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Essays

on the predictive capacity and predictability of sovereign bond yields

in the European Monetary Union

in context of the European sovereign debt crisis

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Summary

This cumulative dissertation includes four essays analysing the institutional challenges of the European Monetary Union (EMU) that have been revealed by the European sovereign debt crisis. The empirical analyses focus on the predictive capacity and the predictability of sovereign bond yields of EMU member states as well as yields of bonds issued by financial institutions in context of the European sovereign debt crisis. Following a general introduction, the dissertation includes four essays that are presented in separate chapters. The dissertation is concluded with a critical assessment.

The first essay, provided in the second chapter, scrutinizes the causality between sovereign bond yields of core member states of the European Monetary Union relative to German Bunds and policy rates set by the European Central Bank. The empirical results suggest that there is no significant response of selected sovereign bond yields to a contractionary monetary policy decision, while in the first months after a positive shock to the sovereign bond yield spreads of the analysed EMU member states, there seems to be a tightening effect on the ECB's policy rate decisions.

The second essay analyses the political and economic situation in Italy in context of the European sovereign debt crisis and its impact on bond yields in the financial sector. The Italian economy back then was characterized by a strong interdependence between the sovereign credit risk and the credit risk of the financial sector. As economic turmoil due to the sovereign debt crisis worsened, the redenomination risk, expressing the possibility of a member state being forced to abandon the common currency, was increasing in Italy. The empirical analysis discloses that in the period under review, there is time varying cointegration between bank funding costs in Italy and Germany.

The third essay describes the Solvency II regulation's impact on investment decisions of insurance companies. The regulation is subject to criticism that it may provoke moral hazard among institutional investors due to the zero-risk weight of sovereign bonds denominated in Euro and issued by member states in the euro area. In the empirical analysis the sovereign bond yields of Austria, Belgium, France, Italy, and Ireland are examined. The empirical findings on the five-year sovereign bonds suggest that the credit risk premia required by selected EMU member states' sovereign bond investors contain information that help predicting liquidity premia of sovereign bonds issued by other EMU member states.

The fourth essay provides insights on the theory of optimum currency areas (OCA). While a lot of research in this area focuses on the question whether the EMU corresponds to the classical criteria of an OCA, this essay sheds some light on the theory claiming the endogeneity of OCA criteria. Furthermore, in this essay the history of the EMU being divided into different phases is analysed with focus on the turmoil in Greece. It played a special role for the European sovereign debt crisis.

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1. General Introduction

Fiscal measures to contain the economic impact of the Global Financial Crisis led to a sharp increase in public debt which then contributed to the European sovereign debt crisis especially affecting peripheral economies in the euro area. During the sovereign debt crisis fears spread that EMU member countries could not be able to service their debt. Contagion risks were supposed to be the reason why sovereign bond yield spread increases in several member states of the euro area could be observed. The empirical analyses in this dissertation focus on the predictive potential and the predictability of sovereign bond yields against the backdrop of the European sovereign debt crisis using time series analysis. The studies aim at identifying information flows from sovereign bond yields of one EMU member state on the one's of another country or a couple of countries in the euro area. The concept of Granger causality is applied. It intends to identify whether one time series helps to predict future values of another time series. Granger causality is given when past values of one variable x and the past values of another variable y better predict future values of y than only considering past values of y.[1] This concept should not be confused with causality because Granger causality only focuses on predictive causality. The findings in the presented essays shall help to identify causal directions between monetary policy and sovereign bond yields as well as among the latter.

This cumulative dissertation provides insights on the EMU's institutional challenges that were exposed by the European sovereign debt crisis like the lack of an adequate risk pricing of sovereign bonds in balance sheets of financial institutions (see chapter 4) or the absence of a common fiscal policy (see chapter 5). The sovereign-bank nexus and its impact on the European sovereign debt crisis is outlined in chapter 3. Furthermore, the impact of sovereign credit risk on bond yields issued by financial institutions is scrutinized. Institutional investors, banks, central banks, and ministries of finance might be interested in the provided results. This is due to the fact that future sovereign bond yields are not only relevant for investment decisions but are also an indicator for the debt sustainability of one country. The essays shall help to trace structural breaks in the history of the EMU which reflected a shift regarding the importance financial investors paid to sovereign credit risk in the euro area. Hence, periods of sovereign bond yield convergence and periods that were characterized by a widening of sovereign bond yields among EMU member states alternated.

The dissertation is divided into six chapters. The first chapter aims to provide a motivation for the selected issues and to give an overview of the covered topics in the following essays. The next four chapters each include an essay that has been published in a scientific journal already. The chapters are of chronological order according to the essays' date of issue. The final chapter concludes with a critical assessment. It draws possible conclusions of the previously presented results and provides insights on further required research. All essays are presented as they were published. Minor text deviations are for linguistic reasons only and intend to facilitate reading. Although the essays cover similar topics, they can be read separately. It is not required to follow the given order of chapters. Prior to the introduction, lists of figures and tables for all essays are provided. The references to each essay can be found at the end of the corresponding chapter.

The essay presented in the second chapter sheds some light on the development of interest rate differentials between German sovereign bonds and those of other eurozone member states over time

[1] Croux, C., & Reusens, P. (2013). Do stock prices contain predictive power for the future economic activity? A Granger causality analysis in the frequency domain. Journal of Macroeconomics, 35, 93-103.

since the introduction of the European Monetary System.[2] Between 1991 and 2005 yield spreads responded to the difference of debt-to-GDP ratios between one of the later euro area member states and Germany. Before the outbreak of the Global Financial Crisis a yield spread convergence among EMU member states could be observed. This happened also due to the fact that national monetary policies have been replaced by a common monetary policy in the currency union. It meant that sovereign credit risk played a minor role in the pricing of sovereign bonds. In the aftermath of the Global Financial Crisis yield spreads began to widen, putting the spotlight on public debt. Especially in peripheral economies of the euro area yield spreads increased significantly. Since the implementation of the ECB's quantitative easing measures yield spreads began to contract again. The empirical analysis of the essay in chapter 2 focuses on the causal relationship between government bond yield spreads in France, Italy and Spain (relative to Germany) and the ECB's monetary policy. The empirical assessment aims to scrutinize the impact of a policy rate hike by the ECB on long-term yields (10- or 30-year) of French, Italian or Spanish sovereign bonds. The results show no strong response by the sovereign bond yields with 10- and 30-year maturities of the economies named above to a contractionary monetary policy shock. This holds especially true for the first six months after a policy rate hike. Six months after a policy tightening by the ECB the picture is slightly different. In some cases, yield spreads do increase but even then, there is not a strong response by the yield spreads on a monetary policy contraction. In the other causal direction, the empirical analyses suggest that there is a contractionary impact of increasing spreads between French and German 10-year sovereign bond yields as well as between Italian and German 10-year sovereign bond yields on key interest rates set by the ECB. The latter could be interpreted as an attempt by the central bank to contain a yield spread widening in the euro area in order to prevent a deterioration of the member states' fiscal position.

The sovereign-bank nexus is subject to many economic studies. The essay presented in chapter 3 illustrates, using the example of Italy, how the interdependence between banks and the sovereign is even closer in times of crisis.[3] As mentioned in the first essay, at the beginning of the EMU a period of sovereign bond yield convergence among the economies in the euro area until the outbreak of the Global Financial Crisis was followed by a period of rising yield spreads which i.a. characterized the European sovereign debt crisis. Fiscal rescue measures of unprecedented volumes were implemented by several countries in the euro area to contain the spillover effects into the real economy. The corresponding increase in public debt spurred fears of EMU member states being unable to service their debt. Consequently, this led to a rising redenomination risk which further hampered the financial situation in these countries. Investors of assets issued by countries being exposed to redenomination risks require a compensation for the possible scenario that a member state of the currency union is forced to abandon the common currency and the sovereign bond "could be redenominated into a devalued legacy currency."[4] Due to the sovereign-bank nexus an increasing redenomination risk weighs on the financial sector through various transmission channels. Banks being invested in assets of its home sovereign

[2] This article has been published in Zeitschrift für die gesamte Versicherungswissenschaft: Rodriguez Gonzalez, M., Basse, T., & Tholl, J. (2019). Interest rate differentials and monetary policy in the European monetary union: the case of 10- and 30-year bonds. Zeitschrift für die gesamte Versicherungswissenschaft, 108(1), 19-42.

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[3] This article has been published in International Review of Law and Economics: Tholl, J., Schwarzbach, C., Pittalis, S., & von Mettenheim, H. J. (2020). Bank funding and the recent political development in Italy: What about redenomination risk?. International Review of law and Economics, 64, 105932.

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[4] De Santis, R. A. (2019). Redenomination risk. Journal of Money, Credit and Banking, 51(8), 2173-2206.

suffer from impairment losses as increasing redenomination risks devaluate the outstanding sovereign assets. Furthermore, a potentially worsening creditworthiness harms the sovereign's capacity to provide rescue packages for banks in times of financial distress which makes investors require higher risk premia for assets issued by the home country's banks. Analyzing other potential transmission mechanisms of the sovereign-bank nexus, it turns out that the financial situation of the sovereign even affects bank funding costs. The empirical assessment in chapter 3 indicates an impact of sovereign credit risk respectively redenomination risk on the pricing of Italian bank bonds as there is time-variation in the cointegration between bond yields of the financial sector in Italy and Germany.

The essay presented in chapter 4 sheds some light on EMU member sovereign bond yields' capacity to predict sovereign bond yields of other issuing countries in the euro area.[5] The fourth chapter provides insights on the institutional framework of the insurance sector with respect to sovereign bonds issued by EMU member states. As the third chapter already touched upon, the close sovereign-bank nexus played an important role in the European sovereign debt crisis. Regulatory flaws are supposed to worsen the close interdependence among banks and the sovereign and even provoke moral hazard. The empirical analysis indicates that interest rate differentials between French, Italian, Spanish, Belgian and Irish sovereign bond yields relative to German sovereign bond yields with a maturity of five years help to predict the yield spread between German and Austrian sovereign bonds with the same maturity. Assuming that Austria's solid fiscal position corresponds to the same sovereign credit risk as Germany, the remaining interest rate differential between the two countries could be explained by a liquidity risk premium that is required by investors of Austrian sovereign bonds. Hence, the sovereign credit risk of the EMU member states under review helps to forecast Austria's liquidity risk.

Chapter 5 provides an article dealing with the impact of how risk premia required for Greek sovereign debt affected sovereign bond yields of other EMU member states.[6] The European sovereign debt crisis called into question the EMU membership of economies particularly affected by the crisis. Discussions sparked-off about the so-called Maastricht criteria that determine the rules that need to be met to access the EMU. This was due to the fact that over time the criteria were met by hardly any member state of the euro area. At the height of the crisis the currency union as a whole was put into question. This brought the optimum currency area (OCA) theory by, amongst others, Robert Mundell back to spotlight.[7] Critics claimed that the euro area does not comply with OCA criteria and therefore should at least be downsized. The fifth chapter sheds some light on the theory that a common currency area thanks to its institutional framework fosters economic integration and hence, meets the OCA criteria over time. In the empirical analysis bidirectional Granger causality between Greek and French, Italian and Spanish sovereign bond yield spreads relative to German government bond yields in the period when Greece faced economic turmoil is tested. The findings suggest bidirectional information flows between the bond yields under review. This is to say Greek 10-year sovereign bond yield spreads help to predict the sovereign bond yield spreads of France, Italy and Spain and vice versa.

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[5] This article has been published in Zeitschrift für die gesamte Versicherungswissenschaft: Tholl, J., Basse, T., Meier, S., & Rodriguez Gonzalez, M. (2021). Risk premia and the European government bond market: new empirical evidence and some thoughts from the perspective of the life insurance industry. Zeitschrift für die gesamte Versicherungswissenschaft, 110(1), 49-78.

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This article is joint work with Christoph Schwarzbach. Each of us contributed equally.

[7] Mundell, R. A. (1961). A theory of optimum currency areas. The American Economic Review, 51(4), 657-665.

2. Interest Rate Differentials and Monetary Policy in the European Monetary Union: The Case of 10- and 30-Year Bonds

2.1. Introduction

Central banks all around the world were forced to react to the global financial crisis by lowering short term interest rates (see, for example, Fawley and Neely 2013; Ricci 2015). Additionally, measures of unconventional monetary policy were used to support global economic growth—which essentially means that government bonds and other fixed income securities have been bought by central banks (see, for example, Curida and Woodford 2011; Fawley and Neely 2013). Both types of monetary policy measures have affected bond yields. As a matter of fact, medium- and long-term bond yields have fallen in many countries. Especially "secure" fixed income securities (for example sovereign bonds issued by some member states of the European Monetary Union) also profited from "flight-to-quality" effects that pushed down interest rates even further (see, among others, Basse 2014; Gürtler and Neelmeier 2018). In Germany, for example, 10-year government bond yields even fell below zero for a while. Low long-term interest rates have caused major problems for the European life insurance industry (see, for example, Basse et al. 2014; Berdin and Gründl 2015). In fact, Berdin and Gründel (2015) have argued convincingly that especially German life insurers have had to face significant challenges due to the situation in the bond market, because these financial services firms were used to sell products with relatively high guaranteed returns to their customers in the past. Financing these guarantees certainly has become a problem for asset managers in the insurance industry (see, for example, Linderkamp et al. 2013; Niedrig 2015). Meanwhile some central banks have started a gradual process of normalization to their monetary policy stance; most notably, of course, the Federal Reserve in the United States began to increase the Fed Funds Target Rate in December 2015 (see, for example, Feroli et al. 2017; Basse et al. 2017). Market participants now seem to wait for the European Central Bank to also increase short term interest rates. Rate hikes in the European Monetary Union most probably should also affect medium- and long-term interest rates in Germany and the other member states of the currency union. Major changes to the interest rate environment, of course, would have consequence for life insurers (see, for example, Basse et al. 2014; Berdin and Gründl 2015).

However, not all European sovereign states were confronted with falling medium- and long-term interest rates during the crisis. As a matter of fact, fears about sovereign credit risk pushed up government bond yields in a number of European countries that were believed to be fiscally less solvent than Austria, Germany or the Netherlands (see, among others Ludwig 2014 and Gruppe et al. 2017). In any case, investors back then demanded significantly higher interest rates as a compensation to fund the budget deficits of some member states of the European Monetary Union (e.g., Portugal, Italy or Spain). Especially the insurers in these countries should also be interested in how government bond yield spreads relative to "secure" German sovereign debt will react to the anticipated rate hikes by the European Central Bank. In fact, these insurance companies often tend to have some kind of home bias concentrating their holdings of sovereign paper on bonds issued by their home countries. Moreover, because of the implementation of one very special rule in Solvency II, this question is also of more general relevance for the European life insurance industry. As a matter of fact, from a regulatory perspective Solvency II treats the debt of all European Union member states as free of default risk. This principle of the new regulatory framework of European insurance industry has been criticized (see, for

example, Basse et al. 2012; Ludwig 2014). Indeed, given that market prices of sovereign debt reflect at least some default risk of countries like Italy or Spain there is some room for regulatory arbitrage (see Basse et al. 2012). Therefore, not only insurers in the European Union member states with fiscal problems could be interested in the behavior of government bond yield spreads to rate hikes by the European Central Bank.

This study presents and evaluates new empirical evidence about the linkages between the monetary policy of the European Central Bank and the yield spreads of French, Italian and Spanish government bonds relative to German ones employing techniques of time series analysis. The paper is structured as follows: The 2nd paragraph provides some relevant background information with regard to the behavior of interest rates in the European Monetary Union. The 3rd section introduces the data examined, provides the results of the necessary pre-testing efforts and then discusses a number of important methodological issues. Some data problems are also addressed here. The empirical evidence is presented and evaluated in the 4th paragraph. The 5th section then concludes.

2.2. Interest Rates and the Euro

Long before the outbreak of the European sovereign debt crisis, there were controversial discussions about the decision which countries should belong to the European Monetary Union (see, for example, Altmann 1994; Calomiris 1999). In fact, even shortly before the start of the new monetary regime there was no clear picture which countries should join the currency union. Although the founders of the European Monetary Union defined some convergence criteria (see, for example, Pollard 1995, 2003) that needed (and still need) to be fulfilled in order to become a member of the euro zone, the "admission tickets" to the prestigious club of member countries of the new currency union most probably were distributed on political thoughts rather than on economic facts. Moreover, it has also been argued that the convergence criteria codified in the Maastricht treaty cannot ensure the needed real convergence among the member states (see, for example, Bayoumi and Eichengreen 1997; Boreiko 2003). Holtemöller (2005) and De Grauwe and Schnabl (2005), for example, have discussed different convergence issues from the perspective of potential accession countries. The theory of optimum currency areas could provide a scientific background when trying to determine which countries (or even regions) should use the same currency. Mundell (1961), McKinnon (1963) and Kenen (1969) have suggested different criteria that an optimum currency area should comply with, helping to minimize the costs of the introduction of a common currency. Among the most important costs of abolishing a country's own currency is that the member states surrender their monetary independence (see, for example, Graboyes 1990; Beetsma and Giuliodori 2010). In fact, a currency union necessarily results in a situation in which the member countries have to give up the ability to autonomously decide about the course of future monetary policy. However, Beine et al. (2003) have questioned the usefulness of the optimum currency area approach to determine which countries should join the European Monetary Union because the potential members of the currency union already were part of an exchange rate system that limited the exchange rate volatility of the currencies participating in this framework. A number of additional studies could be of some relevance at this point. Most importantly, Goodhart (1998) also has challenged the point of view that the theory of optimum currency areas can act as a good starting point trying to analyze how the new monetary union should be designed. This was the so-called European Monetary System. Thus, accepting the German Dominance Hypothesis, the monetary policy decisions taken in Germany also affected the interest rates in the other member states of the European Monetary System (see, for example, Hagen and Fratianni 1990; Herz and Röger 1992). Phrased somewhat

differently, even before the introduction of the Euro there was a controversial discussion which countries should be defined as core Eurozone member states, and which countries ought to belong to the periphery. In fact, there even was no agreement with regard to the criteria how to determine which countries should join the currency union and which countries should stay out (at least for the moment). While there was almost no doubt that Germany and France as biggest European economies should belong to the group of core members (this clearly changed with the European sovereign debt crisis—see Basse 2014), no clear picture with regard to the peripheral did exist back then. Thinking about the now well-known acronym "PIIGS" (referring to the Southern European States Portugal, Italy, Greece and Spain, as well as Ireland), it cannot be surprising that Portugal and Spain were classified as peripheral by Beine and Hecq (1997), while Kouparitsas (1999) identified Ireland and Finland. In retrospect, this seems to be counterintuitive as the only Scandinavian country in the currency union clearly has become one of the more "hawkish" members of the Eurozone in terms of financial soundness.

Without any doubt, the birth of the new common currency in Europe was of major importance for international financial markets (see, for example, Holder 1999 and Hardouvelis et al. 2006). Most importantly, the introduction of the Euro led to strong convergence tendencies among nominal short-, medium- and long-term interest rates in the participating countries. This was a direct consequence of the absence of exchange rate risk after the common currency was created (see, for example, Sibbertsen et al. 2014; Basse et al. 2018). Assuming the absence of differences in liquidity or credit risk, the uncovered interest rate parity indeed does predict that the creation of the currency union should have led to convergence among government bond yields (see, for example, Sibbertsen et al. 2014; Basse 2014). As a matter of fact, the European Monetary System, which also reduced exchange rate risk should already have affected bond yields in the member countries of this exchange rate system (see Basse et al. 2012; Basse 2014). However, Graboyes (1990) has stressed that the European Monetary System was no monetary union. There still were exchange rate movements back then. Thus, the introduction of the Euro should still have affected the price of exchange rate risk in the European bond markets. Additionally, there was just one policy rate in all the countries entering the European Monetary Union from the year 1999 onwards (see, for example, Gaspar et al. 2001; Gruppe et al. 2017). This significantly changed monetary policy environment had some consequence for short-term interest rates in the currency union. Clearly, both facts discussed above were important causes for nominal interest rate convergence in the European Monetary Union. However, fiscal solidity still did seem to matter somewhat for fixed income markets back then (see, most importantly, Codogno et al. 2003). v. Hagen et al. (2011), for example, have examined sovereign credit risk premia in the European government bond market in the period between 1991 and 2005 and have shown that yield spreads depended on the difference in the debt-to-GDP ratios between the respective other member states and Germany, being the reference country. These results have later on been confirmed by Bernoth et al. (2012). Laopidis (2008) also has focused on the development of interest rates in the countries participating in the currency union and was able to split the member countries into two groups using techniques of cointegration analysis – the core countries, like Germany and France, and the peripheral member states like Italy or Ireland.

As already noted, the turmoil that was caused by the financial crisis brought the "PIIGS" into big trouble which was reflected in a significant increase in the interest rate differential between government bonds issued by these countries and German sovereign debt (see, for example, Gruppe and Lange 2014; Ludwig, 2014). Analyzing the interest rate environment in the European Monetary Union at least three different regimes can be identified (see, most importantly, Afonso et al. 2018). More specifically, shortly after (or most probably even before) the Euro had been introduced in 1999, there were clear tendencies for nominal interest rate convergence in the countries that joined the new currency union. The financial

crisis then caused increasing risk premia compensating investors for sovereign credit risk (see, most importantly, Sibbertsen et al. 2014). This important development (at least for a while) seems to have ended the tendencies of interest rate convergence in the European Monetary Union. The reaction of the European Central Bank – which (as already discussed above) decided to loosen its monetary policy drastically as a response to the crisis – then was a kind of "game changer" again. Afonso et al. (2018), for example, have argued convincingly that the quantitative easing measures that have been implemented in 2012 seem to have helped to ease the tensions in the market for European government bonds. As a matter of fact, the unconventional monetary policy measures taken by European Central Bank seem to have lowered risk premia again (see, for example, Krempf 2016; Krishnamurthy et al. 2018).

Gruppe et al. (2017) have noted that the timing of structural change detected in the relationship between government bond yields of peripheral member countries of the European Monetary Union and German interest rates is very interesting. In fact, they have argued that the breakpoint dates reported in a number of empirical studies are quite early. This could be a consequence of the subprime mortgage crisis in the United States. The near collapse of the financial system in North America could indeed have increased the risk aversion among European investors in general. Moreover, concerns about costly rescue programmes for European banks that had invested in mortgage backed securities and collateralized debt obligations issued in the United States might also have had negative effects on the solidity of public finances in some member countries of the European Monetary Union. As a matter of fact, Ejsing and Lemke (2011) have detected structural change in the relationship between bank and sovereign credit default swap premia after the bailouts of European banks. Moreover, Quaglia and Royo (2015) have stressed the need to divide the European sovereign debt crisis into a banking crisis and balance of payments crisis. At this point it is important to note that European insurers did not have a very significant exposure to mortgage backed securities and collateralized debt obligations issued in the United States (see Eling and Schmeiser 2010; Reddemann et al. 2010). Therefore, the direct consequences of the subprime debacle seem to have been rather limited. However, Eling and Schmeiser (2010) have stressed the importance of in- direct negative effects. Given that numerous central banks were forced to reduce short term interest rates and to supply ample liquidity to financial markets long- term bond yields in many countries (and, of course, also in the European Monetary Union) came under considerable pressure. As already noted, a "flight-to-quality" effect then seems to have increased the demand for low-risk assets pushing down interest rates of German government bonds and similar securities even further (see, for example, Basse 2014 and Gürtler and Neelmeier 2018). Additionally, Niedrig (2015) has noted that life insurers based in the monetary union are important holders of fixed income securities issued by European banks. Therefore, there is a direct financial connection between the two types of financial services firms. Consequently, problems in the European banking industry certainly do matter for the insurance industry in the currency union.

2.3. Data and methodological issues

Given that European life insurers have to manage the interest rate risk that is a result from their liabilities (guarantees given to their customers), they have to buy debt obligations with high maturities. Therefore, this study examines sovereign bond yield time series calculated from fixed income securities with maturities of 10 and 30 years. German government bond yields are commonly used as the benchmark interest rate for the European Monetary Union (see, for example, Paniagua et al. 2017 and Rodriguez Gonzalez et al. 2017). This can be explained by the fact that financial markets usually do not see any real risk for a sovereign default in the biggest European economy (see, for example, Ang and Longstaff

2013 and van de Ven et al. 2018). Additionally, the market for government debt issued by Germany is characterized by a very high level of liquidity. Therefore, it is very common to examine interest rate differentials to German government bond yields in the literature. Given that German government bonds are highly liquid and that fixed income investors see no real risk of a debt default of this country, it certainly does make sense to use sovereign debt issued by Germany as benchmark for bonds denominated in the currency Euro. More formally, based on the different interest rates *i* that are examined here, yield spreads *SP* of sovereign debt issued by country *X* (France, Italy or Spain) relative to German bonds with the maturity *Z* (10 or 30 years) are calculated using the simple formula:

$$SP_{X,Z} = D\, i_{x,z} - i_{Germany,Z} \qquad (1)$$

Equation 1 defines an interest rate differential that can be interpreted as risk premium compensating investors for the higher default and liquidity risk of country *X* relative to Germany. The data is taken from Bloomberg. The 10-year and 30-year interest rate time series all are generic government bond yields calculated from the bid side of market quotes. The monetary policy variable examined is the so-called Main Refinancing Operations Announcement Rate, which is directly controlled by the European Central Bank. The study examines monthly data (end of period) from January 1999 to August 2018. The starting point of the sample is determined by limitations to the availability of data. As already noted, there was no single monetary policy instrument for the whole European Monetary Union before the introduction of the Euro.

Examining data from 1999 to 2018 clearly results in some problems with structural change. As already discussed in some detail, the fears about the stability of the fiscal policies in some member states of the European Monetary Union caused structural change in the relationship between the level of interest rates in these countries and government bond yields in Germany (see, for example, Gruppe and Lange 2014; Ludwig 2014). Moreover, Afonso et al. (2018) have argued convincingly that the quantitative easing measures taken by the European Central Bank in August 2012 have helped to ease the tensions in the European government bond market. Phrased somewhat differently, this policy intervention seems to have affected the pricing of sovereign credit risk in the market (see, among others, Krempf 2016; Krishnamurthy et al. 2018). In sum, government bond yield spreads against Germany are now higher than before the crisis and lower than during the crisis. Therefore, Afonso et al. (2018) have argued that three regimes seem to exist. Arghyrou and Kontonikas (2012) have even gone one step further suggesting that the European government debt crisis should be divided into an early and a later phase. They have argued that the events in Greece played a major role in the first part of the crisis. Moreover, Basse, Wegener and Kunze (2018) have noted that financial markets did not care much about sovereign credit risk before the crisis. Thus, interest rate differentials relative to Germany back then probably were too low from the perspective of financial risk managers and, as a consequence, might not be a good reference point for making predictions with regard to the behavior of government bond yield spreads today. This problem could simply be handled by reducing the size of the sample in the process of the estimation of an empirical model. Walsh and Wilcox (1995), for example, have suggested to use this empirical modelling strategy. However, given that this study plans to examine how government bond yield spreads in the European Monetary Union will likely react to the first rate hike by the European Central Bank, this approach would be somewhat problematic because there have been no increases to the monetary policy rate since the year 2008. Moreover, Sims (1998) has argued that omitting clearly unusual periods from econometric models examining central bank actions is not necessarily a good idea because these data points should pro- vide important evidence with regard to the effects of monetary policy. Therefore, he

has suggested to estimate models using the full sample. This position seems to be based on the general idea that the existence of certain mechanisms should lead to some robust linkages among specific economic and financial time series. Obviously, there are no universal laws in the field of economics that lead to absolutely constant interrelationships. However, certain more or less robust relationships still seem to exist. Well-functioning markets, for example, should lead to a situation where the prices of goods and services react to changes to the demand for or to the supply of these goods and services. From a certain perspective this relationship that determines market prices comes quite close to some kind of universal law. Focusing on the research question examined here it seems to be obvious that monetary policy makers in the European currency union will only hike interest rates when there is clear evidence that the financial crisis is over. But clarity seems to end here. In fact, the crisis period that seems to be ending right now, probably is not a good reference point to judge how interest rate increases by the European Central Bank are going to affect sovereign bond yields in the currency union. However, while more convergence among interest rates in the member countries of the European Monetary Union is likely to be seen again after the end of the financial turmoil, it is also improbable that the spread between government bond yields in Germany and in fiscally less stable countries will behave in the future as if there was no crisis in the past (see Sibbertsen et al. 2014). Moreover, given the research question under investigation here, the forecasting financial market literature might also be of some relevance. Dimson et al. (2003), for example, have stressed the need for a long-run perspective projecting the future risk-return trade-off of stock market investments and have argued convincingly that long periods of capital market history should be examined in order to predict the equity risk premium. This approach can help to avoid an overly strong focus on recent historic data that would lead to highly volatile forecasts. In any case, reducing the sample size of regression models as an empirical research strategy to cope with possibly relevant structural change, most probably is not always a good idea.

The unit root test suggested by Phillips and Perron (1988) is performed to determine the order of integration of all variables that are considered in this study. The critical values tabulated by MacKinnon (1996) are used. The results of the unit root tests are reported in Table 1 to 14. All time series seem to be integrated of order 1. Therefore, cointegration between the government bond yield spreads and the monetary policy rate could be a phenomenon of economic relevance. This would have implications for the empirical modelling strategy to be used. However, employing the cointegration test procedures developed by Johansen (1988) no signs for cointegration can be found (see Table 15 to 20). This important empirical finding is robust to different deterministic trend assumptions.

Table 2-1: Unit Root Test Interest Rate Differential (Level) France and Germany (10-year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 4

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.086954	0.2502
Test critical values:	1% level	-3.458104	
	5% level	-2.873648	
	10% level	-2.573298	

Table 2-2: Unit Root Test Interest Rate Differential (First Difference) France and Germany (10-year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 4

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-16.76509	0.0000
Test critical values:	1% level	-3.458225	
	5% level	-2.873701	
	10% level	-2.573327	

Table 2-3: Unit Root Test Interest Rate Differential (Level) France and Germany (30 Year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 4

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.612440	0.4746
Test critical values:	1% level	-3.458104	
	5% level	-2.873648	
	10% level	-2.573298	

Table 2-4 :Unit Root Test Interest Rate Differential (First Difference) France and Germany (30 Year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 3

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-14.46513	0.0000
Test critical values:	1% level	-3.458225	
	5% level	-2.873701	
	10% level	-2.573327	

Table 2-5: Unit Root Test Interest Rate Differential (Level) Italy and Germany (10-year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 5

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.428626	0.5679
Test critical values:	1% level	-3.458104	
	5% level	-2.873648	
	10% level	-2.573298	

Table 2-6: Unit Root Test Interest Rate Differential (First Difference) Italy and Germany (10-year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 6

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-15.40881	0.0000
Test critical values:	1% level	-3.458225	
	5% level	-2.873701	
	10% level	-2.573327	

Table 2-7: Unit Root Test Interest Rate Differential (Level) Italy and Germany (30 Year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 2

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.175161	0.6855
Test critical values:	1% level	-3.458104	
	5% level	-2.873648	
	10% level	-2.573298	

Table 2-8: Unit Root Test Interest Rate Differential (First Difference) Italy and Germany (30 Year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 1

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-15.39120	0.0000
Test critical values:	1% level	-3.458225	
	5% level	-2.873701	
	10% level	-2.573327	

Table 2-9: Unit Root Test Interest Rate Differential (Level) Spain and Germany (10-year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 2

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.459215	0.5527
Test critical values:	1% level	-3.458104	
	5% level	-2.873648	
	10% level	-2.573298	

Table 2-10: Unit Root Test Interest Rate Differential (First Difference) Spain and Germany (10-year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 2

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-17.28893	0.0000
Test critical values:	1% level	-3.458225	
	5% level	-2.873701	
	10% level	-2.573327	

Table 2-11: Unit Root Test Interest Rate Differential (Level) Spain and Germany (30 Year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 1

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.278942	0.6397
Test critical values:	1% level	-3.458104	
	5% level	-2.873648	
	10% level	-2.573298	

Table 2-12: Unit Root Test Interest Rate Differential (First Difference) Spain and Germany (30 Year Bonds)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 2

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-17.17415	0.0000
Test critical values:	1% level	-3.458225	
	5% level	-2.873701	
	10% level	-2.573327	

Table 2-13: Unit Root Test Main Refinancing Operations Announcement Rate (Level)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 9

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.149388	0.6963
Test critical values:	1% level	-3.458104	
	5% level	-2.873648	
	10% level	-2.573298	

Table 2-14: Unit Root Test Main Refinancing Operations Announcement Rate (First Difference)

Null Hypothesis: time series has a unit root
Exogenous: Constant
Bandwidth: 9

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-12.62504	0.0000
Test critical values:	1% level	-3.458225	
	5% level	-2.873701	
	10% level	-2.573327	

Table 2-15: Johansen Cointegration Tests Spread 10 Year France

Sample: 1999M01 2018M12
Included observations: 231
Lags interval: 1 to 4

Selected (0.05 level*) Number of
Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	0	0	0	0
Max-Eig	0	0	0	0

Table 2-16: Johansen Cointegration Tests Spread 30 Year France

Sample: 1999M01 2018M12
Included observations: 231
Lags interval: 1 to 4

Selected (0.05 level*) Number of
Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	0	0	0	0
Max-Eig	0	0	0	0

Table 2-17: Johansen Cointegration Tests Spread 10 Year Italy

Sample: 1999M01 2018M12
Included observations: 231
Lags interval: 1 to 4

Selected (0.05 level*) Number of
Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	0	0	0	0
Max-Eig	0	0	0	0

Table 2-18: Johansen Cointegration Tests Spread 30 Year Italy

Sample: 1999M01 2018M12
Included observations: 231
Lags interval: 1 to 4

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	0	0	0	0
Max-Eig	0	0	0	0

Table 2-19: Johansen Cointegration Tests Spread 10 Year Spain

Sample: 1999M01 2018M12
Included observations: 231

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	0	0	0	0
Max-Eig	0	0	0	0

The empirical findings discussed above do have implications for the modelling strategy to be used in this study. As a matter of fact, vector autoregressions (VAR) can be employed to examine the relationship between the interest rate differentials calculated with Eq. 1 and the monetary policy instrument used by the European Central Bank. Meanwhile, this technique is considered to be an important analytic tool in the field of applied time series econometrics. This approach has been suggested by Sims (1980) and is able to adequately model the feedback relationships among a set of relevant endogenous variables. Therefore, it is certainly no surprise that VAR models have often been used to analyze the effects of central bank actions (see, for example, Eichenbaum and Evans 1995; Walsh and Wilcox 1995). The time series examined have to be stationary. Each of the n endogenous variables in a VAR model is explained by past values of itself and of all remaining other $n– 1$ variables that are considered in the model.

Table 2-20: Johansen Cointegration Tests Spread 30 Year Spain

Sample: 1999M01 2018M12
Included observations: 231
Lags interval: 1 to 4

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	0	0	0	0
Max-Eig	0	0	0	0

More formally, let Y_t be a vector of $(n \times 1)$ endogenous variables that are included in the model:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots A_p Y_{t-p} + \varepsilon_t \quad (2)$$

In Eq. 2 A_i are $(n \times n)$ coefficient matrices, C is a $(n \times 1)$ vector of constants and ε_t is a $(n \times 1)$ vector of random errors. A VAR model of this type can be used to analyze the possibly dynamic relationships among government bond yield spreads and the short-term interest rate that is used as main monetary policy variable in the European Monetary Union. At this point it is important to note again, that all variables examined here seem to be integrated of order 1. Moreover, no cointegration among the short-term interest rate and the different yield spreads can be found. Therefore, a VAR model in first differences should be estimated (see, for example, Ibrahim 2005; Fodha and Zaghdoud 2010).

2.4. Empirical Analysis

Six bivariate VAR models are estimated to examine the relationship between the government bond yield spreads in France, Italy and Spain relative to Germany (10-year respectively 30-year interest rate differentials) and the monetary policy rate in the European Monetary Union. All variables examined are differenced once. The number of time lags to be considered in the models is determined using the HQ information criterion. In all six cases three time lags are included. Then techniques of impulse response analysis are used to examine the dynamic interactions between the endogenous variables in the VAR models. This approach is a very popular way to interpret the results from a VAR model (see, for example, Eichenbaum and Evans 1995; Sims 1998). The impulse response framework is based on the idea that a simulated exogenous shock to one endogenous variable is generated. Then the impact of this shock to the other variables is evaluated. In order to avoid the well-known problem that the results generated using this technique depend on the ordering of the variables in the VAR model when the Cholesky decomposition is employed, the approach of generalized impulses is used instead to compute the impulse response functions (see, for example, Pesaran and Shin 1998; Basse and Reddemann 2010). These are displayed in Fig. 1 to 12.

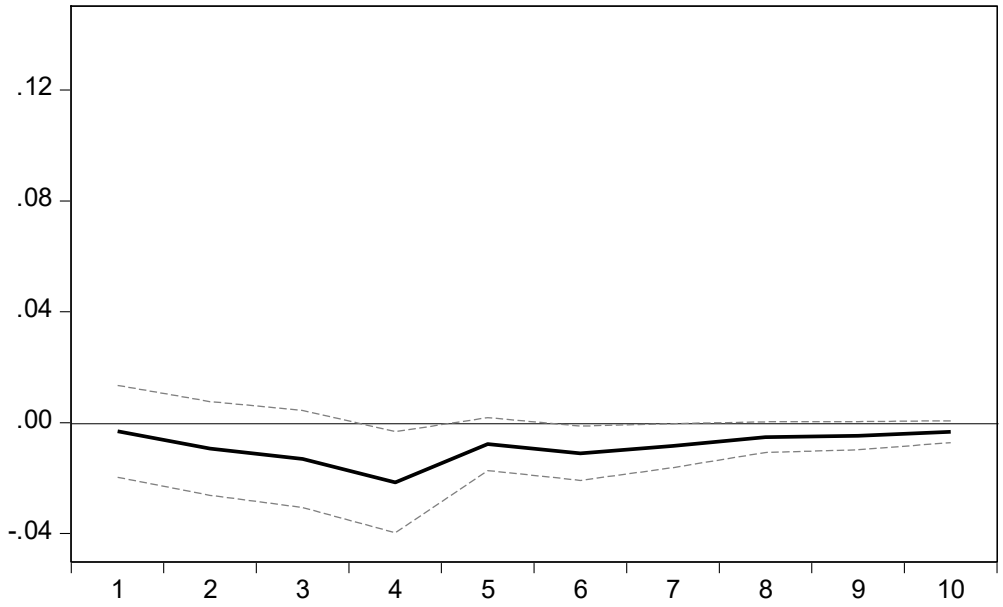

Figure 2-1: Reaction of the monetary policy rate to a shock to the interest rate differential (France and Germany, 10 Years)

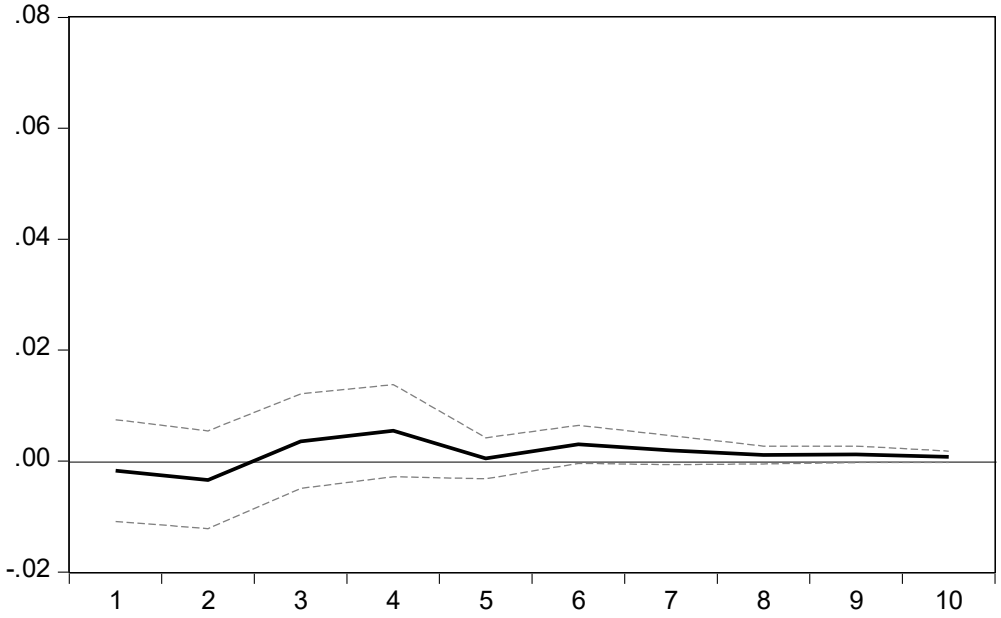

Figure 2-2: Reaction of the interest rate differential (France and Germany, 10 Years) to a shock to the monetary policy rate

The solid lines denote the point estimates from the model. The dashed lines represent the ±2 standard deviation bands. At this point is important to note again that the VAR models are estimated based on the first differences of the time series under investigation.

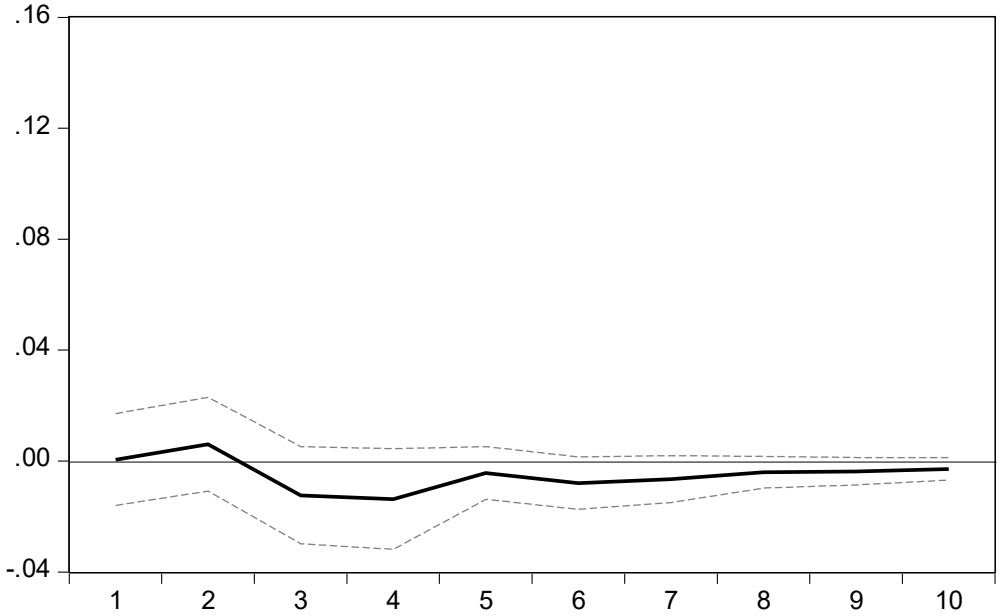

Figure 2-3: Reaction of the monetary policy rate to a shock to the interest rate differential (France and Germany, 30 Years)

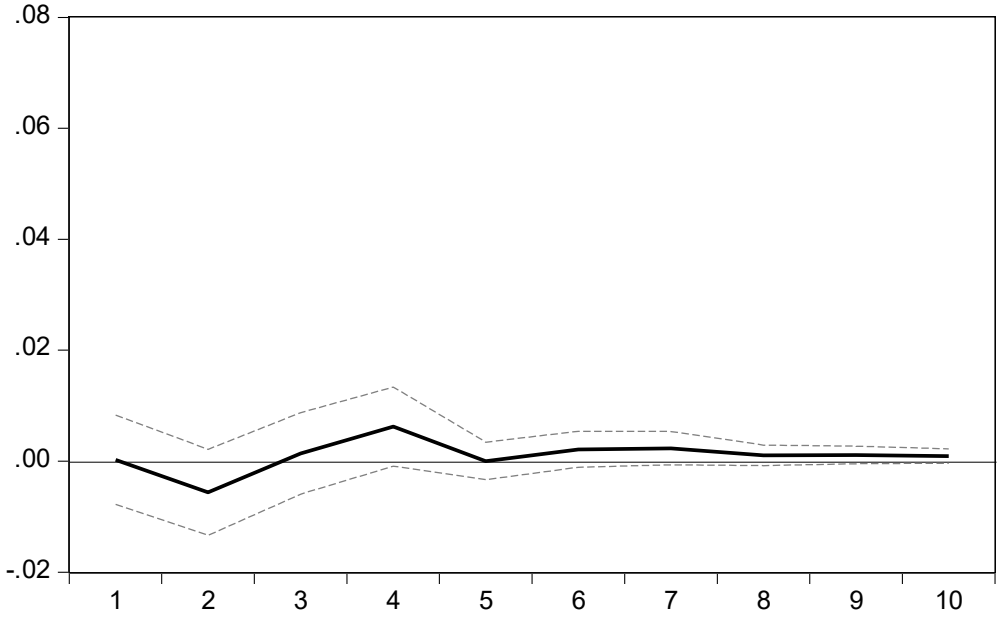

Figure 2-4: Reaction of the interest rate differential (France and Germany, 30 Years) to a shock to the monetary policy rate

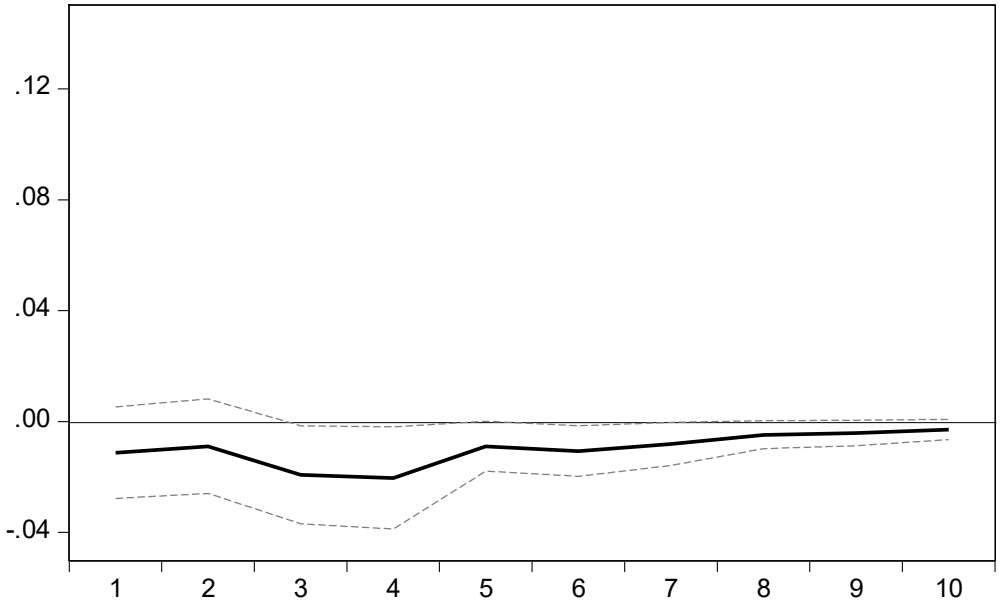

Figure 2-5: Reaction of the monetary policy rate to a shock to the interest rate differential (Italy and Germany, 10 Years)

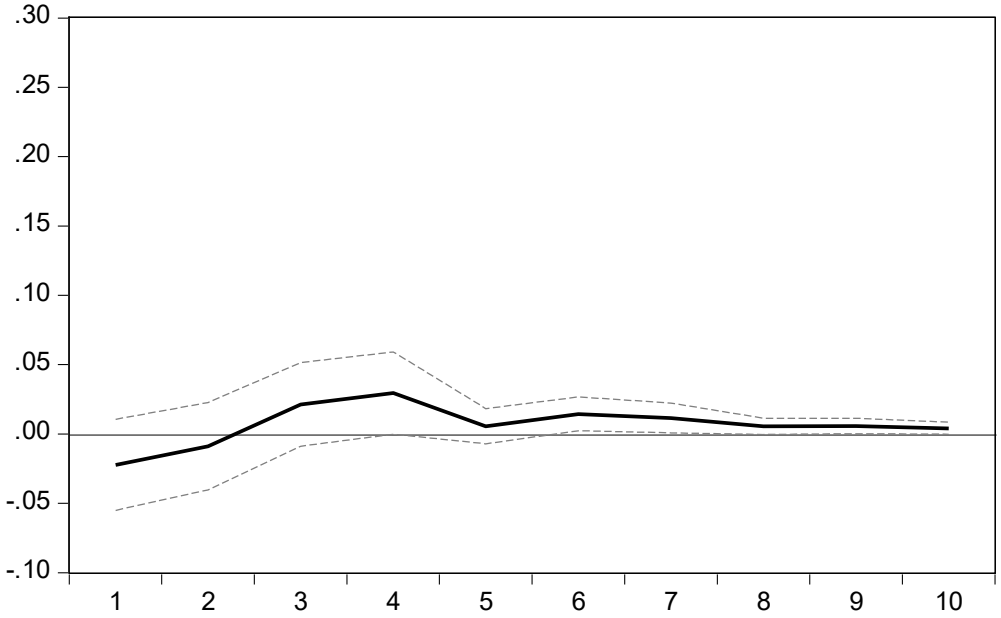

Figure 2-6: Reaction of the interest rate differential (Italy and Germany, 10 Years) to a shock to the monetary policy rate

Therefore, changes to the monetary policy rate respectively the bond yield spread are examined in the models. The impulse response functions show the reaction of one variable to an exogenous positive shock to the other variable included in the six bivariate VAR models. The results that are reported in the Figs. 2, 4, 6, 8, 10 and 12 should be interpreted as a contractionary shock to monetary policy in the European Monetary Union.

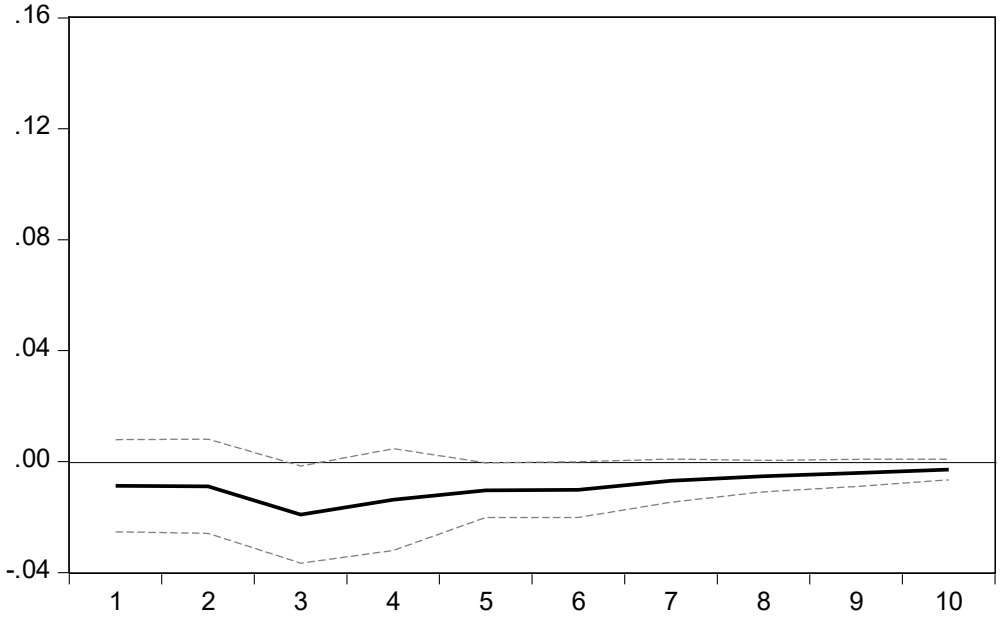

Figure 2-7: Reaction of the monetary policy rate to a shock to the interest rate differential (Italy and Germany, 30 Years)

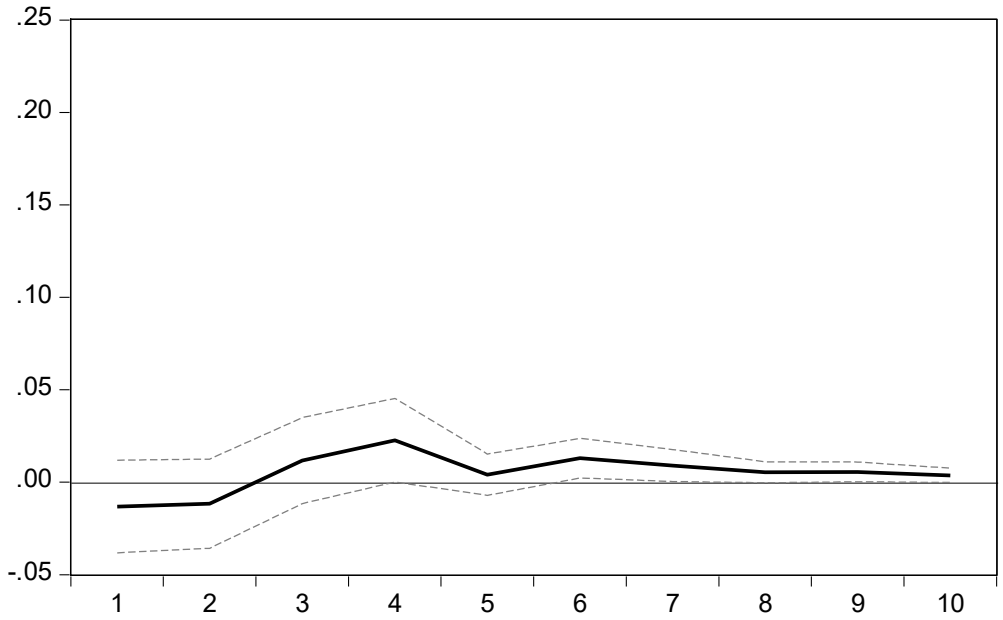

Figure 2-8: Reaction of the interest rate differential (Italy and Germany, 30 Years) to a shock to the monetary policy rate

Phrased somewhat differently, the central bank is increasing the policy rate. In general, there seems to be no strong response of the interest rate differential to a shock to the monetary policy instrument. This is especially true for the first six months after the monetary policy shock.

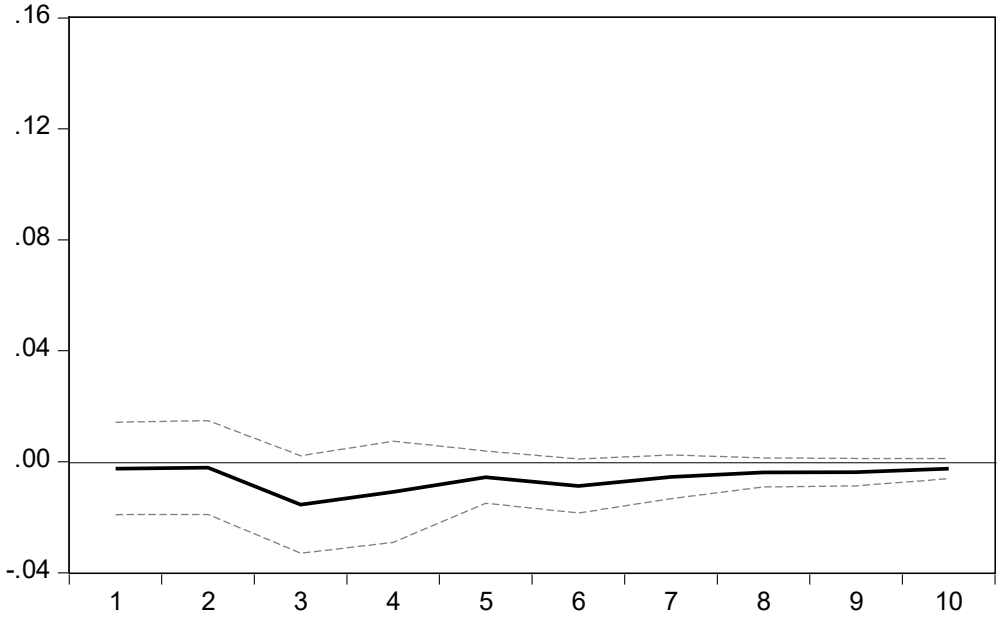

Figure 2-9: Reaction of the monetary policy rate to a shock to the interest rate differential (Spain and Germany, 10 Years)

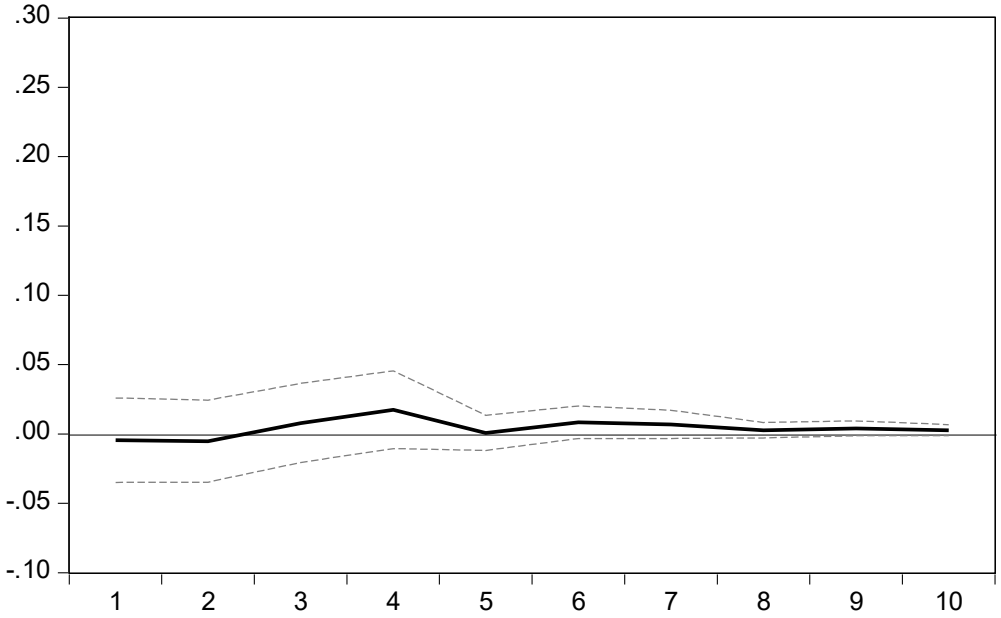

Figure 2-10: Reaction of the interest rate differential (Spain and Germany, 10 Years) to a shock to the monetary policy rate

After about half a year (as the response is slowly fading out) there is a slight and statistically significant reaction of the interest rate differentials to Germany in some cases. However, in general there is no strong positive reaction of the bond yield spreads to a contractionary monetary policy shock implemented by the European Central Bank.

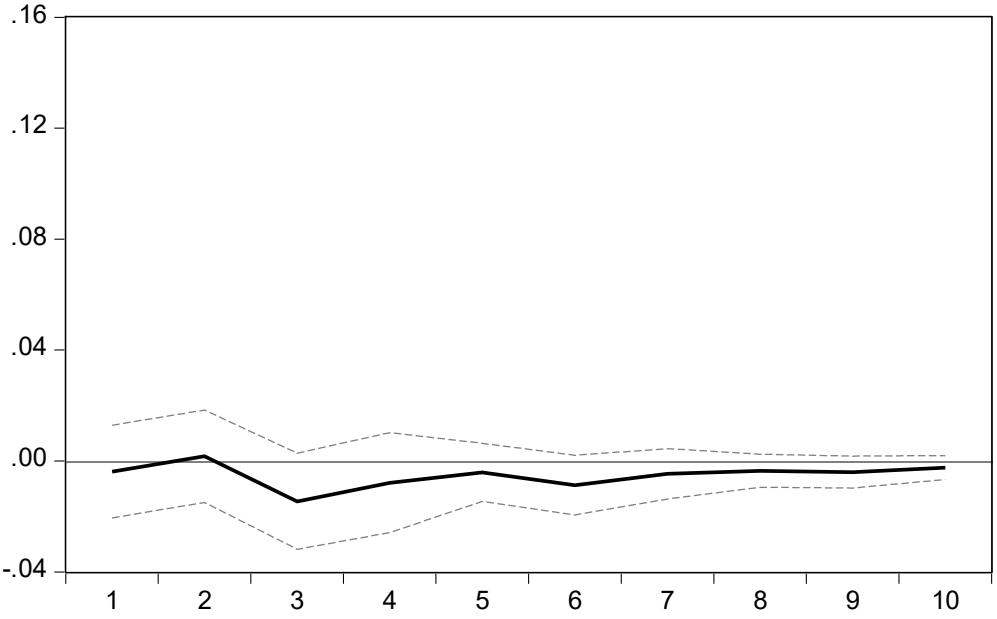

Figure 2-11: Reaction of the monetary policy rate to a shock to the interest rate differential (Spain and Germany, 30 Years)

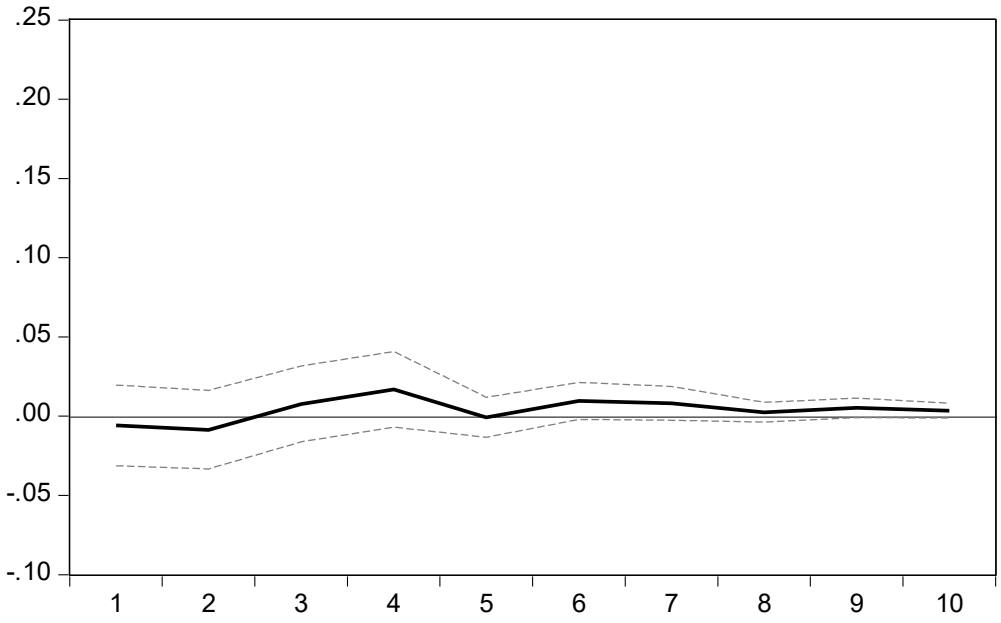

Figure 2-12: Reaction of the interest rate differential (Spain and Germany, 30 Years) to a shock to the monetary policy rate

This empirical finding might be somewhat surprising. Moreover, the results reported above seem to imply that - in general - there is a negative reaction of the monetary policy rate to a positive shock to the government bond yield spread in the first months. In some cases, this empirical finding is statistically significant. This is especially true for the 10-year interest rate differential between France and Germany and between Italy and Germany. Examining Eq. 1 the shock could be a result from higher interest rates in France (respectively Italy), from lower interest rates in Germany or from a combination of both cases. Given the data problems discussed above one certainly should not over-interpret the results reported in the Figs. 1, 3, 5, 7, 9 and 11. However, some thoughts about conceivable explanations still should be discussed here. It is possible that the European Central Bank is reacting to news flow that is pushing down German interest rates. In fact, as already discussed, there have been "flight-to-quality" effects in the crisis that have increased the prices of German sovereign debt and—as a result—lowered the bond yields of these fixed income securities. However, this is most probably not the best explanation for the result reported in Figs. 1 and 5 because the monetary policy rate does not react in statistically significant way to shocks to the interest rate differential between Spanish and German 10-year government bond yields (see Fig. 12). Thus, the central bank seems to respond to changes to the risk premia France and Italy have to offer investors to make them buy debt instruments that have been issued by these countries. One possible reason for this behavior could be the idea that the European Central Bank wants to improve the ability of the two countries to fund their fiscal deficits. Monetary policymakers could also simply react to macroeconomic news that has an effect on government bond yields in France and Italy (for instance, a negative economic environment). In any case, the results reported above seem to be compatible with the European Central Bank trying to use its instruments of monetary policy to anchor Italian and French 10-year government bond yields at sufficiently low levels. This behavior probably could be a result of concerns with regard to the sustainability of government finances in these two economically very important member states of the European Monetary Union. The empirical evidence reported here clearly is interesting and should justify additional efforts to empirically analyze the relationship between government bond yield spreads and central bank actions in the European Monetary Union.

2.5. Conclusion

This paper focuses on the behavior of long-term interest rates in France, Italy and Spain and analyses how government bond yield spreads relative to Germany react to traditional central bank actions (namely rate hikes) in the European Monetary Union. More specifically, fixed income securities with maturities of 10 and 30 years are examined. These long-term bonds are of special importance for the European life insurance industry. Given that other central banks already have hiked rates and that financial markets now seem to be waiting for an increase to the Main Refinancing Operations Announcement Rate, the empirical evidence reported above is of some interest for financial markets. More specifically, techniques of time series analysis are used to gain new insights. The empirical evidence reported here should not only be interesting from the viewpoint of economic theory, but also has practical implications for asset managers working in European insurance companies. Given that there are some data problems, the results of this study probably should not be over-interpreted. Nonetheless, the empirical findings documented in this paper seem to be compatible with the theory that the European Central Bank is trying to use its instruments of monetary policy to anchor Italian and French 10-year government bond yields at sufficiently low levels to help these countries fund their fiscal deficits. Additionally, there is no strong response of the interest rate differentials examined here to a rate hike by the European Central Bank.

2.6. References

Afonso, A., Arghyrou, M.G., Gadea, M.D., Kontonikas, A. (2018) "Whatever it takes" to resolve the European sovereign debt crisis? Bond pricing regime switches and monetary policy effects. J. Int. Money Finance. 86, 1–30.

Altmann, J. (1994): Ist die Europäische Union ein optimaler Währungsraum? Wirtschaftsdienst 74, 312–315.

Ang, A., Longstaff, F.A. (2013). Systemic sovereign credit risk: lessons from the US and europe. J. Monet. Econ. 60, 493–510.

Arghyrou, M.G., Kontonikas, A. (2012). The EMU sovereign-debt crisis: fundamentals, expectations and contagion. J. Int. Financ Mark. Inst Money 22, 658–677.

Basse, T. (2014). Searching for the EMU core member countries. Eur. J. Polit. Econ. 34, S32–S39.

Basse, T., Reddemann, S. (2010). Variable-ordering induced problems of impulse-response analysis and other difficulties: the dividend policy of Austrian firms. Int. J. Comput. Econ. Econom. 1, 278–293.

Basse, T., Friedrich, M., Kleffner, A. (2012): Italian government debt and sovereign credit risk: an empirical exploration and some thoughts about consequences for European insurers. ZVersWiss. 101, 571–579.

Basse, T., Friedrich, M., Kleffner, A., v. d, S.J.-M. (2014). Are interest rates too low? Empirical evidence and implications for German life insurers. ZVersWiss. 103, 31–43.

Basse, T., Kunze, F., Krampen, B., Schwarzbach, C. (2017). German bond markets and US monetary policy. ZVersWiss. 106, 265–276.

Basse, T., Wegener, C., Kunze, F. (2018). Government bond yields in Germany and Spain—empirical evidence from better days. Quant. Finance 18, 827–835.

Bayoumi, T., Eichengreen, B. (1997). Optimum currency areas and exchange rate volatility: theory and evidence compared. In: Cohen, B.J. (ed.) International trade and finance: new frontiers for research, pp. 184–215. Cambridge University Press, Cambridge.

Beetsma, R., Giuliodori, M. (2010). The macroeconomic costs and benefits of the EMU and other monetary unions: an overview of recent research. J. Econ. Lit. 48, 603–641.

Beine, M., Hecq, A. (1997). Asymmetric shocks inside future EMU. J. Econ. Integr. 12, 131–140.

Beine, M., Candelon, B., Sekkat, K. (2003). EMU membership and business cycle phases in Europe: Markov-switching VAR analysis. J. Econ. Integr. 18, 214–242.

Berdin, E., Gründl, H. (2015). The effects of a low interest rate environment on life insurers. Geneva Pap. Risk Insur. 40, 385–415.

Bernoth, K., v. Hagen, J., Schuknecht, L. (2012). Sovereign risk premiums in the European government bond market. J. Int. Money Finance. 31, 975–995.

Boreiko, D. (2003). EMU and accession countries: Fuzzy cluster analysis of membership. Int. J. Finance Econ. 8, 309–325.

Calomiris, C.W. (1999). The impending collapse of the European Monetary Union. Cato J. 18, 445–

452.

Codogno, L., Favero, C., Missale, A. (2003). Yield spreads on EMU government bonds. Econ. Policy 18, 503–532.

Curdia, V., Woodford, M. (2011). The central-bank balance sheet as an instrument of monetary policy. J. Monet. Econ. 58, 54–79.

Dimson, E., Marsh, P., Staunton, M. (2003). Global evidence on the equity risk premium. J. Appl. Corp. Finance 15, 27–38.

Eichenbaum, M., Evans, C.L. (1995). Some empirical evidence on the effects of shocks to monetary policy on exchange rates. Q. J. Econ. 110, 975–1009.

Ejsing, J., Lemke, W. (2011). The Janus-headed salvation: sovereign and bank credit risk premia during 2008–2009. Econ. Lett. 110, 28–31.

Eling, M., Schmeiser, H. (2010). Insurance and the credit crisis: Impact and ten consequences for risk management and supervision. Geneva Pap. Risk Insur. 35, 9–34.

Fawley, B.W., Neely, C.J. (2013). Four stories of quantitative easing. Fed. Reserve Bank St. Louis Rev. 95, 51–88.

Feroli, M., Greenlaw, D., Hooper, P., Mishkin, F.S., Sufi, A. (2017). Language after liftoff: fed communication away from the zero lower bound. Res. Econ. 71, 452–490.

Fodha, M., Zaghdoud, O. (2010). Economic growth and pollutant emissions in Tunisia: an empirical analysis of the environmental Kuznets curve. Energy Policy 38, 1150–1156.

Gaspar, V., Perez-Quiros, G., Sicilia, J. (2001). The ECB monetary policy strategy and the money market. Int. J. Finance Econ. 6, 325–342.

Goodhart, C.A. (1998). The two concepts of money: implications for the analysis of optimal currency areas. Eur. J. Polit. Econ. 14, 407–432.

Graboyes, R.F. (1990). The EMU: forerunners and durability. Fed. Reserve Bank Richmond Econ. Rev. 76, 8–16.

De Grauwe, P., Schnabl, G. (2005). Nominal versus real convergence–EMU entry scenarios for the new member states. Kyklos 58, 537–555.

Gruppe, M., Lange, C. (2014): Spain and the European sovereign debt crisis. Eur. J. Polit. Econ. 34, S3–S8.

Gruppe, M., Basse, T., Friedrich, M., Lange, C. (2017). Interest rate convergence, sovereign credit risk and the European debt crisis: a survey. J. Risk Finance 18, 432–442.

Gürtler, M., Neelmeier, P.: Empirical analysis of the international public covered bond market. J. Empir. Finance 46, 163–181 (2018)

v. Hagen, J., Fratianni, M. (1990). German dominance in the EMS: evidence from interest rates. J. Int. Money Finance. 9, 358–375.

v. Hagen, J., Schuknecht, L., Wolswijk, G. (2011). Government bond risk premiums in the EU revisited: the impact of the financial crisis. Eur. J. Polit. Econ. 27, 36–43.

Hardouvelis, G.A., Malliaropulos, D., Priestley, R. (2006). EMU and European stock market integration. J. Bus. 79, 365–392.

Herz, B., Röger, W. (1992). The EMS is a greater Deutschmark area. Eur. Econ. Rev. 36, 1413–1425.

Holder, M. (1999). The Euro impact on European financial markets. Manag. Finance 25, 27–34.

Holtemöller, O. (2005). Uncovered interest rate parity and analysis of monetary convergence of potential EMU accession countries. Int. Econ. Econ. Policy 2, 33–63.

Ibrahim, M.H. (2005). Sectoral effects of monetary policy: evidence from Malaysia. Asian Econ. J. 19, 83–102

Johansen, S. (1988). Statistical analysis of cointegration vectors. J. Econ. Dyn. Control. 12, 231–254.

Kenen, P. (1969). The theory of optimum currency areas: an eclectic view. In: Mundell, R.A., Swoboda, A. (eds.) Monetary problems of the international economy, pp. 41–60. University of Chicago Press, Chicago.

Kouparitsas, M.A. (1999). Is the EMU a viable common currency area? A VAR analysis of regional business cycles. Fed Reserve Bank Chicago Econ Perspect 23, 2–20.

Krampf, A. (2016). From transparency to ambiguity: The impact of the ECB's unconventional policies on the EMU. J. Eur. Integr. 38, 455–471.

Krishnamurthy, A., Nagel, S., Vissing-Jorgensen, A. (2018). ECB policies involving government bond purchases: impact and channels. Rev. Financ. 22, 1–44.

Laopodis, N.T. (2008). Government bond market integration within European Union. Int. Res. J. Finance Econ. 19, 56–76.

Linderkamp, T., Pollmer, S., Schmidt, P., Siefert, P., Schwalba, M. (2013). Neue Wege in der Kapitalanlage: Die Symbiose zwischen Banken und Versicherungen im Bereich der 'Alternative Assets. ZVersWiss. 102, 273–289.

Ludwig, A. (2014). Credit risk-free sovereign bonds under Solvency II: a cointegration analysis with consistently estimated structural breaks. Appl. Financial Econ. 24, 811–823.

MacKinnon, J.G. (1996). Numerical distribution functions for unit root and cointegration tests. J. Appl. Econom. 11, 601–618.

McKinnon, R.I. (1963). Optimum currency areas. Am. Econ. Rev. 53, 717–725.

Mundell, R.A. (1961). A theory of optimum currency areas. Am. Econ. Rev. 51, 657–665.

Niedrig, T. (2015). Optimal asset allocation for interconnected life insurers in the low interest rate environment under solvency regulation. J. Insur. Issues 38, 31–71.

Paniagua, J., Sapena, J., Tamarit, C. (2017). Sovereign debt spreads in EMU: The time-varying role of fundamentals and market distrust. J. Financial Stab. 33, 187–206.

Pesaran, H.H., Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. Econ. Lett. 58, 17–29.

Phillips, P.C., Perron, P. (1988). Testing for a unit root in time series regression. Biometrika 75, 335–346.

Pollard, P.S. (1995). EMU: will it fly? Fed. Reserve Bank St. Louis Rev. 77, 3–16.

Pollard, P.S. (2003). A look inside two central banks: the European Central Bank and the Federal Reserve. Fed. Reserve Bank St. Louis Rev. 85, 11–30.

Quaglia, L., Royo, S. (2015). Banks and the political economy of the sovereign debt crisis in Italy and Spain. Rev. Int. Polit. Econ. 22, 485–507.

Reddemann, S., Basse, T., v. d, S.J.-M. (2010). On the impact of the financial crisis on the dividend policy of the European insurance industry. Geneva Pap. Risk Insur. 35, 53–62.

Ricci, O. (2015). The impact of monetary policy announcements on the stock price of large European banks during the financial crisis. J. Bank. Finance 52, 245–255.

Rodriguez Gonzalez, M., Kunze, F., Schwarzbach, C., Dieng, C. (2017). Asset liability management and the euro crisis: sovereign credit risk as a challenge for the German life insurance industry. J. Risk Finance 18, 466–483.

Sibbertsen, P., Wegener, C., Basse, T. (2014). Testing for a break in the persistence in yield spreads of EMU government bonds. J. Bank. Finance 41, 109–118.

Sims, C.A. (1980). Macroeconomics and reality. Econometrica 48, 1–48

Sims, C.A. (1998). Role of interest rate policy in the generation and propagation of business cycles: what has changed since the ’30s? In: Fuhrer, J.C., Schuh, S. (eds.) Beyond shocks: what causes business cycles? pp. 121–175. Federal Reserve Bank of Boston, Boston.

van de Ven, R., Dabadghao, S., Chockalingam, A. (2018): Assigning Eurozone sovereign credit ratings using CDS spreads. J. Risk Finance 19, 478–512.

Walsh, C.E., Wilcox, J.A. (1995): Bank credit and economic activity. In: Peek, J., Rosengren, E.S. (eds.) Is bank lending important for the transmission of monetary policy? pp. 83–125. Federal Reserve Bank of Boston, Boston.

3. Bank funding and the recent political turmoil in Italy: What about redenomination risk?

3.1. Introduction

The European government debt crisis has shown that sovereign credit risk is also of some relevance in developed countries (see, for example, Gruppe and Lange 2014 and Ludwig, 2014). Moreover, there have also been fears that redenomination risk could emerge (see, for example, Basse, 2014 and Sibbertsen, Wegener and Basse, 2014). This is a special type of exchange rate risk that will be discussed in more detail later. The European sovereign debt crisis seems to have ended tendencies towards interest rate convergence in the common currency union – at least for a while. Obviously, the introduction of the Euro has eliminated exchange rate risk within the currency union. This simple fact, of course, was also of high relevance for bond investors and should have been a cause for increasing financial integration among those countries that introduced the Euro and for interest rate convergence in the member states of the monetary union (see, amongst others, Holder et al., 2001 and Baharumshah et al., 2005). Then the European government debt crisis triggered fears about sovereign credit risk in some fiscally less solvent member states of the monetary union (and also about a possible breakdown of the currency union). Therefore, there are at least two relevant regimes – which could be called pre-crisis and post-crisis phase. Gruppe et al. (2017) surveyed the relevant literature with regard to this topic. Then the European Central Bank tried to assure investors that it would do whatever it takes to rescue the Euro. In fact, Afonso et al. (2018) have argued convincingly that the monetary policy of 2012 helped to eliminate fears about financial stability (see also Bayer et al., 2018). Consequently, they argue that there are three different regimes. Moreover, Arghyrou and Kontonikas (2012) even have suggested that there was an early and a late crisis phase. Thus, there could even be four regimes. The current political situation in Italy might be the cause of an additional regime shift. In this new potential crisis of the European Monetary Union redenomination risk could play a crucial role. This is the focus of our study. Moreover, there is also quite a lot of empirical evidence indicating that the financial stability of major European economies - which, in this context means governments - is closely related to the stability of the banking systems of these countries (see, for example, Ejsing and Lemke, 2011 and Ludwig and Sobański, 2014). On the one hand, banks that are in trouble could profit from government rescue programs. Therefore, the financial sector can cause fiscal problems for sovereigns. On the other hand, banks do hold government bonds – and tend to have a home bias. Consequently, fears about sovereign debt defaults are also harmful to these financial institutions. Therefore, we will also focus on how the political situation in Rome affects the Italian banking system. Given that there already is empirical evidence examining Italian government bond yields (e.g., Basse, Friedrich and Kleffner, 2012 and Gómez-Puig and Sosvilla-Rivero, 2014) this approach could be quite interesting.

The organization of this paper is as follows; in the next section, the political and economic situation in Italy during our observation period is briefly analyzed. This discussion focuses on economic implications and also explains possible consequences for bond markets. Section 3 then examines the relevance of redenomination risk from a legal and economic perspective. Afterwards, section 4 discusses potential implications for the Italian banking system. The next section presents some empirical evidence focusing on bank refinancing costs in Germany and Italy, employing approaches from time series econometrics. Section 6 concludes.

3.2. Political and economic situation in Italy

Italy is a parliamentary republic formally headed by the president. A prime minister and a cabinet of his choice lead the executive branch. All of them are appointed by the president. The legislative power is divided into two houses – the chamber of deputies and the senate of the republic. They have to approve the cabinet (see Koeppl, 2007). Italy is the 4th largest economy in the European Union (see Eurostat, 2020a) and its government debt-to-GDP ratio is in the EU only surpassed by Greece (see Eurostat, 2020b).

This high ratio partly originated from political and institutional changes and instability, especially in the 1980ies (see Cozzolino, 2020). The European integration enjoyed widespread support in Italy for a long time since it was seen as an external constraint enforcing governmental stability, economic modernization, and control over government finances. The EU also served as a reason for reforms (see Cozzolino, 2020). This was especially true before the Euro crisis during which Italy was one of the countries most affected, resulting in an increase of the debt-to-GDP ratio as depicted in figure 1.

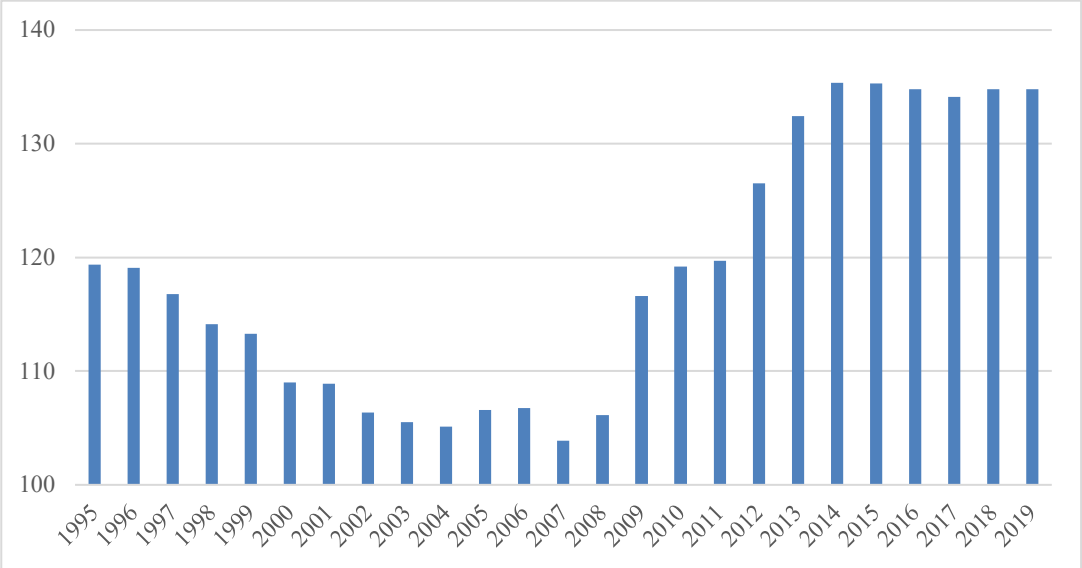

Figure 3-1: Development of government debt relative to GDP (in %) in Italy 1995 – 2019, Source: ECB, 2020e.

As depicted in Figure 2 since 2008 GDP growth rates (blue bars) were low, and especially during the Euro crisis negative, augmenting the debt-to-GDP ratio. Even though the government (except for 2009) produced primary surpluses (red bars) the total resulted in ongoing deficits (orange bars), which were reduced over time but still led to increasing total Government debt (blue line). The economic situation fueled social inequalities and pressure within the country (see Cozzolino, 2020).

The decline in the spread and interest rate around 2011 and 2012 shown in figures 3 and 4 falls parallel to the "Whatever it takes"-comment by Mario Draghi, the asset purchase programs by the ECB as well as the resignation of a Silvio Berlusconi government being directly succeeded by a cabinet considered as "technical" led by Mario Monti (see Balduzzi et al., 2020, and Cozzolino, 2020). In 2018, it became evident that the backing for the European idea faded in Italy and capital markets again focused on its sovereign credit risk. This was primarily due to political changes and the parliamentary elections on March 4, 2018. In May, the populist and rather eurosceptic Lega (League) and Movimento Cinque Stelle (M5S – Five Star Movement) formed a government (see Balduzzi et al., 2020 and Cozzolino, 2020).

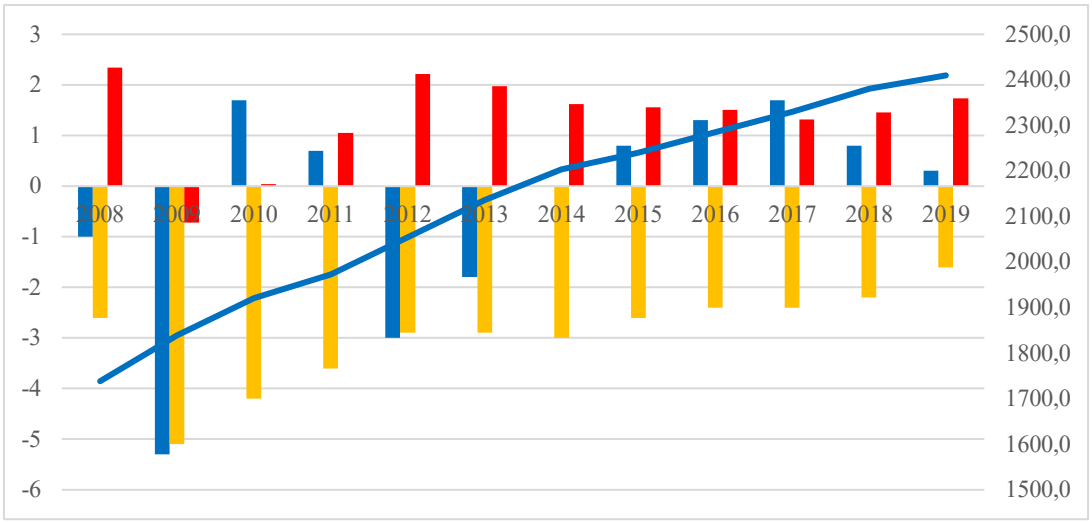

Figure 3-2: Real GDP growth rate (blue bars, in %), Total Government deficit (-) and surplus (+) relative to GDP (orange bars, in %), Primary Government deficit (-) and surplus relative to GDP (red bars, in %), and Government gross debt (blue line, in bn Euro) in Italy 2008 – 2019, Source: ECB, 2020e, Eurostat, 2020b, Eurostat, 2020c, and Eurostat, 2020d.

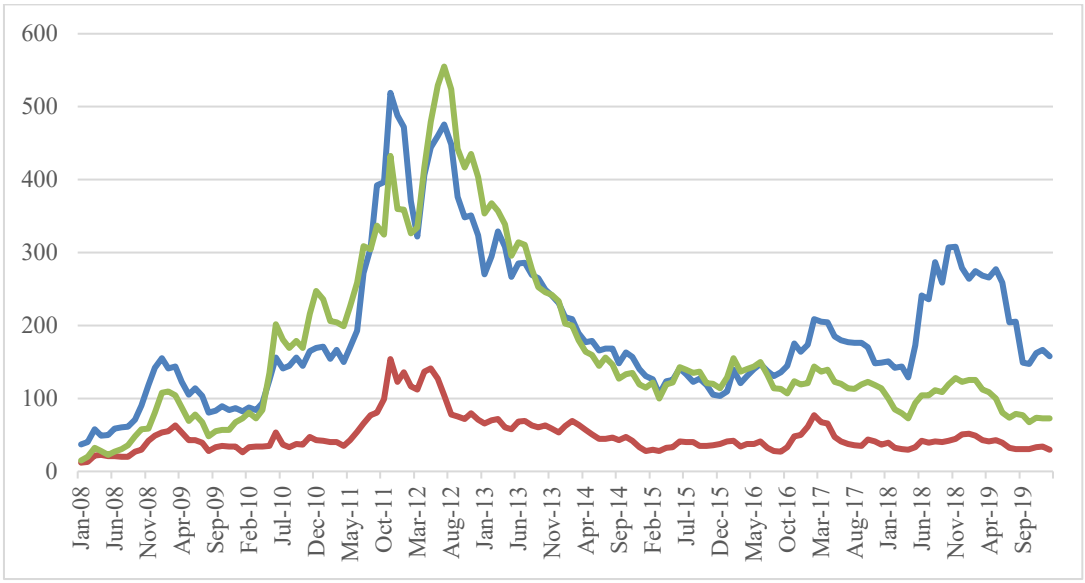

Figure 3-3: Italy (blue line), France (orange line) and Spain (grey line) 10-year vs Germany 10-year bond Spread Jan 2008 to Jan 2020 (in basis points), Source: ECB (2020a), ECB (2020b), ECB (2020c), and ECB (2020d).

The perceived political uncertainty can be seen, for example, in the spread - and thus the risk premium - of Italian vs German government bonds of the same maturity. While the spreads between German and Spanish respectively French government debt remained rather stable, the spread to Italian government debt increased (as shown in figure 2), and the ratings went down (see World Government Bonds, 2020). The spread rose from around 150 basis points at the beginning of 2018 to over 250 basis points in May 2018, with corresponding effects on the correlation between the two government bond markets (see ECB, 2020a, ECB, 2020b, Blanchard et al., 2018 and SVR, 2018). Nonetheless, the peaks remained well below the crisis level at the beginning of that decade.

The yield on Italian government bonds with a remaining maturity of ten years behaved similarly. At its peak, they yielded just above 7.00% at the end of 2011. As can be seen in figure 4, after a steady decline and a longer stable period including large parts of 2017, the interest rate and the risk assessment rose parallel to the political uncertainty in the first half of 2018 and went up to just under 3.70% in October 2018 (see ECB, 2020b). Yield increases could also be observed for other maturities, even though most

pronounced for 4- to 10-year maturities (see Blanchard et al., 2018). All this happened during an ongoing expansive policy by the European Central Bank, which softened the effects (see Balduzzi et al., 2020).

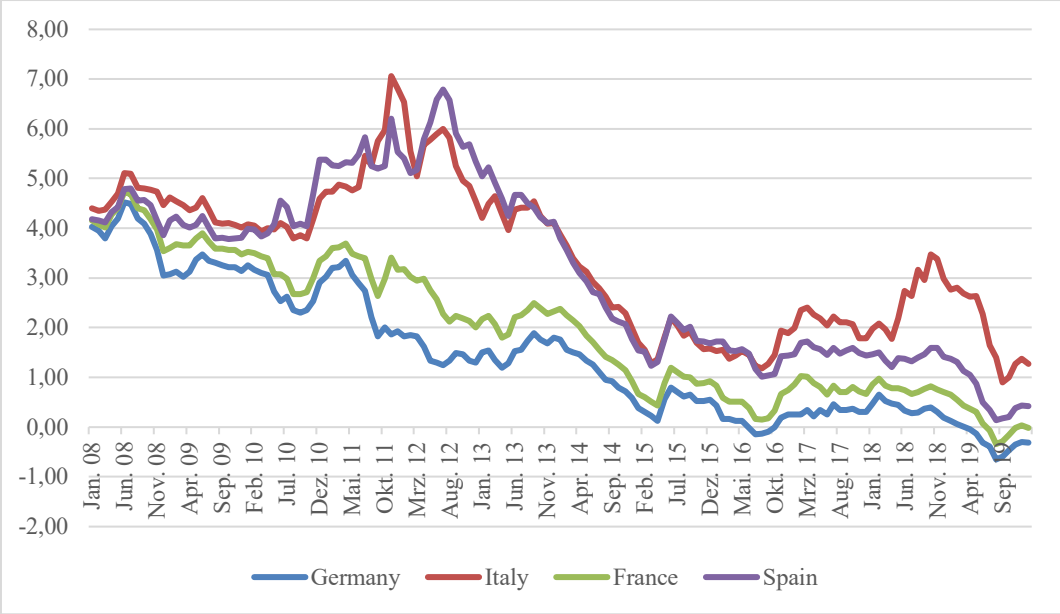

Figure 3-4: Interest rate on 10-year government bonds Jan 2008 to Jan 2020 for Germany, Italy, France, and Spain, Source: ECB (2020a), ECB (2020b), ECB (2020c), and ECB (2020d).

The recognizable skepticism in the financial market was caused by a budget proposal which would have led to a 2.4% deficit. This would have violated European fiscal rules and initiated a controversy between the EU and the Italian government (see Andersen et al., 2019 and Balduzzi et al., 2020).

In the middle of 2019, another proposal sparked a discussion. The Italian government planned to introduce so-called mini-bots (bot stands for "Buono ordinario del Tesoro"), which are basically government-issued debt titles with no maturity and no interest rate in small denominations (e.g. between 5 to 500 EUR) emitted by the ministry of finance. Mini-bots can be used to pay within Italy and should also be accepted for tax payments. Therefore, mini-bots can be seen as a parallel currency to the Euro, which is also reflected in their design resembling classic banknotes (see Menendez, 2019, Meyer et al., 2019 and Meyer, 2020). Consequently, the then president of the Europe Central Bank (ECB), Mario Draghi, asserted that mini-bots are either a currency, which can only be emitted by the ECB and not by a country in the Eurozone, or new debt, which would increase the existing amount outstanding and therefore violate the European fiscal rules (see Menendez, 2019). Fears are that their introduction would facilitate a fast abolishment of the Euro. Proponents of the idea of a parallel currency state that this could improve economic activity within the country (Andresen, 2019). Because of their characteristics, these mini-bots have a theoretical value of zero but receive value through their presumed scarcity and their acceptance as means of payment, e.g. for taxes. A parallel currency with an exchange rate to the Euro would be generated. The construct could lead to Italy leaving the Eurozone requiring some preliminary measures by the other Euro-countries (Andresen et al. 2019, Meyer et al., 2019 and Meyer, 2020).

In August 2019 the government by the Five Star Movement and the League under the independent Prime Minister Giuseppe Conte was ended by the League trying to initiate new elections (Balduzzi et al., 2020 and Cozzolino, 2020). While the positions of the consecutive government are not yet apparent, spreads are declining (Andersen 2020). In the first month of 2020 Europe and especially northern Italy were severely affected by Sars-CoV-2 / Covid-19 with over 230.000 confirmed cases and over 30.000 deaths in Italy alone (Johns Hopkins University & Medicine, 2020). The resulting economic effects will be

severe but their magnitude remains unclear at this point in time. In 2018, especially the political debate in Italy led to increased uncertainty. Especially the discussion about mini-bots led to fears about an exit from the Eurozone. The financial markets reacted with higher yields and spreads in parts also reflecting perceived redenomination risk.

3.3. Some legal thoughts about redenomination risk in the Eurozone

Redenomination risk has to be classified as a special type of exchange rate risk. It is caused by the danger of a member state of a monetary union deciding to leave this currency union. In this case, this country will introduce a new and most probably devaluing currency (see Bayer et al., 2018, Klose and Weigert 2014, and Basse, 2014). Rose (2007) proved that leaving a common currency area does not necessarily lead to financial turmoil. Whether an economy suffers from currency devaluation after leaving a currency area rather depends on the reason for the exit (Eichengreen, 2010). Nevertheless, it should be considered that economies that have already left a currency area in former times did not play a significant role in terms of size. Hence, conclusions that are drawn for the Eurozone from former currency exit experiences should be treated with caution as the Euro is a big player in global financial markets (see, De Santis, 2015).

Due to the principle of currency sovereignty (Lex Monetae) a country that introduces a new currency is likely to convert government bonds issued under national law to the new unit of account. This would be a problem for most foreign investors because the new currency most probably will devalue against most other currencies. In fact, there are hopes that this exchange rate movement could help to solve certain macroeconomic problems (competitiveness) in the country leaving the monetary union. While the member states of the EMU experienced a convergence of sovereign bond yields since the introduction of the Eurozone until the financial crisis, the opposite was the case after the outbreak of the financial crisis. Di Cesare et al. (2012) proved that the until then biggest economic crisis of the new millennium revealed latent macroeconomic problems in the periphery of the euro zone, such as high debt-to-GDP ratio, increasing government budget deficit and low GDP growth, which were reflected in rising spreads. On the other hand, the deterioration of the macroeconomic figures was not sufficient to fully explain the sharp rise in spreads in the peripheral economies (see De Grauwe & Ji, 2012). As these risk premia cannot be completely attributed to quantifiable macroeconomic factors, the gap could correspond to the systemic risk that market investors fear a break-up of the EMU. This is true despite of the fact that there is a lack of a legal basis for this special case (see Siekmann, 2015). Although article 50 of the Lisbon Treaty explicitly provides a legal framework for the process of leaving the European Union (see Lazowski, 2012), it is open to question how a Eurozone exit could be carried out – neither voluntarily, nor by force (see Athanassiou, 2009).

In this context, one should bear in mind that the member states of the Eurozone have lost a popular monetary policy instrument to combat recession: currency devaluation. Nor can the respective central bank can resort to the mechanism used in the USA in the middle of the last century of devaluing public debt through inflation. To restore competitiveness, which has been lost in many countries of the periphery, the protracted adjustment process of wage restraint and painful fiscal cures is needed instead (see Hofmann, 2012). Nevertheless, instruments to establish payment methods independent from the Euro with the idea to strengthen economic development have been brought into the discussion (see the paragraph on mini-bots in chapter 2).

In order to avoid these harsh procedures, politicians could be tempted to pursue an exit of the monetary union and then introduce a national currency. In case of a suffering economy, it would be directly subject

to a sharp devaluation (Di Cesare et al. 2012). The intended short-term side effect would be a sudden increase in competitiveness. The fact that the possibility of the sharp rise in interest spreads was even on the horizon, plunged the entire monetary union into a crisis of confidence, which manifested itself in investors fleeing into safe haven assets. ECB President Mario Draghi stated the risk of a member state leaving the Eurozone as redenomination risk (see Klose and Weigert, 2014).

3.4. Political uncertainty, economic problems, a possible exit from the Euro: Implications for Italian banks

Aiming at scrutinizing the impact of deteriorating sovereign risk on financial institutions, the first option to look at is Italy. This is due to the fact that the worsening of the creditworthiness commenced in the public sector which negatively impacted the ratings in the banking sector and not vice versa like in Ireland or Spain (see Panetta et al., 2011). Moreover, Italy has a long history of high debt levels. The debt-to-GDP ratio between 1993 and 2011 on average amounted to 107% corresponding to the debt level that already prevailed between 1876 until the end of the 19th century. After the end of the post-second-world-war-boom Italy's debt-to-GDP level rose from 34% in the mid-1970s to 119% in the mid-1990s when the then-government commenced conducting a contractionary fiscal policy accompanied by privatization of state-owned companies. Supported by decreasing interest rates, the Treasury managed to push down the debt-to-GDP level to 96% in 2007 when debt levels began to rise again (see Bartoletto et al., 2015).

Italy's sovereign bonds are principally held by domestic financial intermediaries of which the most significant share falls upon domestic banks. Including loans, the Italian banks' exposure to domestic government debt amounts to about EUR 690 bn, making Italian banks the biggest creditor of the government in Rome (see Gros, 2019). Having these numbers in mind is important as the risk of a default decreases with a rising share of domestic debt holders (see Brutti & Sauré, 2013, Broner et al., 2014 and Brunnermeier et al., 2016).

In the past, like in the mid-1940s, Italy reduced its high debt burden through inflation provoking a currency depreciation (see Bartoletto et al., 2015). Since being a member of the EMU, this instrument has disappeared (see Lanotte et al., 2016). Even if the ECB tried to increase competitiveness through value depreciation by following a loose monetary policy, most member states would not benefit as they mostly trade within the Eurozone (see Hofmann, 2012). Hopes that the lack of this instrument of monetary policy would discipline the Italian government's fiscal policy were dashed. On the contrary, Italian politicians were tempted to conduct a loose fiscal policy by converging sovereign yields compared to the time of issuing Lira bonds (see, for example Zoli, 2013). The expansive fiscal policy only began to negatively impact investors' demand for risk premia since the beginning of the financial crisis when distrust started to spread in the financial markets (see Klose & Weigert, 2014 and figure 1).

In times of crises, members of a currency union that are highly indebted can be exposed to redenomination risks. When investors fear that countries are supposed to leave the currency union, in order to regain control of their monetary policy which might help decrease the debt burden by increasing the inflation rates, redenomination risks rise. Anticipating these risks makes investors demand higher risk premia which could provoke a vicious circle (see Kriwoluzky et al., 2019). This is what happened to Italian and Spanish bonds that were exposed to higher sovereign credit spreads due to increasing redenomination fears (see De Santis, 2019).

As a consequence of the emerging sovereign debt crisis, more attention was once again paid to the state-bank nexus that had been slumbering for years. Among others, Barth et al. (2012) could prove that the

worsening of sovereign creditworthiness also harmed its financial institutions. If the depreciation of the banks' portfolios required government aid, the fiscal situation would continue to worsen and turn into a chain reaction (see, for example, Brunnermeier et al., 2016). The negative impact of a struggling fiscal situation on financial institutions is transmitted through several channels. As a fundamental insight in this context, it should be acknowledged that banks tend to hold substantial shares of sovereign bonds as they comply with liquidity requirements and regulatory rationales like the zero-risk weighting for sovereign bonds (see Bolton & Jeanne, 2011). As there is a widespread home bias of banks buying mainly bonds of the home sovereign, a downgrade of one notch of the corresponding sovereign bonds weakens the bank's balance sheet that is holding sovereign debt. In case that the bonds are accounted at market value, the impact is quite immediate. The same applies to loans granted to the domestic country that financial markets consider to get closer to default.
In this regard, claims against a country are not any different than the ones against private debtors apart from the fact that banks tend to have significant exposures to the domestic sovereign. Angelini et al. (2014) emphasize that the EU regulation based on directive 2006/48 does not foster a home bias rather than a preferable treatment of sovereign debt issued regardless by which EU member state. Ongena et al. (2019) could show that banks from the PIIGS countries (Portugal, Italy, Ireland, Greece, and Spain were all suffering from increased sovereign debt yields during the sovereign debt crisis which led to the acronym PIIGS) tripled their holdings of domestic sovereign assets while foreign banks started to lower their exposures to the respective sovereign bonds with the outbreak of the sovereign debt crisis in 2010. Acharya and Steffen (2015) claimed to explain this behavior by moral hazard: Banks in a financially distressed situation increase their exposure to high-yielding sovereign debt that does not burden the banks' risk weighting.
Another transmission channel is the deterioration of sovereign bonds as collateral. This is the case for repo transactions as well as interbank loans and liquidity facilities offered by central banks that require highly liquid assets as collateral (see Bolton & Jeanne, 2011). As the sovereign security is decreasing in its value, the bank that aims to use this security as collateral for repo transactions is limited in its capacity to demand funding due to the worsening of the underlying sovereign asset (see Cooper & Nikolov, 2018). Even here, the regulation does indicate preferable treatment for sovereign bonds but not necessarily for domestic sovereign bonds (see Angelini et al., 2014). Another transmission channel for the negative feedback loop of aggravating sovereign credibility is driven by the fact that it is supposed to correspond to lower output expectations through depressing investment which in turn pulls down output. This leads to lower tax income for the Treasury which implies a weakened debt-paying capacity with a negative impact on banks as credit providers for governments (see Bolton & Jeanne, 2011).

It may also happen that the sovereign asset is not regarded as being liquid at all times, which increases the liquidity risk. Moreover, in case of decreasing creditworthiness of a sovereign, its implicit guarantee for the national banks is weakened as well, which leads to rising funding costs. To prevent a shortfall of liquidity supply, public debt issuers suffering financial problems are forced to apply the same instruments as their private counterparts – they have to elevate the yields in order to compensate the investors for the increased default risk. The increased wholesale refinancing costs depress the profit and loss account, which weighs on the bank's capital figures. As rating agencies anticipate these transmission channels a worsening of one or more notches in a sovereign's rating has a trickle-down-effect on the credit assessment of domestic banks (see among others Gertler and Kiyotaki, 2010). This also happens because the sovereign's rating corresponds to an implicit ceiling for the rating of financial institutions registered in the same jurisdiction. The sovereign's rating can also have a negative back-

loop on being used as collateral. The worst-case would be losing investment-grade status because the investment regulations of institutional investors tend not to accept such underlying (see Angelini et al., 2014).

No matter which transmission channel triggered the sovereign's rating downgrade, it deteriorates the banks' funding which trickles down to companies and other borrowers of the same jurisdiction, which could finally lead to a negative feedback loop of worsening the sovereign's as well as the banks' solvency. The impact of the sovereign debt crisis on financial institutions could be perceived in the market for commercial papers which is a common instrument for short term bank funding. In the second half of 2010, the outstanding amounts of commercial papers issued by Italian banks have decreased sharply. As a consequence of their weakening creditworthiness, other PIIGS' countries also had difficulties to place their debt securities during the public debt crisis. In contrast to what would be an intuitive reaction, banks and other financial intermediaries were supposed to foster its portfolio diversification to compensate the home bias and outweigh the deteriorating rating of its sovereign. Corresponding to the renationalization hypothesis, the financial institutions instead expanded their purchases in domestic sovereign papers aiming to hedge the redenomination risk (see Panetta et al., 2011). Brutti and Sauré (2013) could show that the repatriation effect was only true for the PIIGS countries. Between 2006 and 2011, the share of sovereign debt held by domestic creditors of these economies increased from 80% to 87% in contrast to the core countries where this share remained unchanged. In economies with a worsening fiscal situation, the golden rule for banks of matching assets and liabilities in terms of maturities or currencies was transferred into a matching at the national level (see Battistini et al., 2014).

The carry trade hypothesis relieved a different motivation for the described flight to domestic sovereign debt. In the search for profitable investments with low risk adjustments, the increased risk spreads for sovereign bonds of the PIIGS states became a very attractive asset for banks. The investment became even more reasonable, considering the increasing volume of write-offs for corporate loans. Although the theory is called gambling for resurrection, figures do not prove that struggling financial institutions were deeper involved in these trades than more solid banks (see Acharya & Steffen, 2015).

A different hypothesis claimed that banks were forced to buy domestic sovereign debt through moral suasion as public issuers were faced with undersubscribed bonds in times of financial problems. If due to a lack of market demand, a sovereign bond auction was undersubscribed, it would harm the government's credibility which would lead to higher sovereign spreads and thereby backfire on the banks' funding costs (see Ongena et al., 2019). Whether an increase in buying sovereign debt even led to a crowding out of corporate lending is still open to discussion. There is no doubt regarding the curtailment of corporate lending in Italy after the outbreak of the sovereign debt crisis due to increased risk spreads for new credits (see Albertazzi et al., 2014).

There is no clear evidence that the experienced credit crunch was mainly driven by banks' priority for sovereign assets or in their deteriorating financial situation that limited their ability to expand their credit portfolio. Figures indicate that the increased funding costs forced the banks to implement tighter lending conditions that especially smaller firms could not accomplish. Apart from that, the decline in credit lending was also driven by decreasing demand due to an unfavorable economic outlook. The strong interdependence between sovereign credit risk and the credit risk of Italian banks can be perceived by looking at the correlation of changes in the Italian banks' CDS spreads and changes in the Italian sovereign spreads. The close ties between Italian sovereign credit risk and the banks' credit risk are also reflected in lending rates (see Zoli, 2013).

3.5. Bank funding costs in Germany and Italy: Some empirical evidence

At this point it is of some importance to examine data in some detail. We analyze the funding costs of banks in Italy and Germany. To do so, we examine senior unsecured bond yields issued by banks in the two countries. We only consider fixed income securities that are denominated in Euro. All time series are generic bond yields derived from a sample of different banks. The yields are calculated from bond prices at market close. The time series are taken from Bloomberg. It would, of course, also be possible to analyze credit default swap data for German and Italian banks. However, given the research question examined here (and the existence of the interesting Bloomberg data set analyzed here), we decided not to follow this approach. However, it would certainly be interesting to do so in future research. We use weekly data examining bond yields of fixed income securities with maturities of 2 and 5 years. Data availability is a problem (especially in Italy). Therefore, we start in early April 2012. This should be no major problem given the research question examined here (namely how the current political situation in Rome affects the funding costs of banks in Italy). It has to be noted that all Italian banks examined here are rated BBB+, BBB or BBB-. In Germany, the sample of banks used to calculate generic yield time series also includes financial institutes with a better rating. On the other hand, the status of senior unsecured bank bonds in Italy is more favorable for investors than, e.g. German ones in the case of a resolution of the financial institution that has issued the securities (see, for example, Bschor, 2015 and Stanghellini, 2016). In this context, it is of some importance to stress that the empirical evidence that has been reported by Crespi, Giacomini and Mascia (2018) clearly indicates that investors' bail-in rules do matter for buyers of bank debt.

The four time series examined here all seem to be nonstationary and integrated of order one (no details are given in order to conserve space). Given the existence of a common currency, bank bonds in Italy should ceteris paribus be close substitutes to German bank bonds for investors that are searching for exposure in fixed income securities issued by financial companies and denominated in Euro. Therefore, the time series could be cointegrated. However, redenomination risk could be a problem for investors. In fact, local law bank bonds could be redenominated in the new (and most probably depreciating) Italian currency when Rome really would decide to leave the Euro. Moreover, given that governments can fund bank rescue programs, the fiscal stability of the two countries Germany and Italy, should also be of some relevance. Zaghini (2014) has reported empirical evidence that the expectation of implicit sovereign support does matter for market prices of bank bonds. Consequently, both redenomination and sovereign credit risk could affect the equilibrium relationship among senior unsecured bonds issued by German and Italian banks. Therefore, we first test for cointegration among bond yields in Germany and Italy. More specifically, the Johansen procedure (see Johansen, 1988 and Johansen, 1991) is employed. This approach searches for cointegration using maximum likelihood techniques.

Then, the Bierens and Martins (2010) test is applied to search for nonlinearities in the relationship between the interest rate time series. This approach examines the stability of the cointegration vectors. There may also be very abrupt structural change. In this case, it could be a good idea to use empirical techniques that test for breakpoints in vector error correction models (see for example Hansen and Johansen, 1999) instead of the approach suggested by Bierens and Martin (2010). However, the graphical examination of the time series (see figures 5 and 6) seems to suggest that the technique proposed by Bierens and Martin (2010) is the more appropriate way to analyze the relationship between the funding costs of banks in the two countries. In fact, finding time-varying cointegration between German and Italian bank bond yields in the time period examined here could be interpreted as a sign for changes to risk premia that affect the equilibrium relationship among German and Italian senior

unsecured bonds. Given the development in Rome empirical evidence that indicates the relevance of time-variation in the cointegration relationship between the time series examined here might be a consequence of fixed income markets repricing redenomination and sovereign credit risk in Italy.

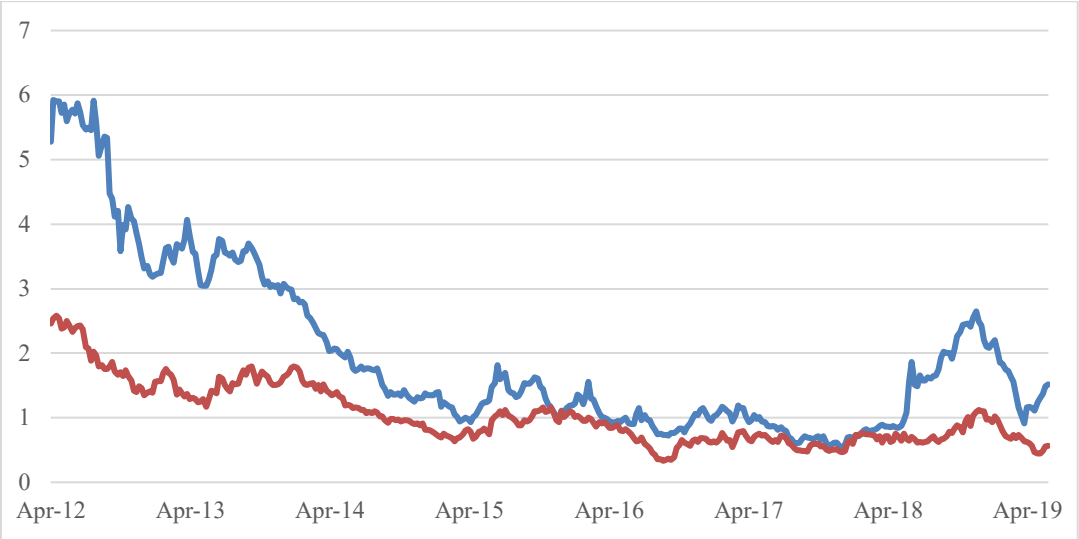

Figure 3-5: 5-year bank bond yields in Germany (orange line) and Italy (blue line) from April 2012 to May 2019. Source: Bloomberg.

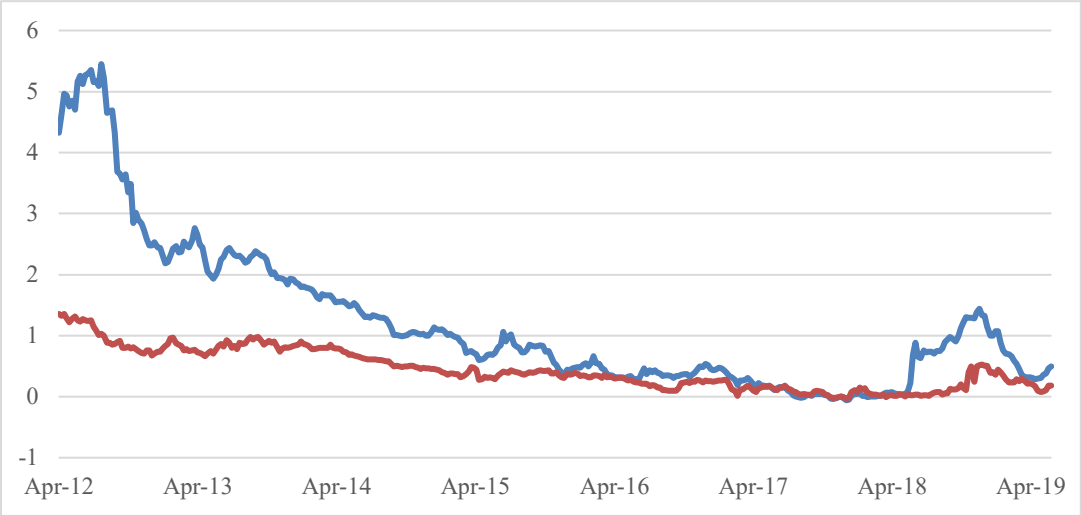

Figure 3-6: 2-year bank bond yields in Germany (orange line) and Italy (blue line) from April 2012 to May 2019. Source: Bloomberg.

There should be no difficulties with degrees of freedom because we examine weekly data here. However, some challenges remain. Most importantly, assumptions with regard to the existence of deterministic trends are a well-known problem when testing for cointegration. We assume that the time series analyzed in this paper are integrated of order one without drift. At least for the first part of the sample examined here, this seems to be an adequate trend assumption. The results for the Johansen tests for bonds with a maturity of 2 years are reported in table 1. Table 2 then provides empirical evidence for 5-year senior unsecured bank bonds in Italy and Germany. In both cases, the critical values are taken from Johansen and Juselius (1990).

Table 3-1: Cointegration between 2-year bank bond yields in Germany and Italy

Trace Test:

Hypothesized No. of CE(s)	Test Statistic	0.10 Critical Value	0.05 Critical Value
None	15.0	12.1	14.0

Max Eigenvalue Test:

Hypothesized No. of CE(s)	Test Statistic	0.10 Critical Value	0.05 Critical Value
None	24.3	13.3	15.2

Table 3-2: Cointegration between 5-year bank bond yields in Germany and Italy

Trace Test:

Hypothesized No. of CE(s)	Test Statistic	0.10 Critical Value	0.05 Critical Value
None	14.9	12.1	14.0

Max Eigenvalue Test:

Hypothesized No. of CE(s)	Test Statistic	0.10 Critical Value	0.05 Critical Value
None	20.8	13.3	15.2

The assumption of no cointegration can be rejected examining 2 and 5-year yields (5% error level). This could be interpreted as empirical evidence for the existence of a strong equilibrium relationship between the markets for Italian and German senior unsecured bank bonds. However, the results of Bierens and Martins (2010) tests reported in tables 3 and table 4 show that nonlinearities do matter. In both tables, m is the number of Chebyshev time polynomials considered.

Table 3-3: Time-varying cointegration test: 2-year bond yields

	Test Statistic	0.10 Critical Value	0.05 Critical Value
m=1	8.52	4.61	5.99
m=2	12.99	7.78	9.49
m=3	25.82	10.64	12.59
m=4	33.62	13.36	15.51
m=5	44.06	15.99	18.31

Table 3-4: Time-varying cointegration test: 5-year bond yields

	Test Statistic	0.10 Critical Value	0.05 Critical Value
m=1	39.34	4.61	5.99
m=2	45.47	7.78	9.49
m=3	56.05	10.64	12.59
m=4	70.91	13.36	15.51
m=5	72.38	15.99	18.31

Independently from m the null hypothesis that the cointegrating vector is time-invariant is always rejected. Therefore, nonlinearities are present. Therefore, the cointegrating vector is not stable over time. Consequently, there is no robust equilibrium situation in both cases. Given the sample examined here this – as already discussed above – should be a consequence of the political situation in Rome. Quite clearly, redenomination risk could be a potential explanation for our empirical findings reported in tables 3 and 4.

3.6. Conclusion

This paper examines the current political and economic situation in Italy and discussed implications for sovereign credit and redenomination risk. The focus of our paper is the funding situation of Italian banks in relation to government debt. Then empirical evidence is reported examining generic bond yields of senior unsecured bank debt issued by German and Italian financial institutions (with maturities of 2 and 5 years). In both cases, there is clear empirical evidence for cointegration using the Johansen approach (see Johansen, 1988 and Johansen, 1991). This empirical finding seems to indicate a long-term equilibrium relationship between the funding costs of banks in Italy and Germany. However, nonlinearities do matter in this context. In fact, Bierens and Martins (2010) tests suggest that the cointegration vector between both 2- and 5-year generic bank bond yields in Italy and Germany is not stable over time. Without a doubt, changes to risk premia might help to explain this observation. Given the sample analyzed here, redenomination risk could indeed be of some relevance.

3.7. References

Acharya, V.V., Steffen, S. (2015). The “greatest” carry trade ever? Understanding eurozone bank risks. J. financ. econ. 115 (2), 215–236.

Afonso, A., Arghyrou, M.G., Gadea, M.D., Kontonikas, A. (2018). “Whatever it takes” to resolve the European sovereign debt crisis? Bond pricing regime switches and monetary policy effects. J. Int. Money Finance 86, 1–30.

Albertazzi, U., Ropele, T., Sene, G., Signoretti, F.M. (2014). The impact of the sovereign debt crisis on the activity of Italian banks. J. Bank. Financ. 46, 387–402.

Andersen, T.M., Bertola, G., Driffill, J., Fuest, C., James, H., Sturm, J.-E., Uronalosa, C., James, H., Sturm, J.-E., sevic, B. (2020). Chapter 1: Macroeconomic Conditions and Outlook. EEAG Report on the European Economy, 19. CESifo Group Munich, Munich, pp. 10–37.

Andresen, T. (2019). Initiating a parallel electronic currency in a eurocrisis country – why it would work. Real-world economics review 89, 23–31, URL: http:// www.paecon.net/PAEReview/issue89/Andresen89.pdf (from 29.05.2020).

Angelini, P., Grande, G., Panetta, F. (2014b). The Negative Feedback Loop Between Banks and Sovereigns. Bank of Italy Occasional Paper, pp. 213.

Arghyrou, M.G., Kontonikas, A. (2012). The EMU sovereign-debt crisis: fundamentals, expectations and contagion. J. Int. Financ. Mark. Inst. Money 22, 658–677.

Athanassiou, P. (2009). Withdrawal and Expulsion From the EU and EMU: Some Reflections. ECB Legal Working Paper Series, No. 10.

Baharumshah, A.Z., Haw, C.T., Fountas, S. (2005). A panel study on real interest rate parity in East Asian countries: pre-and post-liberalization era. Glob. Financ. J. 16, 69–85.

Balduzzi, P., Brancati, E., Brianti, M., Schiantarelli, F. (2020). Populism, Political Risk and the Economy: Lessons From Italy. IZA Discussion Papers, No. 12929. Institute of Labor Economics (IZA), Bonn.

Barth, J.R., Prabha, A., Yun, G. (2012). The Eurozone financial crisis: role of interdependencies between bank and sovereign risk. J. Financ. Econ. Policy 4 (1), 76–97.

Bartoletto, S., Chiarini, B., Marzano, E., Piselli, P. (2015). Business Cycles, Credit Cycles and Bank Holdings of Sovereign Bonds: Historical Evidence for Italy., pp. 1861–2013.

Basse, T. (2014). Searching for the EMU core member countries. Eur. J. Polit. Econ. 34, S32–S39.

Basse, T., Friedrich, M., Kleffner, A. (2012). Italian government debt and sovereign credit risk: an empirical exploration and some thoughts about consequences for European insurers. ZVersWiss. 101, 571–579.

Battistini, N., Pagano, M., Simonelli, S. (2014). Systemic risk, sovereign yields and bank exposures in the euro crisis. Econ. Policy 29 (78), 203–251.

Bayer, C., Kim, C., Kriwoluzky, A. (2018). The Term Structure of Redenomination Risk. German Institute for Economic Research (DIW), pp. 1740, Discussion Papers.

Bierens, H.J., Martins, L.F. (2010). Time-varying cointegration. Econ. Theory 26, 1453–1490.

Blanchard, O., Leandro, A., Merler, S., Zettelmeyer, J. (2018). Impact of Italy's Draft Budget on Growth and Fiscal Solvency. Peterson Institute for International Economics, Policy Brief., pp. 18–24.

Bolton, P., Jeanne, O. (2011). Sovereign default risk and bank fragility in financially integrated economies. Imf Econ. Rev. 59 (2), 162–194.

Bootle, R., Revised resubmission for the Wolfson Prize. (2012). Leaving the Euro: a Practical Guide.

Broner, F., Erce, A., Martin, A., Ventura, J. (2014). Sovereign debt markets in turbulent times: creditor discrimination and crowding-out effects. J. Monet. Econ. 61, 114–142.

Brunnermeier, M.K., Garicano, L., Lane, P.R., Pagano, M., Reis, R., Santos, T., Thesmar, D., Van Nieuwerburgh, S., Vayanos, D. (2016). The sovereign-bank diabolic loop and ESBies. Am. Econ. Rev. 106 (5), 508–512.

Brutti, F., Sauré, P.U., Available at SSRN 2253404 (2013). Repatriation of Debt in the Euro Crisis: Evidence for the Secondary Market Theory.

Bschor, B. (2015). Italian bail-in proposal raises MREL fears. International Financial Law Review 34, 1.

Cooper, R., Nikolov, K. (2018). Government debt and banking fragility: the spreading of strategic uncertainty. Int. Econ. Rev. (Philadelphia) 59 (4), 1905–1925.

Cozzolino, A. (2020). The discursive construction of Europe in Italy in the age of permanent austerity. J. Common Mark. Stud. 58 (3), 580–598.

Crespi, F., Giacomini, E., Mascia, D.V. (2018). Bail-in rules and the pricing of Italian bank bonds. European Financial Management. Early View.

De Grauwe, P., Ji, Y. (2012). Mispricing of sovereign risk and macroeconomic stability in the Eurozone. Jcms J. Common Mark. Stud. 50 (6), 866–880.

De Santis, R.A. (2015). A Measure of Redenomination Risk. European Central Bank. Working Paper Series, pp. 1785.

De Santis, R.A. (2019). Redenomination risk. J. Money Credit Bank. 51 (8), 2173–2206.

ECB (2020a). European Central Bank, Statistical Data Warehouse, Long-term Interest Rate Statistics, Long-term Interest Rate for Convergence Purposes - 10 Years Maturity, Denominated in Euro – Germany.

ECB (2020b). European Central Bank, Statistical Data Warehouse, Long-term Interest Rate Statistics, Long-term Interest Rate for Convergence Purposes - 10 Years Maturity, Denominated in Euro – Italy.

ECB (2020c). European Central Bank, Statistical Data Warehouse, Long-term Interest Rate Statistics, Long-term Interest Rate for Convergence Purposes - 10 Years Maturity, Denominated in Euro – France.

ECB (2020d). European Central Bank, Statistical Data Warehouse, Long-term Interest Rate Statistics, Long-term Interest Rate for Convergence Purposes - 10 Years Maturity, Denominated in Euro – Spain.

ECB (2020e.) European Central Bank, Statistical Data Warehouse, GFS: Government Finance Statistics, Gross Consolidated Government Debt – Total.

Eichengreen, B. (2010). The breakup of the euro area. In: Europe and the Euro. 11-51. University of Chicago Press.

Ejsing, J., Lemke, W. (2011). The Janus-headed salvation: sovereign and bank credit risk premia during 2008–2009. Econ. Lett. 110, 28–31.

Eurostat (2020a.) GDP And Main Components (output, Expenditure and Income).

Eurostat (2020b)., URL: https://ec.europa.eu/eurostat/product?code=GOV 10DD EDPT1&mode=view (from 29.05.2020) General Government Gross Debt - Annual Data.

Eurostat (2020c), URL: https://ec.europa.eu/eurostat/product?code=GOV 10DD EDPT1&mode=view (from 29.05.2020) General Government Deficit (-) and Surplus (+) - Annual Data.

Eurostat (2020d), URL: https://ec.europa.eu/eurostat/product?code=NAMA 10 GDP&mode=viewand https://ec.europa.eu/eurostat/product?code=NAMA 10 PC&mode=view (from 29.05.2020) Real GDP Growth Rate Volume - Annual Data.

Gertler, M., Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. Handbook of Monetary Economics, vol 3. Elsevier, pp. 547–599.

Gómez-Puig, M., Sosvilla-Rivero, S. (2014). Causality and contagion in EMU sovereign debt markets. Int. Rev. Econ. Financ. 33, 12–27.

Gros, D. (2019). Who Holds Italian Government Debt? A Primer. CEPS Policy Insight No 2019-11/June 2019.

Gruppe, M., Lange, C. (2014). Spain and the European sovereign debt crisis. Eur. J. Polit. Econ. 34, S3–S8.

Gruppe, M., Basse, T., Friedrich, M., Lange, C. (2017). Interest rate convergence, sovereign credit risk and the European debt crisis: a survey. J. Risk. Finance 18, 432–442.

Hansen, H., Johansen, S. (1999). Some tests for parameter constancy in cointegrated VAR-models. Econom. J. 2, 306–333.

Hofmann, C. (2012). A legal analysis of the euro zone crisis. Fordham J. Corp. & Fin. L. 18, 519.

Holder, M., Sinha, A.K., Severiens, J.T. (2001). The Euro and capital market integration: are we there yet? Manag. Financ. 27, 32–40.

Johansen, S. (1988). Statistical analysis of cointegration vectors. J. Econ. Dyn. Control 12, 231–254.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica 59, 1551–1580.

Johansen, S., Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. Oxf. Bull. Econ. Stat. 52, 169–210.

Johns Hopkins University & Medicine (2020), URL: https://coronavirus.jhu.edu/map.html (from 30.05.2020) Coronavirus Resource Center.

Klose, J., Weigert, B. (2014). Sovereign yield spreads during the euro crisis: fundamental factors versus redenomination risk. Int. Financ. 17, 25–50.

Koeppl, S. (2007). Das Politische System Italiens - Eine Einfuehrung, 1st ed. VS Verlag für Sozialwissenschaften / GWV Fachverlage GmbH, Wiesbaden.

Kriwoluzky, A., Müller, G.J., Wolf, M. (2019). Exit expectations and debt crises in currency unions. J. Int. Econ. 121, 103253.

Lanotte, M., Manzelli, G., Rinaldi, A.M., Taboga, M., Tommasino, P. (2016). Easier Said Than Done? Reforming the Prudential Treatment of Banks' Sovereign Exposures. Reforming the Prudential Treatment of Banks' Sovereign Exposures (April 14, 2016). Bank of Italy Occasional Paper, pp. 326.

Ludwig, A. (2014). Credit risk-free sovereign bonds under Solvency II: a cointegration analysis with consistently estimated structural breaks. Appl. Financ. Econ. 24, 811–823.

Ludwig, A., Sobanski, K. (2014). Banking sector fragility linkages in the euro area: evidence for crisis years 2007–2010. Econ. Lett. 125, 451–454.

Menendez, A.J., Goldoni, M., Dani, M. (2019). Mini-BOTs, Complementary Currencies and the European Monetary Malaise. VerfBlog https://verfassungsblog.de/ mini-bots-complementary-currencies-and-the-european-monetary-malaise/.

Meyer, D., et al. (2019). Sorge um Europa: Schuldenkrise und (drohendes) Defizitverfahren gegen Italien – wie geht es weiter? ifo Institut – Leibniz-Institut fuer Wirtschaftsforschung an der Universität München 72 (01), 3–22.

Meyer, D., 2020. Europäische Union Und Währungsunion in Der Dauerkrise - Analysen Und Konzepte Fuer Einen Neuanfang. Springer, Wiesbaden.

Ongena, S., Popov, A., Van Horen, N. (2019). The invisible hand of the government: moral suasion during the European sovereign debt crisis. Am. Econ. J. Macroecon. 11 (4), 346–379.

Panetta, F., Correa, R., Davies, M., Di Cesare, A., Marques, J.-M., Nadal de Simone, F., Signoretti, F., Vespro, C., Vildo, S., Wieland, M., Zaghini, A. (2011). The impact of sovereign credit risk on bank funding conditions. In: Bank for International Settlements, Committee on the Global Financial System (CGFS) Papers, 43. Rose, A.K., 2007. Checking out: exits from currency unions. In: CEPR Discussion Papers 6254. C.E.P.R, Discussion Papers.

Ryvkin, B. (2013). Saving the euro: tensions with european treaty law in the european union's efforts to protect the common currency. Cornell Int'l LJ 45, 227–255.

Scott, H.S. (1998). When the euro falls apart. Int. Financ. 1 (2), 207–228.

Sibbertsen, P., Wegener, C., Basse, T. (2014). Testing for a break in the persistence in yield spreads of EMU government bonds. J. Bank. Financ. 41, 109–118. Siekmann, H., 2015. Exit, Exclusion, and Parallel Currencies in the Euro Area (No. 99). IMFS Working Paper Series.

Stanghellini, L. (2016). The implementation of the BRRD in Italy and its first test: policy implications. J. Financ. Regul. 2, 154–161.

SVR – Sachverstaendigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (2018). Vor Wichtigen Wirtschaftspolitischen Weichenstellungen – Jahresgutachten 18/19.

World Government Bonds (2019), URL: http://www.worldgovernmentbonds.com/credit-rating/italy/ (from 29.08.2019). Italy Credit Ratings Historical Data.

Zaghini, A. (2014). Bank bonds: size, systemic relevance and the sovereign. Int. Financ. 17, 161–184.

Zoli, M.E. (2013). Italian Sovereign Spreads: Their Determinants and Pass-through to Bank Funding Costs and Lending Conditions (No. 13-84). International Monetary Fund.

4. Risk premia and the European government bond market: new empirical evidence and some thoughts from the perspective of the life insurance industry

4.1. Introduction

Low interest rates are currently a major problem for the European life insurance industry (see, for example, Basse et al. 2014 and Berdin and Gründl 2015). As a matter of fact, Berdin and Gründl (2015) have argued convincingly that prolonged periods with low long-term interest rates can be regarded as a possibly very dangerous threat to the solvency of those life insurers in Europe that, in the past, have extensively sold policies with expensive guarantees to their customers. This problem is particularly acute in the case of those life insurers that have invested in fixed income securities with durations shorter than those of their liabilities. In any case, the current interest rate environment has caused a hunt for yield among investors that traditionally prefer to buy high quality fixed income securities (see, for example, Conner 2016 and Boubaker et al. 2017). Generally speaking, the low level of interest rates observed today regarding low-risk bonds denominated in Euro is, of course, a direct consequence of the European Central Bank's (ECB) monetary policy. This policy has applied conventional and unconventional tools to provide stimuli to the crisis-shaken economies in the currency union (see, for example, Burriel and Galesi 2018 and Rodriguez Gonzalez et al. 2019). As will be discussed subsequently in more detail, the severe fiscal problems faced by some countries that belong to the European Monetary Union (EMU) have also caused fears about sovereign credit risk and redenomination risk among investors. As a consequence, risk premia have increased resulting in higher yield spreads of bonds issued by countries that suffer from fiscal challenges. In fact, given the regulatory environment (Solvency II) implemented in the European Union (EU) it could be an interesting option for life insurers to buy government bonds issued by member states of the EMU that have to cope with budgetary difficulties (see, most importantly, Basse et al. 2012 and Ludwig 2014).

The rather high risk premia, that the EMU member countries with fiscal imbalances have to pay in order to issue bonds at the moment, certainly could help life insurers to cope with the problems originating from the guarantees embedded in the old policies they have sold to their customers. However, as Lempérière et al. (2017) have persuasively outlined, there are still major problems when trying to explain how risk premia are determined. Additional empirical evidence with regard to interest rate differentials between government bond yields issued by EMU member countries, with and without budgetary problems, certainly is of importance. Currently, the literature examining sovereign yield spreads in the Eurozone seems to follow a macroeconomic approach by, for instance, analyzing the role of the volume of government debt relative to the respective real gross domestic product or the terms of trade as explanatory variables for interest rate differentials (see, amongst others, Maltritz 2012 and Oliveira et al. 2012). This paper takes a different approach by focusing on the information flow between the sovereign yield spreads, examining data from selected member countries of the EMU. To be more precise, lead-lag relationships between interest rate differentials in a number of member countries of the common currency area are examined in detail. Consequently, the question of predictability is another issue. In other words, it is analyzed whether specific interest rate differentials can help to predict other yield spreads. In order to do so, the concept of Granger causality is employed (see, most importantly, Granger 1969). More specifically, the procedure suggested by Toda and Yamamoto (1995) is used to test for Granger causality (respectively Granger non-causality). Gunay (2020) has already applied this

technique to analyze the relationship between liquidity risk and credit risk in the United States. Our study tries to further explore this issue. As already noted we focus on data from the European government bond market. Moreover, the results of our empirical investigations are then primarily assessed from the perspective of the European life insurance industry. However, these findings obviously should also be of interest for the financial economics community in general.

The paper is structured as follows: Section 2 considers the role of government bonds as asset class for European life insurers. In the 3rd section, regulatory issues are examined focusing on Solvency II. Section 4 then briefly addresses the relevant types of risk. The 5th section discusses the tendencies towards interest rate convergence in the currency union after the introduction of the Euro, and then considers the role of the European sovereign debt crisis as well as other related problems. In this context, the ECB's monetary policy response to the economic crisis caused by the on-going Covid-19 pandemic in Europe and other parts of the world is considered in the 6th section. After discussing some relevant methodological issues, the data is presented in the 7th section. The results of our empirical investigations are discussed and evaluated in section 8. The last section then concludes.

4.2. Government bonds as asset class for European life insurers

Since long-maturity sovereign bonds are an asset class of particular importance for long-term investors like life insurance companies, this chapter sheds some light on the manifold reasons for the relevance of this asset class for European life insurers. In general, life insurers' business models are broadly clustered into two product categories: life risk products covering the risk of mortality, and life savings products covering the risk of longevity. Especially the old-age provision business of life insurance is particularly susceptible to interest rate changes. Because of these liabilities with a high duration, the investment horizon of life insurers is rather long-term oriented. This fact may even help to stabilize financial markets by anti-cyclical investment behavior, respectively stimulating economic growth (see, for example, Della Croce et al. 2011 and Focarelli 2017). This highlights the macroeconomic relevance of this financial sector, even though, in the case of sovereign bonds, there are indications of a pro-cyclical investment behavior in economic crises—like the European sovereign debt crisis (see, for instance, Bijlsma and Vermeulen 2016 and Fache Rousová and Giuzio 2019). Moreover, Düll et al. (2017), find evidence for a transmission of sovereign risk to the default risk of insurance companies in the wake of the European sovereign debt crisis, which further illustrates the usefulness of empirical evidence on the lead-lag relationships of EMU sovereign yield spreads. Obviously, the ability to predict future developments of government bond spreads is not only of interest to risk and asset managers in the life insurance industry, as well as policymakers and regulators, but also to pension funds and other long-term investors with high exposure to sovereign bonds in their portfolios.

As already stated above, investors worldwide faced aggravating developments in capital markets in the follow-up of the Global Financial Crisis. Indeed, Domanski et al. (2017) argue that in case of the EMU, the relevance of long-term government bonds has increased during the European low interest rate environment (see, for instance, ECB 2015 for a detailed discussion of the difficulties faced by the European insurance sector in a prolonged period of low interest rates). Overall, yields on European government bonds have fallen sharply, not only due to the aforementioned hunt for yield among European investors, but also because of a self-reinforcing herding effect and a hunt for duration in the insurance sector, which is to some extent explained by an increasing negative duration gap (see Domanski et al. 2017). Likewise, Gründl et al. (2017) argue, that in the context of sovereign bonds, life insurers are especially interested in long-maturity bonds to match the duration of their assets to their

mostly long-term liabilities. According to the 2018 EIOPA insurance stress test report, the average duration of sovereign bond assets is 7.4 years in the insurance industry, in contrast, the average duration of technical provisions (weighted Macaulay) amounts to 12.5 years for life insurers, and thus, indicating an asset liability mismatch (Battiston et al. 2019). Especially large providers of savings products have to deal with a long-term debt structure.

To demonstrate the negative effects in the insurance sector, Fig. 1 shows the guarantee rate contained in classic German life insurance products and the average current interest rate (the sum of the operating profit participation and the guaranteed interest for the life insurance industry weighted by market share) for new business with classic annuity policies. Since the calculation of the maximum technical interest

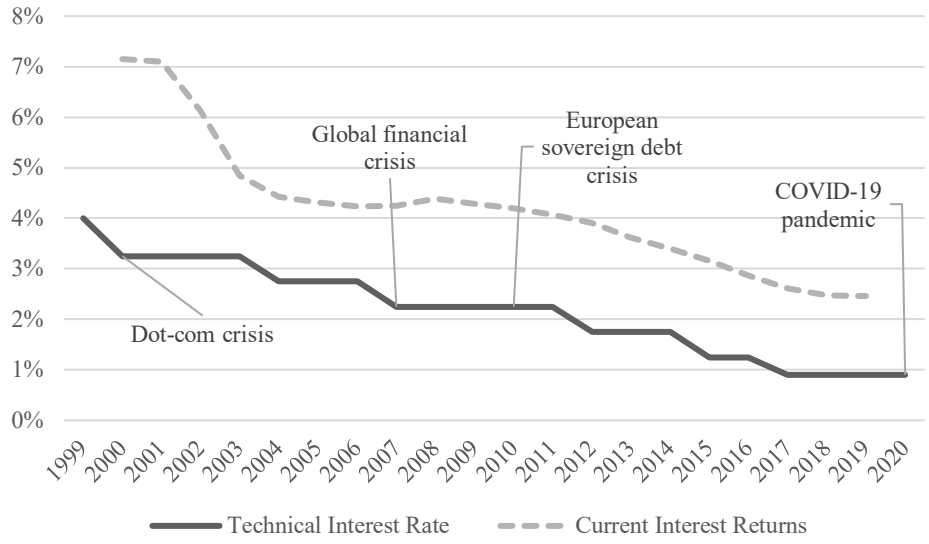

Figure 4-1: The current interest rate and the technical interest rate of German life insurance companies. (Source: Own representation based on Statista Research Department (2020) and German Association of Actuaries (2020).)

rate is based on average historical government bond yields (see Eling and Holder 2013), the figure shows that both values are continuously decreasing over time, undoubtedly, because of past financial and economic crises and the current low interest rate environment. Since many insurance contracts have a maturity of several decades and some older policies carry interest rates of up to 4%, many life insurers in Germany still have guarantee obligations of around 2–3% in their portfolios. Accordingly, there is a combination of existing high yield liabilities and continuously decreasing average yields in the traditional life insurance business.

In fact, the ECB's expansive monetary policy reduced interest rates in Europe, which further challenged the EMU insurance market's returns due to a high sensitivity to interest rate changes in this sector (see, for instance, Van Riet 2017 and Jareño et al. 2020). Berdin and Gründl (2015) state that the impact of the ongoing low interest rate environment will be particularly strong for small and medium-sized life insurance companies that are invested strongly in sovereign bonds. According to the authors, two major features of the life insurance industry trigger these effects: firstly, the high share of fixed income securities in insurers' portfolios, and secondly, the high sensitivity of interest rate effects on discount rates of insurance liabilities. Besides the current interest rate landscape that puts further pressure on government bond yields, due to low interest rates combined with high financial obligations (see Niedrig 2015), the impact of the Covid-19 pandemic could affect the insurers' investment behavior, for example because of a lack (and possible worsening) of investment opportunities. However, as described in more

detail below, there are many indications that investments in sovereign bonds will prevail, as this is still a preferred investment strategy for the European life insurance industry.

In general, according to Fache Rousová and Giuzio (2019), there are at least five aspects that may influence the insurers' investment behavior: Namely "[...] the type of firm and its business model, the structure of the balance sheet, the investment preferences of its management and stakeholders, market developments and the regulatory framework under which an insurance firm operates." (see Fache Rousová and Giuzio 2019, p. 8). Furthermore, when compared to property-liability insurance, life insurers are interested in generating stable cash flows to generate a more predictable calculation of payouts in life insurance products. Moreover, in the life insurance business, the policy provider and the policyholder usually have a business relationship lasting many decades. For this reason, customers' trust in the long-term solvency of the insurance company is of central importance. Therefore, life insurers are known as conservative investors in the institutional environment, as they are primarily interested in secure investments with low volatility (see Focarelli 2017). As a result, the relationship in European (long-term) government bond yield spreads is of special importance for asset managers in the insurance industry.

In the case of the EMU, also tighter regulatory and solvency requirements, put pressure on investment strategies of pension funds and insurance companies (Gründl et al. 2017). Due to the issuing country's membership in the currency union, EMU government bonds in particular were seen as safe investments—at least until the default of Greece in 2012. In addition, government bonds are particularly important to life insurers because of their regulatory treatment under the Solvency II Directive in EMU countries (see Ludwig 2014 and Braun et al. 2017). In fact, the regulatory minimum capital requirements under the Solvency II regime enable the regulator to provide incentives for supposedly safe asset classes—for example, EMU government bonds. This will be discussed in more detail later on in chapter 3. However, Düll et al. (2017) find empirical evidence for regulatory flaws in the Solvency II Directive related to risks in insurers' government bond portfolios being crucial drivers of insurers' default risk in Europe.

Table 4-1: Investment behaviour of European insurance companies (in %). (Source: Own representation based on EIOPA

	2018Q2	2018Q3	2018Q4	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1
Investments (other than assets held for								
Index-linked and Property (not for own use)	3.19	3.27	3.42	3.27	3.22	3.04	3.11	3.31
Holdings in related undertakings, incl. participations	6.35	6.25	6.37	6.55	6.13	5.04	6.45	6.08
Equities	5.04	5.05	4.08	4.29	4.23	3.85	3.76	3.72
Equities – listed	4.15	4.12	3.14	3.37	3.33	2.89	2.90	2.69
Equities – unlisted	0.89	0.93	0.95	0.92	0.90	0.96	0.86	1.03
Bonds	69.65	69.59	67.32	66.46	66.34	66.37	64.82	65.66
Governments Bonds	34.95	34.78	33.85	33.29	33.37	34.26	32.51	33.63
Corporate Bonds	32.48	32.63	31.42	31.09	30.95	30.18	30.46	30.02
Structured notes	1.39	1.36	1.27	1.23	1.21	1.17	1.31	1.18
Collateralized securities	0.84	0.82	0.77	0.85	0.81	0.77	0.54	0.84
Collective Investment undertakings	13.40	13.57	16.40	16.56	17.04	17.90	18.45	16.95
Derivatives	1.21	1.14	1.30	1.64	1.88	2.67	2.27	3.09
Deposits other than cash equivalents	0.83	0.82	0.78	0.90	0.82	0.77	0.77	0.86
Other investments	0.32	0.31	0.34	0.32	0.33	0.34	0.36	0.34

Table 4-2: Insurance companies' asset exposure of CIC 1 government bond assets in selected European countries in Q2 2020. (Source: Own representation based on EIOPA (2020b).)

Country	Exposure	Austria	Belgium	France	Germany	Ireland	Italy	Total
Austria	in %	23.85	9.19	9.92	7.13	3.44	2.95	100
	in EURm	5759	2219	2395	1721	830	711	24,148
Belgium	in %	4.09	52.69	13.16	5.05	1.91	4.57	100
	in EURm	5821	75,056	18,745	7190	2714	6511	142,440
France	in %	2.60	5.42	65.08	2.92	1.08	5.52	100
	in EURm	19,638	40,880	490,854	22,053	8142	41,670	754,270
Germany	in %	4.67	7.78	9.48	41.21	1.77	0.94	100
	in EURm	18,015	30,027	36,589	159,096	6816	3639	386,101
Ireland	in %	4.01	3.67	19.31	13.89	6.43	9.49	100
	in EURm	1732	1586	8345	6002	2778	4102	43,224
Italy	in %	23.85	9.19	9.92	7.13	3.44	2.95	100
	in EURm	2060	6127	13,742	5719	3780	330,822	415,895

To clarify, the equal regulatory treatment of government bonds issued by EMU countries in the internal risk model motivates insurers to invest in European sovereign bonds with the same capital backing requirements, but higher risk premia at the same time. Therefore, in our study, compared to "safe haven assets" like German government bonds, we will analyze both, European government bonds with higher risk premia (like Italy) and lower risk premia (like Austria). Other classification categories are core member states (Austria, Belgium, France) and peripheral member states (Ireland) of the EMU.

The importance of sovereign bonds as asset class is also illustrated by current investment data on the asset structure in the European insurance industry. In Europe, the life insurance sector accounts for 53.62% of all insurers' assets in the second quarter of 2020 and is consequently the largest investor in this industry.[8] In the first quarter of 2020, these companies invested primarily in fixed income products like bonds (65.66%). Table 1 shows that the largest share of capital is invested in government bonds (33.63%) and corporate bonds (30.02%) followed by investment funds (16.95%). These collective investment undertakings represent additional important channels for investing in fixed income securities (see Fache Rousová and Giuzio 2019). Additionally, Table 2 shows the relative and absolute exposures to government bonds in the portfolios of European insurers for the countries analyzed in this paper. The data shows that a high proportion of exposure arises in the domestic market (except in the case of Ireland), but also a large proportion of the total exposure to government bonds in other EMU countries. In brief, Table 1 shows the importance of EMU government bonds as asset class for European insurers, whereby Table 2 stresses the particular importance of being able to identify cross-country lead-lag movements in EMU government bond yield spreads because of the high exposure of bonds of other EMU member countries. As already discussed, insurance market data confirm the relevance of information on this asset class. The EIOPA data shows that Europe's insurance industry is mostly invested in government bonds. However, long-term government bonds are of particular importance for European life insurers, as the average duration of assets is highest for them.

To conclude, life insurance companies and pension funds are long-term investors and, therefore, of particular importance for the financial and economic development. Besides, negative impacts on capital

[8] Authors' own calculations based on EIOPA (2020c).

investments of institutional investors are likely to endure, for example, due to the economic impact of the Covid-19 pandemic. Moreover, new risks in insurers' sovereign bond portfolios could emerge—like, for example, climate risks (see, for example, Battiston et al. 2019). However, it can be expected that insurers will continue to be increasingly invested in government bonds in the future. If the exposure is even increased, for example to lower the negative duration gap, a higher share of long-term fixed income securities would also imply higher risks of interest rate changes in the insurers' portfolios. Such developments could further aggravate the already precarious situation to a so-called "double blow", as for example happened in Japan in the 1990s. Because of various risk scenarios, like a long-lasting low interest rate environment, as well as the danger of a "double blow", or the danger of rising interest rates, our empirical investigation is of specific interest for the insurance industry. Therefore, empirical evidence on the information flow among sovereign yield spreads could be helpful for improving financial risk measures in insurers' asset liability management approaches.

4.3. Some regulatory issues

Aiming to harmonize the EU's regulatory landscape, a reform process targeting the European insurance industry was introduced resulting in a renewed and modernized regulatory framework—the Solvency II Directive (2009/138/EC) (see, for example, Doff 2008 and Ashby 2011). The establishment of a universal industry standard and the underlying political process are widely regarded as ambitious (see, for instance, Smith 2010 and Basse 2020). Amongst others, Quaglia (2011) and Van Hulle (2011), provide an overview of this political reform process and the underlying drivers. Despite its approval in 2009, the Solvency II Directive only entered into force in 2016. Delays and amendments (for example, the Omnibus II Directive approved by the EU Parliament in 2014), which may at least be partly attributed to the emergence of the sovereign debt crisis, prolonged the process (see, most importantly, Doff 2016). In addition to harmonizing the EU insurance market and improving EU insurers' competitiveness, Solvency II mainly aims at promoting a more resilient regulation, effective risk management and transparency (see, for instance, Rae et al. 2018 and Hopt 2013).

To achieve the latter, a so-called three-pillar structure had been designed: the first of the three pillars established quantitative regulation of insurance companies' capital requirements, e.g. the market-consistent valuation of assets and liabilities as well as the determination of the minimum capital requirements (see, for example, Liebwein 2006 and Braun et al. 2018). Hereby, capital requirements for insurance companies in the European Union are harmonized and quantitative reporting is imposed. The second pillar contains qualitative elements of supervision, such as principles for internal risk management and control as well as the supervision of such (see, most importantly, Elderfield 2009). The third pillar predominantly concerns transparency and disclosure requirements, for example, provision of data and information to the supervisor with the overarching aim to promote market discipline (see, for example, Eling et al. 2007 and Liebwein 2006). The three-pillar structure follows a twofold objective: on the one hand, policy holders shall be protected as insurers are required to hold sufficient economic capital, and on the other hand, financial stability is increased (see, amongst others, Boonen 2017 and Gatzert and Wesker 2012). Besides its complexity (see, for instance, Monkiewicz 2013 and Meier, Rodriguez Gonzalez and Kunze, 2020), the Solvency II Directive and its risk-based approach is regarded as highly sophisticated and viewed as a significant improvement to previous regulatory frameworks governing the EU's insurance industry (see, for example, Rae et al. 2018 and Doff 2016).

However, Solvency II does not come without criticism. For example, Eling et al. (2007) review the cost appropriateness of Solvency II, whereas Monkiewicz (2013) criticizes comprehensiveness and

complexity which could be viewed as indicators of compliance costs insurers face. Moreover, another crucial area with room for improvement is addressed in this paper, namely sovereign credit risk under Solvency II.

Vis-a-vis, it is investigated how sovereign credit risk is treated under the three pillars of Solvency II. This evaluation shall help determine whether the current regulatory framework adequately reflects this specific type of risk. With respect to Pillar I, the solvency capital requirements (SCR) specify the amount of funds insurers shall constantly hold in order to withstand an extreme crisis with significant losses. This is a formula-based figure which is newly determined every 12 months quantifying various risks and intending to ensure that insurance companies may avoid default with a 99.5% probability (see, most importantly, European Parliament 2009). In essence, there are two possible approaches to calculate the SCR: (1) applying an internal, bespoke model which requires approval by the supervisor or (2) using the so-called European standard formula (see European Parliament 2009). When applying the standard formula, however, sovereign bonds issued by member states of the European Economic Area (EEA) are classified as risk free with zero risk weight (this has already been discussed briefly in section 2—moreover see, for instance, Basse et al. 2012 and Ludwig 2014). In other words, when an insurance company's regulatory capital requirements are calculated with the standard formula, sovereign credit and default risks are neglected. As a result, these risks are not accounted for under Pillar I of the Solvency II Directive when quantitative risk-based calculations of capital are conducted from a regulatory point of view.

Simultaneously, it should be noted, that Pillar II of the governance system requires insurers to thoroughly examine their sovereign risk exposure. To be precise, under Pillar II insurers are supposed to undertake the so-called own risk and solvency assessment (ORSA), a strategic analysis of an individual company's risk profile and risk management practice to be published as a qualitative report (see, amongst others, Düll et al. 2017; European Parliament 2009). The ORSA aims to ensure that solvency needs related to an individual insurer's risk profile are met, particularly those that are not included or only partly included in the risk assessment based on the standard formula. Consequently, as European government bonds have a zero- risk weight under the standard formula, sovereign risk is supposed to be one of the relevant factors to be determined in the ORSA. In theory, insurers exposed to significant sovereign risk shall reflect scenarios like default of one or more states in their stress tests (Von Saldern 2016). However, ORSA remains ill-defined, especially with respect to the interplay with the calculation of the aforementioned capital requirements (see, most importantly, Gründl and Gal 2013). Ergo, in practice, the results and analysis presented in ORSA reports are not always reliable; this has, for example been stressed by Grima (2017).

Additionally, Pillar II is based on the so-called prudent person principle which states that insurers are only allowed to invest in those kinds of assets of which they are able to properly assess, measure, monitor and manage risks (see, most importantly, European Parliament 2009). Naturally, this also applies to sovereign bonds (Von Saldern 2016). Moreover, as outlined in Art. 5 (1) of the amendment to the Credit Rating Regulation of 2013, insurers are required to undertake their individual credit risk assessments, including risk assessment of government bonds or any other financial instrument contained in their portfolios (see, for example, European Parliament 2013 Von Saldern 2016). For example, indicators like political stability, quality of governance (see, most importantly, Boysen-Hogrefe 2017) as well as a comparison of national economic indicators, such as budget deficits or debt-to-GDP, are useful to properly assess a sovereign bond's default risk (see, most importantly, Maltritz and Molchanov 2014).

Considering the aforementioned challenges and the long-term low interest rate environment in particular, it has become crucial to review the sovereign credit risk treatment under Solvency II, specifically under

the standard formula. Due to the zero-risk weight under the standard formula, any government bond that is issued by any EEA member state in its domestic currency is exempt from solvency capital requirements (see, for instance, Basse et al. 2012 and Ludwig 2014). In consequence, Solvency II does not account for sovereign default risk and ignores sovereign credit risk differentials of member states. Thus, from a regulatory point of view, government bonds issued by countries with comparably larger fiscal imbalances, like e.g. Italy or Spain, are viewed as equally risky and equally unlikely to default as those sovereign bonds issued by fiscally stronger member states, such as Germany, Austria or Finland (see, for example, Basse et al. 2012 and Basse 2020). However, this approach is problematic as government bonds are exposed to individual credit and default risks (see, most importantly, Chaumont 2020). In fact, this has been particularly demonstrated during the Sovereign Debt Crisis in the European Monetary Union (see, most importantly, Meier, Rodriguez Gonzalez and Kunze, 2020). Still, due to the classification as risk-free under SCR, these specific risks are neglected (see, for instance, Basse et al. 2012 and Ludwig 2014). Yet, empirical evidence further proves that sovereign credit risk is priced in by market participants in government bond markets (see, amongst others, Bernoth et al. 2012 and Gruppe and Lange 2014). As pointed out by Basse et al. (2012), it is important to note that regulatory arbitrage may arise when sovereign credit risk is disregarded under Solvency II as this specific risk is generally feared by at least some financial market participants (see, for example, Gruppe and Lange 2014 and Ludwig 2014).

4.4. Risk premia and different types of risk

Risk premia in the segments of the fixed income market that are examined in this paper mainly seem to be driven by three different types of risk—namely liquidity risk, sovereign credit risk and redenomination risk. While liquidity certainly is a key concept in financial economics, there seems to be no well-accepted definition for this important type of risk. Most observers would probably accept the idea that liquidity risk is the risk that a specific asset cannot always be sold without causing a price drop due to a lack of demand for this particular asset. Boudoukh and Whitelaw (1993) have stressed the fact that the value of liquidity seems to be the result of uncertainty concerning future trading needs of current investors. Investors, for example, might be hit by liquidity shocks that would force them to sell assets at specific points in time when prices may be low (see, for instance, Goldreich et al. 2005 and Officer 2007). In these situations, prices of illiquid assets tend to decline more strongly than prices of more liquid assets. As a consequence, investors should be compensated for the existence of liquidity risk. Phrased somewhat differently, a liquidity risk premium ought to exist. However, buy-and-hold investors normally do not plan to sell assets. Therefore, it might be attractive for these investors to prefer holding illiquid assets ("liquidity premium harvesting"). It could be argued that, due to their business model, life insurance companies—which are characterized by a long-term perspective—might not have problems buying assets that cannot be sold instantly without losses due to their illiquidity (see, for example, Möhlmann 2021 and Chodorow-Reich et al. 2021). Liquidity risk obviously does matter for European government bond prices and is directly related to market size (see, for example, Jankowitsch et al. 2006 and Gómez-Puig 2006). Generally speaking, while other factors are also of relevance (for instance active trading in futures), a larger volume of outstanding government debt ought to increase liquidity. Therefore, the smaller member countries of the EMU (e.g., Finland, Ireland or Portugal) should in principle have to pay higher risk premia than the bigger ones (Germany, France and Italy). In fact, empirically evidence seems to clearly point in this direction (see for example, Jankowitsch et al. 2006 and Gómez-Puig 2006). As discussed below in more detail, sovereign credit risk and redenomination risk did not seem to matter

that much for the pricing of government bonds issued by member states of the currency union in the early days of the Euro (see, for example, Gibson et al. 2014 and Basse, Wegener and Kunze, 2018). This has definitely changed since severe fiscal problems have emerged in some member countries of the EMU in the aftermath of the house price collapse in the United States. In any case, the term sovereign credit risk describes the risk that, because of different possible reasons, governments are unable (for example, due to fiscal problems) or unwilling (for instance, because of certain political pressures) to repay their debt (see, for example, Dincecco 2009 and Rodriguez Gonzalez et al. 2019). Should markets anticipate sovereign defaults, investors certainly will demand a compensation for this risk. Countries that are considered to be vulnerable in this context are therefore likely to have to pay higher interest rates to their investors in order to compensate investors for this risk.

Redenomination risk is a very special type of currency risk (see, for example, Grund 2017 and Rodriguez-Gonzalez et al. 2017). A member state that is leaving a currency union because of, for example, fiscal problems or a very strong currency that is hurting the international competitiveness of the respective state's domestic economy, could decide to introduce a new currency and to redenominate its outstanding government bonds that are not governed by foreign law (see, for example, Grund 2017 and Lapavitsas 2018). This measure of economic policy would most certainly affect investors that hold these fixed income securities in a negative way because the new currency of the country leaving the monetary union would likely devalue against the currency that is still used by the states that remain in the currency union. Consequently, investors should demand a compensation for holding bonds that could be redenominated in a weaker new currency. As a result, countries would have to offer higher interest rates in order to sell such fixed income securities.

The different types of risk discussed here seem to be interconnected. As a matter of fact, Paltalidis et al. (2015) have argued convincingly that macroeconomic shocks can have effects on the level of liquidity in financial markets. Negative news flow or losses at certain banks may, for example, lead to contagious fire sales of banks. This could have an impact on liquidity in financial markets. In this context, Paltalidis et al. (2015) have highlighted the importance of sovereign credit risk. From this perspective, our empirical research approach to search for lead-lag-relationships among risk premia certainly makes a lot of sense. As already noted, this approach has already been used by Gunay (2020) to examine the relationship between credit and liquidity risk in the United States.

4.5. Interest rate convergence in the European Monetary Union

In January 1999, the Euro became the new currency in initially 11 European countries (see, for example, Pollard 2003 and Gruppe et al. 2017). From this point on, these states have started to form the EMU. The creation of the common currency in Europe resulted in the founding of the ECB, a new supranational institution assuming responsibility for monetary policy in the common currency area (see, for example, Kool 2000 and Pollard 2003). There is only one so-called Main Refinancing Operations Announcement Rate determined by the ECB. This key interest rate is identical in all member states of the monetary union. Consequently, the introduction of the Euro should—more or less by definition—have resulted in a convergence of money market interest rates in the member states of the EMU (see, for example, Holder 1999 and Gruppe et al. 2017). Obviously, the introduction of the Euro not only had substantial impact on money markets, but also on bond markets. In fact, Kim et al. (2006) have argued convincingly that the adoption of the new common currency caused structural change in the European bond market. First of all, short and long-term interest rates are closely connected to each other. Moreover, the Euro has eliminated the influencing factor exchange rate risk for investors situated in one member state buying

bonds issued in other countries also belonging to the currency union (see, amongst others, Gómez-Puig 2006 and Gruppe et al. 2017). As a matter of fact, Lund (1999) has argued that even before 1999, there already was interest rate convergence between the bond yields in at least some states that later on introduced the Euro because of the pre-agreed binding timetable and the rules for the adoption of the common currency. In any case, the introduction of the Euro and the founding of the ECB caused strong convergence tendencies among nominal short-, medium- and long-term interest rates in the member states of the EMU.

About one decade later, the European Sovereign Debt Crisis changed the way financial markets priced government debt issued by member countries of the monetary union (see, for example, Gruppe and Lange 2014 and Ludwig 2014). Basse (2014) and Sensoy et al. (2019) have stressed, that during the crisis, there have been two groups of countries—namely those with and those without noteworthy fiscal problems. In the context of this crisis, fixed income investors holding bonds issued by certain member countries of the EMU started to fear sovereign credit and redenomination risk (see, among others, Basse 2014 and Sibbertsen et al. 2014). In this difficult environment, there was no broad convergence of interest rates in the currency union anymore. In fact, even flight-to-quality-effects could be observed back then. The strong demand for German sovereign bonds and those of some other fiscally more stable member states of the currency union pushed down the level of interest rates in these countries (see, for example, Sibbertsen et al. 2014 and Phillips and Shi 2019). Investors indeed seemed to fear a collapse of the financial system in the EMU. As a consequence, the responsible economic policy makers saw an urgent need for action. Afonso et al. (2018), for example, have stressed that the ECB's monetary policy measures taken in August 2012 with the aim to improve the liquidity situation in financial markets seem to have contributed greatly to the reduction of tensions in the market for European government bonds. In fact, meanwhile many observers believe that Mario Draghis's now famous speech ("whatever it takes") has helped to more or less completely eliminate the fears prevalent among investors that the EMU could break up (see, for example, Klose and Weigert 2014 and De Vries and De Haan 2016). Phrased somewhat differently, Draghi's words most probably have dramatically reduced the risk premia compensating buyers of sovereign bonds issued by fiscally weaker member states (like, for example, Italy or Spain) for redenomination risk. Additionally, not only the speech (which certainly had an impact on market expectations) but also the unconventional monetary policy measures taken by ECB after Draghi's words (quantitative easing) seem to further have lowered risk premia (see, amongst others, Krampf 2016 and Krishnamurthy et al. 2018).

As a result, the European government bond market seems to be characterized by at least three different pricing regimes for fixed income securities issued by sovereign states (namely before the crisis, after the crisis and after Draghi). Yet the matter is perhaps even more complicated. Arghyrou and Kontonikas (2012), for instance, have suggested that the sovereign debt crisis in Europe should be divided into an early and a later phase and that the mounting fiscal problems in Greece could be of some importance in this context. The meltdown of the housing market in the United States and its effect on the global financial system may also be of relevance (see, most importantly, Wegener, Kruse and Basse 2019). Accompanied by a higher level of risk aversion among investors due to the collapsing mortgage market in North America, the fears of costly bank bail-out programs in Europe (see Basse et al. 2012 and Wegener, Kruse and Basse, 2017) could, in fact, help to explain, why "all of sudden" a sovereign debt crisis has disrupted the government bond market in the EMU. Therefore, it seems reasonable to distinguish between an early phase of the crisis that probably was caused by problems in the banking industry and a more fundamental macroeconomic crisis in specific member countries. The empirical evidence that has been presented by Ejsing and Lemke (2011) seems to point in this direction. Accepting

this perspective, there could be at least four different relevant pricing regimes for government bonds issued by member states of the monetary union after the introduction of the Euro in 1999 (before the crisis, early crisis, late crisis and after Draghi). Moreover, the political turmoil in Italy after the election in 2018 and the monetary policy response to the economic crisis caused by the Covid-19 virus might also have affected sovereign bond markets in Europe.

In any case, meanwhile many observers seem to believe that there certainly was an underpricing of sovereign credit risk in the EMU before 2008 (see, for example, Gibson et al. 2014 and Basse, Wegener and Kunze, 2018), it was possibly followed by an overpricing of redenomination risk and sovereign credit risk after the debt crisis in Greece (see, on the one hand, Gibson et al. 2014 and, on the other hand, the more cautionary comments by Afonso et al. 2020).

Italy represents a suitable example where the two aforementioned crises culminated. The country that is home to the oldest bank in the world was hit not only by a sovereign debt crisis, but also by a financial sector crisis that inflicted harm to each other. Domestic banks suffered from Italy's sovereign rating downgrades that had a negative impact on default rates which adversely affected banks' balance sheets as these were exposed to large volumes of Italian sovereign assets. The same mechanism applies to receivables against the sovereign. Simultaneously, Italy's national budget suffered due to the fact that domestic banks fell into financial distress and required financial support from the government (see Tholl et al. 2020).

4.6. How monetary policy aims at combatting Covid-19

As a lesson learned from the Global Financial Crisis, many governments introduced fiscal measures to tackle a symmetric decline in aggregated demand immediately after the Covid-19 virus began to spread around the world. The fiscal impulse was accompanied by monetary stimuli from central banks following the intention to provide crisis relief more swiftly compared to the 2008 Global Financial Crisis (see Haas and Neely 2020). As this kind of economic shock has been unprecedented in its scale and speed of impact, extensive fiscal and monetary responses have been regarded as proportional to the purpose (see Altig et al. 2020). The monetary authorities repeatedly adjusted their key interest rates due to the pandemic induced supply- and-demand shock (see Botta et al. 2020). As a consequence of the interest rate cuts, the gaps between the key interest rates of major central banks narrowed (see Haas and Neely 2020). In order to understand why the ECB adopted the Pandemic Emergency Purchase Program (PEPP) shortly after Covid-19 began to spread in Europe, the learnings from the sovereign debt crisis in 2011/2012 should be taken into account. Valiante (2011) identified two main drivers of the debt crisis: macroeconomic imbalances and flaws in the institutional organization. In fact, some observers seem to believe that the ECB did not adopt the role as lender of last resort and thereby did not manage to prevent yield spreads of sovereign issuers from the periphery of the EMU to rise. This only changed with the introduction of the Outright Monetary Transactions (OMT) which helped to calm the financial markets (see Filoso et al. 2021).

Prior to the outbreak of Covid-19, the United States experienced interest rate levels that had returned towards some kind of normalization, while the ECB maintained its deposit facility rate (DFR) at record low levels. In September 2019, the DFR was reduced even further to –0.50% (see Aguilar et al. 2020). The ECB also continued its Asset Purchase Programme (APP) comprising a volume of C20 bn and claimed to do so until inflation rates would rise (see Boeckx et al. 2020). The ECB aimed at achieving its inflation rate target of close to 2% by keeping this course of expansionary monetary policy (see Asshoff et al. 2020). Since July 2019 and April 2021, the ECB has failed to meet its inflation target. The

latter has been defined by its Governing Council in 2003, proclaiming the pursuit of price stability that is given when inflation rates remain "below, but close to, 2% over the medium term (see ECB 2021c)." The clarification "but close to" compared to the definition of 1998 can be interpreted as ECB's intention to eliminate potential deflationary fears (see Paloviita et al. 2021). In times of very low inflation rates, monetary policymakers have to deal with the challenge of navigating between Scylla and Charybdis by either falling into the deflation trap or the inflation trap (see Brunnermeier 2021). This implies the increased risk in case of an external shock, that expansionary monetary policy measures conducted to prevent a deflation trap may provoke an over-shooting, and thus, could cause an inflationary spiral. As a result of its current monetary policy review, the ECB adopted a new inflation target of 2% and is willing to tolerate short periods of inflation rates "moderately above target" (see ECB 2021d). This change in the ECB's monetary policy strategy may be interpreted as an effort to widen the corridor between the deflation and the inflation trap.

Figure 4-2: Inflation rate Euro Area (consumer prices). (Source: Own representation based on ECB (2021a).)

With interest rates lowered to levels below zero, traditional monetary tools have limited effect to stimulate economic activity and the ECB continued to adopt unconventional monetary policy instruments as crisis response (see Benmelech and Tzur-Ilan 2020). As a result, the ECB not only expanded but also accelerated its unconventional monetary policy. In consequence, the year 2020 recorded the highest asset purchases per month since the APP was launched (see Fig. 2). The growing ECB balance sheet reflects this process (see Haas and Neely 2020). Thanks to these immediate actions, the central banks' purchase programs helped to control the yield curve which is especially beneficial for highly indebted countries and corporations that issue investment grade bonds (see Zabala and Prats 2020). Due to the monetizing mechanism, governments suffering from fiscal imbalances are somewhat protected from running into a debt crisis as the central banks' behavior implicitly guarantees that there is a stable demand for sovereign bonds issued by these countries. This, in turn, keeps interest rates close to those of low-debt countries. Thereby, the ECB aimed at preventing this economic crisis from mutating into yet another sovereign debt crisis (see Blanchard and Pisani-Ferry, 2020). Further support for this argument can be found when considering the announcement of the PEPP program in March 2020, which intended to raise the share of bonds held by ECB by about 30% and helped to narrow yield spreads against German bunds (see Haas and Neely 2020). Particularly Italian sovereign bonds benefitted from the ECB's extensive monetary stimulus to address the economic impact induced by the pandemic (see Bernoth et al. 2020). This is underlined by Table 3, showing the purchases per country under the PEPP

regime. It becomes apparent that the Italian share is significantly disproportionate to its economic importance due to the fact that the country was not only severely hit by Covid-19 but it already suffered from a high debt burden even before the pandemic sparked-off.

Given that the EMU has been shaped by two crucial events—the Global Financial Crisis and the sovereign debt crisis, it may be subject to future discussions, whether the ECB's reaction to the impact of Covid-19 has been a new landmark in the history of the EMU. Since its creation, the EMU faces criticism referring to the theory of optimum currency area (OCA) which proclaims conditions that should be fulfilled by a common currency area, like providing integrated financial markets, in order to cope with the disadvantages of monetary integration. According to these sceptic views, it is a matter of time that the EMU will collapse in the aftermath of an economic crisis, as the Euro Area does not fully meet the conditions of an OCA. Therefore, the EMU is supposed to lack capacity to cope with severe economic shocks (see Eichengreen 1992). In this regard, the Euro Area proved its resilience during and after the Global Financial Crisis and the following sovereign debt crisis as these events sparked financial fragmentation and put the EMU at risk to break up. The ECB was forced to create instruments to tackle the lack of liquidity in financial markets and later the widening of sovereign bond spreads.

Table 4-3: Bimonthly breakdown of public sector securities under PEPP. (Source: Own representation based on ECB (2020a).)

Book value as at end-July 2020 (EUR ms)	**Net purchases June-July 2020**	**Cumulative net purchases as at end-July 2020***	**Current WAM of public sector securities holdings under the PEPP****	**WAM of eligible universe of public sector securities under the PEPP as at end-July 2020****
Austria	5,142	10,056	10.01	7.33
Belgium	6,392	12,853	5.83	9.27
Cyprus	455	936	11.79	8.31
Germany	46,266	93,016	3.97	6.60
Estonia	163	163	9.30	7.29
Spain	23,719	46,111	8.18	7.40
Finland	3,225	6,456	7.56	7.07
France	35,845	59,420	9.05	7.07
Greece	5,256	9,946	8.62	9.07
Ireland	2,972	5,972	8.31	9.29
Italy	**36,067**	**73,432**	**7.00**	**6.72**
Lithuania	543	1,593	9.21	10.92
Luxembourg	348	807	6.56	5.74
Latvia	391	787	9.88	9.08
Malta	0	123	6.33	8.02
Netherlands	10,285	20,674	3.60	7.36
Portugal	4,655	8,805	7.14	6.81

Book value as at end-July 2020 (EUR ms)	Net purchases June-July 2020	Cumulative net purchases as at end-July 2020*	Current WAM of public sector securities holdings under the PEPP**	WAM of eligible universe of public sector securities under the PEPP as at end-July 2020**
Slovenia	958	1,896	6.84	8.71
Slovakia	1,487	3,790	7.17	8.13
Supranationals	14,045	27,980	8.23	7.23
Total	198,214	384,817	6.71	7.12

Hartmann et al. (2021) have provided evidence that the first weeks of the pandemic spreading in Europe also show sharp tendencies of financial disintegration. This was driven by a strong demand for money-market instruments and a widening of sovereign spreads among EMU member states which indicates that the economic impact of the COVID-19 crisis could challenge the stability of the Euro Area like the Financial Crisis and the sovereign debt crisis.

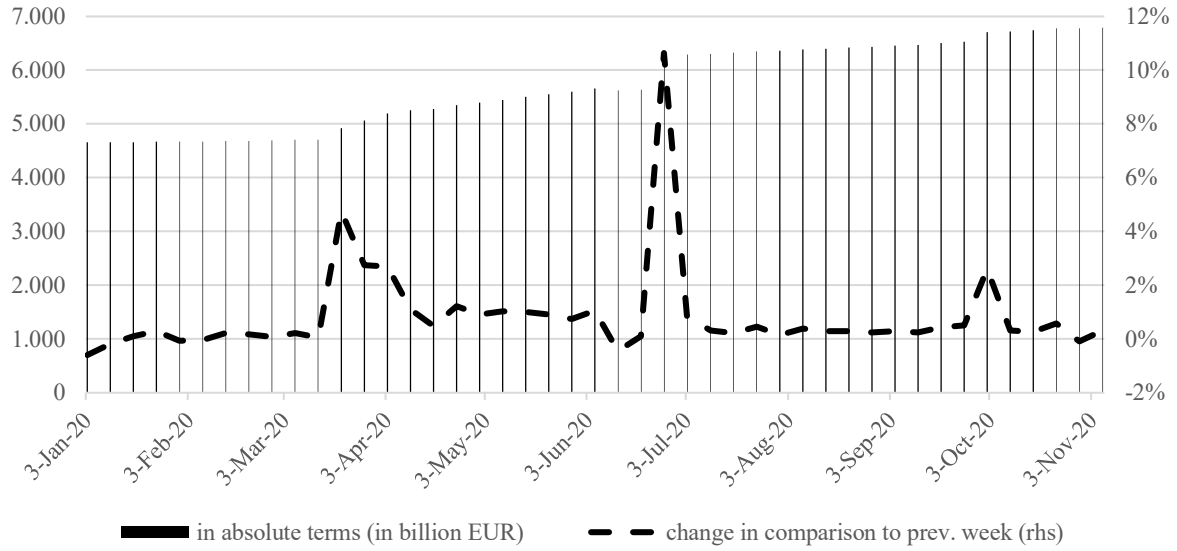

Figure 4-3: ECB balance sheet. (Source: ECB (2020b).)

In mid-March 2020, the ECB announced the launch of the aforementioned PEPP, including a package of asset purchases and a bank relief program with a volume of originally €120 bn that was later extended to an amount of €750 bn, and even further increased to €1,350 bn in June 2020 (see Fig. 3; Jinjarak et al. 2020), being topped up by further €500 bn in December 2020 totaling €1,850 bn (ECB 2021b). Referring to Mario Draghi's famous "whatever it takes"-quote that helped to calm down market fears (see Claeys 2020), on March 18, 2020 the ECB proclaimed that the PEPP design can be adapted "as much as necessary and for as long as needed" (see Bénassy-Quéré et al. 2020). This program comprises various instruments to not only prevent a credit crunch as consequence of the economic downturn, but also to stabilize markets, so that the monetary policy mechanism is preserved. When investors grasped the economic impact of Covid-19, there was a high risk of liquidity shortfall, and flight to safe-haven assets with potentially severe consequences, especially for highly indebted member states of a monetary union (see Hutchinson and Mee, 2020). Between the beginning of January 2020 and mid of March of

the same year, the yield spreads between German government bonds and, for example, Italian sovereign bonds had widened sharply. After the ECB announced its PEPP-program to cushion the economic effects of Covid-19, Italian and Spanish sovereign bond spreads, interrupted by a widening in April, have narrowed (see Boeckx et al. 2020).

Further crisis response by the ECB includes the Governing Council's decision to extend the additional credit claim (ACC) framework by accepting credit claims as collateral which did not meet the predefined eligibility criteria, inter alia loans with lower credit quality standards (see ECB, 2020c). Furthermore, the threshold for using credit claims as collateral for banks to obtain new liquidity was lowered from formerly €25,000 to 0. This measure was intended to incentivize an additional credit supply to small and medium enterprises. Another ECB instrument to mitigate the economic impact of the pandemic included an increase in tolerating collateral devaluations by 20% (see ECB 2020d). In order to prevent a liquidity shortfall for the real economy, the ECB aimed at establishing improved refinancing conditions for banks as these play an even more important role as financial intermediary in Europe than in the United States. Hence, the ECB continued to provide targeted (TLTROs) and non-targeted liquidity programs that intend to ease banks' borrowing from ECB, a program launched in September 2019 already. Based on the longer-term refinancing operations (LTROs) that have expired in March 2020, the ECB opted for maintaining the pandemic emergency longer-term refinancing operations or short: PELTROs (see ECB 2020e). On the flip side, lending rates for banks turned negative (see Haas and Neely 2020). Another important change includes the ECB's decision to revise its rules with respect to public bond purchases so that the commitment to hold no more than one third of a country's outstanding government bond was abolished (see Bernoth et al. 2020).

4.7. Data and methodological issues

This empirical study examines interest rate differentials between 5-, 10- and 30-year bond yields in five different member countries of the EMU relative to German sovereign bond yields. Fixed income securities issued by the Federal Republic of Germany are usually considered to be more or less free of default risk. Moreover, there is a very high degree of liquidity in the market for German government bonds. Therefore, sovereign bond yields from Germany are frequently used as the benchmark interest rate for the EMU (see, for example, Basse 2014 and Rodriguez Gonzalez et al., 2019). Given the research question under examination here, it is certainly necessary to also consider 30-year interest rate differentials (which is often not employed in empirical studies). In fact, Rodriguez Gonzalez et al. (2019) and Basse (2020) have argued convincingly that this segment of the sovereign bond market in the EMU is of special importance for the life insurance industry because of their long-term liabilities. Besides Germany (as benchmark), we examine interest rate data from five other member states of the EMU (namely, Austria, Belgium, France, Italy and Ireland). Austria is a smaller country that in general is assumed to belong to the fiscally more prudent EMU member states. Therefore, liquidity risk should play a special role for bond prices issued by Austria. France and Italy are large member countries of the EMU with highly liquid sovereign bond markets. Consequently, government bond yields in these two countries should not be driven by liquidity risk. Given the aforementioned recent political turmoil in Rome, sovereign credit risk and redenomination risk should indeed be of some importance for Italian government bond prices. Belgium and Ireland are medium-sized respectively smaller member countries of the EMU. In both cases, liquidity risk, sovereign credit risk and redenomination risk could impact government bond prices and interest rates. Moreover, Ireland was among the countries that suffered most

during the European sovereign debt crisis (see, for example, Gómez-Puig and Sosvilla-Rivero 2014 and Wegener, Kruse and Basse, 2017).

The yield spread SP of sovereign debt (see, for example, Gómez-Puig 2006 and Rodriguez Gonzalez et al. 2019) issued by country W (Austria, Belgium, France, Italy and Ireland) relative to German bonds with the maturity Z (5, 10 or 30 years) is calculated form generic government bond yields using Eq. 1:

$$SP_{W,Z} = i_{W,Z} - i_{Germany,Z} \quad (1)$$

All interest rate data is taken from Bloomberg. Given that identical maturities are examined and that investors consider German government bonds to be somewhat special—as already discussed, these fixed income securities are characterized by high liquidity and without fears of a sovereign default—the interest rate differentials computed according to Eq. 1 can be interpreted as risk premia compensating investors for the higher default and liquidity risk of country W relative to Germany (and, of course, also for the possibly existing redenomination risk). We examine weekly data. In order to avoid problems with structural change, the data sample analyzed is 3/29/2019 to 7/03/2020. Focusing on this period of time does make sense because the 10-year German government bond yield was negative for the whole sample. This is a very important fact with regard to the existence of structural breaks in the bond yield spread time series. The procedure suggested by Phillips and Perron (1988) is employed to test for unit roots in the time series calculated with Eq. 1. According to the results of these tests, all yield spreads seem to be non-stationary variables integrated of order 1. Given the empirical findings that have been reported by Rodriguez Gonzalez et al. (2019), this result is not surprising. Therefore, no test data is reported in order to conserve space.

The concept of Granger causality is of high relevance in the field of time series econometrics. One-time series X is Granger causing another time series Y when past values of X can predict the variable Y (see, most importantly, Granger 1969). Expressed somewhat more formally, the variable *Xt* is said to not be Granger causing the time series *Yt* if for all $n > 0$

$$F(Y_{t+n} \mid \Omega_t) = F(Y_{t+n} \mid \Omega_t - X_t) \quad (2)$$

In Eq. 2, *F* denotes the conditional distribution, and $_t - X_t$ is all potentially relevant information except of *Xt*. Feedback effects may exist between the two variables *Xt* and *Yt*. Then there is bidirectional Granger causality (see, for example, Thornton 1996 and Amiri and Ventelou 2012). On the other hand, there is unidirectional Granger causality in situations where one variable Granger causes the other variable but not vice versa (see, for example, Oxley 1993 and Thornton 1996).

The Granger causality tests are performed using the approach developed by Toda and Yamamoto (1995). This procedure has become very popular among applied econometricians in recent times. As a matter of fact, Bauer and Maynard (2012) have highlighted how useful this approach to test for Granger causality can be. Due to the large number of relevant studies, we can only give two examples here. Amiri and Ventelou (2012), for instance, have used the technique that has been suggested by Toda and Yamamoto (1995) to examine the relationship between healthcare expenditures and economic activity. Moreover, Kunze et al. (2020) have employed this approach to search for a useful leading indicator of house prices in the United Kingdom. This popularity most probably is a result of the favorable Monte Carlo evidence that has been presented by Zapata and Rambaldi (1997). The technique that has been developed by Toda and Yamamoto (1995) is based on the concept of vector autoregressive models. More specifically, vector

autoregressions are very useful tools to describe the dynamic interrelationships between two or more-time series (see, most importantly Sims, 1980). The *n* endogenous variables in a vector autoregressive models are explained by past values of itself and of the remaining other variables examined. In Eq. 3 *Yt* is a vector of (n x 1) endogenous variables, *Ai* are (n x n) coefficient matrices, *C* is a (n x 1) vector of constants and *εt* is an (n x 1) vector of random disturbances:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \varepsilon_t \quad (3)$$

This technique can account for possibly existing feedback effects among the variables that are included in the model. Toda and Yamamoto (1995) have suggested to estimate a vector autoregression in levels considering *p* time lags and to extend this model by *m* time lags to then perform modified Wald tests to search for Granger causality, where *m* is the highest order of integration of any exogenous variable examined and *p* is the optimal number of time lags for the vector autoregressive model:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \ldots + A_{p+m} Y_{t-.(p+m)} + \varepsilon_t \quad (4)$$

This procedure using a modified Wald test ensures that the test statistic is asymptotically chi-square distributed. The additional m lags in Eq. 4 are added to the augmented model as exogenous variables and *p* is the optimal number of time lags for the vector autoregression that can, for example, be selected by using the traditional information criteria (in or case AIC). Phrased somewhat differently, the null hypothesis of Granger non-causality is tested by only examining the coefficient matrices A_1 to *Ap*. The procedure suggested by Toda and Yamamoto (1995) can be problematic when there is structural change (see, most importantly, Gormus et al. 2018; and Nazlioglu et al. 2019); employing the so-called Fourier Toda Yamamoto test should be helpful in these cases. However, working with small sample sizes (as done here) using the traditional test procedure could have advantages. In fact, Monte Carlo evidence presented by Nazlioglu et al. (2019) does suggest that the test procedure developed by Toda and Yamamoto (1995) seems to be less distorted than the Fourier Toda Yamamoto test examining small samples. Moreover, given that we already have selected the data sample examined here in a way that should help to minimize possible problems with structural change (as discussed above), we prefer to employ the traditional version of the test.

4.8. Empirical analysis

The results of the Granger causality tests (*p*-values) employing the technique suggested by Toda and Yamamoto (1995) are presented in the Table 4 and 5 and 6 and 7 and 8 and 9 and 10 and 11 and 12 and 13. The reported probabilities are calculated using the asymptotic Chi-square distribution. In the tables, X → Y denotes Granger causality running from the variable X to the variable Y, and Y → X denotes Granger causality running from the variable Y to the variable X. Examining the empirical findings that are presented in the tables, there are some very interesting results.

Table 4-3: Granger causality test Austria and Belgium. Source: Own calculations.

Maturity	Austria → Belgium	Belgium → Austria
5 Years	0.2973	0.0000
10 Years	0.0199	0.0225
30 Years	0.5081	0.5016

Table 4-4: Granger causality test Austria and France. Source: Own calculations.

Maturity	Austria → France	France → Austria
5 Years	0.4560	0.0004
10 Years	0.1272	0.2755
30 Years	0.6941	0.4054

Table 4-5: Granger causality test Austria and Ireland. Source: Own calculations.

Maturity	Austria → Ireland	Ireland → Austria
5 Years	0.2130	0.0047
10 Years	0.1151	0.1152
30 Years	0.5237	0.9869

Table 4-6: Granger causality test Austria and Italy. Source: Own calculations.

Maturity	Austria → Italy	Italy → Austria
5 Years	0.1522	0.0197
10 Years	0.0741	0.1704
30 Years	0.1343	0.2800

Table 4-7: Granger causality test Belgium and France. Source: Own calculations.

Maturity	Belgium → France	France → Belgium
5 Years	0.1223	0.0553
10 Years	0.0066	0.0056
30 Years	0.6603	0.9254

Table 4-8: Granger causality test Belgium and Italy. Source: Own calculations.

Maturity	Belgium → Italy	Italy → Belgium
5 Years	0.4027	0.1626
10 Years	0.2156	0.8855
30 Years	0.3214	0.1023

Table 4-9: Granger causality test Belgium and Ireland. Source: Own calculations.

Maturity	Belgium → Ireland	Ireland → Belgium
5 Years	0.0686	0.2799
10 Years	0.5297	0.3274
30 Years	0.2591	0.8005

Table 4-10: Granger causality test France and Italy. Source: Own calculations.

Maturity	Italy → France	France → Italy
5 Years	0.6450	0.0748
10 Years	0.5462	0.0237
30 Years	0.0905	0.3881

Table 4-11: Granger causality test France and Ireland. Source: Own calculations.

Maturity	Ireland → France	France → Ireland
5 Years	0.5007	0.5761
10 Years	0.9434	0.2460
30 Years	0.8838	0.1708
Maturity	Ireland → Italy	Italy → Ireland
5 Years	0.0455	0.4472
10 Years	0.1477	0.8209
30 Years	0.6689	0.7892

From the perspective of asset managers in life insurance companies, it is of predominant importance to note that with regard to interest rate differentials of bonds with a maturity of 30 years, there is no empirical evidence for Granger causality among the time series examined here. As a matter of fact, in no case the null hypothesis of no causality can be rejected. Consequently, focusing on bonds with high durations yield spreads relative to Germany in one of the member countries of the EMU do not help to forecast yield spreads in the other countries. This is somewhat different in the other segments of the European government bond market. When examining fixed income securities with a maturity of 10 years, there is no clear picture at all. In some cases, there is no Granger causality, in others there is uni- or bidirectional causality. Focusing on medium-term bonds (which here means a maturity of 5 years), there is one very interesting empirical finding. All models do suggest that there exists unidirectional Granger causality running from the yield spreads in all other countries to Austrian interest rate differentials relative to German 5-year bonds. This result is remarkable. As already noted, Austria is a smaller European country which is considered by most investors to be fiscally very sound. Therefore, yield spreads to Germany mainly are compensating holders of Austrian government bonds for liquidity risk and not for sovereign credit risk. Consequently, the data set examined here seems to suggest that sovereign credit risk, which is reflected by the prices of medium-term European government bonds issued by, for example, Italy or Ireland, can help to forecast liquidity risk premia in this segment of the global fixed income market. One explanation for this empirical finding could be that additional fears about sovereign credit risk can lead to liquidity shocks which then tend to increase liquidity premia. This interpretation of the empirical evidence reported here is, of course, based on the point of view that fixed income investors do not seem to believe that sovereign credit risk per se can become a major problem in Austria.

4.9. Conclusion

Lempérière et al. (2017) have argued convincingly that there still are surprisingly large obstacles when trying to explain how risk premia are determined in financial markets. With this study, we try to close some of the existing knowledge gaps. Doing so, we focus on the government bond market in the EMU. This segment of the global fixed income market is of particular importance for insurance companies in

Europe. More specifically, we employ the procedure developed by Toda and Yamamoto (1995) to test for Granger causality among yield spreads in five different member countries of the EMU relative to Germany. The member states included in the analysis are Austria, Belgium, France, Italy and Ireland. We examine interest rate data from bonds with three different maturities (5, 10 and 30 years). Our empirical research approach is inspired by Gunay (2020) who has analyzed the relationship between credit and liquidity risk in the United States using Granger causality tests. With regard to long-term sovereign debt, there is no evidence for Granger causality among the time series examined here. Consequently, the risk premia required by investors to hold government bonds of one specific member country of the monetary union do not help to forecast the risk premia that have to be paid by other countries. Given the structure of their liabilities, this empirical finding should be of relevance for the European life insurance industry. With regard to the yield spreads to be observed in the market for 10-year government bonds, there seems to be no clear picture. Focusing on fixed income securities with a maturity of 5 years, there is one very interesting empirical finding. The test results reported above seem to imply that there is unidirectional Granger causality running from the yield spreads of all other four countries to Austria. Given that Austria is a smaller country which is viewed to be in a fiscally stable position, this result could be interpreted as evidence for credit risk premia being helpful to forecast liquidity risk premia in the market for medium-term government bonds issued by member states of the EMU. Future empirical research that focuses on the European government bond market should examine the relationship between sovereign credit risk and liquidity risk in more detail. Moreover, the empirical research strategy employed here can also be used to improve our understanding of how risk premia are determined in financial markets in general by analyzing lead-lag-relationships between the historical risk premia offered by different types of investment opportunities (e.g., small cap stocks versus growth stocks).

4.10. References

Afonso, A., Arghyrou, M.G., Gadea, M.D., Kontonikas, A. (2018). “whatever it takes” to resolve the European sovereign debt crisis? Bond pricing regime switches and monetary policy effects. J. Int. Money Finance 86, 1–30.

Afonso, A., Jalles, J.T., Kazemi, M. (2020). The effects of macroeconomic, fiscal and monetary policy announcements on sovereign bond spreads. Int. Rev. Law Econ. 63, 105924.

Aguilar, P., Arce, Ó., Hurtado, S., Martínez-Martín, J., Nuño, G., Thomas, C. (2020). The ECB monetary policy response to the Covid-19 crisis. Banco España Documentos Ocasionales 2026.

Altig, D., Baker, S., Barrero, J.M., Bloom, N., Bunn, P., Chen, S., Davis, S.J., Leather, J., Meyer, B., Mihaylov, E., Mizen, P., Parker, N., Renault, T., Smietanka, P., Thwaites, G. (2020). Economic uncertainty before and during the COVID-19 pandemic. J. Public Econ. 191, 104274.

Amiri, A., Ventelou, B. (2012). Granger causality between total expenditure on health and GDP in OECD: evidence from the toda-yamamoto approach. Econ. Lett. 116(3), 541–544.

Arghyrou, M.G., Kontonikas, A. (2012): The EMU sovereign-debt crisis: fundamentals, expectations and contagion. J. Int. Financial Mark. Inst. Money 22(4), 658–677.

Ashby, S. (2011): Risk management and the global banking crisis: lessons for insurance solvency regulation. Geneva Pap. Risk Insur. Issues Pract. 36(3), 330–347.

Asshoff, S., Belke, A., Osowski, T. (2020). Unconventional monetary policy and inflation expectations in the Euro area. Econ. Model. 102, 105564.

Basse, T. (2014). Searching for the EMU core member countries. Eur. J. Polit. Econ. 34, 32–39.

Basse, T. (2020). Solvency II and sovereign credit risk: additional empirical evidence and some thoughts about implications for regulators and lawmakers. Int. Rev. Law Econ. 64, 105933.

Basse, T., Friedrich, M., Kleffner, A. (2012). Italian government debt and sovereign credit risk: an empirical exploration and some thoughts about consequences for European insurers. ZVersWiss. 101(5), 571–579.

Basse, T., Wegener, C., Kunze, F. (2018). Government bond yields in Germany and Spain — empirical evidence from better days. Quantitative Finance 18(5), 827–835.

Basse, T., Friedrich, M., Kleffner, A., Graf von der Schulenburg, J.-M. (2014). Are interest rates too low? Empirical evidence and implications for German life insurers. ZVersWiss. 103(1), 31–43.

Battiston, S., Jakubik, P., Monasterolo, I., Riahi, K., van Ruijven, B. (2019). Climate risk assessment of the sovereign bond portfolio of European insurers. EIOPA financial stability report, December 2019. 69–89). https://www.eiopa.europa.eu/sites/default/files/publications/reports/eiopa_dec2019_financial-stability-report-thematic_review_climate_risk.pdf, Accessed: 28 Nov 2020

Bauer, D., Maynard, A. (2012). Persistence-robust surplus-lag Granger causality testing. J. Econom. 169(2), 293–300.

Bénassy-Quéré, A., Boot, A., Fatás, A., Fratzscher, M., Fuest, C., Giavazzi, F., Marimon, R., Martin, P., Pisani-Ferry, J., Reichlin, L., Schoenmaker, D., Teles, P., Weder die Mauro, B. (2020). A proposal for a Covid credit line. https://voxeu.org/article/proposal-covid-credit-line, Accessed: 14

Dec 2020.

Benmelech, E., Tzur-Ilan, N. (2020). The determinants of fiscal and monetary policies during the COVID-19 crisis. NBER Working Paper No. 27461.

Berdin, E., Gründl, H. (2015): The effects of a low interest rate environment on life insurers. Geneva Pap. Risk Insur. 40(3), 385–415.

Bernoth, K., Dany-Knedlik, G., Gibert, A. (2020): ECB and fed monetary policy measures against the economic effects of the Coronavirus pandemic have little effect. DIW focus No. 3.

Bernoth, K., von Hagen, J., Schuhknecht, L. (2012). Sovereign risk premiums in the European government bond market. J. Int. Money Finance 31(5), 975–995.

Bijlsma, M., Vermeulen, R. (2016.: Insurance companies' trading behaviour during the European sovereign debt crisis: flight home or flight to quality? J. Financial Stab. 27, 137–154.

Blanchard, O., Pisani-Ferry, J.: Monetisation (2020). Do not panic. Vox CEPR Policy Portal. https://voxeu.org/article/monetisation-do-not-panic. Accessed: 15 July 2020

Boeckx, J., Deroose, M., Vincent, E. (2020). The ECB's monetary policy response to COVID-19. NBB Econ. Rev. (2), 37–52.

Boonen, T.J. (2017). Solvency II solvency capital requirement for life insurance companies based on expected shortfall. Eur. Actuar. J. 7(2), 405–434.

Botta, A., Caverzasi, E., Russo, A. (2020). Fighting the COVID-19 emergency and re-launching the European economy: debt monetization and recovery bonds. GPERC Policy Briefs No. PB26.

Boubaker, S., Gounopoulos, D., Nguyen, D.K., Paltalidis, N. (2017). Assessing the effects of unconventional monetary policy and low interest rates on pension fund risk incentives. J. Bank. Finance 77, 35–52.

Boudoukh, J., Whitelaw, R.F. (1993): Liquidity as a choice variable: a lesson from the Japanese government bond market. Rev. Financ. Stud. 6(2), 265–292.

Boysen-Hogrefe, J. (2017): Risk assessment on Euro area government bond markets—the role of governance. J. Int. Money Finance 73, 104–117.

Braun, A., Schmeiser, H., Schreiber, F. (2017). Portfolio optimization under solvency II: implicit constraints imposed by the market risk standard formula. J. Risk Insur. 84(1), 177–207.

Braun, A., Schmeiser, H., Schreiber, F. (2018). Return on risk-adjusted capital under solvency II: implications for the asset management of insurance. Geneva Pap. Risk Insur. Pract. 43(3), 456–472.

Brunnermeier, M.K. (2021). De-and inflationary traps: strengthening ECB's second pillar to avoid fiscal and financial dominance. ECB Forum on Central Banking. Conference Proceedings., pp 275–283.

Burriel, P., Galesi, A. (2018). Uncovering the heterogeneous effects of ECB unconventional monetary policies across Euro area countries. Eur. Econ. Rev. 101, 210–229.

Chaumont, G. (2020). Sovereign debt, default risk and the liquidity of government bonds. University of Rochester. https://doi.org/10.2139/ssrn.3714870

Chodorow-Reich, G., Ghent, A., Haddad, V. (2021): Asset insulators. Rev Financ Stud 34(3), 1509–

1539.

Claeys, G. (2020). The European Central Bank in the COVID-19 crisis: whatever it takes, within its mandate. European Parliament Monetary Dialogue Papers

Conner, R. (2016). Bubble or overblown: ambiguous signals in the subprime auto lending market. J. Struct. Finance 22(3), 32–44.

Croce, D.R., Stewart, F., Yermo, J. (2011): Promoting longer-term investment by institutional investors: selected issues and policies. OECD J. Financial Mark. Trends. https://doi.org/10.1787/fmt-2011- 5kg55b0z1ktb

Dincecco, M. (2009). Political regimes and sovereign credit risk in Europe, 1750–1913. Eur. Rev. Econ. Hist. 13(1), 31–63.

Doff, R. (2008). A critical analysis of the solvency II proposals. Geneva Pap. Risk Insur. Pract. 33(2), 193–206.

Doff, R. (2016). The final solvency II framework: will it be effective? Geneva Pap. Risk Insur. 41(4), 587–607.

Domanski, D., Shin, H.S., Sushko, V. (2017). The hunt for duration: not waving but drowning? IMF Econ. Rev. 65(1), 113–153.

Düll, R., König, F., Ohls, J. (2017). On the exposure of insurance companies to sovereign risk—portfolio investments and market forces. J. Financial Stab. 31, 93–106.

ECB (2015). Euro area insurers and the low interest rate environment. Financial stability review, November 2015. https://www.ecb.europa.eu/pub/pdf/fsr/financialstabilityreview201511.en.pdf, Accessed: 14 July 2020

ECB (2020a). Pandemic emergency purchase programme (PEPP). https://www.ecb.europa.eu/mopo/implement/pepp/html/index.en.html, Accessed: 14 Dec 2020

ECB (2020b): Press release: ECB announces package of temporary collateral easing measures. https://www.ecb.europa.eu/press/pr/wfs/html/index.en.html, Accessed: 14 Dec 2020

ECB (2020c). Decisions taken by the Governing Council of the ECB (in addition to decisions setting interest rates). https://www.ecb.europa.eu/press/govcdec/otherdec/2020/html/ecb.gc200731, Accessed: 14 Dec 2020

ECB (2020d): The impact of the ECB's monetary policy measures taken in response to the COVID-19 crisis. Economic Bulletin Boxes. 5, 37–43. https://www.ecb.europa.eu/pub/economic-bulletin/focus/2020/html/ecb.ebbox202005_03, Accessed: 14 Dec 2020

ECB (2020e). Monetary policy accounts: meeting of 29–30 April 2020. https://www.ecb.europa.eu/press/accounts/2020/html/ecb.mg200522, Accessed: 14 Dec 2020

ECB (2021a). Inflation rate (HICP). https://sdw.ecb.europa.eu, Accessed: 18 June 2021

ECB (2021b). Pandemic emergency purchase programme (PEPP). https://www.ecb.europa.eu/mopo/implement/pepp/html/index.en.html, Accessed: 7 Oct 2021

ECB (2021c). The definition of price stability. https://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.en.html, Accessed: 7 Oct 2021

ECB (2021d): The ECB's monetary policy strategy statement. https://www.ecb.europa.eu/home/search/review/html/ecb.strategyreview_monpol_strategy_statement.en.html, Accessed: 7 Oct 2021

Eichengreen, B. (1992). Is Europe an optimum currency area? In: Borner, S., Grubel, H. (eds.) The European Community after 1992, pp. 138–161. Palgrave Macmillan, London.

EIOPA (2020a). EEA Group quarterly balance sheet statistics. https://www.eiopa.europa.eu/tools-and-data/insurance-statistics_en, Accessed: 28 Nov 2020

EIOPA (2020b). Solo quarterly asset exposure statistics. https://www.eiopa.europa.eu/tools-and-data/insurance-statistics_en, Accessed: 28 Nov 2020

EIOPA (2020c). Solo quarterly balance sheet data. https://www.eiopa.europa.eu/tools-and-data/insurance-statistics_en, Accessed: 28 Nov 2020

Ejsing, J., Lemke, W. (2011). The Janus-headed salvation: sovereign and bank credit risk premia during 2008–2009. Econ. Lett. 110(1), 28–31.

Elderfield, M. (2009): Solvency II: setting the pace for regulatory change. Geneva Pap. Risk Insur. Pract. 34(1), 35–41.

Eling, M., Holder, S. (2013). Maximum Technical Interest Rates in Life Insurance in Europe and the United States: An Overview and Comparison. The Geneva Papers on Risk and Insurance — Issues and Practice 38, 354–375.

Eling, M., Schmeiser, H., Schmit, J.T. (2007). The solvency II process: overview and critical analysis. Risk. Manag. Insur. Rev. 10(1), 69–85.

European Parliament (2009). Directive 2009/138/EC of the European parliament and of the council of 25 November 2009 on the taking-up and pursuit of the business of insurance and Reinsurance (solvency II) (recast). Official journal of the European Union (2009on). https://eur-lex.europa.eu/legal-content/ EN/TXT/PDF/?uri=CELEX, Accessed: 18 Oct 2020.

European Parliament: Regulation (2013). (EU) no 462/2013 of the European parliament and of the council of 21 May 2013 amending regulation (EC) no 1060/2009 on credit rating agencies (2013). https://eur- lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0462&from=de, Accessed: 18 Oct 2020.

Fache Rousová, L., Giuzio, M. (2019). Insurers' investment strategies: pro- or countercyclical?. European central bank working paper series no. 2299. https://www.ecb.europa.eu/pub/research/working-papers/ html/index.en.html, Accessed: 13 Dec 2020.

Filoso, V., Panico, C., Papagni, E., Purificato, F., Suárez, V.M. (2021). Timing does matter: institutional flaws and the European debt crisis. Rev. Polit. Econ. https://doi.org/10.1080/09538259.2020.1859717.

Focarelli, D. (2017). Why insurance regulation is crucial for long-term investment and economic growth. Insurance regulation in the European Union. In: Marano, P., Siri, M. (eds.) Insurance regulation in the European Union, pp. 339–359. Palgrave Macmillan, Cham.

Gatzert, N., Wesker, H. (2012). A comparative assessment of Basel II/III and solvency II. Geneva Pap.

Risk Insur. Pract. 37(3), 539–570.

German Association of Actuaries (2020). Hoechstrechnungszins in der Lebensversicherung. https://aktuar.de/unsere-themen/lebensversicherung/hoechstrechnungszins/Seiten/default.aspx, Accessed: 14 Dec 2020.

Gibson, H.D., Hall, S.G., Tavlas, G.S. (2014). Fundamentally wrong: market pricing of sovereigns and the Greek financial crisis. J. Macroecon. 39, 405–419.

Goldreich, D., Hanke, B., Nath, P. (2005). The price of future liquidity: time-varying liquidity in the US treasury market. Rev. Financ. 9(1), 1–32.

Gormus, A., Nazlioglu, S., Soytas, U. (2018). High-yield bond and energy markets. Energy Econ. 69, 101–110.

Granger, C.W. (1969). Investigating causal relations by econometric models and cross-spectral methods. Econometrica 37(3), 424–438.

Grima, S. (2017). The ORSA requirement: insurance practitioners' concerns. 18th Annual Conference Proportionality and Legal Certainty in Insurance Law, Palic., pp 269–278.

Grund, S. (2017). Restructuring government debt under local law: the Greek case and implications for investor protection in Europe. Cap. Mark. Law J. 12(2), 253–273.

Gründl, H., Gal, J. (2013). Own risk and solvency assessment within the solvency II framework and its interplay with the quantitative solvency capital requirements. SAFE Policy Letters. 11.

Gründl, H., Dong, M.I., Gal, J. (2017). The Evolution of Insurer Portfolio Investment Strategies for Long-term Investing. OECD J. Financial Mark. Trends. 2016(2), 1–55.

Gruppe, M., Lange, C. (2014). Spain and the European sovereign debt crisis. Eur J Polit Econ 34, 3–8.

Gruppe, M., Basse, T., Friedrich, M., Lange, C. (2017). Interest rate convergence, sovereign credit risk and the European debt crisis: a survey. J. Risk Finance 18(4), 432–442.

Gunay, S. (2020). Seeking causality between liquidity risk and credit risk: TED-OIS spreads and CDS indexes. Res. Int. Bus. Finance 52, 101189.

Gómez-Puig, M. (2006). Size matters for liquidity: evidence from EMU sovereign yield spreads. Econ Lett 90(2), 156–162.

Gómez-Puig, M., Sosvilla-Rivero, S. (2014). Causality and contagion in EMU sovereign debt markets. Int. Rev. Econ. Finance 33, 12–27.

Haas, J., Neely, C.J. (2020). Central bank responses to COVID-19. Econ. Synopses. https://doi.org/10.20955/es.2020.23.

Hartmann, P., Borgioli, S., Kempf, A., Molitor, P., Mongelli, F.P. (2021). Financial integration and structure in EMU during the corona crisis. https://voxeu.org/article/financial-integration-and-structure- emu-during-corona-crisis, Accessed: 19 June 2021.

Holder, M. (1999). The Euro impact on European financial markets. Manag. Finance 25(11), 27–34.

Hopt, K.J. (2013). Corporate governance of banks and other financial institutions after the financial crisis. J. Corp. Law Stud. 13(2), 219–253.

Hutchinson, J., Mee, S. (2020). The impact of the ECB's monetary policy measures taken in response to the COVID-19 crisis. ECB Economic Bulletin Boxes 5. https://www.ecb.europa.eu//pub/economic-bulletin/focus/2020/html/ecb.ebbox202005_03~12b5ff68bf.en.html. Accessed: 14 July 2020

Van Hulle, K. (2011). Solvency II: state of play and perspectives. Z Gesamt. Versicherungswiss. 100(2), 177–192.

Jankowitsch, R., Mösenbacher, H., Pichler, S. (2006). Measuring the liquidity impact on EMU government bond prices. Eur. J. Finance 12(2), 153–169.

Jareño, F., Tolentino, M., González, M.D.L.O., Medina, M.Á. (2020). Interest rate exposure of European insurers. Int. J. Econ. Bus. 27(2), 255–268.

Jinjarak, Y., Ahmed, R., Nair-Desai, S., Xin, W., Aizenman, J. (2020). Pandemic shocks and fiscal-monetary policies in the Eurozone: COVID-19 dominance during January-June 2020. NBER Working Paper No. 27451.

Kim, S. J., Moshirian, F., Wu, E. (2006). Evolution of international stock and bond market integration: Influence of the European Monetary Union. Journal of Banking and Finance 30(5), 1507–1534.

Klose, J., Weigert, B. (2014). Sovereign yield spreads during the Euro crisis: fundamental factors versus redenomination risk. Int. Finance 17(1), 25–50.

Kool, C.J. (2000). International bond markets and the introduction of the Euro. Fed. Reserve Bank St. Louis Rev. 82(5), 41–56,

Krampf, A. (2016). From transparency to ambiguity: the impact of the ECB's unconventional policies on the EMU. J. Eur. Integr. 38(4), 455–471.

Krishnamurthy, A., Nagel, S., Vissing-Jorgensen, A. (2018). ECB policies involving government bond purchases: impact and channels. Rev. Financ. 22(1), 1–44.

Kunze, F., Basse, T., Gonzalez, M.R., Vornholz, G. (2020). Forward-looking financial risk management and the housing market in the United Kingdom: is there a role for sentiment indicators? J. Risk Finance 21(5), 659–678.

Lapavitsas, C. (2018). The Redenomination risk of exiting the Eurozone: an estimation based on the Greek case. Eur. Law J. 24(2–3), 226–243.

Lempérière, Y., Deremble, C., Nguyen, T.T., Seager, P., Potters, M., Bouchaud, J.P. (2017). Risk premia: asymmetric tail risks and excess returns. Quant. Finance. 17(1), 1–14.

Liebwein, P. (2006). Risk models for capital adequacy: applications in the context of solvency II and beyond. Geneva Pap. Risk Insur. Pract. 31(3), 528–550.

Ludwig, A. (2014). Credit risk-free sovereign bonds under solvency II: a cointegration analysis with consistently estimated structural breaks. Appl. Financial Econ. 24(12), 811–823.

Lund, J. (1999). A model for studying the effect of EMU on European yield curves. Eur. Finance Rev. 2(3), 321–363.

Maltritz, D. (2012). Determinants of sovereign yield spreads in the Eurozone: a Bayesian approach. J Int Money Finance 31(3), 657–672.

Maltritz, D., Molchanov, A. (2014). Country credit risk determinants with model uncertainty. Int. Rev. Econ. Finance 29, 224–234.

Meier, S., Rodriguez Gonzalez, M., Kunze, F. (2020). The global financial crisis, the EMU sovereign debt crisis and international financial regulation: lessons from a systematic literature review. International Review of Law and Economics 65, 105945.

Möhlmann, A. (2021). Interest rate risk of life insurers: evidence from accounting data. Financ Manage 50(2), 587–612.

Monkiewicz, J. (2013). Dialectics of the current regulatory and supervisory developments in insurance. Geneva Pap. Risk Insur. Pract. 38, 183–188.

Nazlioglu, S., Gormus, A., Soytas, U. (2019). Oil prices and monetary policy in emerging markets: structural shifts in causal linkages. Emerg. Mark. Finance Trade 55(1), 105–117.

Niedrig, T. (2015). Optimal asset allocation for interconnected life insurers in the low interest rate environment under solvency regulation. J. Insur. Issues 38(1), 31–71.

Officer, M.S. (2007). The price of corporate liquidity: acquisition discounts for unlisted targets. J financ econ 83(3), 571–598.

Oliveira, L., Curto, J.D., Nunes, J.P. (2012). The determinants of sovereign credit spread changes in the Eurozone. J. Int. Financial Mark. Institutions Money 22(2), 278–304.

Oxley, L. (1993). Cointegration, causality and export-led growth in Portugal, 1865–1985. Econ. Lett. 43(2), 163–166.

Paloviita, M., Haavio, M., Jalasjoki, P., Kilponen, J. (2021). What does “below, but close to, 2 percent” mean? Assessing the ECB’s reaction function with real-time data. Int. J. Cent. Bank. 17(2), 125–169.

Paltalidis, N., Gounopoulos, D., Kizys, R., Koutelidakis, Y. (2015). Transmission channels of systemic risk and contagion in the European financial network. J. Bank. Finance 61, 36–52.

Phillips, P.C., Perron, P. (1988). Testing for a unit root in time series regression. Biometrika 75(2), 335–346.

Phillips, P.C., Shi, S. (2019). Detecting financial collapse and ballooning sovereign risk. Oxf. Bull. Econ. Stat. 81(6), 1336–1361.

Pollard, P. (2003). A look inside two central banks: the European central bank and the federal reserve. Fed. Reserve Bank St. Louis Rev. 85, 11–30.

Quaglia, L. (2011). The Politics of Insurance Regulation and Supervision Reform in the European Union. Comp. Eur. Polit. 9(1), 100–122.

Rae, R.A., Barrett, A., Brooks, D., Chotai, M.A., Pelkiewicz, A.J., Wang, C. (2018). A review of solvency II: has it met its objectives? Br. Actuar. J. 23, 1–72.

Rodriguez Gonzalez, M., Basse, T., Tholl, J. (2019). Interest rate differentials and monetary policy in the European monetary union: the case of 10- and 30-year bonds. ZVersWiss 108(1), 19–42.

Rodriguez-Gonzalez, M., Kunze, F., Schwarzbach, C., Dieng, C. (2017). Asset liability management and the Euro crisis: sovereign credit risk as a challenge for the German life insurance industry. J.

Risk Finance 18(4), 466–483.

Sensoy, A., Nguyen, D.K., Rostom, A., Hacihasanoglu, E. (2019). Dynamic integration and network structure of the EMU sovereign bond markets. Ann. Oper. Res. 281(1), 297–314.

Sibbertsen, P., Wegener, C., Basse, T. (2014). Testing for a break in the persistence in yield spreads of EMU government bonds. J. Bank. Finance 41, 109–118.

Sims, C.A. (1980). Macroeconomics and reality. Econometrica 48(1), 1–48.

Smith, M.J.-H. (2010). Solvency II: the ambitious modernization of the prudential regulation of insurers and reinsurers across the European Union (EU). Connect. Insur. Law Journal. 16(2), 357–398.

Statista Research Department (2020): Laufende Verzinsung der Lebensversicherer in Deutschland von 2000 bis 2019. https://de.statista.com/statistik/daten/studie/168461/umfrage/ueberschussbeteiligung-der-lebensversicherer-seit-1995/, Accessed: 15 Dec 2020

Tholl, J., Schwarzbach, C., Pittalis, S., von Mettenheim, H.J. (2020). Bank funding and the recent political development in Italy: what about redenomination risk? Int Rev Law Econ 64, 105932

Thornton, J. (1996). Cointegration, causality and export-led growth in Mexico, 1895–1992. Econ Lett 50(3), 413–416.

Toda, H.Y., Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. J Econom 66(1-2), 225–250.

Valiante, D. (2011). The Eurozone debt crisis: from its origins to a way forward. Center for European Policy Studies Policy Briefs No. 251.

Van Riet, A. (2017). The ECB's Fight against Low Inflation: On the Effects of Ultra-Low Interest Rates. International Journal of Financial Studies 5(2):12. https://doi.org/10.3390/ijfs5020012

Von Saldern, N. (2016). Government bonds: treatment of risk under solvency II. BaFin. https://www.bafin.de/SharedDocs/Veroeffentlichungen/EN/Fachartikel/2016/fa_bj_1607_staatsanleihen_en.html, Accessed: 7 Jan 2021

De Vries, T., De Haan, J. (2016). Credit ratings and bond spreads of the GIIPS. Appl. Econ. Lett. 23(2), 107–111

Wegener, C., Kruse, R., Basse, T. (2019). The walking debt crisis. Journal of Economic Behavior and Organization 157, 382–402.

Zabala, J.A., Prats, M.A. (2020). The unconventional monetary policy of the European central bank: effectiveness and transmission analysis. World Econ. 43(3), 794–809.

Zapata, H.O., Rambaldi, A.N. (1997). Monte Carlo evidence on cointegration and causation. Oxf. Bull. Econ. Stat. 59(2), 285–298.

5. The Greek sovereign debt crisis as an important chapter in the history of the European Monetary Union: empirical evidence and some thoughts on implications for investors and financial risk managers

5.1. Introduction

The European sovereign debt crisis undoubtedly had a significant impact on international financial markets (see, for instance, Gruppe and Lange 2014 and Wegener et al. 2016). Prior to this, government bond yields that European Monetary Union (EMU) member countries had to pay to their investors were closely related to each other. In fact, at the beginning of the European common currency, there was interest rate convergence among short-, medium- and long-term yields of government bonds issued by EMU member countries. This was no surprise since there is only one Main Refinancing Operations Announcement Rate in the EMU that is determined by the European Central Bank (ECB) and since the advent of the common currency, the exchange rate risk was eliminated (see, for example, Wegener et al. 2016a and Gruppe et al. 2017). Moreover, there were no major fears about fiscal problems in the EMU member states in the early days of the currency union and government bonds issued by countries that had introduced the Euro were considered to be risk-free assets until the Greek debt swap (see, most importantly, Gruppe and Lange 2014 and Sibbertsen, Wegener and Basse 2014). Meanwhile, fears about sovereign credit risk and possibly even redenomination risk increased the risk premia that at least some of the less fiscally stable member countries had to provide to attract investors (see, amongst others, Basse 2014 and Sensoy, Nguyen, Rostom and Hacihasanoglu 2019). In fact, there seems to be a belief that risk premia before the crisis were too low and that there was an underpricing of sovereign credit risk in the EMU in this period (see, for example, Gibson, Hall and Talvas 2014 and Basse, Wegener and Kunze 2018). Monetary policy is also relevant in this context (see, for instance, Eser and Schwaab 2016 and Afonso et al. 2018). The ECB helped to ease the funding problems of the less fiscally stable EMU governments. In sum, there are at least two pricing regimes for EMU government bonds – and most likely even more. These pricing regimes are characterized by significant differences between the risk premia demanded by buyers of sovereign debt issued by member states of the EMU that are considered to be fiscally stable and those considered to be more unstable.

In this context, it is important to note that Lempérière et al. (2017) stressed that there is still no clear picture of how financial markets determine risk premia. Consequently, a need for more empirical research seems to prevail. Most importantly, Gunay (2020) recently suggested using Granger causality tests (see, most importantly, Granger 1969) to improve our understanding of the information flows between different risk premia. We follow his example and investigate how the risk premia in the market for Greek sovereign debt affected the markets for other EMU government bonds. This empirical evidence is of particular interest because Arghyrou and Kontonikas (2012) argued that the fiscal problems in Greece were of special importance for some time and, at least in this period, also had major consequences for ending the tendency towards an interest rate convergence in the EMU. Given that EMU government bonds and related assets are an important asset class for European insurance companies (see, amongst others, Ludwig 2014 and Tholl et al. 2021), the empirical evidence reported here certainly is highly relevant for this sector. This is especially true for asset and financial risk managers in the life insurance industry. In fact, the current low interest rate environment that is also a

consequence of the recent crisis events seems to be a significant problem for European life insurance companies (see, for example, Basse et al. 2014 and Berdin and Gründl 2015). Moreover, the fact that the EMU government bond market started to price sovereign credit risk also led to some critical questions about regulatory issues in the European insurance industry – namely with regard to the way Solvency II handles investments in sovereign government bonds (see, most importantly, Basse, Friedrich and Kleffner 2012 and Ludwig 2014). Some more recent papers stimulated these discussions (see, amongst others, Meier, Rodriguez Gonzalez and Kunze 2020 and Basse 2020).
The paper is structured as follows. Section 2 briefly reviews the relevant literature. The third section examines the difficulties in Greece in some detail and also analyzes monetary policy issues that are relevant in this context. Section 4 discusses some methodological issues and introduces the data set examined here. The results of the empirical investigations are presented and analyzed in section 5. The sixth section concludes.

5.2. Literature Review

Looking at the EMU from a historical perspective, it is open to question how many different phases it went through. Among others, Lane (2012) states that the history of the EMU is divided into three phases – before the sovereign debt crisis, during the crisis, and after the crisis when pressure on fiscally instable countries began to ease (see also, Arghyrou and Kontonikas 2012). Tholl et al. (2021) suggest that the outbreak of COVID-19 can complement the above-mentioned three phases in EMU history as the beginning of a fourth period. Before the EMU was implemented, optimistic expectations were that the common currency would foster the ability, especially of peripheric member states, to attract financial market investors more easily. This would be achieved thanks to the EMU's proposition of fiscal solidity, which is formally expressed by the convergence criteria as part of the Maastricht treaty (see, for instance, Franzmeyer, 1995 and Söllner, 2000). The treaty also determined three steps as a pre-condition for creating the EMU, starting with free capital flows among the member states, followed by a stronger cooperation among the national central banks, and ending in the introduction of the Euro as the common currency. The convergence criteria, which are also called Maastricht criteria, aimed at binding the EMU member states to fiscal consolidation and forcing their national banks towards a solid monetary policy. Fiscal solidity means that a country that wants to become a member of the EMU should have a public debt of not more than 60% of its GDP and an annual fiscal deficit of not more than 3% of GDP. From a monetary perspective, the Maastricht criteria stipulate that during an observation period of one year, a candidate country's key interest rate is not allowed to exceed the policy rate of the three most solid EMU member countries by more than 200 base points, for two years before joining the EMU the exchange rate needs to be in-between a fixed fluctuation margin, and for one year of observation the country's inflation rate should not exceed the three lowest rates of EMU member countries by more than 1.5 percentage points (see, for example, Fatás and Mihov 2003 and Camba-Mendez and Lamo 2004). The Maastricht criteria were complemented by the adoption of the Stability and Growth pact (SGP) in 1997, which intended to strengthen the commitment of the EMU member states to conduct a policy of fiscal solidity. In the absence of a common fiscal policy, the contract intended to obligate the Eurozone members to keep fiscal discipline in order to tackle a moral hazard problem: as the instrument of exchange rate adjustments is not available, members of the Euro area might be tempted to pursue a less stringent fiscal policy – not only in times of crisis. Moreover, investors might lose their disciplining influence since EMU member states issue bonds in a common currency instead of separate national currencies (see, Eijffinger and Hoogduin 2012). The Maastricht criteria, as well as the SGP, were subject

to widespread discussions (see, for example, Bibow 2013 and Savona 2015). On the one hand, they supposedly do not sufficiently reflect the necessities of a Keynesian demand-supporting fiscal policy in times of external shocks. On the other hand, the rules are questioned as nowadays nearly all EMU members do not fulfill the fiscal requirements set by the Maastricht criteria.

Before the start of the sovereign debt crisis, the expectations of converging EMU sovereign bond yields corresponded to later developments – independent of the maturity (see, for example, Gruppe et al. 2017, Feldstein 2015, and Dellas and Tavlas 2012). This trend came to an end only because of the outbreak of the sovereign debt crisis. This second phase of the EMU is characterized by sharp increases in sovereign bond spreads (see, for example, Ludwig 2014). Greece's financial situation provoked fears that it may be contagious and, therefore, could cause financial turmoil for other highly indebted EMU member states like Portugal, Ireland, Italy, and Spain. Additionally, France and Belgium experienced widening spreads (see, for example, de Santis 2012 and Claeys and Vašíček 2014). The contagion risk was also caused by the sovereign-bank-nexus that, among other things, already had contributed to the transition of the financial crisis to the sovereign debt crisis, which may have provoked a worsening of the financial crisis and thereby may have established a vicious circle (see, amongst others, Wegener, Kruse and Basse 2019 and Cuadros-Solas and Salvador Muñoz 2021). The idea of contagion is based on the assumption that restructuring Greek sovereign debt would also have a negative impact on banks that are creditors to Greece – whether as credit grantors or asset holders of Greek sovereign bonds (see, for example, Roman and Bilan 2012). These fears are supported by the fact that lendings to the home sovereign made up 11% of Greece's banks' assets. The Greek insurance and pensions fund sector's exposure to its own government even amounted to 29% (see, Ardagna and Caselli 2014). To prevent a worsening of the financial crisis, the governments would be forced to provide financial rescue packages, which would aggravate the burden on the respective sovereign's budget (see, for instance, de Santis 2012, Basse, Friedrich and Kleffner 2012, and Figure 1).

Despite the no-bail-out clause, in May 2010, the EMU members opted to provide bilateral credits to Greece, summing up to 80 bn EUR. This was accompanied by an IMF lending amounting to an additional 30 bn EUR, conditional on fiscal and structural reforms (see, Mink and de Haan 2013). Shortly after, the European Financial Stability Facility (EFSF) was created with a volume of 440 bn EUR to provide funds for EMU member states suffering financial turmoil (see, Gocaj and Meunier 2013). The funds were backed by financial guarantees of the EMU member states. At the same time, the IMF and the European Financial Stabilization Mechanism (EFSM) provided in total 310 bn EUR. This adds up the potentially available liquidity for states in financial need to 750 bn EUR. This framework was paralleled by the ECB's announcement to purchase sovereign debt of EMU states. The EFSF was created to provide liquidity via loans to EMU countries at short notice (see, Horváth and Huizinga 2011) and was subject to criticism regarding its legal framework as an implicit step towards the communitization of public debt in the Eurozone. From a moral hazard perspective, this approach supposedly weakens a country's incentive to follow a solid fiscal policy (see, Pisani-Ferry 2010).

On the monetary side, support was achieved by the Securities Market Programme (SMP) of the ECB, which aimed to stabilize the demand for sovereign bonds and bills coming under market pressure (see, e.g., Zettelmeyer et al. 2013). In July 2011, when it became clear that Greece would not be able to return to the financial markets in 2012, Eurozone member states further increased their financial support by 109 bn EUR in addition to 135 bn EUR contributed by the private sector (see, Zettelmeyer et al. 2013). Due to the central banks' actions against the financial crisis, there was little maneuvering space left for the monetary policy to counteract the arising sovereign debt crisis. Financial markets doubted that all members of the Eurozone would remain in the common currency area. These fears were only allayed

with the famous Draghi speech on 26 July 2012 and the corresponding unconventional monetary policy instruments like asset purchase programs (e.g., OMT and LTRO) by the ECB (see, Acharya et al. 2019). They helped to provide liquidity to the financial markets in order to overcome a liquidity shortfall in the sovereign bond markets and, at the same time, stabilize the demand for sovereign bonds (see, Cour-Thiemann and Winkler 2013). They also convinced financial markets that the EU institutions would do everything to maintain the EMU. The main arguments were, on the one hand, the volume of the ECB response and, on the other hand, the central bank's promise to even strengthen its measures if they proved not to be sufficient. It marked the beginning of the third phase in EMU history – a time of recovery (see, Lane 2012).

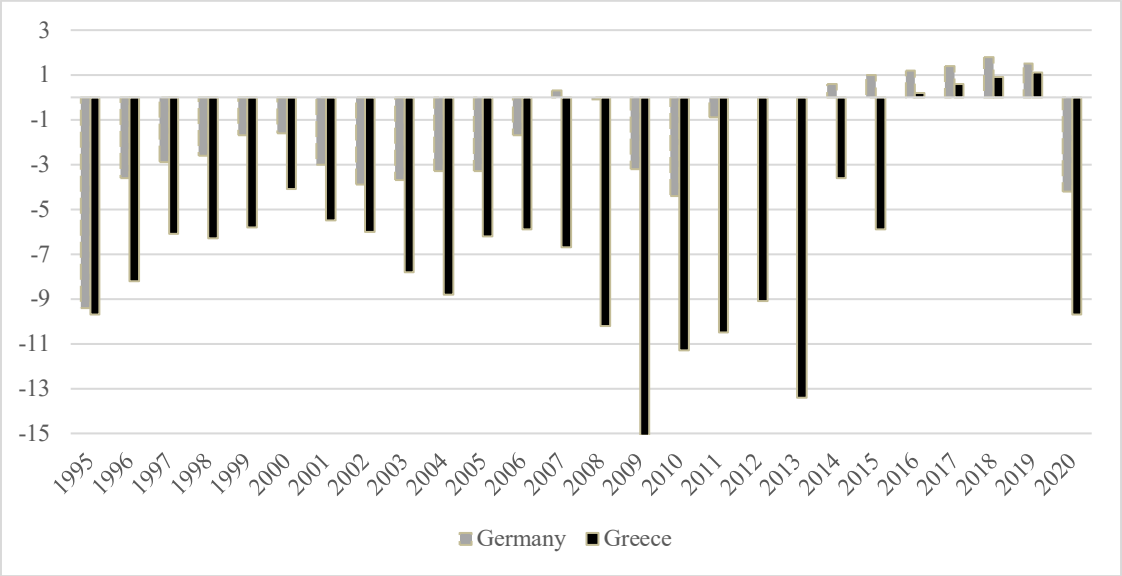

Figure 5-1: Government deficit/surplus in percentages of Gross Domestic Product. Source: Eurostat (2021a).

Our empirical research (which will be reported later) provides strong evidence that Greece played an essential role in the sovereign debt crisis. This is due to its significant impact on the crisis development in other highly indebted EMU member states and the financial market's reaction. Therefore, the history of the European currency area might be divided not only into three but rather into four phases. Without a doubt, there was a pre- and post-sovereign debt crisis phase in the EMU. Additionally, the phase in between could be divided into phases II a and II b of the EMU history. To understand the situation in Greece during the sovereign debt crisis, we look back at the main events and the issues discussed at the time as well as provide some background information.

5.3. Greece's special characteristics in the sovereign debt crisis

The until than severest crisis in EMU history started in October 2009, when Greece's newly elected government announced that the forecast for its fiscal budget deficit of the same year would rise from 7% to 12% (see, Zettelmeyer et al. 2013). Considering an already elevated debt level and fiscal measures that fell short of expectations (see, Baum et al. 2016), in October 2009, Fitch decided to downgrade the Hellenic sovereign debt to A- and two months later, further to BBB. Standard & Poor's and Moody's, the two other relevant rating agencies, followed that development. This highlighted an issue that had been largely ignored by financial markets before, although the financial circumstances had already existed for some time (see, Akram et al. 2011). Six months later, due to the downgrades and the

corresponding increased yield demands by investors, Greece was implicitly cut off from the financial markets and consequently about to run out of liquidity. The Greek government responded by adopting austerity measures aimed at preparing for bailout negotiations (see, Ardagna and Caselli 2014).

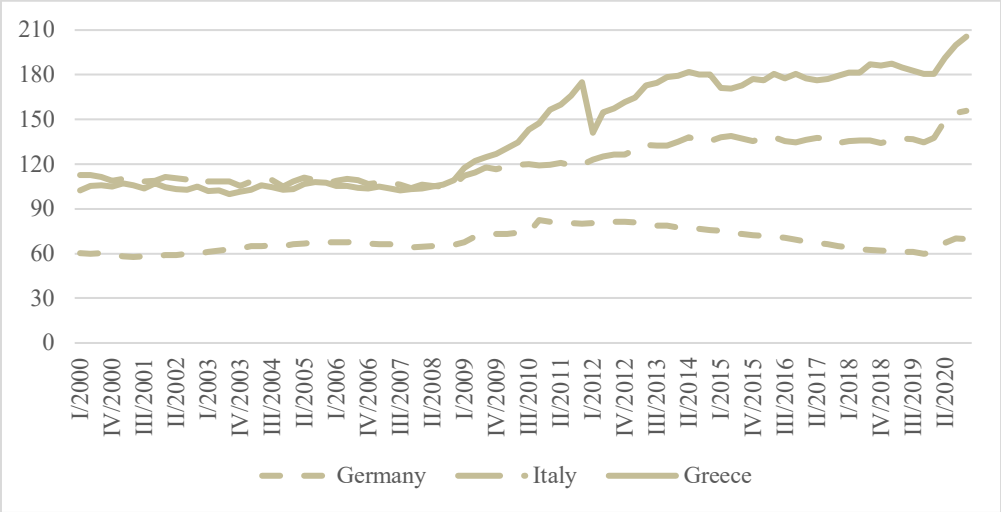

Figure 5-2: Public debt to GDP ratio in percentages. Source: Eurostat (2021b).

Greece's worsening financial situation (see also, Figure 2) fostered criticism that had already prevailed before but gained importance due to the crisis. Since its beginning but especially since the outbreak of the sovereign debt crisis, the EMU has faced criticism with regards to some basic ideas of economic theory: the idea of the "Optimum Currency Area" (OCA) by Mundell (1961), which was later enhanced by McKinnon (1963) (see, among others, Schwartz et al. 2013 as well as Jager and Hafner 2013, and the literature survey by Kunroo 2013) and the idea of public financial sustainability that is associated with a maximum debt level. According to the OCA theory, a region interconnected by trade but divided by national borders should aim to create a common monetary area as long as certain conditions are fulfilled. The latter should compensate the members for the disadvantage of abandoning their own monetary policy and the corresponding instruments. According to Mundell (1961), an OCA is given when asymmetric shocks can be absorbed. This can be achieved by facilitating a rapid adaptation of wage and price levels as well as high factor mobility which is to say not only capital but also labor mobility. The latter enables the workforce to move from regions with rising unemployment to regions capable of absorbing unemployed workers. The OCA theory claims that a country should maintain its own currency if the disadvantages of crisis adaptation mechanisms regarding price and wage changes outweigh the absence of a rapid crisis mechanism: exchange rate depreciation.

With regard to the EMU, there are a lot of relevant papers examining which countries should be part of this monetary union (see, for instance, Artis 2003 and Kim and Chow 2003). In summary, it can be stated that there does not seem to be a clear picture trying to answer this question. Savona (2015), for instance, has argued that the EMU might be a non-optimal currency area. It is open to discussion whether an OCA requires a common fiscal transfer system that compensates for a sudden decline in aggregated demand by fiscal means. According to Buiter (1999), fiscal measures fostering aggregated consumption on national levels can be as effective as a supranational fiscal transfer system. He assumes that fiscal deficits are reflected in current account imbalances. There are indicators for this phenomenon in the EMU as well (see, Sinn and Wollmershäuser 2011). Low price rigidities or, in other terms, low menu costs can also contribute to the absorption of asymmetric shocks (see, Buiter 1999). Baldwin and

Wyplosz (2019) point out that asymmetric shocks in a monetary union reveal the biggest challenges for an economy that lost its sovereign monetary policy as a tool to absorb these shocks. OCA theory presumes that joining a monetary union is beneficial if the loss of monetary policy that helps to stimulate economic growth by fostering credit demand through lowering policy rates and strengthening international competitiveness by decreasing exchange rates is compensated by increased competitiveness through better price comparability and higher competition intensity in a more integrated market (see, Jager and Hafner 2013). Among others, Pisani-Ferry (2013) and Krugman (2013) claim that the EMU does not fulfill the OCA conditions and, therefore, is supposedly more vulnerable in times of crisis. The sovereign debt crisis nourished this kind of criticism as it apparently proved the EMU's and especially Greece's inability to deal with asymmetric shocks. Among others, the OCA theory provided the theoretical background for arguments in favor of Greece leaving the Eurozone as the OCA criteria are not fulfilled. Referring to OCA theory, a common currency area should be characterized by (i) extensive trade relations, (ii) similar business cycles, (iii) high level of labor mobility, as well as (iv) a mechanism to cushion economic slump, which usually are fiscal transfers (see, Frankel and Rose, 1998) in order to address asymmetric shocks.

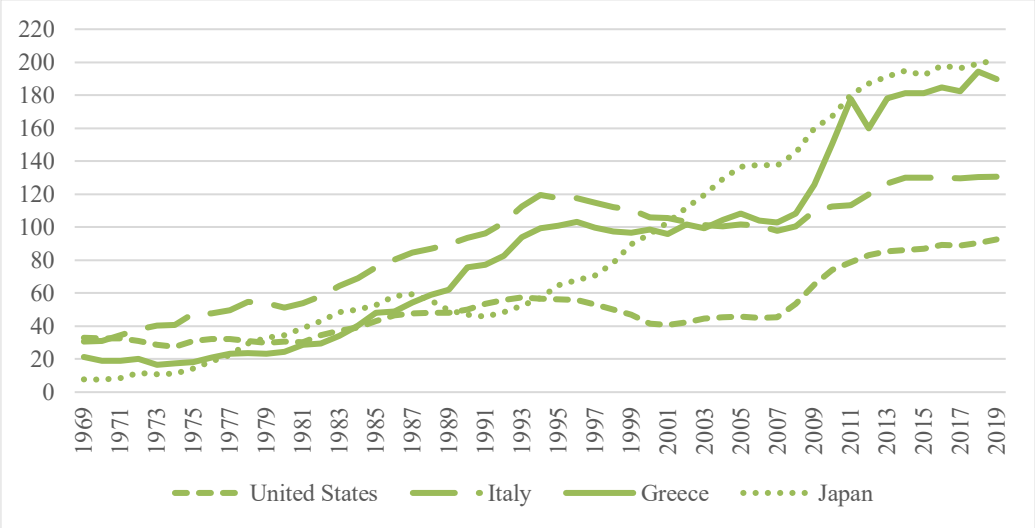

Figure 5-3: Central government debt to GDP ratio in percentages. Source: IMF (2021).

Among others Fidrmuc (2004), de Grauwe and Mongelli (2005) support an optimistic view regarding the question whether a currency union shortly after having been founded meets the OCA criteria or not. They claim that even though a monetary union might not comply with the conditions of an OCA right away, there are indications that economic integration fosters symmetry in business cycles (see, Rose 2008), whereby a monetary union might comply with OCA criteria over time. According to Frankel and Rose (1998) as well as Mongelli (2002), this phenomenon reflects the endogeneity of OCA, which is to say that a monetary union approaches the OCA criteria through its higher degree of integration which is a result of eliminated exchange rates and increased price transparency. The symmetry in business cycles relieves the members of the monetary union of the disadvantages associated with having abandoned their sovereign monetary policy: in contrast to asymmetric shocks, symmetric economic shocks can also be contained by a common monetary policy. Referring to Buiter (1999), fiscal policy responses are on a national level as effective as on a supranational level. From these perspectives, the question whether the EMU a few years after its introduction has complied with the OCA criteria or not becomes irrelevant

over time because a currency union will converge to an OCA.
The exit argument was strengthened further by Reinhart and Rogoff (2010) and later Reinhart, Reinhart and Rogoff (2012), who scrutinized public debt overhangs in advanced economies since the early 1800s. The paper fostered discussions in the economic and political sphere concerning the question of which debt-to-GDP level can still be regarded as sustainable. This would possibly have implications for the Greek rescue program. Reinhart, Reinhart and Rogoff (2012) proclaim that a debt-to-GDP ratio of over 90% is considered threatening to the debt sustainability of developed economies. But in this explanation, not only the structure of the public debt was disregarded but also the question of why, e.g., Japan's sovereign debt level was considered to be sustainable. In contrast, Greece and other highly indebted European countries were deemed to be overindebted even at comparably far lower debt levels (see also, Figure 3). Instead of associating fiscal sustainability with certain debt levels, the market-oriented response would be that a sovereign's debt level can be regarded as sustainable as long as private investors are willing to buy government bonds (see, Collignon 2012). The most popular theory of public debt sustainability is based on the idea of an intertemporal budget constraint. It claims that the discounted value of a sovereign's current and future income has to be sufficient to cover the discounted value of a government's current and future expenses in addition to the given debt (see, Quintos 1995). Uncertainty might also play a role. In fact, Kotlikoff (2006) has argued convincingly that there are two types of relevant uncertainties: first of all, there is some uncertainty about the economy's underlying technology and preferences. Secondly, there also is uncertainty about future government policies. In this context, one should be aware of how the interaction between fiscal and monetary policy contributes to fiscal solidity. Public debt rises as long as the real interest rate exceeds the economy's growth rate and cannot be compensated by the primary surplus. The interdependency of the parameters is well described by the Fisher effect claiming that the real interest rate depends on the nominal interest rate and the inflation rate, which are, together with the growth rate, affected by monetary and fiscal policy (see, Summers 1982). A restrictive fiscal policy is supposed to weaken money demand and thereby put pressure on the interest and inflation rate but it might also be a burden on economic growth (see, Collignon 2012). For more than 200 years, the US could generate growth rates that mostly outran average interest rates (see, Bohn 1998), which did not prevent debt levels from rising (see, figure 3).
When the European sovereign debt crisis began to spread in 2010, Japan's debt-to-GDP ratio already amounted to 198%, while Greece suffered much more from its debt-to-GDP level of then 129% (see, Doi et al. 2011). Additionally, Greece's debt-to-GDP ratio already amounted to 94.4% in 1993 (see, Gourinchas et al. 2017). Nikiforos et al. (2015) state that shortly before the start of the sovereign debt crisis, 80% of Greek's sovereign debt was issued in bonds, of which 73% were held by foreign investors, most of which were private financial institutions. This fact supposedly increases the likelihood that investors will withdraw their funds in the event of a crisis. In 2015, the share of foreign creditors remained nearly the same (75%) but had changed from the private to the public sector (see, Nikiforos et al. 2015). In contrast, in Japan, significant parts of the government debt are owned by social security funds which control assets amounting to about 40% of the Japanese GDP (see, Doi et al. 2011).

5.4. Data and Methodology

We examine 10-year government bond yields in five different EMU member countries (namely France, Germany, Greece, Italy, and Spain). This monthly data is taken from the Federal Reserve Bank of St. Louis database FRED and was compiled by the Organisation for Economic Co-operation and Development (OECD). More specifically, we examine interest rate differentials (id) of the bonds issued

by the other countries relative to German bonds, with x denoting the member states France, Greece, Italy, and Spain, respectively (see, equation 1):

$$id_X = i_X - i_{Germany} \quad (1).$$

Given that the default risk of the Federal Republic of Germany usually is considered to be negligible and that there is a highly liquid and very active market for German government bonds, these debt obligations can be described with the expression of a risk-free asset. Consequently, German sovereign bond yields are frequently used as the EMU benchmark interest rate (see, for example, Gruppe and Lange 2014 and Rodriguez Gonzalez et al. 2017). Therefore, the term id in equation (1) can be interpreted as a risk premium. Our data sample covers the time from 2009/10 to 2017/12. In this period, Greek bond yields were particularly high. Thus, we examine data from a phase in which the difficulties in this country should have mattered most for the entire EMU government bond market. Consequently, our empirical work presented below is also an indirect test of the idea that Greece, at least for some time, was of special importance when trying to explain the European sovereign debt crisis (see, most importantly, Arghyrou and Kontonikas 2012). Finding no information flow from the market for Greek bonds to the one for other EMU government bonds even in this period of time would certainly contradict this point of view.

As already noted, we follow Gunay (2020) and use Granger causality tests to improve our understanding of the information flow between different risk premia. This technique has also been employed to test the so-called German Dominance Hypothesis (GDH), which was an important theoretical concept examining European interest rates before the introduction of the common currency (see, for example, Bajo-Rubio and Montávez-Garcés 2002 and Booth and Ciner 2005). The GDH predicts that German interest rates were of special importance for the bond yields in the other member countries of the European Monetary System (EMS) (see, amongst others, Camarero and Tamarit 1995 and Chen and Mazumdar 1995). More specifically, we use procedures developed by Toda and Yamamoto (1995) to test for Granger causality. Concerning the empirical evidence that is reported later in this paper, the empirical study by Booth and Ciner (2005) is of special importance because these authors used a test procedure (which was developed by Dolado and Lütkepohl 1996) that is very similar to the Toda and Yamamoto (1995) test that is employed here. At this point, it has to be noted that Granger causality implies that one time series can be helpful in forecasting a second variable (see, most importantly, Granger 1969). Thus, one time series X_t is said not to be Granger causing the variable Y_t for all $n > 0$ under the condition that:

$$F(Y_{t+n} \mid \Omega_t) = F(Y_{t+n} \mid \Omega_t - X_t) \quad (2).$$

In equation (2), F denotes the conditional distribution and Ω_t is all information that could be of relevance in the context under investigation. There may also be feedback effects between the variables. In this case, bidirectional Granger causality would be present among the variables examined (see, for instance, Patev, Kanaryan and Lyroudi 2006 and Tholl et al. 2021). Otherwise, there is uni-directional Granger causality. The procedure developed by Toda and Yamamoto (1995) is based on the concept of vector autoregressive models introduced by Sims (1980).

Following Sims (1980) Y_t in equation (3) is a vector of $(n \times 1)$ endogenous variables, A_i are $(n \times n)$ coefficient matrices, C is a $(n \times 1)$ vector of constants, and ε_t is an $(n \times 1)$ vector of disturbance terms:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t. \quad (3).$$

In order to test for Granger causality, Toda and Yamamoto (1995) suggested estimating a vector autoregression in levels considering p time lags and extending this model by m time lags (see, equation 4). Here m is the highest order of integration of any exogenous variable examined and p is the optimal number of time lags for the vector autoregressive model:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \cdots + A_{p+m} Y_{t-(p+m)} + \varepsilon_t \quad (4).$$

Using this approach – which often is called a modified Wald test – ensures that the test statistic is asymptotically chi-square distributed by adding m lags in equation (4). The optimal number of time lags for the vector autoregression can be selected using the traditional information criteria (here, the AIC) and m is determined employing unit root tests.

5.5. Empirical Evidence

To determine the order of integration of the variables under observation here, we use the test suggested by Phillips and Perron (1988) with the critical values tabulated by MacKinnon (1996). The results of these tests examining the four interest rate differentials are presented in tables 1 through 4.

Table 5-1: Unit Root Test Spread France to Germany

Null Hypothesis: idFrance has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.018381	0.2786
Test critical values:	1% level	-3.497727	
	5% level	-2.890926	
	10% level	-2.582514	

Null Hypothesis: D(idFrance) has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-9.628260	0.0000
Test critical values:	1% level	-3.497727	
	5% level	-2.890926	
	10% level	-2.582514	

*MacKinnon (1996) one-sided p-values.

Table 5-2: Unit Root Test Spread Greece to Germany

Null Hypothesis: idGreece has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.884948	0.3381
Test critical values:	1% level	-3.497727	
	5% level	-2.890926	
	10% level	-2.582514	

Null Hypothesis: D(idGreece) has a unit root
Exogenous: Constant
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.801587	0.0000
Test critical values:	1% level	-3.497727	
	5% level	-2.890926	
	10% level	-2.582514	

*MacKinnon (1996) one-sided p-values.

Table 5-3: Unit Root Test Spread Italy to Germany

Null Hypothesis: idItaly has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.647776	0.4545
Test critical values:	1% level	-3.497727	
	5% level	-2.890926	
	10% level	-2.582514	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(idItaly) has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.014487	0.0000
Test critical values:	1% level	-3.497727	
	5% level	-2.890926	
	10% level	-2.582514	

*MacKinnon (1996) one-sided p-values.

Table 5-4: Unit Root Test Spread Spain to Germany

Null Hypothesis: idSpain has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.383385	0.5875
Test critical values:	1% level	-3.497727	
	5% level	-2.890926	
	10% level	-2.582514	

Null Hypothesis: D(idSpain) has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.531971	0.0000
Test critical values:	1% level	-3.497727	
	5% level	-2.890926	
	10% level	-2.582514	

*MacKinnon (1996) one-sided p-values.

According to the tests, all four interest rate differentials seem to be non-stationary variables that are integrated of order one. Therefore, when employing the procedure developed by Toda and Yamamoto (1995), m in all cases under investigation here is 1. Given the research question of our empirical study (namely, the role of Greece in the European sovereign debt crisis), we examine the relationship between markets for government bonds from Greece and France, Greece and Italy, as well as Greece and Spain. As already noted, we follow Gunay (2020) and are interested in the information flow between these fixed-income markets. More specifically, we examine the risk premia. Therefore, we analyze interest rate differentials relative to German 10-year government bond yields and estimate three augmented vector-autoregressive models (as suggested by Toda and Yamamoto 1995) to test for Granger causality.

Table 5-5: Granger Causality Test examining France

TY Granger Causality Tests
Sample: 2009M10 2017M12
Included observations: 99

Dependent variable: idFrance

Excluded	Chi-sq	df	Prob.
idGreece	11.12782	5	0.0489

Dependent variable: idGreece

Excluded	Chi-sq	df	Prob.
idFrance	54.12560	5	0.0000

Table 5-6: Granger Causality Test examining Italy

TY Granger Causality Tests
Sample: 2009M10 2017M12
Included observations: 99

Dependent variable: idItaly

Excluded	Chi-sq	df	Prob.
idGreece	26.77646	6	0.0002

Dependent variable: idGreece

Excluded	Chi-sq	df	Prob.
idItaly	27.63546	6	0.0001

Table 5-7: Granger Causality Test examining Spain

TY Granger Causality Test
Sample: 2009M10 2017M12
Included observations: 99

Dependent variable: idSpain

Excluded	Chi-sq	df	Prob.
idGreece	20.63153	7	0.0044

Dependent variable: idGreece

Excluded	Chi-sq	df	Prob.
idSpain	31.51690	7	0.0000

The results are reported in tables 5 to 7. As already discussed, m in all cases is 1 because all the time series examined are integrated of order one. The information criterium AIC is used to determine p and results in p being 5 with regard to France, 6 with regard to Italy, and 7 with regard to Spain. In all cases, the hypothesis of no Granger causality can be rejected at the 5% error level. Therefore, all three models indicate that there is bidirectional Granger causality between the examined bond yield spreads. Consequently, Greek interest rate differentials to Germany help to forecast the bond yield spreads of the other three countries (France, Italy, and Spain) and the interest rate differentials to Germany for French, Italian, and Spanish government bonds seem to be helpful to predict the spread between 10-year government bond yields of Greece and Germany. Therefore, data from Greece does matter for the EMU government bond market. This empirical finding is compatible with the ideas highlighted by Arghyrou

and Kontonikas (2012). In fact, the data seem to imply that there are good reasons to divide the sovereign debt crisis in Europe into an early (II a) and a later (II b) phase.

5.6. Conclusion

This empirical study examines the European sovereign debt crisis and focuses on the role of Greece. More specifically, we first discuss the question of fiscal stability in Greece and then analyze interest rate differentials to Germany of several EMU member countries (namely France, Greece, Italy, and Spain). We show that bidirectional Granger causality between all examined bond yield spreads does indeed exist. Therefore, the information embedded in Greek government bond yields (risk premia) seems to be helpful in forecasting interest rates in the economically more important member countries France, Italy, and Spain. This empirical finding is of some interest when trying to identify different phases of the crisis. Greece seems to matter in this context (see, most importantly, Arghyrou and Kontonikas 2012). Our results reported above are not only interesting from a macroeconomic point of view. In fact, fixed-income investors and risk managers working for financial institutions with high exposures to sovereign bonds issued by EMU member countries (e.g., European insurance companies) should also pay attention to this aspect. Our findings might, for example, be of relevance for models of government bond yield spreads in the monetary union. Given that Lempérière et al. (2017) highlighted that there still is no absolutely clear picture of how financial markets determine risk premia, the results reported in this paper clearly could be of value for investors and risk managers controlling asset managers when investing in government bonds or related assets.

5.7. References

Acharya, V.V., Eisert, T., Eufinger, C., Hirsch, C. (2019). Whatever it takes: The real effects of unconventional monetary policy. Rev. Financ. Stud. 32(9), 3366–3411.

Afonso, A., Arghyrou, M.G., Gadea, M.D., Kontonikas, A. (2018) "Whatever it takes" to resolve the European sovereign debt crisis? Bond pricing regime switches and monetary policy effects. J Int Money Finance 86, 1–30.

Akram, M., Noreen, H., Karamat, M. (2011). The Greek sovereign debt crisis: Antecedents, consequences and reforms capacity. J. Econ. Behav. Stud. 2(6), 306–318.

Ardagna, S., Caselli, F. (2014). The political economy of the Greek debt crisis: A tale of two bailouts. Am. Econ. J. Macroecon. 6(4), 291–323.

Arghyrou, M.G., Kontonikas, A. (2012). The EMU sovereign-debt crisis: Fundamentals, expectations and contagion. J. Int. Financ. Mark. Instit. Money 22(4), 658–677.

Artis, M.J. (2003). Reflections on the optimal currency area (OCA) criteria in the light of EMU. Int. J. Fin. Econ. 8(4), 297–307.

Bajo-Rubio, O., Montávez-Garcés, M.D. (2002). Was there monetary autonomy in Europe on the eve of EMU? The German dominance hypothesis re-examined. J Appl Econ 5(2), 185–207.

Baldwin, R., Wyplosz, C. (2019). The economics of European integration, 6th edn. McGraw-Hill, London.

Basse, T. (2014). Searching for the EMU core member countries. Eur J Polit Econ 34, S32–S39.

Basse, T. (2020). Solvency II and sovereign credit risk: Additional empirical evidence and some thoughts about implications for regulators and lawmakers. Int Rev Law Econ 64, 105933.

Basse, T., Friedrich, M., Kleffner, A. (2012). Italian government debt and sovereign credit risk: An empirical exploration and some thoughts about consequences for European insurers. ZVersWiss. 101, 571–579.

Basse, T., Friedrich, M., Kleffner, A., von der Schulenburg, J.-M.G. (2014). Are interest rates too low? Empirical evidence and implications for German life insurers. ZVersWiss. 103, 31–43.

Basse, T., Wegener, C., Kunze, F. (2018). Government bond yields in Germany and Spain—Empirical evidence from better days. Quant. Finance 18(5), 827–835.

Baum, C.F., Schäfer, D., Stephan, A. (2016). Credit rating agency downgrades and the Eurozone sovereign debt crises. J. Financ. Stab. 24, 117–131.

Berdin, E., Gründl, H. (2015). The effects of a low interest rate environment on life insurers. Geneva Pap. Risk Insur. Pract. 40, 385–415.

Bibow, J. (2013). The Euroland crisis and Germany's euro trilemma. Int. Rev. Appl. Econ. 27(3), 360–385.

Bohn, H. (1998). The behavior of US public debt and deficits. Q J Econ 113(3), 949–963.

Booth, G.G., Ciner, C. (2005). German dominance in the European Monetary System: A reprise using robust Wald tests. Appl Econ Lett 12(8), 463–466.

Buiter, W.H. (1999). The EMU and the NAMU: What is the case for North American Monetary Union? Can. Public Policy 25(3), 285–305.

Camarero, M., Tamarit, C. (1995). A rationale for macroeconomic policy coordination: Evidence based on the Spanish peseta. Eur J Polit Econ 11(1), 65–82.

Camba-Mendez, G., Lamo, A. (2004). Short-term monitoring of fiscal policy discipline. J. Appl. Econom. 19(2), 247–265.

Chen, A.H., Mazumdar, S.C. (1995). Interest rate linkages within the EMS and bank credit supply. Eur. Financ. Manag. 1(1), 37–48.

Claeys, P., Vašícek, B. (2014). Measuring bilateral spillover and testing contagion on sovereign bond markets in Europe. J. Bank. Finance 46, 151–165.

Collignon, S. (2012). Fiscal policy rules and the sustainability of public debt in Europe. Int. Econ. Rev. 53(2), 539–567.

Cour-Thimann, P., Winkler, B. (2012). The ECB's non-standard monetary policy measures: the role of institutional factors and financial structure. Oxf. Rev. Econ. Policy 28(4), 765–803.

Cuadros-Solas, P.J., Salvador Muñoz, C. (2021). Potential spillovers from the banking sector to sovereign credit ratings. Appl Econ Lett 28(12), 1046–1052.

De Grauwe, P.: Only a more active ECB can solve the euro crisis. Centre for European Policy Studies policy briefs, vol. 250. (2011)

De Santis, R.A. (2012). The Euro area sovereign debt crisis: safe haven, credit rating agencies and the spread of the fever from Greece, Ireland and Portugal. European Central Bank, working paper series, vol. 1419.

De Grauwe, P., Mongelli, F.P. (2005). Endogeneities of optimum currency areas: What brings countries sharing a single currency closer together? European Central Bank working paper series, vol. 468.

Dellas, H., Tavlas, G.S. (2012). The road to Ithaca: the Gold Standard, the Euro and the origins of the Greek sovereign debt crisis. Bank of Greece, vol. 149.

Doi, T., Hoshi, T., Okimoto, T. (2011). Japanese government debt and sustainability of fiscal policy. J. Jpn. Int. Econ. 25(4), 414–433.

Dolado, J.J., Lütkepohl, H. (1996). Making Wald tests work for cointegrated VAR systems. Econom. Rev. 15(4), 369–386.

Eijffinger, S., Hoogduin, L. (2012). The European central bank in (the) crisis. CESifo DICE Rep. 10(1), 32–38.

Eser, F., Schwaab, B. (2016). Evaluating the impact of unconventional monetary policy measures: Empirical evidence from the ECB's Securities Markets Programme. J Financ Econ 119(1), 147–167.

Eurostat (2021a): Government deficit/surplus. https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=gov_10dd_edpt1&lang=en, Accessed: 11 Oct 2021.

Eurostat (2021b): Debt-to-gdp-ratio. https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=gov_10q_ggdebt&lang=en, Accessed: 8 Oct 2021.

Fatás, A., Mihov, I. (2003). On constraining fiscal policy discretion in EMU. Oxf. Rev. Econ. Policy 19(1), 112–131.

Feldstein, M.S. (2015). Ending the Euro crisis? National Bureau of Economic Research. Working paper, vol. 20862.

Fidrmuc, J. (2004). The endogeneity of the optimum currency area criteria, intra-industry trade, and EMU enlargement. Contemp. Econ. Policy 22(1), 1–12.

Frankel, J.A., Rose, A.K. (1998). The endogenity of the optimum currency area criteria. Econ. J. 108(449), 1009–1025

Franzmeyer, F. (1995): The Maastricht convergence criteria from a German perspective. Econ. Bull. 32, 17-24.

Gibson, H.D., Hall, S.G., Tavlas, G.S. (2014). Fundamentally wrong: market pricing of sovereigns and the Greek financial crisis. J. Macroecon. 39(B), 405–419.

Gocaj, L., Meunier, S. (2013). Time will tell: The EFSF, the ESM, and the euro crisis. J. Eur. Integr. 35(3), 239–253.

Gourinchas, P.O., Philippon, T., Vayanos, D. (2017). The analytics of the Greek crisis. NBER Macroecon Annu 31, 1–81.

Granger, C.W. (1969). Investigating causal relations by econometric models and cross-spectral methods. Econometrica 37(3), 424–438.

Gruppe, M., Lange, C. (2014). Spain and the European sovereign debt crisis. Eur J Polit Econ 34, S3–S8.

Gruppe, M., Basse, T., Friedrich, M., Lange, C. (2017). Interest rate convergence, sovereign credit risk and the European debt crisis: A survey. J. Risk Finance 18(4), 432–442.

Gunay, S. (2020). Seeking causality between liquidity risk and credit risk: TED-OIS spreads and CDS indexes. Res. Int. Bus. Finance 52, 101189.

Horváth, B.L., Huizinga, H. (2011). Does the European financial stability facility bail out sovereigns or banks? An event study. CEPR discussion papers, vol. 8661.

IMF (2021): Central government debt. https://www.imf.org/external/datamapper/CG_DEBT_GDP@GDD/ITA/USA/GRC/JPN, Accessed: 17 Oct 2021.

Jager, J., Hafner, K.A. (2013). The optimum currency area theory and the EMU. Intereconomics 48, 315–322.

Kim, Y., Chow, H.K.: Optimum currency area in Europe: an alternative assessment. Econ Lett 81(3), 297–304 (2003)

Kotlikoff, L.J. (2006). Is the United States bankrupt? Fed. Reserve Bank St. Louis Rev. 88(4), 235–249.

Krugman, P. (2013). Revenge of the optimum currency area. NBER Macroecon Annu 27, 439–448

Kunroo, M.H. (2015). Theory of optimum currency areas: A literature survey. Rev. Mark. Integr. 7(2), 87–116.

Lane, P.R. (2012). The European sovereign debt crisis. J. Econ. Perspect. 26(3), 49–68.

Lempérière, Y., Deremble, C., Nguyen, T.T., Seager, P., Potters, M., Bouchaud, J.P. (2017) Risk premia: Asymmetric tail risks and excess returns. Quant. Finance 17(1), 1–14.

Ludwig, A. (2014). Credit risk-free sovereign bonds under solvency II: A cointegration analysis with consistently estimated structural breaks. Appl. Financial Econ. 24(12), 811–823.

MacKinnon, J.G. (1996). Numerical distribution functions for unit root and cointegration tests. J. Appl. Econom. 11(6), 601–618.

McKinnon, R.I. (1963). Optimum currency areas. Am. Econ. Rev. 53(4), 717–725.

Meier, S., Rodriguez Gonzalez, M., Kunze, F. (2020). The global financial crisis, the EMU sovereign debt crisis and international financial regulation: Lessons from a systematic literature review. Int Rev Law Econ 65, 105945.

Mink, M., De Haan, J. (2013). Contagion during the Greek sovereign debt crisis. J. Int. Money Finance 34, 102–113.

Mongelli, F.P. (2002). 'New' views on the optimum currency area theory: What is EMU telling us? European central bank working paper series, vol. 138.

Mundell, R.A. (1961). A theory of optimum currency areas. Am. Econ. Rev. 51(4), 657–665.

Nikiforos, M., Papadimitriou, D.B., Zezza, G. (2015). The Greek public debt problem. Nova Econ. 25, 777–802.

Patev, P., Kanaryan, N., Lyroudi, K. (2006). Stock market crises and portfolio diversification in Central and Eastern Europe. Manag. Finance 32(5), 415–432.

Phillips, P.C.B., Perron, P.(1988). Testing for a unit root in time series regression. Biometrika 75(2), 335–346.

Pisani-Ferry, J. (2010). Euro-area governance: What went wrong? How to repair it? Bruegel Policy Contribution, vol. 2010/05.

Pisani-Ferry, J. (2013). The known unknowns and unknown unknowns of European Monetary Union. J. Int. Money Finance 34, 6–14.

Quintos, C.E. (1995). Sustainability of the deficit process with structural shifts. J. Bus. Econ. Stat. 13(4), 409–417.

Reinhart, C.M., Rogoff, K.S. (2010). Growth in a time of debt. Am. Econ. Rev. 100(2), 573–578.

Reinhart, C.M., Reinhart, V.R., Rogoff, K.S. (2012). Public debt overhangs: advanced-economy episodes since 1800. J. Econ. Perspect. 26(3), 69–86.

Rodriguez Gonzalez, M., Kunze, F., Schwarzbach, C., Dieng, C. (2017). Asset liability management and the Euro crisis: Sovereign credit risk as a challenge for the German life insurance industry. J. Risk Finance 18(4), 466–483.

Roman, A., Bilan, I. (2012). The euro area sovereign debt crisis and the role of ECB's monetary policy. Procedia Econ. Finance 3, 763–768.

Rose, A.K. (2008). Is EMU becoming an optimum currency area? The evidence on trade and business cycle synchronization. University of California, Berkeley, Haas School of Business, working paper.

Savona, P. (2015). The future of the Euro still lies in its past. Atl. Econ. J. 43, 407–414.

Schwartz, P., Cabrillo, F., Castaneda, J.E. (2013). Saving monetary union? A market solution for the orderly suspension of Greece. In: Booth, P. (ed.) The Euro—the Beginning, the Middle ... and the End? pp. 123–146. The Institute of Economic Affairs, London.

Sensoy, A., Nguyen, D.K., Rostom, A., Hacihasanoglu, E. (2019). Dynamic integration and network structure of the EMU sovereign bond markets. Ann. Oper. Res. 281, 297–314.

Sibbertsen, P., Wegener, C., Basse, T. (2014). Testing for a break in the persistence in yield spreads of EMU government bonds. J. Bank. Finance 41, 109–118.

Sims, C.A.: (1980). Macroeconomics and reality. Econometrica 48(1), 1–48.

Sinn, H.-W., Wollmershäuser, T. (2011). Target-Kredite, Leistungsbilanzsalden und Kapitalverkehr: Der Rettungsschirm der EZB. Ifo working paper, vol. 105.

Söllner, F. (2000). Die Umsetzung der Maastricht-Kriterien zur Staatsverschuldung im föderalen System der Bundesrepublik Deutschland. Ifo Schnelld. 53(10), 8–18.

Summers, L.H. (1982). The nonadjustment of nominal interest rates: A study of the Fisher effect. NBER working papers, vol. 0836.

Tholl, J., Basse, T., Meier, S., Rodriguez Gonzalez, M. (2021). Risk premia and the European government bond market: new empirical evidence and some thoughts from the perspective of the life insurance industry. ZVersWiss. 110, 49–78.

Toda, H.Y., Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. J Econom 66(1–2), 225–250.

Wegener, C., Basse, T., Kunze, F., von Mettenheim, H.-J. (2016a). Oil prices and sovereign credit risk of oil producing countries: an empirical investigation. Quant. Finance 16(12), 1961–1968.

Wegener, C., von Spreckelsen, C., Basse, T., von Mettenheim, H.-J. (2016b). Forecasting government bond yields with neural networks considering cointegration. J. Forecast. 35(1), 86–92.

Wegener, C., Kruse, R., Basse, T. (2019). The walking debt crisis. J. Econ. Behav. Organ. 157, 382–402.

Zettelmeyer, J., Trebesch, C., Gulati, M. (2013). The Greek debt restructuring: an autopsy. Econ. Policy 28(75), 513–563.

6. Critical assessment

This cumulative dissertation comprises four different essays aiming at analyzing the flow of information directed to and from sovereign bond yields and bank bond yields in the euro area. The presented essays shall help to improve the prediction of sovereign bond yields in the EMU. The impact of monetary policy decisions and sovereign credit risk on sovereign bond yields in the context of crisis is scrutinized. This is especially important for institutional investors but also for central banks and governmental institutions dealing with sovereign debt. The results may also foster the anticipation of the ECB's monetary policy decisions. In this concluding chapter, the findings of the four presented essays and the applied methodologies are discussed. Room for further research is suggested.

The four presented essays cover the interaction between sovereign credit risk, sovereign bond yields, bank bond yields, and monetary policy in the euro area. The history of the EMU and its different periods are touched upon. The periods were characterized by sovereign bond yield convergence being alternated with periods of sovereign bond yield spreads widening. These different phases reflect the extent to which financial markets paid attention to sovereign credit risk. Chapter 5 indicates Greek sovereign bond yields played an important role in the pricing of sovereign bonds in the period under review (October 2009 to December 2017). This might be interpreted as Greek sovereign debt being an indicator for the sustainability of sovereign debt in the whole monetary union. Hence, the findings suggest that Greek sovereign yield spreads might be crucial to determine when the second phase of EMU history began which was characterized by widening sovereign bond yield spreads. The results support the hypothesis proposed by Arghyrou and Kontonikas that economic turmoil in Greece played a major role in at least the first part of the European sovereign debt crisis.[9] Further research analyzing sovereign CDS spreads might validate this hypothesis.

The fourth chapter provides insights how sovereign credit risk can be materialized in liquidity risk. The findings suggest that there is Granger causality running from all examined sovereign bond yield spreads (French, Italian, Belgian and Irish sovereign bond yield spreads relative to Germany) with a maturity of five years to the interest differential between German and Austrian sovereign bonds with the same maturity. Assuming that there is no major difference in the sovereign credit risk of the two German speaking countries, the remaining interest rate differential can be interpreted as liquidity risk premium. This corresponds to the different volume of German respectively Austrian sovereign debt and hence, to its trading volume. The results suggest that the sovereign credit risk respectively the redenomination risk of one EMU member country can help to predict the liquidity risk premium that a different EMU member country needs to pay for its issued bonds. This might be explained by financial market's response to rising sovereign debt risk in an adverse scenario in which the sovereign credit risk provokes liquidity shortcomings. It also corresponds to the fears of contagion that played a dominant role in the behavior of financial markets during the sovereign debt crisis in Europe. At that time, the currency union was subject to fears that Greece might not be able to service its debt. In the course of the crisis these fears spread to further countries in the periphery of the euro area. If yield spreads widened further at the height of the crisis, the debt burden in euro area member states suffering from high yield spreads was supposed to become unsustainable. The question was how to contain this kind of contagion risk.

Chapter 2 indicates that the ECB's policy rate responds to a spread widening of French, Italian or

[9] Arghyrou, M.G., Kontonikas, A. (2012). The EMU sovereign-debt crisis: fundamentals, expectations and contagion. Journal of International Financial Market, Institutions and Money 22, 658–677.

Spanish sovereign bond yields in the period under review. Such a monetary policy approach would be consistent with the Transmission Protection Instrument (TPI) that was introduced by the ECB in July 2022. The TPI aims at containing a widening of sovereign yield spreads in the EMU that do not correspond to the affected country's fundamentals.[10] It is a consequence of the outright monetary transactions (OMT) announced in summer 2012 which helped to push down sovereign bond yields in the euro area. If the ECB had not decided to implement its expansionary monetary policy, the euro area could have split up as the debt burden of some member states might have unsustainable. However, the empirical findings presented in chapter 2 must be handled with care as the period under review was characterized by structural breaks which might weaken the model's liability. On the other hand, dealing with structural breaks was kind of inherent to this essay. As it aimed at analyzing how sovereign bond yields in the euro area would respond to a policy rate hike by the central bank. After a several years enduring period of very low policy rates, any rate hike would correspond to a structural break.

The findings in the third chapter suggest that sovereign credit risk not only has an impact on sovereign bond yields but also on bonds issued by financial institutions due to the sovereign-bank nexus. The empirical results provide evidence for cointegration of senior unsecured bank debt issued by German and Italian banks. However, nonlinearities can be observed. One explanation could be that sovereign credit risk plays a role in the pricing of bonds issued by financial institutions. The reasons for this are driven by the strong sovereign-bank nexus. It can be explained by the fact that the risk of a bank running out of business strongly depends on its home sovereign's capacity to provide rescue programs. A downgrade of a country's rating weighs on banks' balance sheet in case that the banks hold assets of their home sovereign. The liquidity situation of banks being subject to a home sovereign that faces increasing credit risks might also be compromised due to impairments of sovereign debt as collateral for capital market transactions. If the sovereign credit risk severely exacerbates, redenomination risks can be provoked which would induce an increase of required risk premia by bank bond investors. Further research is needed to study the Granger causality between yield spreads of Italian sovereign bonds relative to the one's issued by Germany and yield spreads between Italian and German financial institutions.

As a general evaluation that fits to all presented essays, availability and quality of data is not supposed to be a weakness of the conducted analyses. The data for sovereign bond yields in the euro area and key policy rates set by the central bank are publicly available. Improvements could arise from the applied models and the corresponding estimations. The method that was used to test for Granger causality – namely the approach suggested by Toda and Yamamoto[11] - actually seems to be a major strength of the papers due to its flexibility in dealing with variables with different orders of integration. However, when examining non-stationary variables, cointegration could be a phenomenon of relevance. In other words, long-term common stochastic trends can be identified. In this case, some observers might argue that the Johansen procedure[12] should be used instead of the approach developed by Toda and Yamamoto.[13] More specifically, a vector error correction model could be estimated. Following this idea, the Granger

[10] Wellink, N. (2023). Crises have shaped the European Central Bank. Journal of International Money and Finance, 138, 102923.

[11] Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. Journal of Econometrics, 66(1-2), 225-250.

[12] Johansen, S. (1988). Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12, 231–254.

[13] Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. Journal of Econometrics, 66(1-2), 225-250.

causality tests should then be performed using this model. However, Zapata and Rambaldi[14] have shown that even for cointegrated variables doing so will not improve the performance of the Granger causality tests when there are enough data points. In fact, there already will be no major differences for samples of 50 or more observations.

Regardless of that, the provided findings are not exhaustive. There is still room for further research e.g. on the sovereign-bank nexus in the EMU. The outlined issue of zero-risk weight for capital requirements of banks holding sovereign bonds plays an important role in discussions about deepening the EU banking union. In negotiations dealing with this topic a common European deposit insurance scheme (EDIS) is one of the major proposals.[15] As a risk balancing for this significant step, Germany requires an adequate risk assessment of sovereign bonds issued by EMU member states in bank balance sheets with regard to bank capital requirements. The home bias, expressed by a high concentration of home sovereign's bonds in bank balance sheets, shall be addressed. EMU members states with an elevated debt-to-GDP ratio and home to banks that hold a significant share of their home sovereign's bonds hesitate to accept such a significant change in bank capital requirements. Deeper knowledge of the sovereign-bank nexus in the EMU would help to potentially break-up the stalemate triggered among other aspects by the strong interdependence between states and banks. Based on these findings, solutions for deepening the EU banking union could be developed.

A use case for further empirical analyses covering the sovereign-bank nexus could be the financial crisis in Cyprus in 2012/2013 that severely affected the domestic financial sector. It is still open to discussion whether the country was facing a sovereign-debt crisis or a banking crisis. Among other problems, the Cypriot financial sector was subject to high concentration risks due to an elevated exposure to Greek sovereign debt that even exceeded Cyprus' GDP.[16] Due to the high Greek debt exposure the Hellenic sovereign-debt crisis spilled over to Cypriot banks that needed a bailout. In the end, the rescue package for banks in Cyprus comprised a bail-in mechanism. A share of unsecured deposits was used to provide liquidity for banks facing financial distress.[17] Further research on the crisis in Cyprus might help to improve the comprehension and anticipation of contagion risks that played a major role during the European sovereign debt crisis.

The presented essays provide insights on the forecasting of sovereign bond yields. These findings might improve the anticipation of looming debt sustainability crises. Additional analyses on the sovereign-bank nexus in other currency areas might help to establish effective instruments dealing with debt restructurings in countries that face unsustainable debt levels. Further research is required on how the creditor structure affects a country's debt sustainability. To anticipate and ideally to prevent debt sustainability crises, it would be helpful to understand whether a predominantly domestic creditor structure is beneficial or whether a more international creditor structure should be strived for. A comparative analysis of the creditor structure of e.g. Japanese, Italian, Greek or Ghanaian sovereign debt could be compelling. Complementary to the above provided insights on the relevance of the European insurance industry as institutional investor of sovereign bonds, further research on the role of Japanese insurance companies and the regulatory environment in Japan would be beneficial.

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[14] Zapata, H. O./Rambaldi, A. N. (1997). Monte Carlo evidence on cointegration and causation. Oxford Bulletin of Economics and Statistics, 59, 285–298.

[15] De Groen, W. P., & Gros, D. (2015). Estimating the Bridge Financing Needs of the Single Resolution Fund: How expensive is it to resolve a bank? CEPS Special Report No. 122, 25 November 2015.

[16] Zenios, S. A. (2013). The Cyprus debt: perfect crisis and a way forward. Cyprus Economic Policy Review, 7(1), 3-45.

[17] Brown, S., Demetriou, D., & Theodossiou, P. (2018). Banking crisis in Cyprus: Causes, consequences and recent developments. Multinational Finance Journal, 22(1/2), 63-118.