and Turner (2009) provide evidence on the direct and indirect influence of risk-aversion on the sovereign yields. The authors find that the financial markets price the deteriorating fundamentals more substantially during times of substantial risk aversion. Thereby, the sovereign yields surged during the Sovereign Debt Crisis, as risk aversion increased relative to the unusually low level in the years preceding the crisis.

On the contrary, Sgherri and Zoli (2009) ascribe a more modest influence to risk-aversion. The macro-economic fundamentals have become more prominent components in the pricing of sovereign risk, as these reflect default- and credit-risk premiums. The increased sensitivity is the consequence of increased discrimination among Eurozone members by the financial markets. On the contrary, investors demand similar yields for the Greek and German Bund, despite worsening Greek fundamentals (Sgherri & Zoli, 2009);(Gibson, Hall, & Tavlas, 2014).

Manganelli and Wolswijk (2009), who state that besides the strong influence of international risk aversion, the liquidity-risk is substantial as a channel through which risk aversion materialises. As a consequence, the estimate influence of risk-aversion should partly be contributed to the liquidity risk (Manganelli & Wolswijk, 2009). On the contrary, the study of Matei and Cheptea report the insignificant influence of liquidity on the sovereign bond yields during the Sovereign Debt Crisis. As a potential explanation, the authors argue that the European countries were characterised by increasing liquidity in the pre-crisis period. Alternatively, the substantial market integration of the European monetary union resulted in a diminished effect of liquidity on sovereign yields (Matei & Cheptea, 2012).

Bernoth et al., (2012), state that the liquidity risk losses its significance, once the EMU membership is included in the specifications. On the contrary, the study of Gomez-Puig argues that the introduction of the EMU has let to an increase in relative liquidity risk within the EMU. In particular, the country-specific liquidity risk rose relative to the German Bund, as the German public debt market is relatively substantially more liquid than other EMU members (Gomez-Puig, 2006).

The homogenous pricing in the pre-crisis period is often characterised as mispricing of sovereign risk by the financial markets. The financial markets failed to incorporate deteriorating macro-economic fundamentals in the period prior to the crises, which is expressed in increased influence of the country-specific fundamentals on sovereign yields during the post-crisis period (Gibson, Hall, & Tavlas, 2014); (Afonso, Arghyrou, & Kontonikas, 2015); (Schuknecht, Hagen, & Wolswijk, 2010).

In particular, the financial markets price fiscal deficits and increased public debt-to-GDP ratios more intensively relative to the pre-crisis period for the EMU countries (Schuknecht, Hagen, & Wolswijk, 2010). As a consequence, yields rose during the Sovereign Debt Crises as corrections on the mispriced pre-crises period yields occurred.

The study of Aizenman et al., (2013) further indicates that the financial markets demonstrate overshooting characteristics, as the financial markets overpriced risk relative to the country-specific

fundamentals in the post-crisis period. More specifically, investors demanded higher sovereign yields for the PIIGS[2] countries, despite having similar fundamentals as the non-European control sample. The overshooting nature could, however, be explained by the financial markets attaching more weight to the expected deteriorating path of the current fundamentals in the foreseeable future. Alternatively, during times of financial turmoil risk aversion triumphs the influence of the macro-economic fundamentals (Poghosyan, 2012).

The influence of contagion and market sentiment

An alternative explanation of the deviation of the sovereign yields from the macro-economic fundamentals is the presence of contagion effects and negative sentiment on the financial markets. The paper of Gomez-Puig et al., (2014) indicate that the surge in sovereign debt yields is only the modest result of deteriorating fundamentals but more the result of the more prominent influence market sentiment during the Sovereign Debt Crisis. In particular, the more substantial influence of market sentiment is reported in the PIIGS countries. This finding explains the previous finding of homogeneous pricing by Aizenman et al., (2013), while it is also in line with the paper of Favero and Missale (2011). The authors report that the pricing of this market sentiment is only found to be significant for the financially distressed countries, while the sovereign yields of countries with credible macro-economic fundamentals are not directly affected.

The paper of de Grauwe and Ji (2012) states that the fundamentals can only explain the surge in Greek sovereign yield, while the remainder of EMU sovereign yields are not correctly priced based upon the country-specific fundamentals. Consequently, the finding of unaffected United States and United Kingdom sovereign yields, despite similar fundamentals, can be ascribed to negative market sentiments of the financial markets.

The study of Beirne et al., (2013) examines the yield-determinants during the 1999-2011 period for a sample of 31 countries. The reported results confirm the substantial influence of contagion and market sentiment as a component of the sovereign yields. Especially, the sharp rise in fundamental pricing in the post-crisis period accounts for most of the yield surges. The study confirms that this form of contagion is mainly present in the PIIGS countries.

The study of Arezki et al., (2011) substantiates on the presence of contagion by determining the significant spill-over effects of a country-specific credit-rating downgrade on the sovereign yields of an alternative EMU member. The spill-over effects are, in particular, present from the PIIGS countries with weak fiscal fundamentals to the EMU core countries, where the size of the spill-overs are country-specific and depends on the extent of the credit adjustment. According to Equation (2.1), the sovereign

[2] Core: Austria, Belgium, Finland, France, Germany, Luxembourg and the Netherlands. PIIGS: Portugal, Ireland, Italy, Greece and Spain.

yields should not be affected by the downgrade of an alternative country. In particular, as the downgrade does not directly affect the country-specific components (Afonso, Furceri, & Gomes, 2011).

Aristei and Martelli (2014), once more, confirm the influence of contagion on sovereign yields. In particular, the study reports highly significant proxies of market sentiment and expectations of the financial markets by performing a non-stationary regression model for ten EU members for the 2000-2012 period. Especially, once the authors' control for the behavioral variables, the fundamentals reflecting credit- and liquidity risk are of a diminished influence. Moreover, the financial market's expectation and contagion became more prominent yield determinants during the Sovereign Debt Crisis.

Asset Purchase Programmes

The purpose of the APP is to stimulate the facilitation of credit provision to the national economies, enhancement of the monetary policy efficiency and to obtain inflation at the lower bound of 2% (European Central Bank, 2018). The APP of the ECB, regularly described as quantitative easing, consist of the individual purchase programs related to the corporate sector, public sector, asset-back securities and covered bond acquisitions (Cœuré, 2018). In general, the APP provides additional liquidity in the markets and increase bond price through the creation of additional demand, which both result in reduced sovereign yields (Neugebauer, 2018). The APP initiated in early 2015 with monthly acquisitions of public sector bonds, asset-backed securities and covered bonds worth 60 billion. The mere announcement of the purchases of public bonds caused the sovereign yields to be reduced by 50 base points, while the financially distressed countries attained a 100 base points yield reduction (Altavilla, Carboni, & Motto, 2015).

The ECB initiated the SMP to restore the dysfunctional Eurozone debt market by ECB acquisitions of public bonds on the secondary market. Consequently, the SMP directly addressed the dysfunctional markets by confining contagion, as the dysfunctionality of the sovereign debt market is the direct consequence of the latter (González-Páramo, 2011). Thereby, the SMP acquisitions are of particular interest, as the programme is directly related to the governmental bond market and the mitigation of contagion on the secondary bond markets.

The study of Ghysels et al., (2014) indicate that the mere announcement of SMP strongly decreased the sovereign bond yields due to the signalling of the ECB's superior information. More specifically, the SMP announcement resulted in a 400 base points reduction on Greek 10-year sovereign bonds yields, while the bond yield spreads of Italian and Spanish public bonds were reduced by 100 base points. Moreover, the effect on sovereign yields depends on the size and default risk of the bond markets (Eser & Schwaab, 2013). Consequently, the study of Jager and Grigoriadis (2017) only finds a yield reduction for the crisis PIIGS countries, while the implementation of the SMP enhances the bond yields of the Core Eurozone countries. The authors argue that this heterogeneous effect materialises due to the purchase of high-risk bonds of the crisis countries, which results in a deterioration of the ECB's balance

sheet due to an increased amount of inferior outstanding bonds. Consequently, the non-crisis public bond yield rises (Jager & Grigoriadis, 2017).

3. Methodology

The theoretical model of Equation (2.1) classifies sovereign bond yields as a function of risk premia originating from credit-, liquidity risk, and risk aversion. The upcoming chapter presents the econometric framework that estimates the influence of these concepts, by providing a proxy for each risk component. The estimates are conducted with panel data structure with monthly observations and robust standard errors. More specifically, the econometric framework, firstly, consists of a fixed-effect panel data regression analyses. Secondly, the concept of contagion is addressed by multiple analysis that needs to determine the exact influence of contagion on sovereign yields during the Sovereign Debt Crisis. In particular, the fluctuations of the time fixed component, the clustering of the residuals over time, the principal component analysis and by directly controlling for contagion are part of the conducted analysis. The final paragraph describes and substantiates the included yield determinants.

3.1 Identification Strategy

The identification strategy consists of three interrelated regression-equation models, which estimate in what degree, which factors can be labelled as significant yield determinants and, more specifically, are responsible for the substantial increase in sovereign bond yields during the Sovereign Debt Crisis. All models serve the purpose of identifying the specific influence of the traditional macro-fundamental variables, liquidity factor, and contagion on the financial markets, while the models control for the ECB purchase programs.

3.2 Baseline Model

The Baseline Model is firstly estimated to unravel the sign and magnitude of the EMU specific yield determinants. Therefore, the following regression specification is estimated:

$$bond\ yields_{it} = \beta_0 + \beta_1 * F_{it} + \beta_2 * LR_{it} + \beta_3 * ECB_{it} + \gamma_t + \delta_i + \varepsilon_{it} \qquad (3.1)$$

where the subscript *i* indicates the relevant country and *t* the monthly observation. The sovereign bond yields serve as the dependent variable of the equation, which is measured at the 10-year to maturity. The first variables of interest are the macro-economic fundamentals, which are symbolized by the vector of *F*. The vector of variables captures the fiscal, competitiveness and economic fundamentals of the country. These fundamentals reflect the credit-risk and the ability of repayment, which are known to be yield affecting by either theory or empirical studies.

The second component, LR_{it} , symbolizes the liquidity risk, while the ECB variable captures the influence of the public bond acquisition under the APP. The included fixed effects are indicated by γ_t and δ_i, which reflect the country and time fixed effects. Additionally, the β's symbolizes the effect

of the respective variable on the sovereign debt yields, while the final variable reflects the idiosyncratic error term of the equation.

3.3 The Sovereign Debt Crisis Model

The Baseline Model intents to provide evidence on the potential yield determinates. The model does, however, not explicitly focus on the relationship during the Sovereign Debt Crisis and contagion during the economic turmoil. Therefore, the Sovereign Debt Crisis model is estimated. The model which addresses the concept of contagion whether the financial markets price the fundamentals and liquidity heterogeneously during times of crisis. Thereby, contagion is defined as the adjustment in the pricing of sovereign risk between the pre-crisis and post-crisis period (Beirne & Fratzscher, 2013). To this end, Equation (3.2) is estimated:

$$bond\ yields_{it} = \beta_0 + \beta_1 * F_{it} + \beta_2 * LR_{it} + \beta_3 * ECB_{it} + \beta_4 * Interaction\ Terms_{it} + \gamma_t + \delta_i + \varepsilon_{it} \quad (3.2)$$

where the similar interpretation of Equation (3.1) is applicable. The interaction term symbolizes the yield determinant interacted with the Sovereign Debt Crisis dummy, which detects whether determinants are priced differently over time.

3.4 The Contagion Model

The Contagion Model further addresses the presence of contagion by directly incorporating a proxy for market sentiment in the regression specification. The first additional independent variables are the 1st and 2nd principal components of the actual sovereign debt yields. The first component reflects the systematic Eurozone risk, as it symbolizes a proportion of risk common to all EMU members yields. Consequently, contagion is present, if the term is significant, as the actual yields are not solely based on the macro-economic fundamentals (De Grauwe & Ji, 2013). On the contrary, the 2nd principal component is often ascribed to the premium demanded for the Eurozone periphery relative to the Core countries. Thereby, the often heard claim of the financial markets neglecting the worsening financial situation of the PIIGS countries in the years preceding the Sovereign Debt Crisis is examined.

Secondly, the regression specification is augmented by the regional contagion measure, which accounts for yield spill-overs across EMU members (Beirne & Fratzscher, 2013). The finding of a significant influence indicates the incorporation of contagion in the pricing of sovereign yields. Consequently, the following regression Equation is estimated:

$$bond\ yields_{it} = \beta_0 + \beta_1 * F_{\ it} + \beta_2 * LR_{it} + \beta_3 * ECB_{it} + \beta_4 * Interaction\ Terms_{it} + \beta_5 * Contagion + \gamma_t + \delta_i + \varepsilon_{it} \quad (3.3)$$

where the Contagion variable is either reflected by the principal components or by the regional contagion measure. Furthermore, the similar interpretation of Equation (3.2) is applicable.

3.5 Vector of fundamentals and controls

In this sub-section, the included macro-economic fundamentals, and alternative yield determinants are substantiated upon and the expected signs are explained. The specifications are augmented by several macro-economic fundamentals that proxy for the influence of the experienced credit-risk by investors, which thereby potentially affect sovereign debt yields. Secondly, the specifications are augmented by a proxy for liquidity risk, while the SMP is captured by the actual acquisition of the program. The risk-aversion of the financial markets is controlled for by the inclusion of fixed effects, as the commonly used VIX-index is constant across countries.

Expected Positively Influence on Sovereign Debt Yields

- Public Debt and the Fiscal Balance are included to take the influence of debt sustainability into account (Gibson, Hall, & Tavlas, 2014). An increase of Public Debt and the deteriorated Fiscal Balance indicate potential problems of debt repayment and, therefore, a higher risk of default (De Grauwe & Ji, 2013).
- The inclusion of the Real Effective Exchange Rate serves the purpose of controlling for the cost of competitiveness (Bruegel, 2017). An appreciation of a countries currency potentially results in a higher risk premium, as the countries competitiveness is reduced with an expected deterioration of the current account (De Grauwe & Ji, 2013). Moreover, the inclusion of the Real Effective Exchange Rate controls for the exchange rate risk potentially still present for Greece, as post-2000 EMU member.
- Relative Prices and the Current Account Balance reflect the relative competitiveness of the country (Gibson, Hall, & Tavlas, 2015). Higher relative prices indicate a worsening international competitiveness position, while a deteriorated Current Account implies higher imports relative to exports (Uz & Ketenci, 2011). A persistent deficit on the current account could eventually result in increased compensation for the risk of default, either through public default or indirectly through private sector default. Moreover, if the current account deficit originates from excessive public expenditures, the risk of default increases with the enlarged interest payments (De Grauwe & Ji, 2013).

Expected Negative Influence on Sovereign Debt Yields

- Trade openness enhances the country's ability to obtain gains from trade and, thereby, improves the available public funds to finance the sovereign debt (Alexopoulou, Bunda, & Ferrando, 2009).
- The Real GDP growth rate affects the bond yields, as higher growth rates improve the sustainability of debt due to higher expected tax revenues and enhanced ability of tax-collection (Blanchard & Johnson, 2013); (De Grauwe & Ji, 2015).

- The liquidity measure is based on the size of the country-specific size of the public bond market (Aristei & Martelli, 2014). Consequently, the liquidity risk is measured as the ratio of government debt relative to the total debt of the EU17 members[3]. In general, the larger the size of the national bond market, the lower the liquidity risk premium as the sovereign debt is more liquid (Bernoth, von Hagen, & Schuknecht, 2012).
- The ECB Security Market Programme is initiated to obtain a reduction in yields, as the country-specific yields became out of proportion relative to the national fundamentals. The acquisitions in the secondary market theoretically result in a price increase and consequentially drop in yields (Eser & Schwaab, 2014). Although the individual programmes of the APP also acquire non-sovereign bonds, each programme is included to incorporate both the direct effect on the sovereign yields, as the indirect effects, such as the crowding-out effects by reducing sovereign bond demand (Santis, 2016).

4. Data

The research question is studied for a monthly dated panel that consists of twelve initial EMU nations for the January 2000- December 2017 timeframe. The analysed countries and time-period are established on the availability of data, which differ per country and per potential yield determinants. As a result, the observations vary per country and the analysed data differs per specification.

The data section, firstly, outlines the examined EMU country sample, the studied time period and the required regression variables. Moreover, the nature of the data is examined by the discussion of the descriptive statistics, correlation matrix, while the scatterplots provide preliminary evidence on the relation between the sovereign debt yields and the potential yield determinants. Finally, data diagnostics and the required data adjustments are discussed.

4.1 Data sample

The examined country sample consists of the initial twelve EMU members. The EMU members are, firstly, classified as advanced economies(International Monetary Fund, 2017). Consequently, the countries are relatively similar, as advanced economies have comparable political systems, economies and cultural aspects. Thereby, the influence of heterogeneous variables and yield determinants, such as the influence of national institutions, is minimized. Secondly, the EMU members that adopted the euro post-Sovereign Debt Crisis are excluded. These countries pursued alternative monetary policies in a substantial part of the sample, which would result in biased estimates. Therefore, the following set of countries is examined:

[3] Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Luxembourg, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom (Simitis, 2012).

Table 4.1: The Analysed Country Sample

Austria	**Finland**	**Luxembourg**	**Netherlands**
Belgium	**Germany**	**Ireland**	**Portugal**
France	**Greece**	**Italy**	**Spain**

Moreover, alternative sub-samples of Table 4.1 are examined to determine whether the yield determinants differ per set of countries. In particular, the existence of alternative pricing between the Core countries and the PIIGS countries, which are affected the most by the Sovereign Debt Crisis, is of particular interest.

4.2 Time Period

The study is based upon monthly data from January 2000 up to December 2017. Thereby, the analyses are based on the most recent data to capture the latest developments in both the sovereign debt market as in the country-specific fundamentals. Moreover, the observations are defined in monthly frequencies to capture high-frequency fluctuations in the yield determinants and thereby model the determinants in a more accurate manner. Finally, the current values of the macro-fundamental variables are used, as forecasted variables contain substantial measurement error and are potentially endogenous due to the forecasted variables depend on current sovereign bond yields (de Grauwe, Ji, & Macchiarelli, 2017).

4.3 Included variables and data sources

The econometric analyses are based on the variables included in Table 4.2. In this paragraph, the proxy, variable description, data source, the measured frequency of the included variables are discussed.
Primarily, the descriptions and indicated proxies occasionally require further substantiation. First of all, the proxy of the real interest rate is validated by the fact that the 10-year maturity yields function as the Maastricht convergence criteria for achieving harmonised long-term interest rates for all Eurozone countries (Eurostat, 2017). Moreover, the analysis abstains from the inclusion of yield spreads as the dependent variable. In particular, as US benchmark spread results in similar estimations, while the yield spread relative to the German Bund results in the exclusion of German observations. For example, Bernoth et al. (2012) are restrained from concluding on the consequences for Germany, while the Bund has a crucial role in the Sovereign Debt Crisis.

Secondly, the liquidity proxy implies that the more debt a country acquires relative to the total EMU debt, the more liquid the national bond market becomes and the lower required compensation for liquidity risk is expected. The graph in Appendix A indicates the stagnation of increased liquidity in the European bond markets during the Sovereign Debt Crisis.

Thirdly, the actual ECB's SMP acquisitions are obtained from the weekly balance statements. However, as only aggregated purchases and no country-specific acquisitions are provided, it is assumed weekly purchases are in proportion to the total acquired and outstanding amounts published by the ECB (European Central Bank, 2013); (Poorter, Martin, & Pruitt, 2015). The development of SMP

acquisitions, once disaggregated, clearly reflects the initiation of the program on the 10th of May 2010 and the re-launch at the 7th of August 2011(Appendix B).

Fourthly, the total accumulated APP are sub-divided by the ECB's capital key, as country-specific acquisitions are not publicly available (European Central Bank, 2018). The Figure of Appendix C credible reflects the multiple stages of the APP. Firstly, the initial acquisitions of the ECB occur from March 2015 onward, which consists of the monthly public sector and covered bond purchases worth 60 billion. Subsequently, on the 1st of April 2016, the ECB increased to monthly acquisition to 80 billion a month. Moreover, the ECB announced to extend the acquisitions to the Corporate sector bonds. Furthermore, in April 2017, the monthly acquisitions were reduced to 60 billion (PIMCO, 2018).

Lastly, the crisis dummy equals one for dates after the 15th of January 2010, the date in which the Greek government announced that the public deficit and balance had been underestimated and zero otherwise (European Stability Mechanism, 2018); (European Commission, 2010).

The expected signs of Column (4) of Table 4.2 are, in general, based upon the description of the variables in paragraph 3.5. Moreover, the sign on the contagion variables is unspecified as market sentiment could influence the sovereign debt yields both positively and negatively, partly because the effect is time-varying and country-specific.

Table 4.2: The description of the relevant variables

	Variable Name (1)	Abbreviation (2)	Description (3)	Expected sign[1] (4)	Frequency (5)	Source (6)
	Interest rate	ir	rates on 10-year maturity government bonds	NA[2]	Monthly	OECD
	Liquidity Risk	liq	ratio of general government debt relative to the total EMU debt measured in euros	-	Quarterly	Eurostat
Contagion	Regional Contagion	con_regio	the unweighted yield average of the EMU excluding country *i*, the analysed country.	+/-	Monthly	own calculations
ECB Asset Purchase Programs	SMP actual data	smp_actual	actual purchases under SMP measured in billions	-	Weekly	ECB
	Asset Purchase Programs	*APP*	the accumulated total of the asset-backed securities-, covered bond-, public sector- and corporate sector purchase programs	-	Monthly	ECB
Public Finances Fundamentals	Public Debt	debt	the market value of credit to the general government as a percentage of GDP	+	Quarterly	BIS
	Fiscal Balance	fb	total revenue - total expenditure, as a percentage of GDP	-	Quarterly	Eurostat
	Real GDP growth	gdp	growth in quarterly GDP	-	Quarterly	OECD
Competitiveness Fundamentals	Relative Prices	prices	Consumer Price Index consisting of all items 2010 is the base year	+	Monthly	IMF[3]
	Current Account Balance	ca	the difference in value for international transactions as a percentage of GDP	-	Quarterly	OECD
	Trade Openness	open	total exports and imports as percentage of GDP in current US$	-	Monthly	WorldBank
	Real Effective Exchange Rate	reer	the weighted average of exchange rate index	+	Monthly	Worldbank

Notes: (1) expected sign symbolizes the influence of an increase in the independent variable on the dependent variable; (2) not applicable as the dependent variable; (3) The year 2017 is an IMF estimate.

4.3 Descriptive Statistics

Table 4.3 reports the mean, maximum-, minimum value and the number of observations for the included variables during the monthly timeframe of 1990-2017.

Table 4.3: Descriptive Statistics

	Mean (1)	Median (2)	Maximum (3)	Minimum (4)	St.dev (5)	Observations (6)
ir	5.09	4.52	29.24	-0.38	3.04	3805 (227)
smp_actual	0.06	0.00	21.27	0.00	0.73	4032 (0)
APP	6.79	34.628	411.428	0	34.628	4032 (0)
debt	78.28	72.66	177.90	6.28	36.16	2757 (1275)
reer	98.43	99.07	137.37	79.00	6.30	3732 (300)
fb	-2.90	-2.47	11.00	-43.81	4.76	2748 (1284)
prices	88.05	89.26	115.42	26..94	15.74	3936 (96)
ca	-0.64	-0.20	22.01	-32.99	5.94	2856 (1176)
liq	8.30	4.36	32.18	0.00	9.20	2568(1464)
open	17.37	14.07	71.75	3.019	11.68	3240 (792)
gdp	0.52	0.52	21.70	-7.95	1.21	4008 (24)

Notes: (1) rounded to two decimals; (2) based upon the raw data.

The average interest rate of the relevant time period and countries sample equals 5.09%. The maximum value of 29.24 is found for Greece in March 2012, at the peak of the Sovereign Debt Crisis. As indicated by the theoretical framework, this increase in the required interest rate is due to investors demanding higher compensation for risk exposure (Blanchard & Johnson, 2013). The minimum interest rate is found to be -0.38% for Luxembourg in August 2016. The large-scale government-led purchase programs are a potential explanation for this slightly counter-intuitive finding, as bond prices increases and yields decreased due to the inverse relation with the bond prices (Platt, 2017).

In September 2011, the ECB acquired Italian bonds for a value of 21.27 billion euro, which represent the maximum value of purchases under the SMP. As a consequence of that the SMP only concerns Portuguese, Spanish, Italian, Irish and Greek sovereign bonds, the median value is zero, as for the substantial part of the observation no SMP purchases occur. Similarly, the largest acquisitions of 411 million under the APP is related to Germany in late 2017. The highest level of public debt, 177.90% of GDP, is attributed to Greece in April 2014, while the lowest debt ratio, 6.28% of GDP, is found for Luxembourg in February 2004. The lowest Real Effective Exchange Rate is found for Ireland in August 2008 at the 79.00 level, while the highest level, 137.37 is attributed to Finland in January 1991. The presumably striking finding of a fiscal balance deficit of -43.81% is explained by the banking crisis in Ireland that resulted in the government issuing a financial rescue package of 45 billion euros in September 2010 (Reuters, 2011); (BBC, 2010).

The highest found price index, is found for Austria at a 115.42 level in December 2017. On the contrary, the relative prices are the lowest, 26.94, for Greece in January 1990. Additionally, Belgium in April 2008 has the highest trade openness, namely,71.75%. Luxembourg has the lowest trade openness, 3.02%, in the sample for the July 2008 period. The maximum value of the GDP growth is found for Ireland in January 2015, due to the relocation of multinationals and the associated intellectual property (OECD, 2016).

The monthly timeframe of 1990-2017 for twelve countries contains a total of 4032 observations.

The sixth Column of Table 4.3, however, indicates that the amount of observations differs substantially between the yield determinants. As a consequence, the all-encompassing regression specification is based upon the sample of January 2000-December 2017, which results in a common sample of 2214 observations, due to listwise deletion (Eviews, 2017). However, there is no indication of systemic omission of variables, which excludes the potential presence of systematic measurement error.

4.4 Correlation Matrix and Scatterplot

The correlation matrix of the included yield determinants and the sovereign debt interest rate are presented in Table 4.4. The matrix indicates that the interest rate is positively related to the amount of purchases under the SMP and the public debt ratio. On the contrary, the interest rate is negatively correlated with the fiscal balance, relative prices, current account, the relevant trade openness, the GDP, liquidity risk and the real effective exchange rate.

The found correlations are mostly in line with the expected relation based upon Table 4.2. However, the finding of a negative relationship between the relative prices and the interest rate is contradicting, as a deteriorating ability of a country to compete results in increased investors risk. Moreover, the finding of a positive relationship between the interest rate and the SMP purchases is surprising, as the ECB acquires bonds of the financially distressed Eurozone countries, thereby raising the bond prices and consequently reduce the interest rates (Helm, 2012). Furthermore, the matrix of Table 4.4 indicates a negative relationship between the real effective exchange rate and the sovereign debt yields, while it is expected that a higher exchange rate index implies a loss of competitiveness and revenues. Moreover, the correlation coefficients are relatively weak, as none of the correlation coefficients are above 0.50.

Table 4.4: Correlation Matrix

	ir	ecb	debt	reer	fb	prices	ca	open	gdp	liq
ir	1.00	0.16	0.17	-0.01	-0.28	-0.24	-0.25	-0.16	-0.22	-0.10
ecb	0.16	1.00	0.06	0.02	-0.11	0.06	-0.07	-0.03	-0.13	0.02
APP	-0.23	-0.01	0.18	-0.21	0.04	0.22	0.13	-0.03	0.01	0.179
debt	0.17	0.06	1.00	-0.22	-0.39	0.29	0.09	0.21	-0.11	0.33
reer	-0.01	0.02	-0.22	1.00	-0.06	0.29	0.05	0.26	-0.20	-0.01
fb	-0.28	-0.11	-0.39	-0.06	1.00	-0.13	0.21	-0.01	0.18	-0.03
prices	-0.24	0.06	0.29	0.29	-0.13	1.00	0.25	0.33	-0.15	-0.04
ca	-0.25	-0.07	0.09	0.05	0.21	0.25	1.00	0.36	0.08	0.21
open	-0.16	-0.03	0.21	0.26	-0.01	0.33	0.36	1.00	-0.01	-0.16
gdp	-0.22	-0.13	-0.11	-0.20	0.18	-0.15	0.08	-0.01	1.00	-0.07
liq	-0.11	0.018	0.33	-0.01	-0.03	-0.04	0.22	-0.16	-0.07	1.00

Notes: (1) Abbreviations of Table 4.2; (2) rounded to two decimals.

Correlations of the EMU Yields

The correlation matrix of the sovereign bond yields of the EMU countries is presented in Table 4.5. The blue shaded area indicates the post-crisis period, while the orange shaded area indicates the correlations at the height of the Sovereign Debt Crisis. The correlation matrix serves the purpose to determine whether the correlation has increased during the Sovereign Debt Crisis, as an indication of spill-overs between EMU members.

Table 4.5 reports that all EMU yields are positively correlated in the post-crisis period. More noteworthy, is the fact that during the initial years of the Sovereign Debt Crisis, 2010-2012, the Core yields are positively correlated among each other, while the Core counties yields are mostly negative with the PIIGS. On the contrary, the PIIGS are positively associated with the other countries of the PIIGS classification. This implies that an increase in the yield of the distressed countries results in an increase of the other financially distressed countries, while it reduces the yield of the Core countries. The latter can potentially be ascribed to flight to liquidity, as the German Bund yield decreased due to investors seeking safe investments during the Sovereign Debt Crisis. The positive correlation among the periphery, except Ireland, potentially indicates contagion, as an increase in yields of the distressed countries results in higher demanded yields for the remainder of the periphery countries. Consequently, the presented correlations serve as preliminary evidence on the presence of contagion.

Table 4.5: Correlation Matrix EMU Sovereign Bond Yields

	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain
Austria	1.00	0.827	0.942	0.985	0.896	-0.629	0.485	-0.235	0.861	0.931	-0.215	-0.474
Belgium	0.982	1.00	0.686	0.871	0.574	-0.258	0.741	0.270	0.515	0.665	0.280	-0.07
Finland	0.988	0.957	1.00	0.909	0.986	-0.771	0.435	-0.471	0.944	0.992	-0.425	-0.589
France	0.994	0.986	0.981	1.00	0.850	-0.543	0.556	-0.131	0.821	0.905	-0.106	-0.356
Germany	0.977	0.932	0.995	0.966	1.00	-0.801	0.359	-0.571	0.944	0.985	-0.533	-0.619
Greece	0.422	0.519	0.323	0.451	0.276	1.00	0.025	0.721	-0.808	-0.754	0.786	0.807
Ireland	0.901	0.945	0.883	0.910	0.859	0.584	1.00	0.30	0.192	0.436	0.441	0.290
Italy	0.846	0.909	0.783	0.878	0.745	0.714	0.861	1.00	-0.573	-0.472	0.878	0.789
Luxembourg	0.967	0.925	0.981	0.963	0.983	0.273	0.827	0.761	1.00	0.943	-0.574	-0.673
Netherlands	0.987	0.956	0.997	0.983	0.994	0.336	0.881	0.798	0.983	1.00	0.971	0.989
Portugal	0.722	0.817	0.638	0.750	0.585	0.832	0.843	0.923	0.585	0.646	1.00	0.991
Spain	0.846	0.891	0.798	0.876	0.769	0.732	0.871	0.969	0.768	0.816	0.878	1.00

Notes: (1) blue shaded area reports post-crisis correlations; (2) orange shaded area reports the correlation coefficients during the 2010-2012 period.

Scatterplots

The potentially relevant yield determinants are plotted against the sovereign yield spreads to serve as preliminary evidence on the relation between the factors. Figure 4.1 presents the scatterplot regarding the relationship between either the fiscal balance or the GDP growth with the real interest rate for the EMU sample. The left-hand and right-hand side of Figure 4.1 indicates a negative relationship between the public bond yields and, either, the GDP growth and the fiscal balance, which is in line with Equation (2.1) and Table 4.2, as increased economic growth or an improved fiscal balance reduces the credit-risk bared by the bond investors. The remainder of scatterplots regarding the yield determinants mainly confirm the expectations of Table 4.2, as similar patterns and signs are found(Appendix D). However, the yield-relative prices and the influence of SMP is counter-intuitive. The paper of Asmussen (2012) explains the latter, the positive relation, as the loss given default increases by outstanding amounts of

debt. Moreover, based on the theoretical framework it is expected that an increase in the relative price index would result in a higher demanded required interest rate and not the found negative relation.

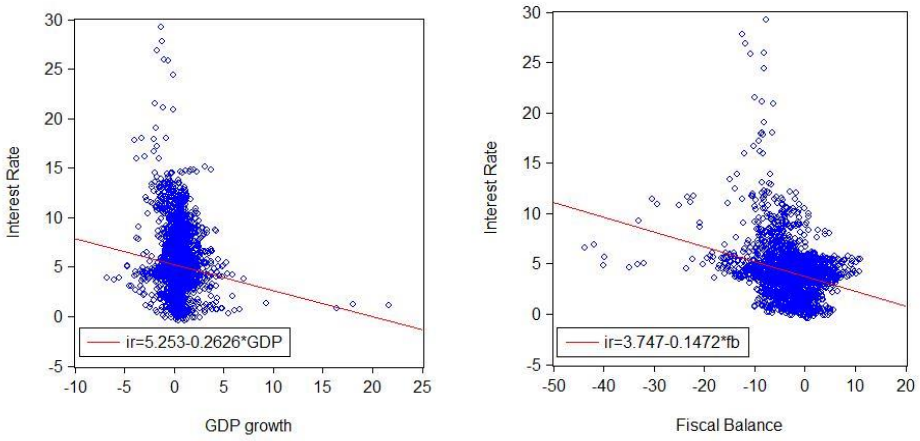

Figure 4.1: Preliminary evidence on the yield determinants by the scatterplots

4.5 Diagnostics Data test and Data Adjustments

4.5.1 Cubic Spline Interpolation

In general, the macro-economic variables are measured and obtainable at a quarterly or annual frequency, while the bond yields and bond purchases under the ECB program are measured on a higher frequency. Therefore, the macro-fundamentals, measured at a quarterly frequency, are interpolated by a cubic spline, while the ECB's weekly purchases are aggregated to obtain the actual purchases under the SMP (Eviews, 2017). Thereby, the econometric panel data model is measured in months, as it will prevent that credible available data is not disregarded in the analyses of yield determinants.

The paper, however, surpasses on interpolating yearly observations to the monthly frequency. This decision is based on the fact that interpolation requires a uniform and continuous change throughout the year to obtain credible monthly estimates (Office for National Statistics, 2014). Invalidating this assumption results in biased variables. As a consequence, Cyprus, Slovak Republic, Slovenia, Estonia, Lithuania, Latvia, and Malta are excluded due to the unavailability of quarterly or monthly data at multiple databases.

4.5.2 Data Diagnostics

Serial Correlation and Heteroscedasticity

The first conducted test studies the existence of serial correlation in the error terms. Beforehand, the presence of autocorrelation is expected as the applied cubic spline interpolation mathematically introduces some degree of autocorrelation between the individual observations and residual terms. Therefore, the Wooldridge test is conducted to validate the presence of serial correlation. The reported

Breusch-Pagan statistic indicates the rejection of the null hypothesis of no serial correlation, which indicates the presence of interrelation of the error terms (Appendix E).

Subsequently, the presence of heteroscedasticity, non-constant variance, in the error terms is examined by the Wald test. The conducted test rejects the null hypothesis of homoscedasticity and thereby indicate the presence of varying variance (Appendix F).

The presence of both violations of the BLUE[4] estimations and the negative consequence of unreliable error term due to the presence of heteroscedasticity and autocorrelation, Consequently, the regression specification are estimated with robust standard errors.

The inclusion of Fixed Effects

The Hausman test is conducted to substantiate augmentation of the regression equations with fixed effects and its preference above the random effects. Appendix G confirms the use of fixed effects, as the null hypotheses of the inclusion of random effects is rejected. Subsequently, the use of fixed effects is further confirmed as significant influence of the time-fixed effects is reported (Appendix H). As a consequence, the regression equations are estimated by a fixed effect model with standard errors that are adjusted for the presence of autocorrelation and heteroscedasticity in the residuals.

Stationarity

Subsequently, the variables are examined on non-stationarity, a common problem in panel data framework. Nonstationary manifests itself by the presence of time-varying mean, variance or a combination, violating the statistical assumptions (Brooks, 2014). Firstly, the Fisher-type and Im-Pesaran-Shin unit root tests are conducted based on the paper of Banerjee et al., (2003); (Marcellino, Banerjee, Osbat, 2003). The test results both indicate the presence of non-stationarity, unit-roots, for sovereign yield, current account and debt (Appendix I). The resultant negative implications of non-stationarity are circumvented, as the Kao test outcomes of Appendix J indicates co-integration between the relevant variables (Purdue & White, 2014).

[4] Best Linear Unbiased Estimator

5. Results

The purpose of the Results chapter is to establish the sovereign debt yield determinants by a panel regression for the initial twelve EMU members for the January 2010-December 2017 period. To this end, the upcoming chapter provides the regression estimates of the identification presented in the Methodology chapter.

5.1 The Baseline Model

The first conducted estimation serves the purpose of determining the influence of macro-economic fundamentals, liquidity and the ECB SMP policy by the OLS estimation method. The regression output of Table 5.1 consists of division of macro-economic fundamentals into the public finances, competitiveness, bond market characteristics and ECB policies.

The regression specifications of Column (1) and (2) report highly significant variables, except the current account and the SMP, with the correct signs according to Table 4.2. Despite, the finding of statistically significant yield determinants, the OLS estimates are discarded, as the estimated coefficients are unreliable and biased. The coefficients are invalid, as robust standard errors are required due to the presence of autocorrelation and heteroscedasticity. Moreover, simple OLS estimation technique incorrectly assumes that the observations are independent. To circumvent the associated statistical problems and to mitigate the omitted variable bias, both forms of fixed effects are included (Bosker, 2017);(Appendix G).

Therefore, the initial emphasis of the study is on the Robust Fixed Effects regression specification reported in Column (4) of Table 5.1. These findings are, however, in strict contradiction with the literature and intuition, as only public debt influences the sovereign debt yields in a statistically significant manner. More specifically, an 1% increase in public debt results in a 0.032 increase in demanded yields on sovereign debt. On the contrary to the OLS specifications, the fixed effects estimates indicate that the time fixed effects do have a significant influence on the yields. The latter implies that time fixed effects itself are a vital yield determinant, as common time events explain a substantial variation of the yields (Appendix K).

The substantial discrepancy between the different estimators is attributed to the inclusion of the fixed effects. In particular, the potential yield determinants of the specifications in Column (3) and (4) are filtered from the potential influence of time and country invariant variables and are therefore solely based upon variation within the countries. On the contrary, these effects are incorrectly attributed to the included yield determinants of the OLS estimators.

Table 5.1: Regression estimations of the Baseline Model.

dependent variable is the 10-year to maturity sovereign bond interest rate level					
	Variables	(1)[1] OLS	(2) OLS-Robust	(3) FE	(4) FE-Robust
	Constant	**3.951 *** (1.241)**	**3.955*** (1.236)**	**-15.881*** (2.039)**	-15.588 (11.242)
Public finances	Public Debt	**0.028 *** (0.002)**	**0.028*** (0.002)**	**0.032*** (0.004)**	**0.032* (0.0157)**
	Fiscal Balance	**-0.061*** (0.011)**	**-0.061*** (0.011)**	-0.015 (0.010)	-0.015 (0.022)
	GDP growth	**-0.357*** (0.036)**	**-0.357*** (0.036)**	**-0.171*** (0.036)**	-0.169 (0.131)
Competitiveness	Relative Prices	**-0.104*** (0.006)**	**-0.104*** (0.006)**	-0.040 (0.042)	-0.040 (0.141)
	Current Account Balance	.0001 (0.008)	0.0001 (0.008)	**0.083*** (0.011)**	0.083 (0.072)
	Trade openness	**-0.043*** (0.004)**	**-0.043*** (0.004)**	0.004 (0.015)	0.004 (0.071)
	REER	**0.095*** (0.013)**	**0.095*** (0.013)**	**0.278*** (0.037)**	0.278 (0.227)
Bond market	Liquidity Risk	**-0.075 *** (0.006)**	**-0.075*** (0.006)**	**-0.326*** (0.032)**	-0.326 (0.203)
ECB policies	ECB	**0.296 *** (0.045)**	**0.296*** (0.045)**	**0.156*** (0.042)**	0.156 (0.095)
	APP	**-0.019*** (0.003)**	**-0.019*** (0.003)**	**0.005* (0.003)**	0.005 (0.005)
Statistics and estimations	Fixed Effects	No	No	Yes	Yes
	Robust Standard Errors	No	Yes	No	Yes
	Adjusted/within R^2	0.338	0.338	0.464	0.464
	Observations	2.214	2.214	2.214	2.214

Notes: (1) standard errors in parentheses; (2) where *,**,*** indicates significance at 10%,5%,1% level;. (3) standard errors are corrected for the presence of serial correlation and heteroskedastic error term; (4) Time and Country fixed effects based upon Hausman test (Appendix L); (5) rounded to three decimals; (6) Estimates obtained from the STATA software.

5.1.1 Predictions of the Sovereign Debt Yields

The minor influence of the macro-economic fundamentals, liquidity and the ECB purchases is confirmed by Figure 5.1, in which it is graphically outlined in what degree the model's predicted values can explain the actual yields.

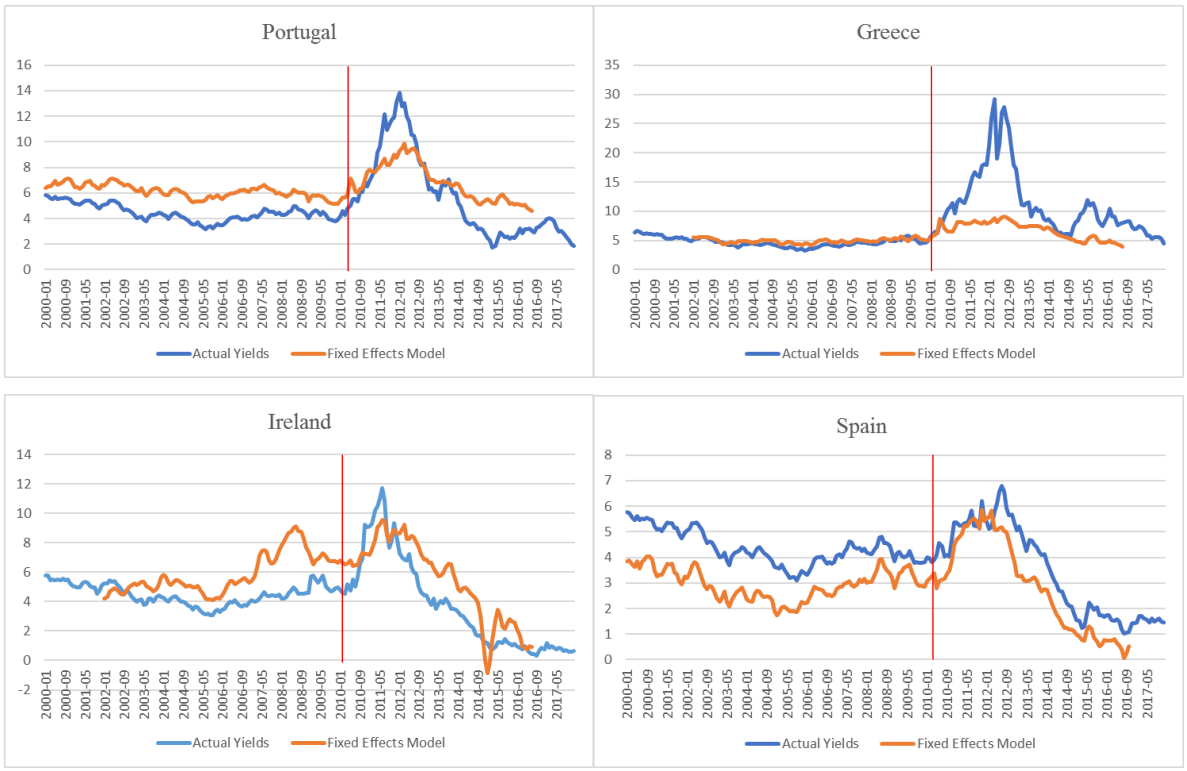

Figure 5.1: The predicted sovereign debt yields relative to the actual yields

Notes: (1) Predicted values of the Baseline Model Column (4) of Table 5.1; (2) Remainder of country-specific fitted values are reported in Appendix M; (3) the vertical red lines indicate the start of the Sovereign Debt Crisis from the 02-2010 period onward.

The discrepancy could, firstly, be attributed to mispricing of the financial markets. The Figure demonstrates that the financial markets under-priced the Portuguese and Irish national fundamentals, as the predicted values lie above the actual yields. The finding of under-pricing indicates the neglecting of worsening fundamentals and the absence of distinguishing between Eurozone members.

Moreover, during the Sovereign Debt Crisis, the actual demanded premium of yields is higher than predicted by the model, which serves either as an indication of the influence of market sentiment, as financial markets over-priced risk, or by the lack of explanatory power of the estimated model.

The Core countries, except France and Germany, demonstrate an alternative development of the discrepancy, as the fair price of sovereign risk should have been at a higher level based on the Baseline Model. A potential explanation is that the financial markets re-allocated their public bond positions to the Core countries public bonds in the form of the flight for safety, which resulted in yield decreases due to the inverse relation with the bond prices (European Commission, 2012).

The discrepancy between the actual sovereign debt yields and the correct yield levels manifests

itself in the residuals of the equations. In particular, the distribution of the residual terms reflects the unexplained proportion of the actual yields. Figure 5.2 demonstrates the heterogeneous effect of the Sovereign Debt Crisis and the fundamentals during the crisis among the EMU members. The Core countries are characterised by negative residuals, especially during the time of the Sovereign Debt Crisis, while the PIIGS are reported to have positive residuals during the height of the crisis. The fact that the actual PIIGS yields are disproportional to the national macro-fundamental variables is often contributed to the negative market sentiment and resulting contagion (Purdue & White, 2014).

Alternatively, the collective drop in Core residuals is potentially caused by market sentiment related the flight to quality and liquidity provided by the Core countries bonds. As a consequence of the enhanced acquisitions, the yields diminished to levels lower than predicted by the country-specific fundamentals. Notably, investors fled to the core countries with low credit-risk and high liquidity, where liquidity seems to dominate the quality of the bonds during times of economic uncertainty (Beber, Brandt, & Kavajecz, 2008). The financial markets, especially, re-allocated their portfolios towards the German Bund, which reached unprecedented lower bounds (Gomez-Puig & Sosvilla-Rivero, 2014).

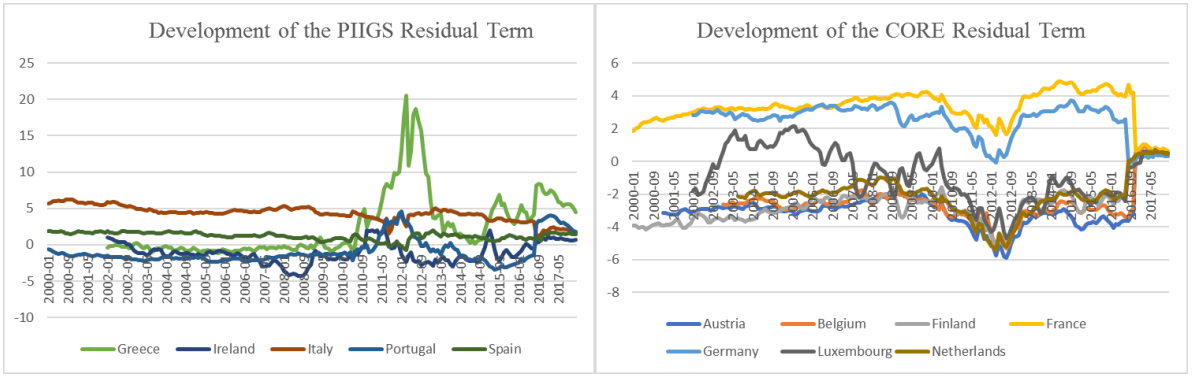

Figure 5.2: Development of the PIIGS and CORE Countries Residual Terms

Notes: (1) Residuals of Column (4) of Table 5.1

5.2 The Sovereign Debt Crisis Model

The previous paragraph indicated the presence of substantial residuals of the Baseline model. Especially, during the Sovereign Debt Crisis. The latter implies the inadequacy of the Baseline Model during times of economic turmoil and the disproportionality of the actual yields relative to the national macro-fundamental variables, which demonstrates the potential influence of contagion as a yield component. Consequently, the specification of the Baseline Model is augmented by interaction terms to determine whether alternative pricing and influence of the fundamentals occur over time.

The influence of the crisis is not studied by introducing a structural break in the form of a pre- and post-crises sample. As this procedure results in a substantial reduction in the amount of observations and variance of the variables, which reduces the likelihood of finding the true significant effects (Aristei & Martelli, 2014). Therefore, the macro-economic fundamentals are interacted with the Sovereign Debt

Crisis dummy variable to determine whether the relation is heterogeneous during times of these financial crises, as expected and implied by Figure 1.1 and the literature.

In addition, Equation (3.2) is estimated for the PIIGS and Core sub-sample of the Eurozone. The distinction between the two-country samples has the purpose of determining whether the financial markets ascribe different weights to specific yield determinants in both sign and magnitude. In particular, further studies are conducted to determine whether the financial markets price the sovereign debt of country-specific Eurozone members equally.

Table 5.2, reports five specifications consisting of both the variables in non-interacted form as in interaction with the Sovereign Debt Crisis dummy. The first three output Columns are based on the general EMU sample, while the (4) and (5) Column are concentrated on the PIIGS- and Core sample.

The Influence of the Sovereign Debt Crisis

Table 5.2 generally reports the finding of insignificant interaction terms, as the interacted term of GDP growth, relative prices, the current account, the real effective exchange rate are insignificant. These estimations imply that the financial markets do not give more weight and do not heterogeneous price these yield determinants during times of Sovereign Debt Crisis.

More noteworthy is the fact that the interaction terms of the public debt and fiscal balance are significant in almost all three specifications, while trade openness and liquidity risk are significant in the most-encompassing specification. Thereby, the estimations indicate the essential influence of credit-risk concerning the public debt and fiscal balance levels. Moreover, it implies that the financial markets incorporate credit-risk more substantially compared to the pre-crisis period. On the contrary, these fundamentals do not affect yields in the un-interacted form. Consequently, the level of the fundamentals, the liquidity of the market and the ECB policies do not significantly affect sovereign bond yields. In particular, it implies that the financial markets neglected differences in country-specific fundamentals in the pre-crisis period, while the financial markets do discriminate based on debt, fiscal balance, trade openness and liquidity during the Sovereign Debt Crisis. The latter, once more, indicates the neglecting of fundamentals in the years preceding the crisis, that have significant influence in and during the Sovereign Debt Crisis.

More specifically, the reported estimated results indicated a positive and significant public debt interaction of public debt, indicating that during the Sovereign Debt Crisis, a country with an 1% higher public debt-to-GDP ratio is confronted with a 0.06 higher required sovereign debt yield. On the contrary, an 1% increase in the surplus on the governmental fiscal balance decreases the sovereign debt yields with 0.134 during the times of economic turmoil. Moreover, the significant trade openness interaction term implies that during times of crisis, an increase in trade openness results in a decrease of the demanded sovereign debt yields. Furthermore, the financial markets significantly price the liquidity of the national bond markets during the Sovereign Debt Crisis. In particular, the estimation reports that an 1% increase in liquidity reduces the yields by 0.146. Thereby, the liquidity is the most dominant factor

in terms of magnitude during the crisis, which is in strict contradicting with the paper of the Deutsche Bundesbank (2011). Consequential, the financial markets demanded lower compensation for borne risk when the degree of market liquidity increases. Finally, Table 5.2 provides evidence of contagion and mispricing as several fundamentals are only priced during the Sovereign Debt Crisis. On the contrary, the similar variables are neglected in the pre-crisis period. Noteworthy is the fact that the fiscal balance dominates the alternative credit-risk determinants. The latter could imply the short-sighted focus of the financial markets, as the public debt represents the accumulation of fiscal balances over time (Constantini, Fragetta, & Melina, 2013).

Heterogeneous pricing among Eurozone Members

Table 5.2 reports that financial markets do distinguish between Eurozone members, as significance levels vary among, both, the un-interacted and interacted variables. First, Column (5) of Appendix N demonstrates that the financial markets significantly price the level of public debt, the current account balance, the country-specific degree of trade openness and liquidity risk measured in levels for the Core countries. On the contrary, the financial markets do not incorporate the levels of country-specific fundamentals into the required PIIGS sovereign debt yields, which serves as evidence of the financial markets disregarding the state of the deteriorating fundamentals of the PIIGS countries(De Grauwe & Ji, 2013). Secondly, Table 5.2 indicates that during the Sovereign Debt Crisis a shift in the incorporate factors by the financial markets occurred for both the Core- as the PIIGS countries. The financial markets price the public debt-to-GDP in both the Core- as PIIGS countries. However, the PIIGS credit-risk coefficient is substantially larger. In particular in Column (4) of Table 5.2, an 1% increase in debt results in 0.06% yield increase for the PIIGS countries, while it results in a 0.01% increase for the Core countries.

Moreover, the financial markets regard the level of the Core countries current account during times of crisis as an important and significant yield determinant. More specifically, an 1% increase in the surplus result in 0.04% yield decrease. On the contrary, the financial markets disregarded the liquidity of the Core countries bond markets, while the liquidity is highly significant during times of the crisis for the PIIGS. Moreover, a one billion increase in country-specific SMP acquisitions result in a 0.19% yield reduction.

Table 5.2: Fixed Effects Regression Estimation Output

	Variables	(1)	(2)	(3)	(4)	(5)
		FE-Robust Eurozone	FE-Robust Eurozone	FE-Robust Eurozone	FE-Robust PIIGS	FE-Robust Core
	Constant	**12.693*** ** (2.062)**	-1.661 (7.832)	-3.125 (5.294)	5.336 (9.629)	**13.10** ** **(3.211)**
Public finances	Public Debt	0.027 (0.018)	**0.033*** **(0. 017)**	-0.052 (0.041)	-0.095 (0.048)	**-0.052** ** **(0.017)**
	Fiscal Balance	**-0.209*** **(0.108)**	**-0.154*** **(0.073)**	0.016 (0.027)	-0.015 (0.047)	-0.028 (0.014)
	GDP growth	-0.086 (0.152)	-0.071 (0.108)	0.026 (0.033)	-0.013 (0.019)	0.057 (0.033)
Competitiveness	Relative Prices	X	-0.048 (0.265)	-0.124 (0.100)	-0.163 (0.252)	0.002 (0.063)
	Current Account Balance	X	**-0.135** ** **(0.061)**	0.061 (0.041)	-0.041 (0.081)	**0.027*** ** **(0.004)**
	Trade openness	X	-0.036 (0.031)	0.021 (0.041)	0.193 (0.136)	**0.026*** **(0.013)**
	REER	X	-0.066 (0.133)	**0.232*** **(0.110)**	0.199 (0.137)	-0.076 (0.059)
Bond Market	Liquidity Risk	X	X	0.044 (0.128)	0.056 (0.204)	**0.321*** **(0.089)**
ECB Policies	ECB Actual	X	X	0.028 (0.084)	**-0.193** ** **(0.06)**	X[1]
	APP	X	X	0.009 (0.005)	0.016 (0.008)	0.002 (0.001)
Public Finances interaction Terms	Debt*SDC	Yes	Yes	**0.062** ** **(0.021)**	**0.065*** **(0.027)**	**0.011*** **(0.004)**
	Fiscal Balance * SDC	Yes	Yes	**-0.129** ** **(0.048)**	-0.058 (0.059)	0.013 (0.017)
	GDP * SDC	Yes	Yes	-0.099 (0.103)	0.067 (0.081)	-0.017 (0.038)
Competitiveness Interaction Term	Relative Prices * SDC	0.539	0.614	0.082 (0.176)	-0.162 (0.474)	-0.064 (0.118)
	Current Account * SDC	2.589	2.322	-0.011 (0.068)	0.124 (0.086)	**-0.043*** ** **(0.008)**
	Trade Openness * SDC	X	X	**-0.0955** ** **(0.032)**	-0.092 (0.063)	-0.001 (0.006)
	REER * SDC	X	X	-0.146 (0.173)	0.159 (0.480)	0.112 (0.075)
	Liquidity Risk * SDC	x	X	**-0.155** ** **(0.059)**	**-0.342*** **(0.135)**	-0.013 (0.008)
Statistics and estimations	FIXED EFFECTS	Yes	Yes	Yes	Yes	Yes
	Robust SE	Yes	Yes	Yes	Yes	Yes
	Adj/within R2	0.539	0.614	0.636	0.775	0.963
	Observations	2.589	2.322	2.214	950	1.264

Notes: (1) standard errors in parentheses; (2) where *,**,*** indicates significance at 10,5,1 level; (3) fixed effects reflect country and time; (4) Robust SE are corrected for the presence of serial correlation and heteroskedastic error terms; (5) ECB omitted as the purchases were restricted to the PIIGS countries.; (6) complete set of estimates in Appendix N; (9) rounded to three decimals

5.3 The Contagion Model

The Baseline Model estimates are characterised by low explanatory power of the actual yields and the finding of insignificant fundamentals considering the full timespan. The Sovereign Debt Crisis Model, however, indicated the significant incorporation of country-specific public debt, fiscal balance, trade openness and the degree of bond market liquidity. Thereby, some form of credit- and liquidity risk materialises in sovereign yields that were not priced beforehand.

The presence of adjustment in pricing between the pre- and post-crisis period and the rise in the unexplained proportion of the yields is evidence of contagion according to Beirne and Fratzscher (2013) and Purdue and White (2014). Despite, the indicated presence of contagion, the exact influence of contagion remains unaddressed. To this end, the upcoming chapter studies the exact influence of contagion on sovereign yields by either data diagnostics or by directly controlling for the presence of contagion.

5.3.1 Data Diagnostics of Contagion

The Time Component of Yields

The influence of contagion as a component of the sovereign debt yields is addressed by graphically exposing the estimated time fixed effects of regression specification of Column (3) of Table 5.2. The time fixed effects capture the concept of contagion, as the effects reflect the exact remainder of the unexplained proportion of the actual yields. Thereby, the contagion is defined as the yield movements unrelated to the traditional macro-economic fundamentals (de Grauwe & Ji, 2015).

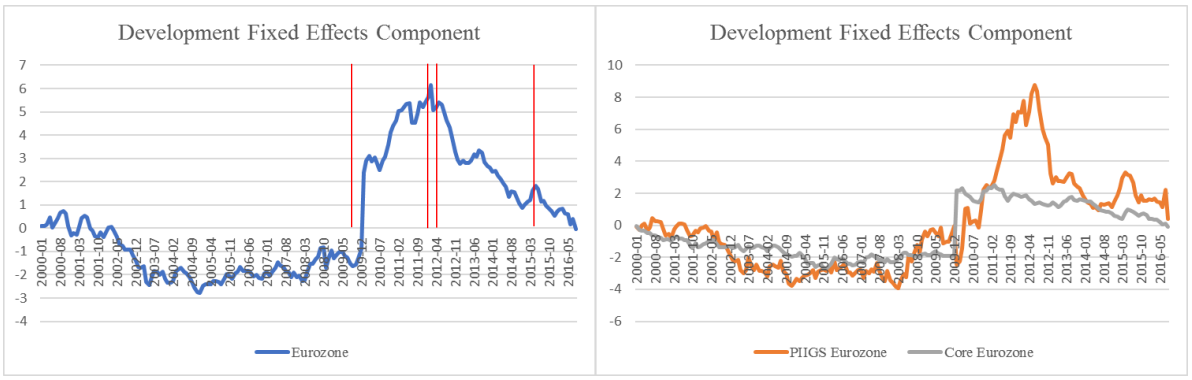

Figure 5.3: Development of Contagion in the Eurozone, Core, and PIIGS.

Notes: (1) the red bars chronological indicate the initiation of the Greek crisis on October 2009, the Greek bond haircuts and second rescue packages on February 2012, the *"whatever it takes"* speech of Draghi and the initiation of the quantitative easing programme on March 2015.

The Figure confirms the significant influence of common trends and events over time, such as market sentiment, as the time fixed effects dummies are found to be significant (Appendix O). Secondly, and more noteworthy, the Figure indicates the time-varying nature and heterogeneous presence of contagion.

The right-hand side Figure demonstrates that contagion is more significantly present in the PIIGS countries, while the surge in the Core countries remains relatively modest.

The pre-Sovereign Debt Crisis period, January 2000-September 2009, is not characterised by any systematic periods of high degrees of contagion. On the contrary, a substantial increase in the influence of the time fixed effects occurs from October 2009 up to July 2012. Thereby, the level of the contagion in Figure 5.3 closely follows the intensity of the Sovereign Debt Crisis. In particular, the level of contagion in Figure surges at October 2009. At this date, the Greek government indicates the need for substantial reforms, as public debt, and deficits are growing out of proportion, simultaneously several credit-rating downgrades occur (Ministry of Finance, 2010).

The peak of the graph is found in February 2012. At this point, market sentiment surges due to concerns regarding the default of Greece and the acceptation of haircuts of more than 50% for Greek bondholders. Moreover, at this point, in time the Eurozone reached consensus to provide the Greek government with a second rescue package of 130 billion to prevent further spread of contagion and Greek default (Spiegel & Barker, 2012); (Budden, 2010)

The decline of contagion as graphically demonstrated in Figure 5.3, occurs from July 2012 onward. The deteriorating influence of market sentiment on the yield spreads is potentially and credibly caused by the *"whatever it takes"* speech held by ECB president Mario Draghi on July the 26th. The content of the speech implicate that the ECB will leave no means will be spared to keep the Eurozone intact (Bloomberg, 2018).

Country-Specific Regression Residuals during the Sovereign Debt Crisis

The substantial surge in the time-fixed effects is a clear indication of the presence of contagion. The diagnostics of the regression residuals further substantiates the presence of contagion. Similar to the study of Beirne et al., (2013), the finding of substantial, positive and clustered residuals for the same time period and multiple EMU members indicates the presence of contagion. As the clustering of correlated residuals implies substantial contagion effects. More specifically, the regression error terms of the examined countries are uncorrelated, if each monthly observation 10% of the error terms of the sample belongs to the 10th percentile of the individual countries residuals.

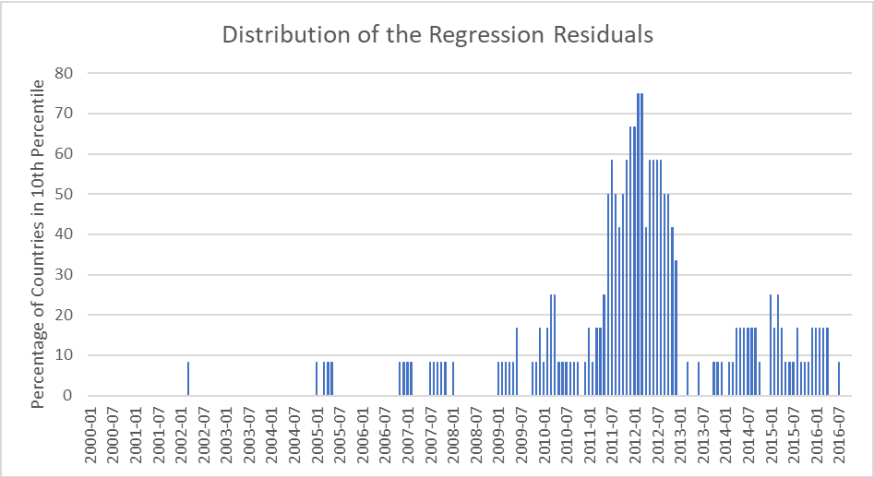

Figure 5.4: Presence of Contagion: the Distribution of the Residuals

Figure 5.4 confirms the finding of substantial contagion during the Sovereign Debt Crisis, as the residuals are indeed clustered during the Sovereign Debt Crisis. The structure of the clustered residuals is similar to the development of the time fixed components of Figure 5.3. As a consequence, the conducted data diagnostics confirm that considerable unexplained proportions of the actual yields are attributed to the occurrence of contagion across Eurozone members during the Sovereign Debt Crisis. In particular, the amount of countries with substantial and positive residuals in the 10^{th} decline increases from one respectively country in late 2010 up to 75%, nine out of twelve countries, in December 2012.

5.3.2 The Direct Influence of Contagion on Sovereign Debt Yields

Figures 5.3 and 5.4 imply that the financial markets expectations about the credit risk of the Eurozone countries is not solely based upon fundamentals but negative sentiments and contagion substantially enhanced the sovereign yields. The preceding conducted analysis does, however, not provide any concrete estimates of the direct effect of contagion, as only the time-varying degree of contagion is demonstrated. Therefore, more accurate estimates are obtained by either directly controlling for the contagion component or by the estimates obtained from the principal component analysis. Consequently, additional regression specifications are estimated to quantify, and determine, the exact impact of contagion on the sovereign debt yields, once controlled for macro-fundamentals, liquidity, and the APP.

Principal Component Analysis

The principal components are acquired from the actual EMU yields and serve the purpose of indicating yield movements common to the twelve EMU members. Thereby, the 1^{st} principal component serves as an indication of the systematic Eurozone risk, such as the general Euro-area risk factor (Cesare, Grande, Manna, & Taboga, 2013); (IMF, 2012). Consequently, the finding of significant influence indicates the pricing of a common euro-area component that is priced besides the

fundamentals. Moreover, it indicates contagion specific to the whole Eurozone as a measure of time-varying risk (IMF, 2012). The second component serves as an indicator of the premium for holding the PIIGS bond relative to the Eurozone Core countries (Afonso, Arghyrou, & Kontonikas, 2015). Thereby, it demonstrates the heterogeneous pricing regarding the different member countries of the EMU. Additionally, the alternative co-movements of the yields and heterogeneous pricing during the sovereign debt crisis indicate contagion effects (Kolstad, 2013). As adjustments in the pricing of sovereign risk occur in the post-crisis relative to the pre-crisis period.

Table 5.3 provides conclusive evidence of a common Eurozone risk factor. The 1st principal component of Column (5) clearly that all countries, except Greece, have comparable 1st components and are thereby equally affected by the systematic Eurozone risk.

The 2nd principal component reported in Column (6), does, however, reflect that the effect of the Sovereign Debt Crisis is heterogeneous and country-specific (Afonso, Arghyrou, & Kontonikas, 2015). Noteworthy is the fact that all the Core countries are negatively associated with the second component, while the PIIGS, are positively associated with the components. These results are in line by the findings of heterogeneous incorporation of yield determinants among the Core and PIIGS countries in Table 5.2, while the factor loadings substantiate the sub-sample distinction into the Core and periphery of the Eurozone (Appendix P).

Table 5.3: The Principal Component Analysis Estimates

Component	Eigenvector	Eigenvalue	Cumulative Proportion	First Principal Component	Second Principal Component
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
1th	Austria	8.6903	0.7242	0.3325	-0.1094
2nd	Belgium	2.6676	0.9465	0.3376	-0.0237
3th	Finland	0.2839	0.9702	0.3275	-0.1521
4th	France	0.1911	0.9861	0.3336	-0.1005
5th	Germany	0.0788	0.9926	0.3231	-0.1780
6th	**Greece**	0.06389	0.9980	-0.0438	0.5752
7th	**Ireland**	0.0148	0.9992	0.2488	0.3375
8th	**Italy**	0.0044	0.9996	0.3069	0.2274
9th	Luxembourg	0.0023	0.9998	0.2905	-0.1446
10th	Netherlands	0.0016	0.9999	0.3283	-0.1477
11th	**Portugal**	0.0008	0.9999	0.1216	0.5581
12th	**Spain**	0.0006	1.0000	0.2958	0.2680

Notes: (1) PIIGS in bold; (2) rounded to four decimal; (3) eigenvalues indicate that retaining the 1st and 2nd component is sufficient (Appendix Q & R) (Cliff, 1988)); (4) the first two components explain 95% of the Eurozone sovereign yield variance; (5) the Kaiser-Meyer-Olkin statistic are above the 0.5 threshold, which implies the correct application of the Principle Component Analyses(Appendix S); (Hadi, Abdullah, & Sentosa, 2016).

The heterogeneous pricing nature of the financial markets between the Core and the PIIGS, reflected by the 2nd component, is clearly demonstrated in Figure 5.5. The heterogeneous pricing occurs in early 2010, confirming the finding of the significant interaction terms of Table 5.2. Moreover, the substantial distinction between the Eurozone Core and PIIGS was not present in the pre-crisis period. In the more recent years, the influence of heterogeneous pricing has diminished, as the contagion potentially has decreased. The common risk-factors of the EMU, as indicated by the first principle component is time-varying. The degree of common EMU risk factor, decreases from the founding of the EMU, while it increases during the times of great financial crisis of 2008 and during the Sovereign Debt Crisis. Thereby, the systematic Eurozone risk surges during the times of economic turmoil.

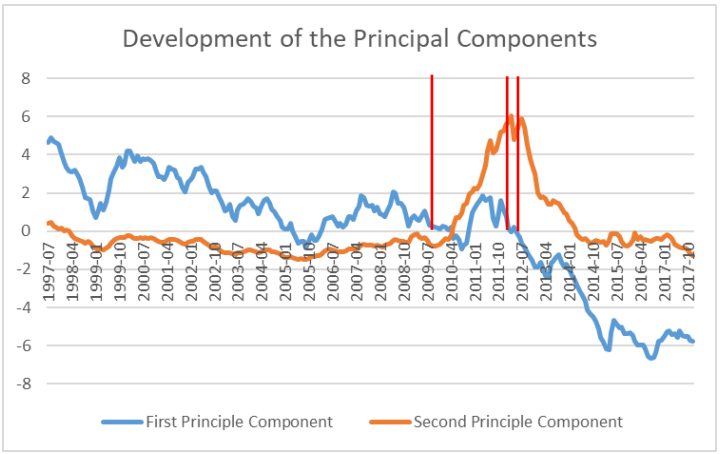

Figure 5.5: Systematic Eurozone risk and Contagion in the form of Heterogeneous Pricing

Notes: (1) the red bars chronological indicate the initiation of the Greek crisis on October 2009, the Greek bond haircuts and second rescue packages on February 2012, the *"whatever it takes"* speech of Draghi and the initiation of the quantitative easing programme on March 2015.

The Contagion Model Analyses

Table 5.4 reports seven regression specifications with either the principal components or the regional contagion measure included to detect the presence and magnitude of contagion. The 1st principal component is significant in all specifications except in Column (6) of Table 5.4. Consequently, the systematic Eurozone risk is significantly priced by the financial markets. Moreover, the 1st component explains 72% of the yield variation that indicates substantial co-movement and commonality in the Eurozone sovereign yields. Furthermore, the influence of systematic Eurozone risk does not alter during the Sovereign Debt Crisis. The reported significant interaction term at the 10% level confirms the modest surge in the systematic Eurozone risk in Figure 5.5

The second variable of interest is the 2nd principal component, which measures the heterogeneous pricing and contagion. The un-interacted second principal component is statistically significant in levels in the specification of Column (3) and (4) of Table 5.4, while the interaction term is significant in all specifications. The latter is expected based upon Figure 5.5, which reports the modest surge during the Sovereign Debt Crisis. Consequential, the PIIGS are priced differently compared to the

pre-crisis period. Thereby, the presence of contagion spill-overs is once more detected, as the sensitivity of pricing adjusts during the crisis.

The seventh Column includes the regional contagion as a direct measure of contagion. The estimation output reports the presence of insignificant contagion spill-overs during the complete sample period. However, during the crisis, contagion is indeed a significant priced yield component. In particular, an 1% increase in contagion results in 1.81% yield increase. Additionally, the regional contagion measure interacts significantly and positively with the PIIGS dummy. Consequently, the contagion spill-overs are a more prominent yield determinant for this alternative set of Eurozone countries(Appendix T). This finding is in line with Table 5.2 and Figure 5.3.

Finally, the public debt, fiscal balance, trade openness and liquidity-risk remain significant with the appropriate sign. The financial markets do not discriminate in the pricing of sovereign risk in the pre-crisis period, despite worsening fundamentals. On the contrary, the significant interaction term demonstrates that the financial markets do discriminate during times of the Sovereign Debt Crisis.

Table 5.4: The Regression Estimations of the influence of Contagion

dependent variable is the 10-year to maturity sovereign bond interest rate level								
	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		1st PC	**1st PC Interacted**	**2nd PC**	**2nd PC Interacted**	**1st and 2nd PC**	**1st and 2nd PC Interacted**	**Regional Contagion**
Contagion	Contagion	X	X	X	X	X	X	-2.986 (2.209)
	Contagion * SDC	X	X	X	X	X	X	**1.814***** **(0.384)**
Principal Components	PC1	**0.7617***** **(0.178)**	**0.553**** **(0.0945)**	X	X	**0.443 ***** **(0.119)**	0.215 (0.199)	X
	PC2	x	X	**0.644**** **(0.243)**	**1.685***** **(0.356)**	0.361 (0.302)	1.131 (0.719)	X
	PC1*SDC	X	0.334 (0.236)	X	X	X	**0.248*** **(0.1222)**	X
	PC2*SDC	X	X	X	**-1.077***** **(0.254)**	X	**-0.079 *** **(0.432)**	X
Public Finances interaction Terms	Debt*SDC	**0.056***** **(0.018)**	**0.062**** **(.0202)**	**0.063**** **(0.022)**	**0.060**** **(0.022)**	**0.061**** **(0.021)**	**0.062***** **(0.022)**	**0.056**** **(0.014)**
	Fiscal Balance * SDC	**-0.108**** **(0.036)**	**-0.106**** **(0.035)**	**-0.113**** **(0.039)**	**-0.123***** **(0.039)**	**-0.108**** **(0.036)**	**-0.116**** **(0.039)**	**-0.118**** **(0.042)**
	GDP * SDC	-0.176 (0.114)	-0.109 (0.094)	-0.014 (0.081)	-0.116 (0.089)	-0.085 (0.088)	-0.109 (0.084)	-0.089 (0.092)
Competitiveness Interaction Terms	Relative Prices * SDC	0.128 (0.097)	0.185 (0.125)	-0.076 (0.061)	-0.024 (0.067)	0.052 (0.042)	**0.107*** **(0.053)**	0.087 (0.164)
	Current Account * SDC	-0.052 (0.057)	-0.042 (0.056)	-0.038 (0.059)	-0.038 (0.067)	-0.035 (0.056)	-0.033 (0.058)	-0.014 (0.043)
	Trade Openness * SDC	**-0.078**** **(0.026)**	**-0.084**** **(0.028)**	**-0.083**** **(0.033)**	**-0.083**** **(0.032)**	**-0.084**** **(0.029)**	**-0.087**** **(0.031)**	**-0.086***** **(0.021)**
	REER * SDC	-0.200 (0.154)	-0.221 (0.165)	0.114 (0.098)	0.042 (0.104)	-0.070 (0.085)	-0.108 (0.087)	-0.055 (0.127)
Bond Market	Liquidity Risk * SDC	**-0.138**** **(0.048)**	**-0.148**** **(0.054)**	**-0.154**** **(0.063)**	**-0.147**** **(0.059)**	**-0.148**** **(0.057)**	**-0.151**** **(0.057)**	**-0.137***** **(0.035)**
Statistics and Estimations	Time Fixed Effects	No	No	No	No	No	No	Yes
	Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	yes
	Robust SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Adj/within R2	0.6001	0.606	0.598	0.610	0.618	0.620	0.669
	Observations	2.214	2.214	2.214	2.214	2.214	2.214	2.214

(1) standard errors in parentheses; (2) where *,**,*** indicates significance at 10,5,1 level; (3) Due to negative factor loadings of second principal component, the component is defined as minus the component; (4) the time-fixed effects are excluded, as the derived components are constant across countries but varying over time (Afonso, Arghyrou, & Kontonikas, 2015); (5) The complete estimation output represented in Appendix T; (6) variables rounded to three decimals.

Predictions of the Contagion Model

The obtained fitted values from the augmented regression equations of Column (6) and Column (7) of Table 5.4 are illustrated in Figure 5.6. The figure demonstrates that the accuracy of the models fitted values comparable to the actual yields increases in most countries. Consequently, the first principal component measure, as systematic Eurozone risk, the second component, as a measure of heterogeneous pricing and contagion and regional contagion improves the quality of the estimates relative to the previous models. Despite an increase in the model's explanatory power, an unexplained proportion remains. Thereby, the Figure either indicates the mispricing of the financial markets or the fact that essential determinants remain to be included. The discrepancy does confirm the current stance in the literature, in which that the surge yield spreads is resultant of deteriorating fundamentals and negative sentiment on the financial markets.

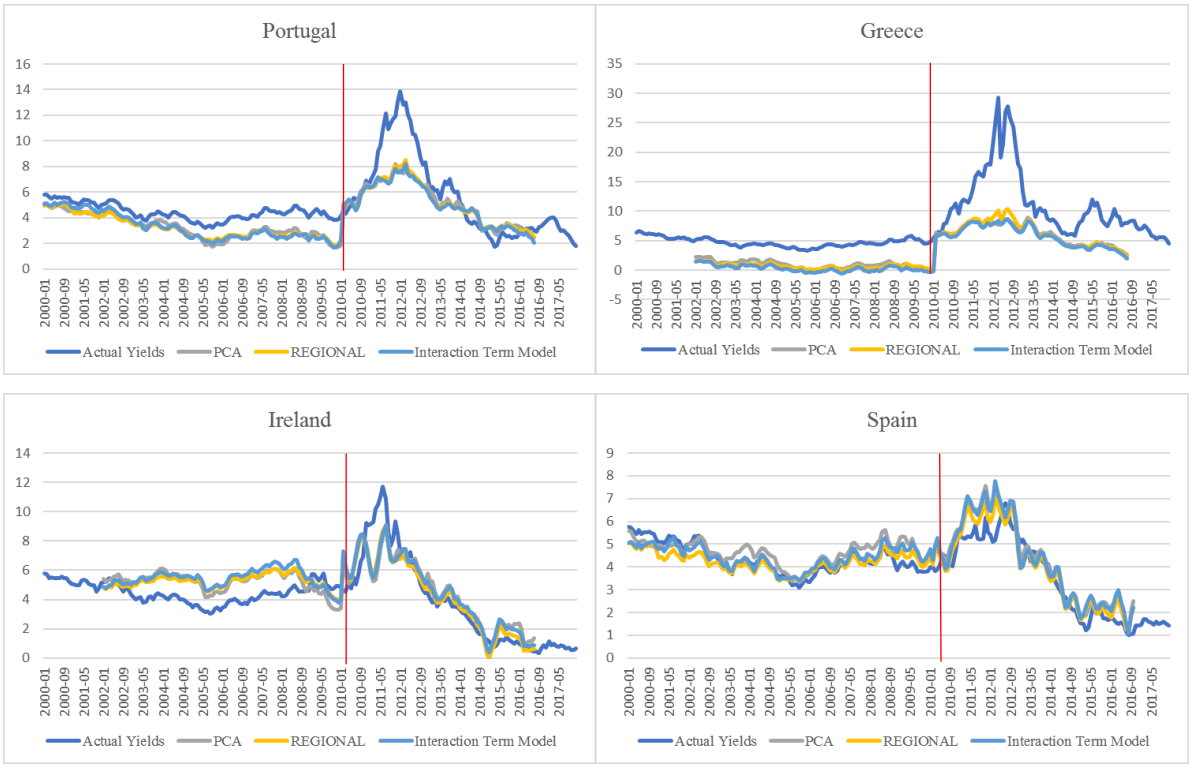

Figure 5.6: The Predicted Yields based upon Table 5.4

Notes: (1) The remainder of country-specific predictions are included in Appendix U; (2) the vertical red lines indicate the start of the SDC from the 02-2010 period onward.

5.4 Granger Causality

The conducted analysis indicates, especially during the crisis, substantial influence of certain yield determinates. However, the presence of bi-directional relationships is expected. For example, an increase in the sovereign bond yield enhances interest rate expenses, which presumably results in deteriorating fiscal balance, which results in higher demanded interest rates, as the credit-risk consequently rises (Baker, Carreras, Kirby, & Meaning, 2016).

The Granger Causality test serves the purpose of determining whether the direction of causality flows from sovereign yields to the determinants or visa-versa. Thereby, the Granger causality test examines the direction of causality. In particular, it tests whether the lagged values of the yield determinants can explain the current value of the yields (Stern, 2011). However, the presence of Granger causality merely indicates the probability of the presence of a causal effect. In particular, it indicates the direction of causality regarding precede, by prediction, of the order of the variables (O'Kane, 2012).

The Granger causality test requires the inclusion of the stationary variables to obtain reliable results (Papana, Kyrtsou, Kugiumtzis, & Diks, 2014). Therefore, the first-difference is taken to obtain stationary yield, debt and current account variables (Appendix V). Moreover, the test is based upon two or three lags to examine the stability of the results and to incorporate more relevant previous values and information (Eviews, 2017).

The outcomes of the Granger Causality test report the presence of bi-directional causality between the macro-economic fundamentals and the sovereign yields(Appendix W). In particular, all fundamentals, except the current account and real effective exchange rate, Granger cause the sovereign yields. On the contrary, the sovereign yield significantly Granger cause all yield determinants, except for the GDP growth. The reported outcomes imply that the macro-economic fundamentals do not only affect the sovereign yields, but the sovereign yields similarly affect the development of the fundamentals simultaneously.

A similar approach is conducted to determine whether specific country-specific yields Granger causes other individual EMU member yields. In particular, as it indicates cross-country spill-overs from specific yields to yield of alternative members. As before, the accuracy of the test is guaranteed by acquiring stationarity of the yields (Appendix X)

The results indicate that fifteen of the twenty-one Granger causal relationships belong to a particular PIIGS country(Appendix Y). Significant spill-over effects occur for five PIIGS countries pair, where most spill-overs originate from Ireland. In addition, seven Granger causal relationships belong to PIIGS countries Granger causing Core yields. The latter plausibly implies contagion of EMU members, despite solid fundamentals. The latter is in strict contradiction with the confinement of contagion to the distressed countries by Gomez-Puig et alk., (2014)

The finding of significant Granger causality from the PIIGS to Core are preliminary evidence of the presence of contagion and spill-overs of country-specific sovereign yields, which strengthens the determined contagion in earlier analyses (Giordano & Gentile, 2012).

5.6 Robustness Checks

The robustness checks are conducted to determine whether the found mispricing and increased sensitivity to credit- and liquidity-risk are robust to alternative regression specifications. The conducted robustness checks are either related to alternative model specifications or the inclusion of additional control variables. The purpose is, first, to determine whether previous interpretations remain valid. Secondly, the obtained coefficients of the alternative control variables facilitate the further understanding of the potential yield determinants.

Great Financial Crisis Dummy

The estimation results of the second Column of Table 5.5 indicate the presence of the heterogeneous pricing of Table 5.2 is robust to the estimation with the use of the Great Financial Crisis dummy. The specification remains to be characterised by significant interaction terms of debt, fiscal balance, trade openness and liquidity. Moreover, it indicates that the financial markets partially started to alter the fundamental pricing in the pre-Sovereign Debt Crisis.

Yield determinants measured in changes

The specification of Column (3) of Table 5.5 is estimated based on the independent variables measured in the change relative to the previous monthly observation. The estimation results are mainly similar, as the interaction terms of debt and liquidity remain comparable in the found significance levels. However, the magnitude of both interaction terms increases substantially, while the fiscal balance and trade openness interaction terms become insignificant. The latter can be attributed to the fact that the interpretation is different, as the independent variables are currently measured in changes.

Estimations Quarterly Data

The estimation results of the regression specifications are based on the January 2000-December 2017 monthly time period. However, the Data section reported that for some variables the monthly observations are obtained by the application of cubic spline interpolation. The fourth Column of Table 5.5, however, indicates that the applied data frequency does not alter the previously obtained results, as similar magnitudes and significance levels are reported.

Non-Linearity

This alternative specification is based on the knowledge that the financial markets acknowledge that the risk of default and credit risk is discontinuous. More specifically, bond investors could demand higher returns when the national fundamentals have moved beyond a certain threshold (Deutsche Bundesbank, 2011). Therefore, as the national debt burden increases, the national governments have an even higher probability of default (de Grauwe & Ji, 2015). Column (5) of Table 5.5, however, indicates that the second-degree debt polynomial is insignificant in both the level as interacted form.

Consequently, the reported finding of higher demanded compensation for the PIIGS in Table 5.2 is not attributed to the non-linear pricing of the debt levels beyond a certain threshold.

Banking Sector

The specification of Column (6) of Table 5.5 is augmented by the banking sector as an alternative driver of sovereign debt yields. The influence and sign of the size of the banking sector are potentially time-varying, as the financial sector contributes to the economic growth of a country by facilitating credit, financial structure, and public revenues, while crisis countries restructured the financial market with substantial sums of government finances (Deutsche Bundesbank, 2011). The yield-determinants of Table 5.2 and 5.3 persist to significantly affect the sovereign debt yields in the alternative specification of Column (6) of Table 5.2. Moreover, it is found that the size of the banking sector enhances the sovereign yields during the Sovereign Debt Crisis, while the influence of the banking sector is absent in the pre-crisis period. The latter can be attributed to an increase in global risk during times of financial crisis, as the banking sector is plausible dependant on public finances (Deutsche Bundesbank, 2011).

Financial and Political Stability

The recent political unrest in the Italian political landscape, with sovereign yields rises from 1.8% to 3.4% in the wake of it, indicates the relevance of including the economic-policy uncertainty measure in Column (7) (henceforth: EPU); (Braaksma & Groot, 2018). Noteworthy is the fact that the fiscal balance and debt interaction terms become insignificant, while the previous significant interaction term of liquidity and trade openness remains of influence. On the contrary, the public debt levels become significant, once the EPU measure is included.

Several explanations for this phenomenon arise. First of all, it is possible that the EPU measure reflects and captures the influence of contagion (European Commission, 2012). Consequently, the previously estimated coefficients are adjusted for further influence of market sentiment. The latter is in line with the finding of decreased fundamental influence once controlled for contagion (Aristei & Martelli, 2014). Secondly, it is plausible that the inclusion mitigates the omitted variable bias. Therefore, the EPU inclusion results in adjusted coefficients of the remaining determinants. Thirdly, the number of observations of the regression decreases significantly, excluding valuable observations of the fiscal balance and public debt. More specifically, 941 observations are excluded from the estimations, which reduces variation and the probability of finding significant effects. Thereby, the estimations of Table 5.2 and Table 5.3 are more reliable and accurate. Similar to the ECB study (2012), the inclusion of the political uncertainty measure results in a moderately, but country-specific, decrease in the discrepancy between the actual and estimated yields (Appendix Z).

Fundamental Index

An index of the fundamental variables is created to determine whether the inclusion of the index results in similar and robust estimation output. The advantage of the index approach is to capture the all-encompassing effect of the fundamentals, while controlling for ECB policies and liquidity of the market. The index is created with the use of principal component analyses, which constructs the index weights based upon the variables eigenvalues(Appendix AA). The regression output indicates that the index of macro-economic fundamentals has a significant influence on the required yield during the Sovereign Debt Crisis, while the index measured in levels is insignificant. Thereby, confirming the homogenous pricing in the pre-crisis period and the discriminative pricing in the post-crisis period. Moreover, Appendix AB indicates that the regional contagion interaction terms are significant in all specification. As the magnitude is positive, an increase in contagion results in higher demanded yields. In particular, an increase by one result in a 5.344% yield decrease, which is in line with the expected sigs of the macro-economic fundamentals. The intuitively large coefficient is explained by the confined range of the index, which fluctuations between -3.274, and 1.648.

Endogeneity

The Two-Stage-Least-Squares estimation technique subsequently analyzes the robustness and causality of the estimated yield-determinants (henceforth: 2SLS). The 2SLS technique corrects for the presence of endogeneity, which manifests itself in inaccurate estimates due to the existence of a correlation between the residual term with the yield determinants.

The existence of endogeneity either occurs due to the omitted variable bias, systematic measurement error or by reverse causality. The Granger Causality tests previously indicated the bi-directional relationships between the sovereign yields and the potential yield determinants. Moreover, the presence of vicious cycles in which a higher required sovereign yields deteriorates the public finances and consequently increases credit risk, which causes the sovereign yield to increase further (De Grauwe & Ji, 2013). Therefore, the macro-economic variables are treated as endogenous variables and are, consequently, instrumented by the first three lagged observations (Afonso, Arghyrou, & Kontonikas, 2015). The validity of the instruments originates from the fact that the sovereign yields may influence the contemporary macro-economic fundamentals but relatively improbable that the current sovereign yields shocks influence the lagged fundamentals (University of London, 2016).

The ninth Column of Table 5.5 reports the similarity of magnitude and significance for the yield determinants between both the Fixed Effects estimation and the 2SLS technique. The yield determinants do not significantly influence the sovereign yields in the pre-crisis period, as reflected by the insignificant level determinants. Moreover, the debt, fiscal balance, trade openness and liquidity interaction terms indicate the significant influence of the determinants during times of the Sovereign Debt Crisis. However, the current account is significant in the 2SLS specification, while the influence of contagion is not restricted to the Sovereign Debt Crisis period.

The 2SLS estimates report the causal effect of the yield determinants, as the instruments are correlated with the potentially endogenous macro-fundamentals but unrelated to the residual term. Thereby, the exogeneity of the macro-fundamentals is guaranteed. Moreover, the high degree of similarity reported by the robustness checks implies that the original specification estimates should be considered as causal and unbiased, as no significant adjustment in coefficients is reported.

The robust findings presumably imply the exogeneity of the macro-fundamentals, which is in line with existing literature. The presence of endogeneity is mostly circumvented by the fact that the simultaneous effects of the increased sovereign yields do not directly affect the fundamentals on a monthly basis, as it takes time for the effect to occur (Beirne & Fratzscher, 2013). Moreover, the presence of biased estimates does not manifest due to the inclusion of the 10-year maturity yields. The latter circumvents the simultaneous bias, as the bonds do not mature on the short-term (Giordano, Linciano, & Soccorso, 2012).

Table 5.5 Robustness Checks

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Original Specification[1]	GFC[11]	Changes	Quarterly	Non-Linearity	Banking Sector[9]	Political Uncertainty [10]	Index	2SLS
Public finances	Public Debt	-0.052 (0.041)	-0.043 (0.035)	-0.028 (0.022)	-0.038 (0.038)	0.004 (0.045)	-0.059 (0.041)	**-0.081* (0.036)**	X	-0.0548 (0.039)
	Public Debt^2	X	X	X	X	-0.0003 (0.0002)	X	X	X	X
	Banking sector	X	X	X	X	X	0.004 (0.008)	X	X	X
	EPU	X	X	X	X	X	X	0.0003 (0.001)	X	X
	INDEX	X	X	X	X	X	X	X	3.076 (2.065)	X
	Banking Sector * SDC	X	X	X	X	X	**0.019* (0.01)**	x	X	X
	EPU * SDC	X	X	X	X	X	X	0.007 (0.007)	X	X
	INDEX * SDC	X	X	X	X	X	X	x	**-5.334** (2.367)**	**X**
Public Financ	Debt^2*SDC	X	X	X	X	-0.0004 (0.0003)	X	X	X	X

	Debt*SDC	**0.062** **(0.021)**	**0.059**** **(0.019)**	**0.830**** **(0.313)**	0.018 (0.018)	**0.147 **** **(0.061)**	**0.062**** **(0.02)**	0.060 (0.032)	X	**0.069***** **(0.023)**
	Fiscal Balance * SDC	**-0.129**** **(0.048)**	**-0.114**** **(0.041)**	0.0001 (0.0001)	**-0.134***** **(0.036)**	**-0.097**** **(0.036)**	**-0.096*** **(0.049)**	0.0005 (0.025)	X	**-0.114***** **(0.039)**
	GDP * SDC	-0.110 (0.103)	-0.068 (0.113)	-0.00003 (0.00002)	-0.052 (0.089)	-0.132 (0.101)	-0.065 (0.081)	0.052 (0.147)	X	-0.087 (0.101)
Competitiveness Interaction Terms	Relative Prices * SDC	0.082 (0.176)	-0.003 (0.146)	**0.154**** **(0.081)**	-0.127 (0.196)	-0.154 (0.304)	0.127 (0.184)	-0.054 (0.243)	X	-0.007 (0.078)
	Current Account * SDC	-0.011 (0.068)	0.042 (0.061)	-1.86e-06 (0.0001)	**-0.215*** **(0.081)**	-0.026 (0.063)	-0.037 (0.062)	0.081 (0.129)	X	-0.026 (0.051)
	Trade Openness * SDC	**-0.096**** **(0.032)**	**-0.087**** **(0.032)**	0.004 (0.01)	**-0.053**** **(0.018)**	**-0.123**** **(0.044)**	**-0.0743*** **(0.036)**	**-0.264*** **(0.111)**	X	**-0.092***** **(0.033)**
	REER * SDC	-0.146 (0.173)	0.069 (0.179)	-0.163 (0.345)	-0.124 (0.230)	-0.087 (0.263)	-0.197 (0.165)	0.749 (0.487)	X	0.018 (0.102)
	Liquidity Risk * SDC	**-0.155**** **(0.059)**	**-0.151**** **(0.06)**	**-0.505*** **(0.258)**	-0.111 (0.041)	**-0.187**** **(0.074)**	**-0.141**** **(0.061)**	**-0.397**** **(0.109)**	-0.078 (0.047)	**-0.168***** **(0.059)**
Statistics and Estimations	Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Robust SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Adj/within R^2	0.636	0.587	0.471	0.653	0.663	0.645	0.738	0.389	0.558
	Observations	2.214	2.214	2.191	694	2.214	2.202	1.273	2.214	2.194

Notes: (1) Original Specification based upon Column (3) of Table 5.2; (2) Standard error in parentheses; (3) where *,**,*** indicates significance at 10,5,1 level; (4) fixed effects reflects country and time; (5) Robust SE are corrected for the presence of serial correlation and heteroskedastic error terms; (6) ECB omitted as the purchases were restricted to the PIIGS countries. (7) Non-applicable, as observations of actual SMP and APP purchases are limited. Therefore, it is unable to derive the change, as most observations are zero; (8) Complete results Table in Appendix AC; (9) banking sector measured as the domestic credit facilitated to the private sector as percentage of GDP, which is common in the literature and obtained from the Bank of International Settlements (WorldBank, 2006); (10) The political stability is measured by the Economic Policy Uncertainty measure created by Baker, Bloom and Davis (2012); (11) The interaction terms are composed of the Great Financial Crisis dummy instead of the noted Sovereign Debt Crisis, which equals one for September 2008 onward; (12) Appendix AD demonstrates the accuracy of the EPU measure.

6. Conclusion

The Sovereign Debt Crisis had adverse effects on the public finances, while sovereign yields rose in the wake of the crisis. The sovereign yields further constrained public finances by higher interest payments and borrowing costs. Consequently, the potential factors that resulted in the rise of the yields became severely debated in both politics as in academics. In particular, the influence of deteriorating country-specific fundamentals and cross-country contagion spill-overs is of dispute. Despite the presence of substantial related literature, the existing studies provide ample evidence based upon an all-encompassing framework including macro-economic fundamentals, liquidity, contagion and the unconventional policies implemented by the ECB.

The conducted study has examined the influence of macro-economic fundamentals, liquidity, SMP policies and contagion on the initial twelve Eurozone sovereign yields during the January 2000-December 2017 period. The purpose of the study is to determine the exact influence of each component and to what degree these factors could explain the substantial surge in Eurozone sovereign yields during the Sovereign Debt Crisis.

The estimated panel data fixed effect regression specifications indicates the neglecting of the macro-fundamentals in the period before the Sovereign Debt Crisis, while the financial markets price the worsening public debt ratio, fiscal balance, trade openness and market liquidity in terms of enhanced sovereign yields. Consequential, credit-risk and liquidity-risk are important components of sovereign yields during the Sovereign Debt Crisis. Nevertheless, the graphically demonstrated predicted sovereign yields indicate the lack of explanatory power of the macro-economic fundamentals in explaining the surge of sovereign yields.

Secondly, the estimated econometric model indicates that the financial markets homogenously price the individuals Eurozone members prior to the crisis. On the contrary, the financial markets attach more weight to the deteriorating fundamentals of the PIIGS countries relative to the Core countries in terms of public debt and liquidity-risk. Moreover, the regression specification that the SMP achieves its purpose, as the sovereign bond acquisitions reduce sovereign yields.

Thirdly, a comprehensive framework of data diagnostics and augmented regression specification addressed and quantified contagion. The time-fixed effects, as the unexplained proportion of the actual yields, indicate the time-varying nature and surge of contagion during times of the Sovereign Debt Crisis. In particular, much of the market sentiment occurs on the sovereign debt markets of the PIIGS countries. The augmentation of the regression by the 2nd principal component and regional contagion as a direct measure of contagion indicates the presence of a significant time-varying premium for holding the PIIGS bond relative to the Eurozone Core countries. Moreover, the regression output reports the significant and yield enhancing nature of regional contagion spill-overs, while the significant influence is, once more, restricted to the period of the Sovereign Debt Crisis. The presence of contagion manifests itself in particular for the PIIGS countries in terms of magnitude and significance.

Consequently, a substantial part of the rise of the sovereign yields is attributed to contagion, while a modest influence of deteriorating fundamentals is uncovered. Besides the reported significant contagion variables, the explanatory power of the contagion manifests itself by more accurate modeling of the actual yields.

The reported influences of credit-risk in terms of priced public debt and fiscal balances, liquidity risk and regional contagion during the height of the Sovereign Debt Crisis are robust to alternative regression specifications, quarterly observations, alternative controls and the corrections for endogeneity by the 2SLS estimation technique.

Policy recommendations

The findings of the paper imply that the policymakers should address the worsening fiscal balance and public debt, as measures of credit-risk to cease the yield surges during the times of economic uncertainty. In particular, budgetary discipline is required for the PIIGS to prevent discriminatory pricing by the financial markets in the future and to remain able to issue sovereign debt at sustainable yields. Thereby, stricter compliance with the Maastricht criteria of budget consolidation and the debt ceiling is a credible solution. However, national governments and supranational institutions cannot prevent the surge of sovereign yields by merely improving the country-specific fundamentals. The European Monetary Union should prevent the spread of contagion and cross-country spill-overs in the future crises, as the current study reported the substantial influence of contagion and market sentiments as a yield component. Moreover, the paper indicates the incomplete financial integration of the European bond markets. The incompleteness manifests itself by the enduring existence of substantial differences between national sovereign bonds regarding credit-risk and liquidity-risk.

Future research

Despite, the robust and significant presence of heterogeneous pricing across Eurozone members and during the Sovereign Debt Crisis, a proportion of the actual yields remains unexplained. The primary challenge of future research is, therefore, to capture the concept of contagion more accurately. An interesting subject for future work is the extension on the conducted Granger Causality test, as a potential measure of contagion. The Granger Causality reported that developments in the PIIGS country mostly preceded the related yield change in the remaining Eurozone countries. In particular, the heterogeneity over time and the bi-directional influence of the sovereign yields are left unaddressed. Moreover, the EPU serves the purpose of controlling and addressing the influence of political uncertainty. However, the EPU measure is used in the European Commission (2012) paper as an alternative measure of contagion. In particular, the fact that debt and fiscal balance interaction terms become insignificant once controlled for the EPU provides opportunities for future work. More specifically, the results question whether the contagion itself partly causes the significant influence of credit-risk during the Sovereign Debt Crisis.

The conducted corrections for the presence of endogeneity has several interesting implications for future work. The estimation results of the 2SLS specification report that the influence of contagion is not restricted to the Sovereign Debt Crisis period. Thereby, the concept of contagion and its presence during the Sovereign Debt Crisis remains an exciting avenue for follow-up research. Moreover, the Principal Component Analysis is plausibly characterised by the simultaneous bias, as the components are composed of the actual yields and, therefore, directly related to movements in the sovereign yields (Giordano, Linciano, & Soccorso, The determinants of government yield spreads in the euro area, 2012).In particular, it is worth investigating whether similar results are obtained when the Generalised Method of Moment is applied, as the method is more efficient than the instrumental variable technique in case of the presence of heteroscedasticity (Baum, Schaffer, & Stillman, 2002).

Subsequently, the insignificant influence of the APP and the SMP is potentially attributed to the fact that the public announcements of the initiation of the programs occurred before they actual acquisitions. As a consequence, future studies should implement an identification strategy reflecting both purchase- and announcement effects. In addition, the financial markets plausible demanded higher sovereign yields when worsening of the public finances are expected to persevere in the future. Therefore, it will be interesting to study the importance of the expected fundamentals values on sovereign yields in future research. In particular, it is interesting how to credibly circumvent the potential endogeneity problems of the inclusion of the expectations, as these are partly formed on the current sovereign yields.

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8. Appendix

Appendix A

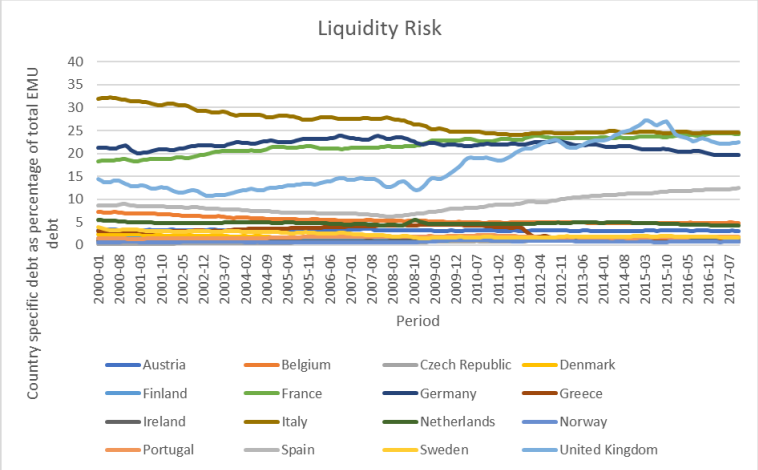


Figure Appendix A: The development of liquidity risk in the Eurozone

Notes: Estimated from 01-2000 due to the requirement of absolute debt to be measured in euro's, as liquidity is measured relative to the total EMU debt.

Appendix B

Table Appendix B: The proportion of the acquired bonds under SMP

Country	Nominal value[5]	Book value	Average years	1st phase	2nd phase
Ireland	14.2	13.6	4.6	14,2/70,9 = 20,03%	14,2/218= 6.514%
Greece	33.9	30.8	3.6	33,9/ 70,9= 47,81%	33,9/218= 15.55%
Spain	44.3	43.7	4.1	NA	44,3/218= 20.32%
Italy	102.8	99.0	4.5	NA	102,8/218= 47.16%
Portugal	22.8	21.6	3.9	22,8/ 70,9= 32%	22,8/218= 10.46%
Total	218	208.7	4.3	70.9 (14.2+33.9+22.8)	218

[5] The nominal and book value are measured in outstanding amount.

Appendix B Continuation

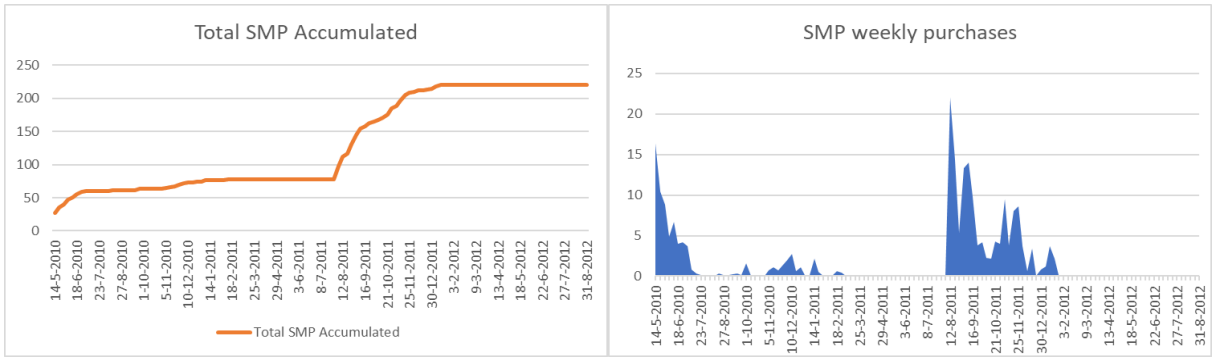


Figure Appendix B: The Accumulated SMP acquisitions and the weekly purchases.

Appendix C

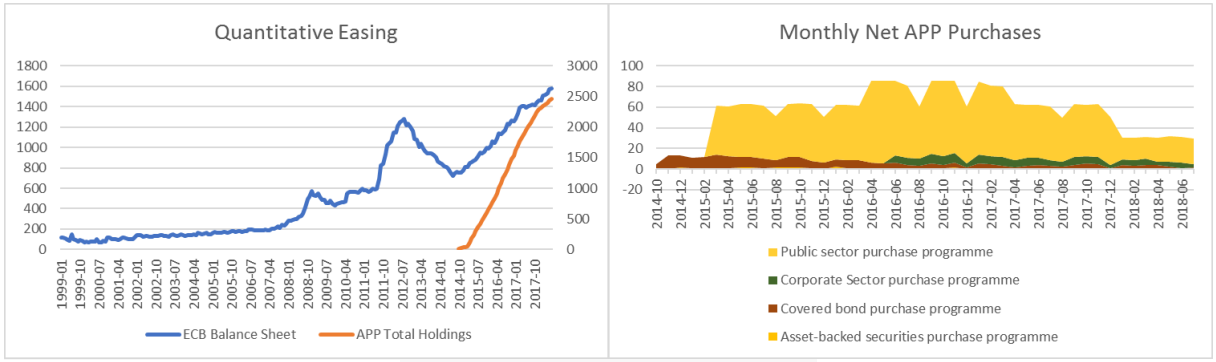


Figure Appendix C: Quantitative Easing

Notes: (1) ECB Balance sheet obtained from ECB's statistical warehouse; (2) The ECB balance reflects the total assets as indication of the intensities of the quantitative easing programmes (3) minor quarter-end amortisation adjustment discarded (4) left-hand side measured in millions, right-hand side in billions.

Appendix D

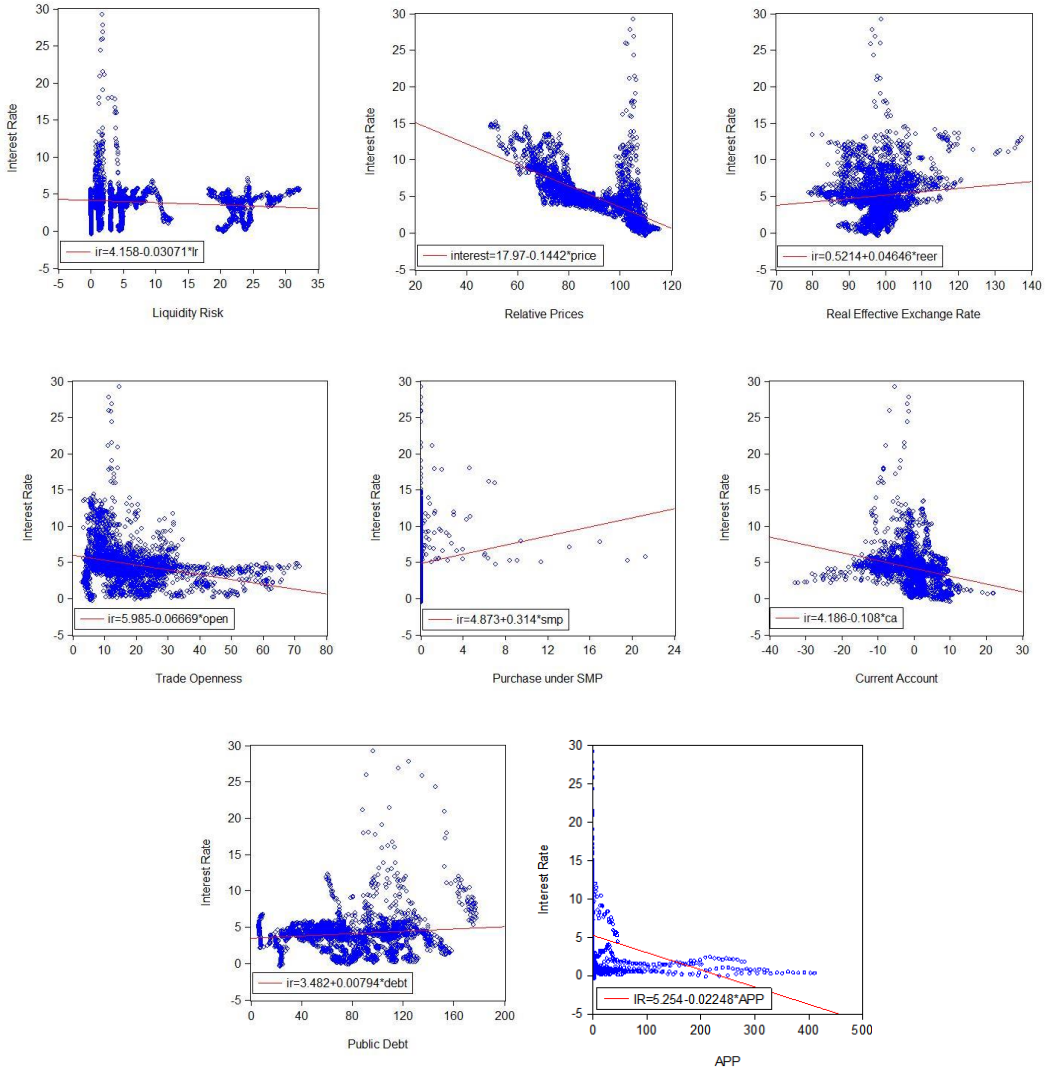


Figure Appendix D: Scatterplots of the potential yield determinants

Appendix E

Woolridge test for autocorrelation in panel data	
F(1,11)	**406.089**
Probability	**0.00***

Notes: (1) H0: no-first order autocorrelation (2) * indicates rejection of H0

Appendix F

Modified Wald test for heteroscedasticity	
Chi2 (12)	**11440.42**
Probability	**0.00*** **

Notes: (1) H0: Homoscedastic variance (2) * indicates rejection of H0

Appendix G

Hausman test	
Chi2 (7)	**107.25**
Probability	**0.00*** **

Notes: (1) H0: errors are not correlated with the independent variables (2) where *,**,***, indicates rejection of H0 at 10,5,1%

Appendix H

Wald test for joint significance	
F (261,2042)	**3.98**
Probability	**0.00***

Notes: (1) H0: joint tests of time dummy coefficient = 0 (2) * indicates rejection of H0

Appendix I

Table Appendix I: Unit Root tests

	Fisher-Type unit root test				*Im-Pesaran-Shin unit root test*
	Inverse chi^2	**Inverse normal**	**Inverse logit**	**Modified inv. Chi^2**	**Z-t-bar**
Yield	**0.89**	**0.84**	**0.83**	**0.88**	**0.82**
Liquidity	**0.01***	**0.39**	**0.30**	**0.00***	**0.98**
Growth	**0.00***	**0.00***	**0.00***	**0.00***	**0.00***
CA	**0.45**	**0.79**	**0.76**	**0.49**	**0.80**
FB	**0.00***	**0.00***	**0.00***	**0.00***	**0.00***
DEBT	**1.00**	**1.00**	**1.00**	**0.99**	**1.00**
Prices	**0.00***	**0.04***	**0.00***	**0.00***	**0.05***
Open	**0.00***	**0.00***	**0.00***	**0.00***	**0.00***
Reer	**0.00***	**0.00***	**0.00***	**0.00***	**0.00***

Notes: (1)where the figures represent p-values; (2)H0: All panels contain unit roots; (3) * indicates rejection of H0.

Appendix J

Kao test for cointegration	
	Probability
Modified DF t	**0.00***
DF t	**0.00***
Augmented DF	**0.00***
Unadjusted modified DF	**0.00***
Unadjusted DF	**0.00***

notes: (1)where DF stands for Dickey-Fuller; (2)H0: no cointegration; (3) * indicates rejection of H0.

Appendix K

Table Appendix K: Significance of the Time Fixed Effects

Wald test	
F(201,1993)	**4.77**
Probability	**0.00*** **

Notes: (1) H0: coefficient dummies for all years = 0

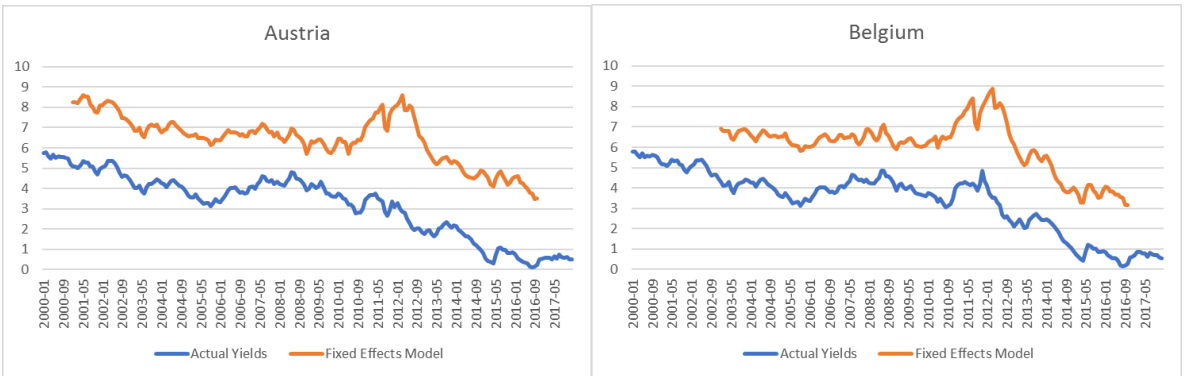
Appendix L

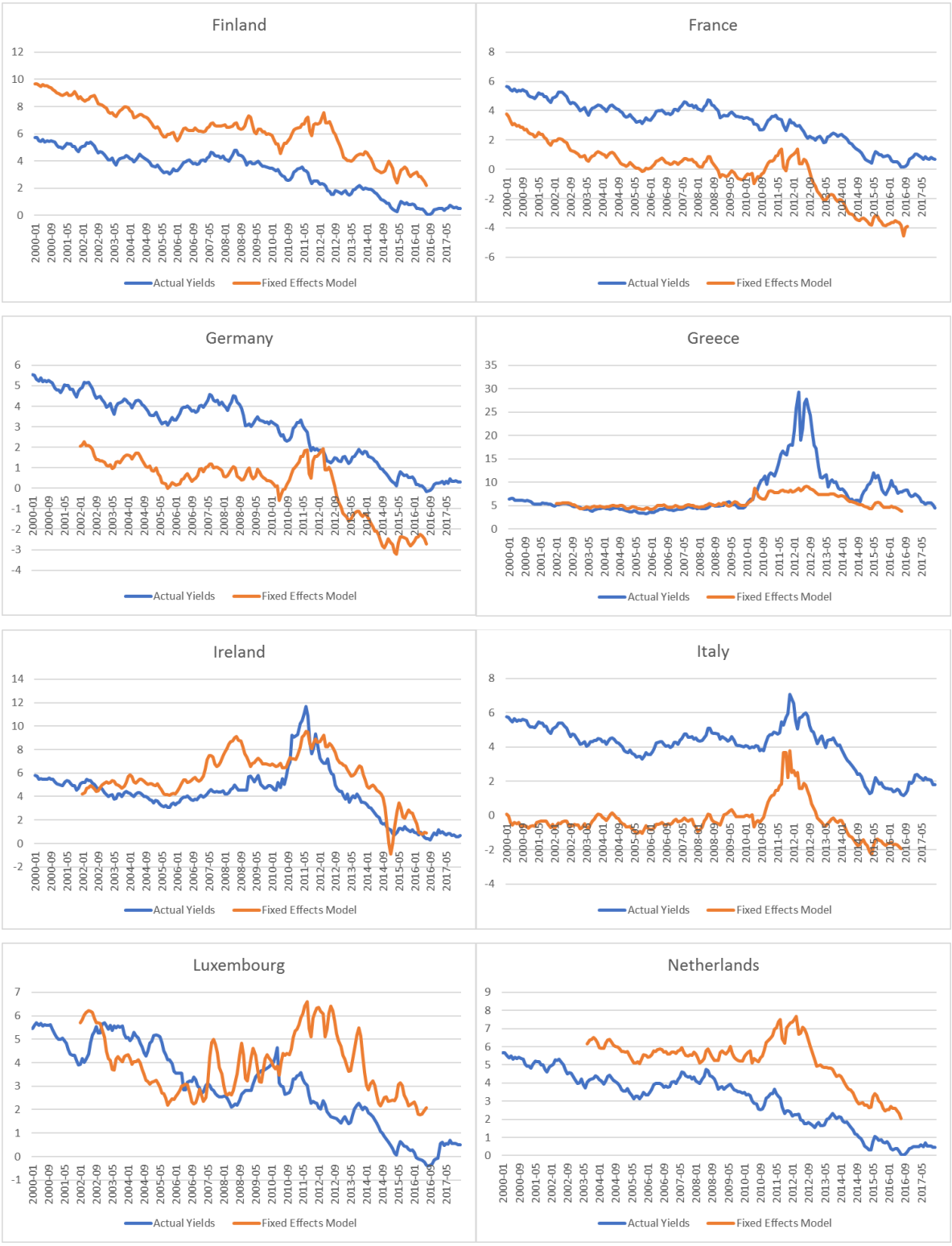
Table Appendix L: The need for the incorporation of Fixed Effects

Hausman test	
Chi2 (7)	**107.25**
Probability	**0.00*** **

Notes: (1) H0: errors are not correlated with the independent variables (2) *,**,***, where indicates rejection of H0 at 10,5,1%

Appendix M




Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Netherlands
Actual Yields
Fixed Effects Model

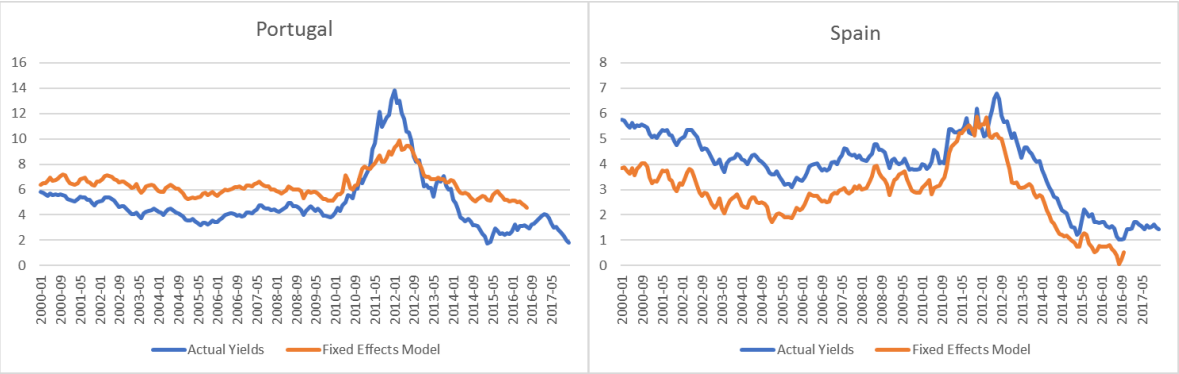


Figure Appendix M: The Predictions of the Baseline Model

Appendix N

Table Appendix N: The Heterogeneous Pricing among EMU Members

	Variables	(1)	(2)	(3)	(4)[1]	(5)
		FE-Robust Eurozone	FE-Robust Eurozone	FE-Robust Eurozone	FE-Robust PIIGS	FE-Robust Core
	Constant	**12.693*** **	-1.661	-3.125	5.336	**13.10** **
		(2.062)	(7.832)	(5.294)	(9.629)	**(3.211)**
Public finances	Public Debt	0.027	**0.033***	-0.052	-0.095	**-0.052** **
		(0.018)	**(0. 017)**	(0.041)	(0.048)	**(0.017)**
	Fiscal Balance	**-0.209***	**-0.154***	0.016	-0.015	-0.028
		(0.108)	**(0.073)**	(0.027)	(0.047)	(0.014)
	GDP growth	-0.086	-0.071	0.026	-0.013	0.057
		(0.152)	(0.108)	(0.033)	(0.019)	(0.033)
Competitiveness	Relative Prices	X	-0.048	-0.124	-0.163	0.002
			(0.265)	(0.100)	(0.252)	(0.063)
	Current Account Balance	X	**-0.135** **	0.061	-0.041	**0.027*** **
			(0.061)	(0.041)	(0.081)	**(0.004)**
	Trade openness	X	-0.036	0.021	0.193	**0.026***
			(0.031)	(0.041)	(0.136)	**(0.013)**
	REER	X	-0.066	**0.232***	0.199	-0.076
			(0.133)	**(0.110)**	(0.137)	(0.059)
Bond Market	Liquidity Risk	X	X	0.044	0.056	**0.321***
				(0.128)	(0.204)	**(0.089)**
ECB Policies	ECB Actual	X	X	0.028	**-0.193** **	X[1]
				(0.084)	**(0.06)**	
	APP	X	X	0.009	0.016	0.002
				(0.005)	(0.008)	(0.001)

Public Finances interaction Terms	Debt*SDC	Yes	Yes	**0.062**** **(0.021)**	**0.065 *** **(0.027)**	**0.011*** **(0.004)**
	Fiscal Balance * SDC	Yes	Yes	**-0.129**** **(0.048)**	-0.058 (0.059)	0.013 (0.017)
	GDP * SDC	Yes	Yes	-0.099 (0.103)	0.067 (0.081)	-0.017 (0.038)
Competitiveness Interaction Term	Relative Prices * SDC	0.539	0.614	0.082 (0.176)	-0.162 (0.474)	-0.064 (0.118)
	Current Account * SDC	2.589	2.322	-0.011 (0.068)	0.124 (0.086)	**-0.043***** **(0.008)**
	Trade Openness * SDC	X	X	**-0.0955**** **(0.032)**	-0.092 (0.063)	-0.001 (0.006)
	REER * SDC	X	X	-0.146 (0.173)	0.159 (0.480)	0.112 (0.075)
	Liquidity Risk * SDC	x	X	**-0.155**** **(0.059)**	**-0.342*** **(0.135)**	-0.013 (0.008)
Statistics and estimations	FIXED EFFECTS	Yes	Yes	Yes	Yes	Yes
	Robust SE	Yes	Yes	Yes	Yes	Yes
	Adj/within R2	0.539	0.614	0.636	0.775	0.963
	Observations	2.589	2.322	2.214	950	1.264

Notes: (1) SE in parentheses; (2) *,**,*** where indicates significance at 10,5,1 level; (3) fixed effects reflect country and time; (4) Robust SE are corrected for the presence of serial correlation and heteroskedastic error terms; (5) ECB omitted as the purchases were restricted to the PIIGS countries.

Appendix O

Table Appendix O: Significance of the Time Effects

Wald test	
F(11,11)	**11.10**
Probability	**0.00*****

Notes: (1) H0: coefficient dummies for all years = 0

Appendix P

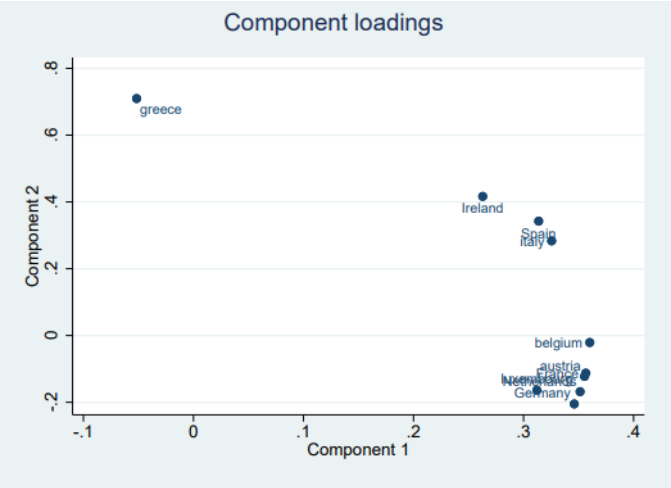


Figure Appendix P: The Alternative Component Loadings across PIIGS and Core

Appendix Q

Table Appendix Q: The Explained Variance by the 1st and 2nd Principal Component

Eigenvector	1th Component	2nd Component	Unexplained
Austria	0.3325	-0.1094	0.007602
Belgium	0.3376	-0.0237	0.007831
Finland	0.3275	-0.1521	0.006112
France	0.3336	-0.1005	0.005823
Germany	0.3231	-0.1780	0.008307
Greece	-0.0438	0.5752	0.1007
Ireland	0.2488	0.3375	0.158
Italy	0.3069	0.2274	0.04342
Luxembourg	0.2905	-0.1446	0.2108
Netherlands	0.3283	-0.1477	0.00501
Portugal	0.1216	0.5581	0.04043
Spain	0.2958	0.2680	0.04809

Appendix R

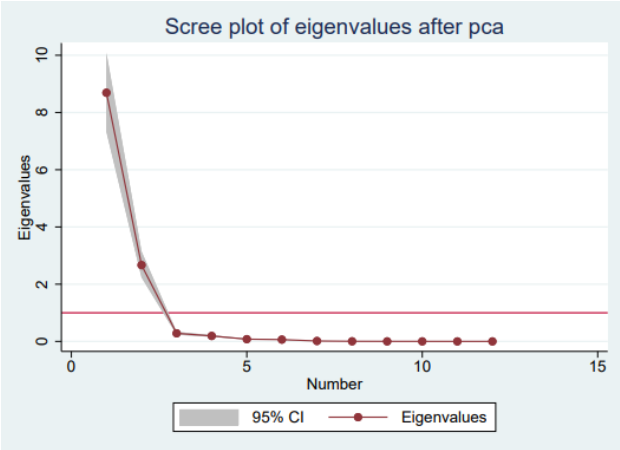


Figure Appendix R: The Scree Plot of the PCA Eigenvalues

Appendix S

Table Appendix S: The Kaiser-Meyer-Olkin Measure

Eigenvector	Kaiser-Meyer-Olkin Measure
Austria	0.8979
Belgium	0.9104
Finland	0.9160
France	0.8848
Germany	0.8995
Greece	0.5582
Ireland	0.7918
Italy	0.8429
Luxembourg	0.9711
Netherlands	0.8968
Portugal	0.7034
Spain	0.8018
Overall	0.8640

Appendix T

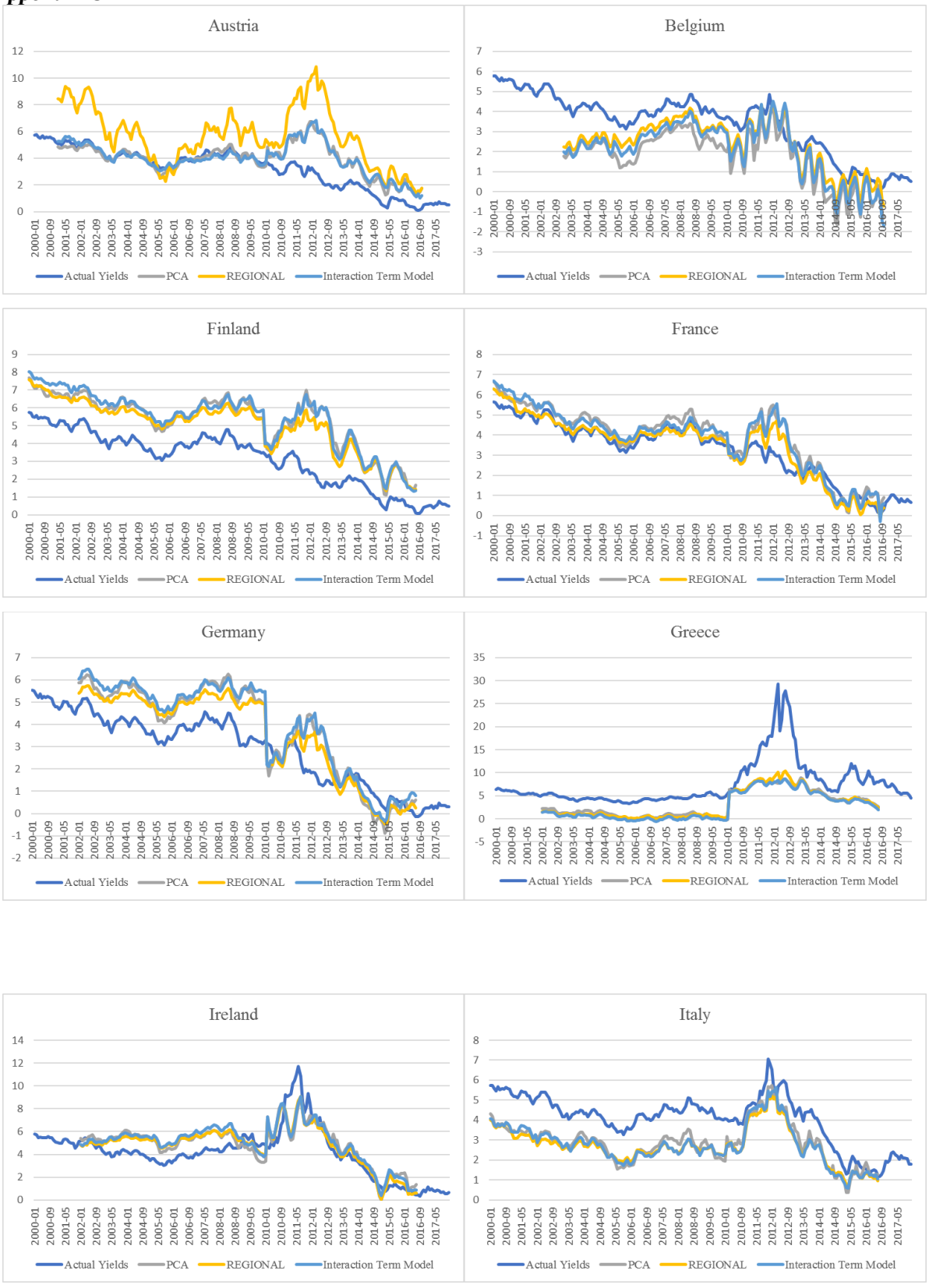
Appendix T: The Regression Estimations of the influence of Contagion

dependent variable is the 10-year to maturity sovereign bond interest rate level									
	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		1st PC	**1st PC Interacted**	**2nd PC**	**2nd PC Interacted**	**1st and 2nd PC**	**1st and 2nd PC Interacted**	**Regional Contagion**	**Regional Contagion PIIGS**
	Constant	-3.813	-0.519	7.375	5.383	0.593	2.812	16.32	10.894
		(5.02)	(3.605)	(3.156)	(3.176)	(2.708)	(3.059)	(13.92)	(14.348)
Public finances	Public Debt	-0.041	-0.045	-0.051	-0.051	-0.046	-0.049	-0.045	-0.038
		(0.033)	(0.034)	(0.035)	(0.035)	(0.035)	(0.035)	(0.031)	(0.026)
	Fiscal Balance	-0.004	-0.005	0.006	0.017	0.001	0.009	0.015	0.014
		(0.024)	(0.025)	(0.026)	(0.025)	(0.025)	(0.026)	(0.022)	(0.022)
	GDP growth	0.021	-0.018	-0.079	0.014	-0.01	0.012	0.019	0.023
		(0.039)	(0.029)	(0.047)	(0.030)	(0.036)	(0.027)	(0.032)	(0.028)
Competitiveness	Relative Prices	-0.011	-0.015	**-0.074***	**-0.123*****	-0.037	-0.083	-0.103	-0.008
		(0.041)	(0.041)	**(0.031)**	**(0.031)**	(0.035)	(0.049)	(0.091)	(0.111)
	Current Account Balance	**0.076***	**0.079***	**0.087***	**0.079***	**0.079***	**0.078***	0.059	0.066
		(0.037)	**(0.036)**	**(0.039)**	**(0.038)**	**(0.037)**	**(0.036)**	(0.039)	(0.041)
	Trade openness	0.002	-0.002	0.003	0.006	-0.003	-0.001	0.023	0.037
		(0.023)	(0.029)	(0.029)	(0.026)	(0.027	(0.026)	(0.031)	(0.028)
	REER	**0.109****	**0.085***	**0.074**	**0.147****	**0.099***	**0.129***	**0.184***	0.152
		(0.049)	**(0.037)**	**(0.046)**	**(0.048)**	**(0.041)**	**(0.058)**	**(0.093)**	(0.093)
Bond Market	Liquidity Risk	0.009	0.032	0.039	0.027	0.029	0.035	0.032	0.002
		(0.103)	(0.113)	(0.129)	(0.123)	(0.118)	(0.118)	(0.104)	(0.076)
ECB Policies	ECB	0.028	0.025	0.009	0.008	0.016	0.014	0.031	-0.016
		(0.078)	(0.076)	(0.075)	(0.076)	(0.078)	(0.079)	(0.075)	(0.054)
	APP	0.006	0.008	0.004	0.003	0.006	**0.006***	0.006	0.004
		(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	**(0.003)**	(0.003)	(0.003)
Contagion	Contagion	X	X	X	X	X	X	-2.986	-3.297
								(2.209)	(2.025)
	Contagion * SDC	X	X	X	X	X	X	**1.814*****	**2.082*****
								(0.384)	**(0.321)**
	Contagion* PIIGS	X	X	X	X	X	X	X	**0.804*****
									(0.247)
Principal Components	PC1	**0.7617*****	**0.553*****	X	X	**0.443 *** **	0.215	X	X
		(0.178)	**(0.0945)**			**(0.119)**	(0.199)		
	PC2	x	X	**0.644****	**1.685*****	0.361	1.131	X	X
				(0.243)	**(0.356)**	(0.302)	(0.719)		

	PC1*SDC	X	0.334 (0.236)	X	X	X	**0.248* (0.1222)**	X	X
	PC2*SDC	X	X	X	**-1.077*** (0.254)**	X	**-0.079 * (0.432)**	X	X
Public Finances interaction Terms	Debt*SDC	**0.056*** (0.018)**	**0.062** (.0202)**	**0.063** (0.022)**	**0.060** (0.022)**	**0.061** (0.021)**	**0.062*** (0.022)**	**0.056** (0.014)**	**0.061*** (0.012)**
	Fiscal Balance * SDC	**-0.108** (0.036)**	**-0.106** (0.035)**	**-0.113** (0.039)**	**-0.123*** (0.039)**	**-0.108** (0.036)**	**-0.116** (0.039)**	**-0.118** (0.042)**	**-0.111*** (0.041)**
	GDP * SDC	-0.176 (0.114)	-0.109 (0.094)	-0.014 (0.081)	-0.116 (0.089)	-0.085 (0.088)	-0.109 (0.084)	-0.089 (0.092)	-0.039 (0.069)
Competitiveness Interaction Terms	Relative Prices * SDC	0.128 (0.097)	0.185 (0.125)	-0.076 (0.061)	-0.024 (0.067)	0.052 (0.042)	0.107* (0.053)	0.087 (0.164)	-0.137 (0.151)
	Current Account * SDC	-0.052 (0.057)	-0.042 (0.056)	-0.038 (0.059)	-0.038 (0.067)	-0.035 (0.056)	-0.033 (0.058)	-0.014 (0.043)	0.008 (0.032)
	Trade Openness * SDC	-0.078** (0.026)	-0.084** (0.028)	-0.083** (0.033)	-0.083** (0.032)	-0.084** (0.029)	-0.087** (0.031)	-0.086*** (0.021)	-0.091*** (0.016)
	REER * SDC	-0.200 (0.154)	-0.221 (0.165)	0.114 (0.098)	0.042 (0.104)	-0.070 (0.085)	-0.108 (0.087)	-0.055 (0.127)	-0.044 (0.131)
Bond Market	Liquidity Risk * SDC	**-0.138** (0.048)**	**-0.148** (0.054)**	**-0.154** (0.063)**	**-0.147** (0.059)**	**-0.148** (0.057)**	**-0.151** (0.057)**	**-0.137*** (0.035)**	**-0.147*** (0.027)**
Statistics and Estimations	Time Fixed Effects	No	No	No	No	No	No	Yes	Yes
	Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Robust SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Adj/within R2	0.6001	0.606	0.598	0.610	0.618	0.620	0.669	0.696
	Observations	2.214	2.214	2.214	2.214	2.214	2.214	2.214	2.214

(1) Due to negative factor loadings of second principal component, the component is defined as minus the component; (2) the time-fixed effects are excluded, as the derived components are constant across countries but varying over time (Afonso, Arghyrou, & Kontonikas, The determinants of sovereign bond yield spreads in the EMU, 2015).

Appendix U


Austria
Belgium
Finland
France
Germany
Greece
Ireland
Italy
Actual Yields
PCA
REGIONAL
Interaction Term Model

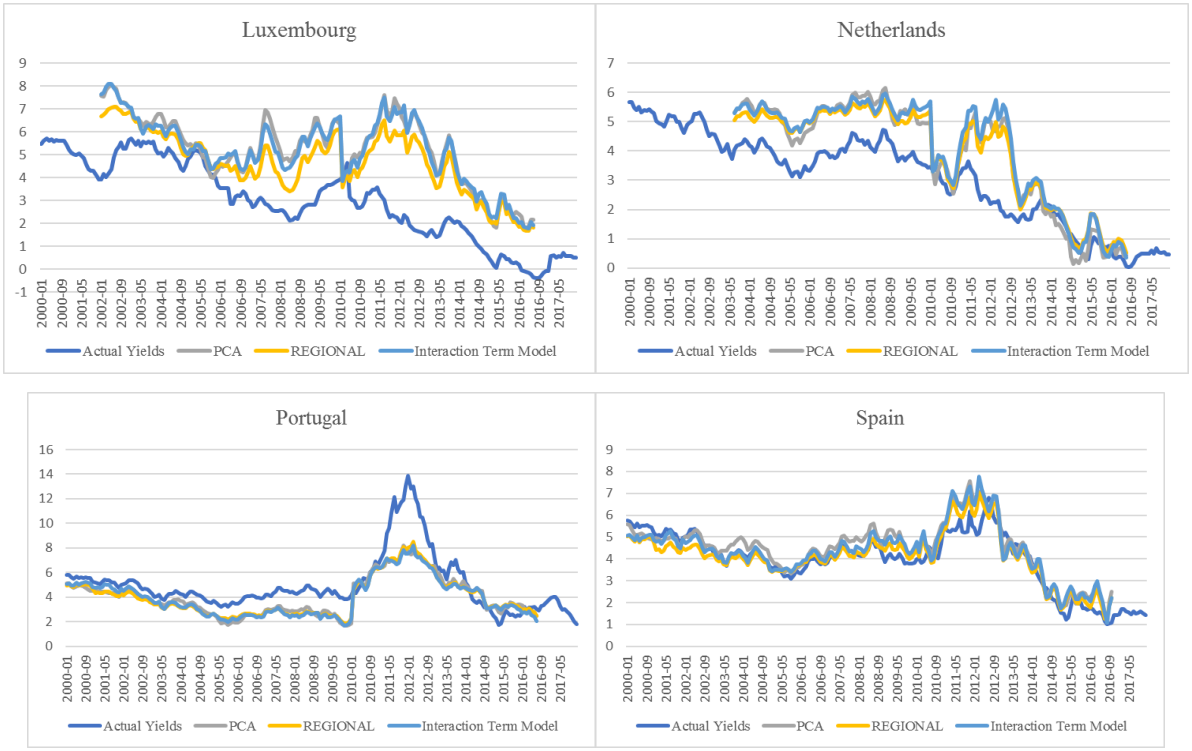


Figure Appendix U: The Predictions of the Principal Component and Regional Contagion Regressions

Appendix V

Table Appendix V: Unit Root tests

	Fisher-Type unit root test				*Im-Pesaran-Shin unit root test*
	Inverse chi^2	**Inverse normal**	**Inverse logit**	**Modified inv. Chi^2**	**Z-t-bar**
Yield	**0.00*** **	**0.00*** **	**0.00*** **	**0.00*** **	**0.00*** **
Debt	**0.00*** **	**0.00*** **	**0.00*** **	**0.00*** **	**0.00*** **
CA	**0.00*** **	**0.00*** **	**0.00*** **	**0.00*** **	**0.00*** **

Notes: (1)where the variable reflect the first difference of the original variables; (2) where the figures represent p-values (3)H0: All panels contain unit roots; (4) where *,**,*** where indicates rejection of H0 at 10,5,1 level.

Appendix W

Test	Probability		Reject
Number of lags	2	3	
ir → gdp	0.58224	0.619	Accept
gdp → ir	7.609***	1.488	Reject
ir → debt	30.406***	23.753***	Reject
debt → ir	38.428***	47.499***	Reject
ir → fb	32.689***	6.854***	Reject
fb → ir	3.980**	3.008**	Reject
ir → open	54.292***	44.019***	Reject
open → ir	3.024**	6.704***	Reject
ir → prices	7.112***	3.607**	Reject
prices → ir	5.114***	3.962***	Reject
ir → reer	3.583**	7.550**	Reject
reer → ir	1.542	2.374*	Accept
ir → ca	4.249**	3.255**	Reject
ca → ir	0.378	0.4300	Accept

Notes: (1) H0= Y does not Granger Cause X; (2) *,**,*** where indicates significance at 10,5,1 level of the F-statistics; (3) "*Rejects"* indicates rejection of the null hypotheses; (4) Statistic based upon stacked tests and common coefficients; (5) rounded to three decimals; (6) abbreviations of Table 4.; (7) Granger Causality estimated by the Eviews software

Appendix X

Country-Specific Yield	Level	First-Difference
Observations	109	108
Austria	-1.180	-8.166***
Belgium	-0.769	-8.138***
Finland	-1.466	-8.260***
France	-1.114	-7.94***
Germany	-1.403	-8.412***
Greece	-1.504	-9.328***
Ireland	-0.553	-8.653***
Italy	-0.707	-8.271***
Luxembourg	-0.773	-8.900***
Netherlands	-1.296	-7.898***
Portugal	-0.483	8.519***
Spain	-0.399	8.740***

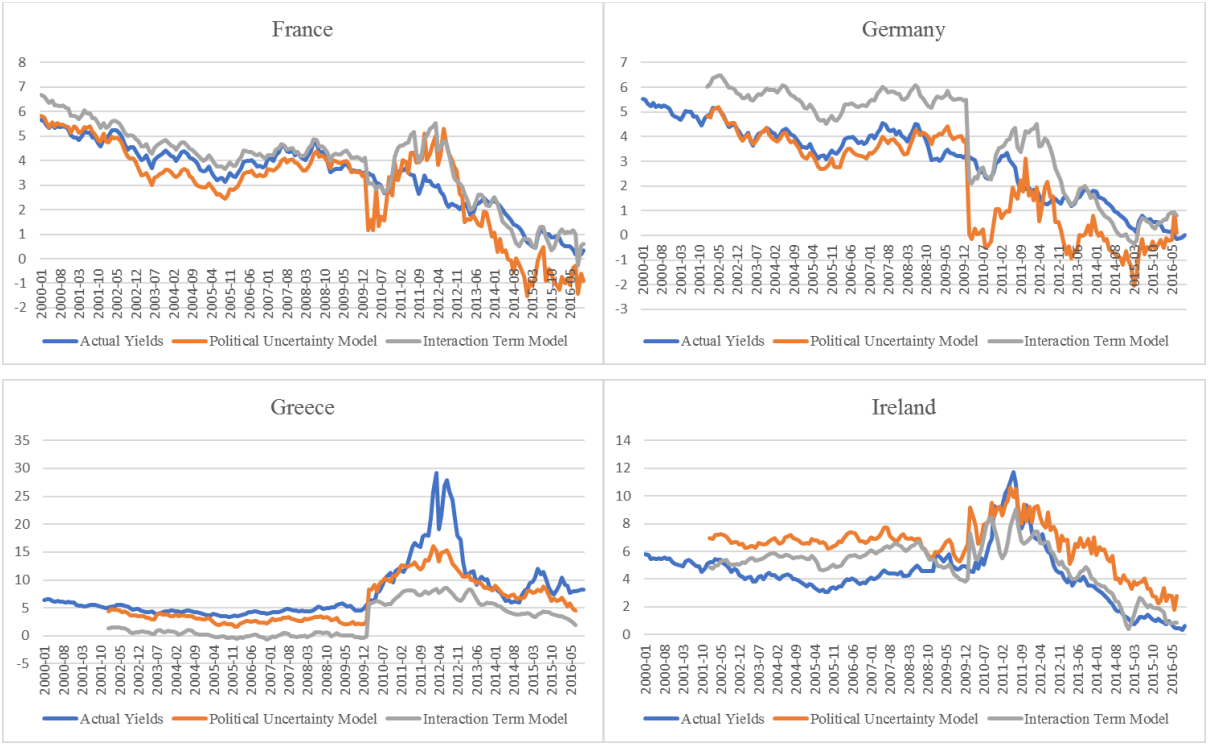
Notes: (1) Test statistics rounded to three decimals; (2) p-value based upon the MacKinnon approximation; (3) *,**,*** where indicates significance at 10,5,1 level of the test-statistics

Appendix Y

		Leading country-specific sovereign yield in terms of Granger Causality											
		Austria	**Belgium**	**Finland**	**France**	**Germany**	**Greece**	**Ireland**	**Italy**	**Luxembourg**	**Netherlands**	**Portugal**	**Spain**
Following country-specific sovereign yield	**Austria**	*X*	0.113	**4.019****	1.253	**4.449****	0.405	**5.511*****	2.271	0.254	2.947*	0.814	2.115
	Belgium	0.116	*X*	*1.867*	***2.609****	***2.991****	*0.290*	***6.533*****	*0.631*	*0.098*	*2.141*	0.933	1.650
	Finland	1.052	*0.686*	*X*	0.928	2.147	0.727	**8.353*****	0.103	0.045	2.040	0.298	0.966
	France	1.180	*1.697*	1.031	*X*	2.155	0.385	4.568**	1.73	0.024	1.385	0.603	**2.488***
	Germany	0.266	*0.274*	1.662	0.638	*X*	0.389	**7.622*****	0.086	1.461	0.422	1.186	0.636
	Greece	0.403	*0.746*	1.751	0.317	1.666	*X*	0.546	6.929	1.432	0.730	**8.139*****	**3.259****
	Ireland	0.219	*0.046*	0.296	0.163	0.711	0.068	*X*	1.215	0.919	1.143	0.659	1.263
	Italy	0.767	***2.677****	2.071	**2.824***	2.202	0.617	**3.143****	*X*	0.906	1.456	0.092	0.043
	Luxembourg	2.271	0.656	0.807	1.840	**3.314****	0.274	1.865	0.159	*X*	2.733	0.2001	0.132
	Netherlands	*0.257*	*0.544*	0.656	1.08	0.618	0.877	**11.157*****	0.692	0.254	*X*	0.829	1.193
	Portugal	1.428	**4.290****	1.332	1.07	0.166	0.987	**5.148*****	0.622	0.165	0.428	*X*	0.065
	Spain	*0.532*	0.616	1.282	1.888	1.971	1.107	**5.897*****	1.882	0.031	0.862	0.008	*x*

Notes: (1) Results based on the Pairwise Granger Causality Test with 2 lags; (2) H0= Y does not Granger Cause X; (2) *,**,*** where indicates significance at 10,5,1 level of the test-statistics; (3) rounded to three decimals; (4) based upon the September 2008 sample.

Appendix Z



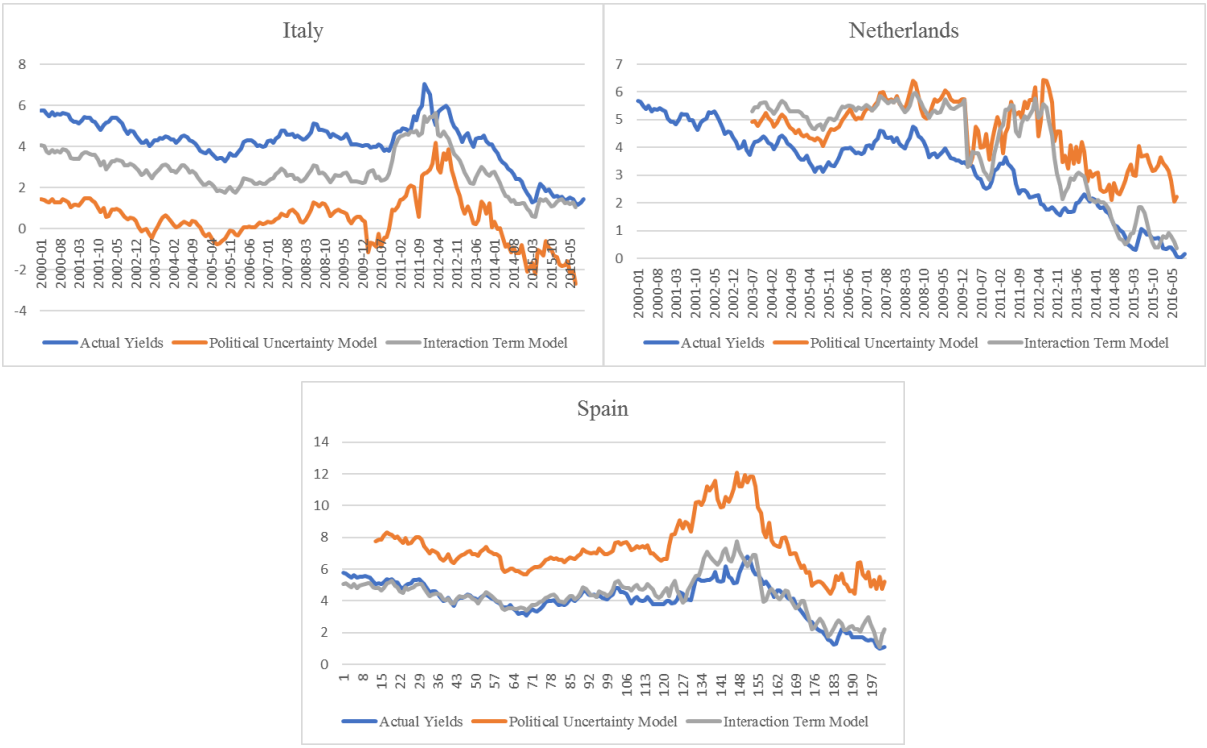


Figure Appendix Z: The predicted Values Based on the EPU Model

Appendix AA

	Sign	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7
gdp	-	-0.2480	0.3113	0.4394	0.7790	0.1586	-0.0801	0.1007
ca	-	0.2906	0.4481	0.4003	-0.3536	-0.1230	-0.6437	0.0016
fb	-	-0.1846	0.6380	-0.0119	-0.3602	0.3242	0.4900	0.2894
debt	+	0.3151	-0.4504	0.5180	-0.1044	0.1635	0.1785	0.6000
prices	+	0.5586	0.0237	-0.0619	0.1141	0.7110	0.0307	-0.4051
open	-	0.5028	0.2291	0.1834	0.1618	-0.5623	0.5185	-0.2233
reer	+	0.3947	0.1983	-0.5838	0.2973	-0.0785	-0.1936	0.5763
Explained Proportion	NA	0.2852	0.2127	0.1764	0.1112	0.0857	0.0787	0.0502

Appendix AB

Table AB: Robustness Checks

	Variables	(1)	(2)	(5)	(6)	(7)	(8)	(9)
		Original Specification[1]	Banking Sector	GFC	Index	Non-Linear	Quarterly	2SLS
	Constant	16.32	17.573	18.388	**30.158***	14.254	6.958	-1.972
		(13.92)	(12.777)	(13.029)	**(15.667)**	(13.712)	(13.564)	(5.473)
Public finances	Public Debt	-0.045	-0.051	-0.034	X	0.003	-0.029	-0.0548
		(0.031)	(0.032)	(0.025)		(0.041)	(0.032)	(0.039)
	Public Debt^2	X	X	X	X	-0.0003	X	X
						(0.0002)		
	Fiscal Balance	0.015	0.009	0.027	X	-0.087	0.037	0.003
		(0.022)	(0.025)	(0.018)		(0.029)	(0.013)	(0.028)
	GDP growth	0.019	0.014	-0.033	X	0.028	-0.01	-0.056
		(0.032)	(0.034)	(0.033)		(0.03)	(0.034)	(0.039)
Competitiveness	Relative Prices	-0.103	-0.122	-0.144	X	-0.0362	0.105	-0.032
		(0.091)	(0.102)	(0.102)		(0.124)	(0.158)	(0.051)
	Current Account Balance	0.059	**0.07***	-0.0007	X	**0.072***	**0.184****	**0.081****
		(0.039)	**(0.036)**	(0.045)		**(0.038)**	**(0.076)**	**(0.036)**
	Trade openness	0.023	0.005	-0.0007	X	0.038	0.027	-0.004
		(0.031)	(0.031)	(0.046)		(0.041)	(0.023)	(0.045)
	REER	**0.184***	**0.179***	0.197	X	0.158	0.067	**0.089****
		(0.093)	**(0.095)**	(0.124)		(0.097)	(0.093)	**(0.042)**
	Liquidity Risk	0.032	0.017	-0.032	-0.197	-0.147	-0.097	0.052
		(0.104)	(0.102)	(0.113)	(0.158)	(0.162)	(0.125)	(0.123)
	ECB	0.031	0.008	0.085	**0.191***	-0.057	0.006	0.022
		(0.075)	(0.066)	(0.067)	**(0.095)**	(0.093)	(0.042)	(0.085)
	APP	0.006	0.005	0.005	0.002	**0.007****	0.001	0.005
		(0.003)	(0.003)	(0.004)	(0.004)	**(0.003)**	(0.001)	(0.004)
	Contagion	-2.986	-2.721	-2.951	-3.980	-3.144	-2.477	**0.891*****
		(2.209)	(2.261)	(2.100)	(2.693)	(2.085)	(1.831)	**(0.290)**
	Banking sector	X	0.001	X	X	X	X	X
			(0.008)					
	EPU	X	X	X	X	X	X	X
	INDEX	X	X	X	0.203	X	X	X
					(0.137)			
	Debt^2*SDC	X	X	X	X	**-0.0004***	X	X
						(0.0002)		
	Contagion * SDC	**1.814*****	**1.550*****	**1.491*****	**1.784*****	**2.281*****	**1.344*****	0.023
		(0.384)	**(0.457)**	**(0.192)**	**(0.592)**	**(0.466)**	**(0.254)**	(0.323)
Public Finances interaction Terms	Debt*SDC	**0.056****	**0.056*****	**0.051*****	X	**0.145*****	0.013	**0.069*****
		(0.014)	**(0.015)**	**(0.011)**		**(0.036)**	(0.017)	**(0.023)**
	Fiscal Balance * SDC	**-0.118****	**-0.088***	**-0.095****	X	**-0.087****	**-0.123****	**-0.114*****
		(0.042)	**(0.042)**	**(0.030)**		**(0.029)**	**(0.031)**	**(0.039)**

	GDP * SDC	-0.089 (0.092)	-0.063 (0.072)	-0.074 (0.099)	X	-0.112 (0.091)	-0.057 (0.072)	-0.087 (0.101)
Competitiveness Interaction Terms	Relative Prices * SDC	0.087 (0.164)	0.118 (0.172)	0.018 (0.124)	X	-0.153 (0.269)	-0.120 (0.142)	-0.007 (0.078)
	Current Account * SDC	-0.014 (0.043)	-0.039 (0.038)	0.024 (0.033)	X	-0.017 (0.043)	**-0.207**** **(0.068)**	-0.026 (0.051)
	Trade Openness * SDC	**-0.086***** **(0.021)**	**-0.068**** **(0.022)**	**-0.074***** **(0.017)**	X	**-0.118***** **(0.029)**	**-0.049**** **(0.017)**	**-0.092***** **(0.033)**
	REER * SDC	-0.055 (0.127)	-0.108 (0.134)	0.098 (0.107)	X	0.023 (0.205)	-0.051 (0.174)	0.018 (0.102)
	Liquidity Risk * SDC	**-0.137***** **(0.035)**	**-0.122***** **(0.038)**	**-0.123***** **(0.032)**	-0.078 (0.05)	**-0.182***** **(0.043)**	-0.09 (0.031)	**-0.168***** **(0.059)**
	Banking Sector * SDC	X	0.017* (0.009)	X	X	X	X	X
	EPU * SDC	X	X	X	X	X	X	X
	INDEX * SDC	X	x	X	0.167 (0.235)	X	X	X
Statistics and Estimations	Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Robust SE	yes	Yes	Yes	Yes	Yes	Yes	Yes
	Adj/within R2	0.669	0.675	0.629	0.486	0.663	0.681	0.558
	Observations	2.214	2.202	2.214	2.214	2.214	694	2.194

Notes: (1) Original Specification based upon Column (3) of Table 5.2; (2) SE in parentheses; (3) *,**,*** where indicates significance at 10,5,1 level; (4) fixed effects reflects country and time; (5) Robust SE are corrected for the presence of serial correlation and heteroskedastic error terms; (6) ECB omitted as the purchases were restricted to the PIIGS countries. (7) Non-applicable, as observations of actual SMP and APP purchases are limited. Therefore, it is unable to derive the change, as most observations are zero; (8) Estimates rounded to three decimals.

Appendix AC

Table AC: Robustness Checks

	Variables	(1)	(2)	(3)	(5)	(6)	(7)	(8)	(9)
		Original Specification[1]	Banking Sector	Political Uncertainty	GFC	INDEX	NON-LINEAR	Quarterly	Changes
	Constant	-3.125 (5.294)	1.069 (5.694)	**22.022** (7.037)**	0.266 (4.768)	**12.639** (4.351)**	-6.689 (7.550)	7.362 (10.529)	**5.554*** (0.289)**
Public finances	Public Debt	-0.052 (0.041)	-0.059 (0.041)	**-0.081** (0.036)**	-0.043 (0.035)	X	0.004 (0.045)	-0.038 (0.038)	-0.028 (0.022)
	Public Debt[2]	X	X	X	X	X	-0.0003 (0.0002)	X	X
	Fiscal Balance	0.016 (0.027)	0.011 (0.029)	-0.034 (0.028)	0.037 (0.029)	X	0.009 (0.020)	0.041** (0.018)	-0.00003 (0.0001)
	GDP growth	0.026 (0.033)	0.021 (0.036)	-0.044 (0.031)	-0.042 (0.042)	X	0.038 (0.031)	-0.011 (0.042)	0.00003 (0.00002)
Competitiveness	Relative Prices	-0.124 (0.100)	-0.151 (0.113)	-0.307 (0.133)	-0.181 (0.122)	X	-0.054 (0.128)	0.068 (0.186)	**-0.161** (0.053)**
	Current Account Balance	0.061 (0.041)	0.074* (0.036)	-0.04 (0.061)	0.068 (0.046)	X	**0.076** (0.037)**	0.191* (0.084)	-0.00004 (0.00006)
	Trade openness	0.021 (0.041)	0.002 (0.041)	-0.016 (0.06)	-0.008 (0.058)	X	0.035 (0.047)	0.019 (0.024)	-0.004 (0.003)
	REER	**0.232** (0.11)**	**0.216** (0.117)**	**0.159** (0.076)**	0.249 (0.146)	X	0.207* (0.113)	0.111 (0.111)	**-0.521** (0.184)**
	Liquidity Risk	0.043 (0.128)	0.035 (0.119)	-0.045 (0.145)	-0.021 (0.123)	-0.192 (0.116)	-0.159 (0.160)	-0.089 (0.129)	0.0001 (0.004)
	ECB	0.028 (0.084)	0.002 (0.072)	-0.072 (0.089)	0.084 (0.074)	**0.188** (0.097)**	-0.06 (0.109)	0.002 (0.048)	X[7]
	APP	0.009 (0.005)	0.008 (0.005)	0.009 (0.008)	**0.01** (0.005)**	0.006 (0.006)	**0.009** (0.004)**	0.002 (0.001)	X[7]
	Banking sector	X	0.004 (0.008)	x	X	X	X	X	X
	EPU	X	X	0.0003 (0.001)	X	X	X	X	X
	INDEX	X	X	x	X	3.076 (2.065)	X	X	X
	Debt[2]*SDC	X	X	X	X	x	-0.0004 (0.0003)	x	x
Public Finances	Debt*SDC	**0.062** (0.021)**	**0.062** (0.02)**	0.060 (0.032)	**0.059** (0.019)**	X	**0.147 ** (0.061)**	0.018 (0.018)	**0.830** (0.313)**
	Fiscal Balance * SDC	**-0.129** (0.048)**	**-0.096** (0.049)**	0.0005 (0.025)	**-0.114** (0.041)**	X	**-0.097** (0.036)**	**-0.134*** (0.036)**	0.0001 (0.0001)

	GDP * SDC	-0.110 (0.103)	-0.065 (0.081)	0.052 (0.147)	-0.068 (0.113)	X	-0.132 (0.101)	-0.052 (0.089)	-0.00003 (0.00002)
Competitiveness Interaction Terms	Relative Prices * SDC	0.082 (0.176)	0.127 (0.184)	-0.054 (0.243)	-0.003 (0.146)	X	-0.154 (0.304)	-0.127 (0.196)	**0.154**** **(0.081)**
	Current Account * SDC	-0.011 (0.068)	-0.037 (0.062)	0.081 (0.129)	0.042 (0.061)	X	-0.026 (0.063)	**-0.215*** **(0.081)**	-1.86e-06 (0.0001)
	Trade Openness * SDC	**-0.096**** **(0.032)**	**-0.0743*** **(0.036)**	**-0.264*** **(0.111)**	-0.087** (0.032)	X	**-0.123**** **(0.044)**	**-0.053**** **(0.018)**	0.004 (0.01)
	REER * SDC	-0.146 (0.173)	-0.197 (0.165)	0.749 (0.487)	0.069 (0.179)	X	-0.087 (0.263)	-0.124 (0.230)	-0.163 (0.345)
	Liquidity Risk * SDC	**-0.155**** **(0.059)**	**-0.141**** **(0.061)**	**-0.397**** **(0.109)**	**-0.151**** **(0.06)**	-0.078 (0.047)	**-0.187**** **(0.074)**	-0.111 (0.041)	**-0.505*** **(0.258)**
	Baking Sector * SDC	X	0.019* (0.01)	x	X	X	X	X	X
	EPU * SDC	X	X	0.007 (0.007)	X	X	X	X	X
	INDEX * SDC	X	X	x	X	**-5.334**** **(2.367)**	X	X	X
Statistics and Estimations	Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Robust SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Adj/within R2	0.636	0.645	0.738	0.587	0.389	0.663	0.653	0.471
	Observations	2.214	2.202	1.273	2.214	2.214	2.214	694	2.191

Notes: (1) Orginal Specification based upon Column (3) of Table 5.2; (2) SE in parentheses; (3) *,**,*** where indicates significance at 10,5,1 level; (4) fixed effects reflects country and time; (5) Robust SE are corrected for the presence of serial correlation and heteroskedastic error terms; (6) ECB omitted as the purchases were restricted to the PIIGS countries. (7) Non-applicable, as observations of actual SMP and APP purchases are limited. Therefore, it is unable to derive the change, as most observations are zero.

Appendix AD

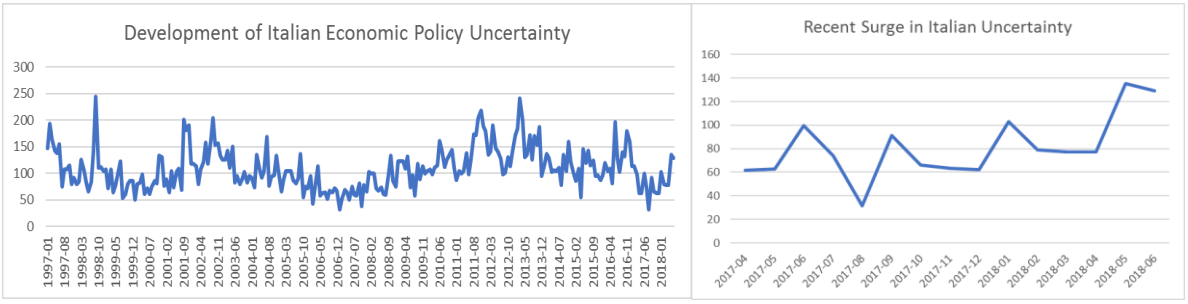


Figure 5.7: The Development of the Economic Policy Uncertainty measure of Italy