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CORRUPTION AND SOVEREIGN BOND YIELDS

Evidence from EU-countries

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ABSTRACT:

Corruption, the misuse of entrusted power for personal gain, is a complex phenomenon which has existed since the beginning of human civilisation. Regardless of this, there are relatively few studies analysing the costs associated with corruption, especially in developed countries. Most previous studies on corruption have focused on its effect on the economies of developing countries.

The aim of this study is to find whether or not there is a relationship between the prevalence of corruption and the price at which a country can borrow money. With rising national debt and increased spreads in interest rates between countries caused by the European sovereign debt crisis, the cost of debt is currently a relevant issue for all EU countries. This question is examined using a Driscoll-Kraay pooled OLS regression to test whether there is a statistically significant correlation between the Corruption Perceptions Index (CPI) score and the sovereign bond yield of a country when major macroeconomic variables are controlled for. Furthermore, the regression is performed both on the entire data, which covers 27 EU countries across 1995-2016, as well as separately for the periods before and during the global financial crisis and for two groups of countries based on when they have joined the EU.

The results, which are highly statistically significant, indicate that corruption was linked with sovereign bond yields in all of the regressions performed, regardless of the period or group of countries analysed. Additionally, the correlation between corruption and sovereign bond yields was stronger during the financial crisis than before it, especially in older EU countries. These results imply that corruption is not merely a moral issue for EU countries, but also a source of significant costs and an issue which needs to be addressed. These findings are in line with previous literature which has found corruption to have notable negative effects on the economies of countries.

KEY WORDS: Corruption, Sovereign debt, European Union

1. INTRODUCTION

Corruption as a phenomenon is as old as human civilization. For as long as there have been positions of power, there have been people who have abused them for personal gain. Despite this, the study of corruption was quite limited until the late 1990s. In recent years organizations such as The World Bank and the European Commission have started taking a stand against corruption. The World Bank (2013) has stated that corruption is public enemy number one for developing countries. As the statement by the World Bank implies, corruption is often seen as mainly a problem for developing countries. Only in recent years has corruption come to be seen as a serious problem for developed countries as well. For example, the European Commission has declared corruption a threat to all European nations, stating that it seriously harms the economy and society as a whole (European Commission 2014: 1).

1.1. Motivation for the study

The relationship between corruption and economic growth has been studied extensively in the past in studies such as Mauro (1995, 1996), Mo (2001), Swaleheen (2011) as well as Freckleton, Wright and Craigwell (2012). Regardless of this, studies on the effect of corruption on the financial sector have been more limited. When the effect of corruption on the financial sector has been studied, such as in Ciocchini et al. (2003), Connolly (2007), Huang et al. (2015) as well as Duyvesteyn, Martens and Verwijmeren (2016), the studies have generally focused on developing countries.

It is a main motivator of this study that understanding the link between corruption and the sovereign bond yields of countries in the EU is especially important during a time when the European sovereign debt crisis has led to significant fluctuations in the sovereign debt market. The aim of this study is to shed light on the ways in which corruption affects economies. While the relationship between corruption and economic growth and investment has been studied before, other ways in which corruption creates costs for economies have received less attention. This is especially true in developed countries. At a time when governments debts are high and rising, it is vital to understand what affects the costs associated with these debts. As some of the costs related to corruption are difficult to estimate or directly observe, the results of this study contribute to the pre-existing debate on how corruption should be prevented in a society and what its

consequences are. Furthermore, the results demonstrate how times of economic turmoil affect how severe of a problem corruption is perceived to be.

1.2. Research questions and main findings

The major question which this study attempts to answer is whether there is a significant relation between the prevalence of corruption and the sovereign bond yield of a country when other major country-level and global variables are controlled for. Because the goal is to find out whether said relation exists independently of time period or countries observed, the question will be answered using a broad panel data set consisting of observations from 27 current EU countries over a span of 22 years. In this way, the dataset is varied enough that long term generalisations can be made based on the results of the analysis.

In addition to the main research question, this study will also attempt to answer whether the financial and European sovereign debt crises or the date when a country has joined the EU affect the relationship between corruption and sovereign bond yields. For these further analyses, the dataset used for the main analysis of the study is divided into two periods and into two groups of countries. The two periods which will also be analysed separately are the periods before and after the beginning of the global financial crisis. The two groups of countries to be analysed separately are the countries which joined the EU in January 1995 or earlier and the countries which joined the EU after January 1995.

The main finding of the study is that when other major macroeconomic variables are controlled for, there is a statistically significant positive correlation between the prevalence of corruption in a country and the sovereign bond yield of said country. This result is found both in the main analysis as well as all of the more specific analyses, which are restricted by country and by the time period examined. It is also found that the magnitude of the dependence between corruption and sovereign bond yields increases significantly after the beginning of the global financial crisis. As far as the two separately analysed groups of countries are concerned, when analysing the full period encompassed by the data or the period before the global financial crisis, the newer EU countries are found to have a more significant link between corruption and sovereign bond yields. Interestingly the opposite is true during the financial crisis, when the dependence between corruption and sovereign bond yields is highest in the older EU countries.

1.3. Structure

The remainder of the study is structured as follows. Basic theory relating to corruption, as well as previous econometric studies on corruption and a brief explanation on how corruption is measured are presented in chapter 2. Chapter 3 includes an introduction to the role of sovereign bonds in the European sovereign debt crisis as well as a brief explanation of ways in which bond yields are used in the mathematical modelling of bond values and investor expectations. The chapter ends with a section briefly discussing select previous regression analyses where the main determinants of bond yields have been studied. Chapter 4 reviews previous studies on the effect of corruption on sovereign bond yields. Chapter 5 includes descriptions of the statistical model and the data used in the study. In addition, the chapter includes data diagnostics which are used for determining the type of regression that will be used to analyse the previously described statistical model. Chapter 6 details the results of the regression analyses. Finally, chapter 7 concludes the study.

2. CORRUPTION

In order to discuss corruption, we first need to define it. Naturally many different definitions exist, but the one used in this study is the one proposed by Transparency International (2009: 14), which defines corruption as “the abuse of entrusted power for private gain”. This definition could include both the abuse of private power, e.g. misusing a position of power in a privately-owned company, as well as the abuse of public power, e.g. a public official asking for bribes. Although the possibility of the existence of large-scale private corruption cannot be dismissed, private companies operate in markets with varying degrees of freedom and accountability to both the government and investors. These factors limit the possibility of systemic private corruption without the aid of a corrupt public sector. Therefore, the term corruption is assumed to only encompass corruption in the public sector. This is a distinction shared by the literature used in this study (Ciocchini et al. 2003: 504; Connolly 2007: 311; Depken & Lafountain 2006: 75).

While corruption has received increasing amounts of attention since the 1990s, it is not a new phenomenon. Corruption has been written about for millennia, and existed as long as people have held positions of abusable power. More than 2000 years ago Kautilya, an Indian political leader, wrote *Arthashastra*, a book discussing corruption. In Europe in the 1300s Dante Alighieri wrote *Divina Commedia*, an epic poem where bribers were placed in the deepest part of hell upon death. In the United States corruption is one of only two crimes mentioned in the constitution which can lead to the impeachment of a president. This is evidence that corruption has been considered a threat to societies throughout history, despite the lack of modern anti-corruption laws. (Tanzi 1998: 4.)

Although corruption has been recognized as an issue throughout recorded history, it has not received attention similar to the attention it receives today before the 1990s. There are multiple possible reasons for the increase in interest towards corruption. Tanzi (1998: 4-6) suggests seven major reasons, the first of which is the end of the Cold War. During the Cold War, the countries involved tended to ignore political corruption in countries which shared their political ideals. After the Cold War, when political allies became less vital for a country, the corruption in many African countries, for example, was finally accepted and discussed.

The second reason suggested by Tanzi (1998: 4) is the prevalence of centrally planned economies, mainly the Soviet Union and its imitators before the 1990s. In centrally planned economies corrupt practices were common but seldom discussed. This is both

due to the strong government not wishing to admit its shortcomings as well as the control of media practiced at the time. The third reason discussed in Tanzi (1998: 5) is mainly a continuation of the second reason. In the 1990s, as multiple countries became democracies, the advent of free press caused government corruption to no longer be a taboo subject in the media. While countries which were formerly part of the Soviet Union are clear examples of this, formerly democratic countries also saw a strengthening in free press in the 1990s.

The fourth reason suggested by Tanzi (1998: 5) is the increased speed of globalisation. Before widespread globalisation, corruption was contained within countries and mainly known about by the citizens of those countries. Globalisation brought with it the movement of people between countries, which led to knowledge of this previously contained corruption being spread to people outside these corrupt countries.

A significant reason for the increased interest in corruption since the 1990s and the fifth reason proposed by Tanzi (1998: 5) is the growing number of nongovernmental organisations focused on anti-corruption research and activity. Among the most important of these organisations is Transparency International. In addition to corruption-focused organisations, large existing international financial organisations such as The World Bank (2013) and The European Commission (2014: 1) have begun to focus more on corruption and ways to combat it. Possibly partly due to the increase in quantitative and qualitative information on corruption provided by these organisations, the amount of empirical research on the subject has also increased, signalling an increased interest from academic institutions as well.

The sixth reason proposed by Tanzi (1998: 5) is the increased role of free markets in financial decision making. When markets are expected to perform with maximal efficiency, the detrimental effects of corruption become more evident.

The seventh and final reason for the increased attention to corruption since the 1990s is the influence of the United States on other large economies in the world. In the United States, it is a crime to pay bribes to foreign officials. This has led to companies from the United States losing contracts to companies from other OECD countries. According to Tanzi (1998: 5-6), this has caused the United States to seek to influence other OECD countries to also prohibit bribery in international commerce.

2.1. Different forms of corruption

Transparency International (2009: 14) classifies three different forms of corruption: petty, political and grand. Petty corruption is defined as “everyday abuse of entrusted power by low- and mid-level public officials in their interactions with ordinary citizens, who often are trying to access basic goods or services in places like hospitals, schools, police departments and other agencies” (Transparency International 2009: 33). Petty corruption is very prevalent in many parts of the world, with over 70% of impoverished citizens in India and 64,5% of citizens in Bangladesh reporting having paid bribes to law enforcement and other authorities (Transparency International 2009: 5–14).

Political corruption is defined by Transparency International (2009: 35) as the “manipulation of policies, institutions and rules of procedure in the allocation of resources and financing by political decision makers, who abuse their position to sustain their power, status and wealth”. Political corruption includes two distinct sides: the supply side and the demand side. The supply side consists of private entities who supply political decision makers with donations in exchange for political decisions being made in a way that is favourable to them. The demand side consists of corrupt political decision makers who receive donations in exchange for specific political decisions, make political decisions which they personally profit from and embezzle public funds. Anti-corruption research has mainly been interested in the demand side of political corruption, which is only a part of the problem. (Transparency International 2004: 2009.)

Grand corruption is in many ways similar to political corruption. Transparency International (2009: 23) defines grand corruption as “acts committed at a high level of government that distort policies or the central functioning of the state, enabling leaders to benefit at the expense of the public good.” As both political corruption and grand corruption are committed by high-ranking political decision makers, the main difference between the two is the scale of the corruption. Political corruption can be at least mildly detrimental to the society as a whole, whereas grand corruption is defined as a practice which distorts the central functioning of the state. An example mentioned by Transparency International (2009: 23) is the Kenyan Anglo Leasing scandal from 2002 where fictitious or over-billing companies were chosen to provide security-related services to the state. In addition to the Kenyan government losing an estimated US\$ 1 billion in these deals, the security-related services were also never provided. The key point in this example is that not only did political leaders abuse their power for personal

gain, they did it in a way which was detrimental towards the state and its citizens. (Transparency International 2009: 23.)

Shleifer and Vishny (1993: 601-603) proposes another way of distinguishing different forms of corruption. Corruption is separated into two distinct forms: corruption without theft and corruption with theft. Corruption without theft is described as bribe-taking where an official whose job it is to sell government-owned permits, for example, sells the permits and demands a bribe in addition to the legal price of the permit. In this case the official forgoes the government's share of the sale, and the buyer's price for the permit is the sum of the legal price and the bribe. In corruption without theft, while the government does not directly suffer financially from the corruption, the buyer must pay the entirety of the bribe demanded by the official. It is reasonable to assume that this type of corruption would be detrimental to the development of a country's privately-owned infrastructure as well as development of new business, as acquiring permits for building and starting businesses, for example, would be costly. Although the government receives its share from corrupt transactions, the lower demand for these transactions due to higher prices would lead to the overall income for the government dropping compared to a situation with no corruption present.

Corruption with theft, on the other hand, is bribe-taking by an official who does not pay the government its fee for selling a permit, for example. In this case the official sets the price for the permit and keeps the entire price paid by the buyer. While the government does not receive any payment for said permit, the price paid by the buyer can be significantly lower than in the case of corruption without theft. While the bribe received by the official in the case of corruption without theft is only the price the buyer is willing to pay above the legal price, in the case of corruption with theft it is possible both for the official to receive a bribe which is larger than in the case of corruption without theft as well as for the buyer to pay a price lower than in the case of no corrupt practice. Although corruption with theft leads to the government not receiving money from corrupt transactions, the lower prices paid by buyers can be assumed to lead to a higher demand for the goods provided by the government. This would lead to possible improvements in infrastructure and competition, at the cost of the government's finances. While corruption with theft may be a better alternative for corrupt officials and their customers, it tends to spread if no legislation is in place to prevent it. This is because the bribe paid to a corrupt official is lower than the price paid by a rule-abiding citizen or business. Therefore, a lawful citizen or business cannot compete with a corrupt one, and must eventually pay the bribe to stay in competition. Because the bribe is also less expensive for the citizen or

company than the corresponding legal fee, the bribe payer is also less likely to expose the corrupt official than in a case of corruption without theft. (Shleifer and Vishny 1993: 601–603.)

2.2. Corruption and the economy

While there is still no clear understanding of what measurable effects corruption has on a country, it is an issue that has been the topic of many academic papers. Corruption's effect on the economic growth of a country has been especially widely studied. An early example is Mauro (1995: 95–705), which found corruption to have a statistically significant negative effect on both growth and investment. In a later study Mauro (1996: 12) suggested that corruption may have affected growth mainly through a lower investment rate, though it is possible that corruption also has a slight direct effect on growth.

Swaleheen (2011: 38) comes to the same conclusion, finding corruption to have a statistically significant, albeit small, direct effect on growth. Swaleheen (2011: 38) also finds evidence that corruption affects growth more in countries with less corruption, which goes against the common assumption that corruption is a problem which mainly highly corrupt developing countries face. This finding is however disputed in studies such as Freckleton, Wright and Craigwell, (2012: 639) which finds that while corruption does not directly affect growth, foreign direct investment (FDI) has a larger positive impact on growth in developing countries with less corruption. This leads more corrupt countries not benefiting as much from investments, which is attributed to the misuse of invested funds by corrupt officials (Freckleton et al. 2012: 645–650).

Most studies on the effect of corruption on the economy do not include any estimates of the costs associated with corruption. This is understandable as corruption is a complex issue that is difficult to quantify. However, a research paper by RAND Europe (2016: 115) for the European Parliamentary Research Service estimates the costs of corruption in the EU to be between €179bn to €990bn annually. These estimates include both the direct and indirect effects of corruption. Although the range between the estimates is large, the cost of corruption is found to be significant regardless of whether it is near the upper or lower part of the estimate. In addition to the monetary costs, corruption is found to have a significant social and political cost as well. These costs include more unequal

societies, more organised crime, weaker rule of law, lower voter turnout and less trust in the EU and its institutions.

2.3. Measures of corruption

As stated by Tanzi (1998: 5), the study of corruption and its effect on growth has seen a large rise since the early 1990s partly due to the rise of nongovernmental anti-corruption organisations. One major nongovernmental anti-corruption organisation is Transparency International, which releases an annual Corruption Perceptions Index (CPI). The CPI has been published yearly since 1995, and it is based on a combination of surveys from multiple institutions worldwide. As its name implies, the index is based on people's perceptions of the prevalence of corruption. This is because actual corruption is difficult to measure, as secrecy is an integral part of corrupt dealings. (Transparency International 2016: 1.)

The CPI is not the only widely used measure of corruption to date. A measure of corruption by The Economist Intelligence Unit (EIU), formerly provided by Business International, was used in Mauro (1995: 683), for example. The EIU corruption index is part of a larger set of 56 country risk indexes, which measure institutional efficiency through political stability, relationships with neighbouring countries, prevalence of terrorism and bureaucracy among other measures (Mauro 1995: 683-685).

Another measure of corruption, used in Mauro (1998: 265) as well as in Duyvesteyn et al. (2016: 499), is the International Country Risk Guide (ICRG) from Political Risk Services, Inc. Similar to the EIU measure of corruption, The ICRG also consists of multiple measures of the political stability of a country. Included in the 12 measures used are government stability, religious tensions and socioeconomic conditions. The maximum score a country could be given is 100, and corruption makes up 6% of the score. Government stability, socioeconomic conditions, investment profile as well as internal and external conflicts are given more weight in the index, with each measure making up 12% of the index (Duyvesteyn et al. 2016: 499-500). Mauro (1995: 685-686), however, points out that all the measures in EIU country risk index, which are similar to those used in the ICRG, are significantly correlated, making it difficult to attribute the findings of a study to a single factor. Still, an aggregate index of bureaucratic efficiency is proposed to be a better measure of corruption than a plain corruption index due to the separate

measures in the aggregate index being highly correlated as well as the aggregation fixing some of the inherent error in each of the separate measures (Mauro 1995: 685–686).

Both the EIU and ICRG indexes are fundamentally different from the CPI not only in that they estimate many different factors of a country's political stability in addition to corruption, but also in that they are both premium materials intended solely for professional use. This is to say neither index is freely available to the public, and in fact according to Mauro (1995: 684) the customers of EIU pay a considerable price for their index. In contrast, the CPI is published annually on the Transparency International (2017) website and all the publications Transparency International has made since being founded in 1995 are available for free.

While the CPI is a valuable tool for analysing corruption, it is not without flaws. One significant flaw is that it is only based on perceptions. This means that it reflects the kind of corruption that is regularly visible to the people surveyed, mainly petty corruption. In addition, the concept of corruption can differ significantly in different cultures, which may lead to inaccuracies when comparing the corruption scores of different countries.

3. BONDS

Bonds are basic debt securities that have either floating or pre-determined yields. The sovereign bonds analysed in this study mainly have pre-determined yields. They are generally thought to be less risky than stocks, for example, as long as their issuer is trustworthy. Bonds can be issued by both private and public entities, with the most commonly traded kind being government-issued Treasury bonds. In addition to treasuries, private corporations, states, local governments and government agencies can also issue bonds. The markets for these bonds are, however, smaller than the market for Treasury bonds. (Bodie, Kane & Marcus 2009: 445–450.)

Bond pricing is a widely studied field in finance and economics. To simplify, the most important aspect from an investor's point of view is that the future value of the bond, or the bond's coupon and principle repayments, are at least as large as the bond's present value, or the current price of the bond. The value of a bond depends largely on expected inflation and a real risk-free rate of return, but is also affected by some bond-specific characteristics. These characteristics can include, but are not limited to, the issuer's risk of default, the liquidity of the bond and taxation. (Bodie et al. 2009: 452.)

Another common way to value bonds is by their yields. When a bond's price, coupon payments and principle payment are known, the bond's yield equals the average interest the investor receives. This calculation is known as the yield to maturity, and it measures the annual interest an investor will receive if they hold the bond to maturity. If a bond is callable, meaning that the bond's issuer can withdraw it at any time for an agreed-upon sum of money, its price tends to be lower than that of a noncallable bond, especially when overall interest rates are low. (Bodie et al. 2009: 456–461.)

Bond spreads or bond yield spreads are also commonly used in studies. They signify a bond's yield over a benchmark bond. Most often these benchmark bonds are from an issuer which is considered risk-free, such as the treasuries of Germany and the United States (Bodie et al. 2009: 482). During times of economic turmoil investors tend to seek less risky investments, which leads to the yields of these benchmark bonds dropping as demand rises significantly. This also leads to bond spreads rising when risky bonds become even riskier due to disturbances that affect the whole market, while benchmark bonds become less profitable, widening the yield gap between the two (Barrios et al. 2009: 5).

3.1. The European sovereign debt crisis

While nomenclature varies from source to source, from a European perspective the global financial crisis, which began in 2007, can be divided into two distinct segments: The global financial crisis and the European sovereign debt crisis. The beginning of the global financial crisis is generally agreed to be in August 2007, (Barrios, Iversen, Lewandowska & Setzer 2009: 2; Abad & Chuliá 2014: 8; Alfonso, Arghyrou & Kontonikas 2015: 4-5) marked by the initial decline in equity markets and central bank intervention to provide liquidity. Another occurrence early in the financial crisis was the decrease of the already low yield of German sovereign bonds as investors sought safe havens for their funds (Barrios et al. 2009: 5).

The beginning of the second part of the crisis is more difficult to place than the first, and different studies use different approximations for it. The general consensus is that the sovereign debt crisis started at some time in 2009, with some studies placing it in March 2009 (Alfonso et al. 2015: 5) and others in January 2010 (Abad & Chuliá 2014: 8; Christiansen 2012: 6) as an approximation of the end of 2009. The crisis originated in Greece, from where it spread mainly to Ireland, Portugal and Spain, but also to other countries to a lesser extent (Christiansen 2012: 6). The sovereign debt crisis was largely the consequence of low savings rates and current account deficits in the countries affected in the years leading up to the crisis, with the Greek current account deficit rising from 7,0% in 1999 to 14,7% in 2007, while the national savings rate fell from 15,0% to 7,6% during the same timeframe (Favaro, Li, Pradelli & Van Doorn 2010: 202-203).

3.2. Mathematics of bond valuation

Mathematically the value of a bond can be presented in many ways. Bodie et al. (2009: 453) models the basic equation of bond values as

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

where T represents the maturity date of the bond and r represents the interest rate. In this simplification, the value of the bond depends on the sum of discounted coupon payments and the discounted value of the principal repayment. This is known as the present value

calculation of bond pricing, and it is the basis of most bond value calculations. It is useful in analysing the competitiveness of the market prices of bonds. It also demonstrates how bond yield is linked to the value of the bond. A higher bond yield decreases the value of both the coupon and the par value. When calculated with the average market interest rate for the bond's maturity the resulting bond value is called the fair value of the bond. If the market price of the bond is higher than the fair price, it is likely the bond is overvalued, and not necessarily a sound investment. On the other hand, if the bond's market price is lower than the fair price, it is possible the bond is undervalued and a profitable investment. (Bodie et al. 2009: 452-453; Fabozzi & Choudhry 2004: 41)

3.2.1. Yield curves

The yield curve, also known as the term structure of interest rates, is an indicator of the expectations investors have about future interest rates (Vasicek 1977: 177). It is typically visualized with a line graph, which has bond yields on one axis and bond maturities on the other. During politically and economically stable times the yield curve typically rises, signalling that investors demand higher yields for bonds with longer maturities. This is because it is not profitable for investors to keep their funds in securities with fixed rates when interest rates are expected to rise as markets strengthen. Correspondingly a downward sloping yield curve signals investors' expectations of lower interest rates in the future. If future interest rates are expected to be lower than current interest rates, the demand for current bonds, which have comparatively high interest rates and coupon payments, rises. This causes their prices to also rise, which in turn lowers their inherent yields. (Bodie et al. 2009: 484-489.)

The yield curve can be used to predict forward rates, or expected future yields calculated from the investor expectations inherent in the yield curve. The forward rate is calculated from

$$(2) \quad (1 + y_n)^n = (1 + y_{n-1})^{n-1} * (1 + r_n)$$

where y_n is the yield to maturity of a discount or zero-coupon bond which has a maturity of n and $1+r_n$ is the short rate of the bond in period n . This calculation assumes that the return from investing in a zero-coupon bond with a maturity of n is equal to the return from investing in a bond with a maturity of $n-1$ and using the return from that investment

to further invest in a one-year bond, the yield of which is the forward rate. Therefore, we can define the forward rate as

$$(3) \quad (1 + f_n) = \frac{(1 + y_n)^n}{(1 + y_{n-1})^{n-1}}$$

where the forward rate is shown to be equal to the ratio of the yields of bonds with maturities of n and $n-1$. Although the utility of the forward rate is limited by the lack of knowledge investors have about future interest rates, the main utility of equation 3 is to explain the implications yield curves have concerning future interest rates. The forward rate is essentially the interest rate at which the investment strategies of either investing in a bond with a maturity of n years or investing in a bond with a maturity of $n-1$ years and using the proceeds from that investment to invest in a bond with a maturity of 1 year break even. Therefore, a larger forward rate implies higher investor expectations regarding the interest rates in the interim period between the maturities of the two bonds. (Bodie et al. 2009: 490-491.)

3.2.2. Short rate models

A commonly used theoretical framework for estimating the spot rates on future yield curves is the short rate model. In this way, short rate models can be used to analyse the behaviour of yield curves through an empirically tested framework. In addition to modelling yield curves, short rate models can be used to value bonds as well as other interest rate driven securities, such as interest rate derivatives. Although short rate models are used for a variety of tasks, the specific choice of model used depends on the kind of security being modelled (Hull & White 1990: 573-574). In short-rate models interest rate typically follows a stochastic mean-reverting process, which was first proposed for use in economics in Vasicek (1977: 179) and later used and modified by multiple studies. A stochastic mean-reverting process is a process where all current and future values are independent of past values and where the interest rate drifts towards its mean value. They are generally a variation of

$$(4) \quad dr = f(r, t)dt + \rho(r, t)dz,$$

where r is the interest rate, $f(r, t)$ signifies the rate at which interest rate drifts towards its equilibrium state, $\rho^2(r, t)$ is the variance of the interest rate and z is a random term (Vasicek 1977: 179). While the exact form of the stochastic mean-reverting process varies

from study to study they all follow a similar form, featuring a function signifying the drift rate followed by a measure of variance and a random term. (Vasicek 1977: 179; Hull & White 1990: 576; Black & Karasinski 1991: 53.)

Cox, Ingersoll and Ross (1980: 394) proposes a slightly different stochastic model of the short-term evolution of the interest rate, defining it as

$$(5) \quad dr = sr^{3/2}d\omega,$$

where s^2 is the variance of the interest rate and ω is a random term. While this model superficially seems less robust than equation (2), for example, there is empirical evidence that supports it being a better model of short-term Treasury bond interest rates than many more commonly used models such as Vasicek (1977). This is explained to be because the model used in Cox et al (1980) allows the volatility of the interest rate to be highly sensitive to changes in the level of the interest rate. This sensitivity is evident from the current interest rate in equation (5) having an immediate impact on the effect the measure of volatility has on the change in interest rate, whereas in equation (4) the level of impact the measure of volatility has on the change in interest rate is only affected directly by the random term (Chan, Karolyi, Longstaff & Sanders 1992: 1224-1225).

3.3. Empirical determinants of bond yields

While bond valuation models provide a theoretical basis for assessing bond yields, empirical studies on the determinants of bond yields aim to find statistically significant relationships between sets of variables and bond yields, either in the short run or the long run. These variables often include country-level measures, such as indexes on a country's financial stability as well as international measures, such as global bond or stock market volatility.

Barrios et al. (2009) studies the sovereign bond yield spreads EMU countries from 1999 to 2009 and finds that domestic factors influence bond spreads to a significantly larger extent after the beginning of the global financial crisis in 2007 than before it. International factors, such as general risk perception, a measure consisting of among others stock market volatility and exchange rate volatility, had a significant impact on sovereign bond spreads before the crisis, but lost some significance after investors started to discriminate more between countries after the crisis. While domestic variables, which include

measures of a country's public debt and current account balance, had a small but non-negligible effect on sovereign bond spreads before the crisis, they became much more significant once the crisis began (Barrios et al. 2009: 2-12). It should be noted, however, that the study in question was published at a time when the global financial crisis was still transforming into a sovereign debt crisis, and therefore its findings may have limited value in explaining current sovereign bond yields.

Alfonso et al. (2015: 22) studies the sovereign bond yield spreads of ten EMU countries from the beginning of 1999 to the end of 2010, considering differences between the period preceding the global financial crisis, (before July 2007) the period when the financial crisis had yet to become a sovereign debt crisis (August 2007 to February 2009) and the period when the financial crisis had transformed into a sovereign debt crisis (after February 2009). The study finds that, in addition to regular explanatory variables, changes in the sensitivity of bond yields to these explanatory variables at different times must be taken into account, as the sensitivities are not static between the aforementioned periods. While sovereign credit ratings are found to have a small but statistically significant effect on bond yield spreads, their effect is limited when compared to macroeconomic and fiscal variables, such as overall market volatility and debt-to-GDP ratios. Alfonso et al. (2015: 28) also reaches the conclusion that as the financial crisis progressed, investors became more interested in country-level variables, which is exemplified by debt-related variables and the 10-year government bond bid-ask spread, which is used as a measure of bond market illiquidity, only becoming statistically significant as explanatory variables during the crisis.

4. PREVIOUS LITERATURE

While corruption and bond prices have been studied extensively on their own, there are not nearly as many studies linking the two. Therefore, this section will include both studies on the effect of corruption on sovereign bond yields, as well as other relevant studies which establish a link between corruption and sovereign bonds.

4.1. Corruption and bond yields

Cioccini et al. (2003) studies the effect of corruption on emerging market bond spreads in 40 developing countries. Using a selection of macroeconomic variables found in previous literature on sovereign bond yields as control variables, the study finds that both private and sovereign lenders in more corrupt countries pay a higher risk premium when issuing bonds than those in less corrupt countries. The study finds no increase in sensitivity to corruption on the bond market following the Asian financial crisis that began in 1997. This means that the perceived effect of corruption on bond prices was nearly unchanged when comparing the periods before and after the beginning of the crisis. (Cioccini et al. 2003: 511-523.)

Cioccini et al. (2003: 516-518) also groups countries by their geographic location and analyses the correlation between corruption and bond yields separately for the different groups of countries. The countries are divided into East Asia and the Pacific, Latin America, as well as the rest of the world. The study finds that while there is a significant difference in the way many control variables behave in the different groups of countries, the correlation between corruption and bond yields is remarkably stable across all of the groups of countries. Although the differences are quite small, the correlation coefficient is found to be lowest in East Asia and the Pacific and highest in the rest of the world. As in the analysis of all countries, no significant change in the size of the correlation coefficient is perceived in any of the country groups when comparing the period before and the period after the Asian crisis. (Cioccini et al. 2003: 516-518.)

4.2. Corruption and bond ratings

Connolly (2007) studies the effects of corruption, namely Transparency International's CPI scores, on Standard and Poor's sovereign bond ratings in 52 countries. Using a

selection of macroeconomic variables found in previous literature as control variables the study finds a strong negative correlation between corruption and bond ratings. More specifically, the study finds a one-point deterioration in the CPI, which at the time ranged from 0 to 10, to lead to a one-step-lowering on the 22-step bond rating scale. This was hypothesized to be the result of corruption leading to funds being put to unproductive use or transferred to offshore accounts, leading to a higher default risk. (Connolly 2007: 314–316.)

Depken and Lafountain (2006) studies corruption and state bond ratings in the United States and, like Connolly (2007), finds more corrupt states to have lower bond ratings. As regional corruption indexes do not exist, the study uses the number of criminals convicted of public corruption in a state per capita as a measure of corruption, and finds the measure for each state to be consistent across time (Depken & Lafountain 2006: 83).

4.3. Political risk and bond yields

The relationship between political risk and sovereign bond yields has previously been studied more extensively than the relationship between corruption and sovereign bond yields. Political risk indexes are aggregates of multiple different measures, one of which is generally corruption. While corruption is only a part of political risk measures, it can be assumed that the different measures of political risk are correlated to some extent, as is stated in Mauro (1995: 685–686).

Huang, Wu, Yu and Zhang (2015) studies the effect of international political risk on sovereign bond yields in 34 countries between 1988 and 2007 and finds evidence that suggests investors demand a higher yield from government bonds during periods when there are more international political crises. While no clear correlation is established between specific country-level political risk and sovereign bond yields, higher country-level political risk is found to increase the effect global political risk has on sovereign bond yields. The study uses multiple variables as measures for political risk, including separate indexes for regulatory and bureaucratic quality as well as dummy variables denoting the existence of certain legislation aimed at protecting investors. International political risk is denoted by a measure of the occurrence of international political crises at a given time. The International Crisis Behaviour database is used to differentiate from national political crises which would mainly affect national investment behaviour and international political crises that influence global investment behaviour (Huang et al.

2015: 394). Control variables used in the study are similar to those in Ciocchini et al. (2003) and Connolly (2007), including macroeconomic variables such as inflation and the rate of economic development as well as measures of the development of stock and debt markets. (Huang et al. 2015: 403.)

Duyvesteyn et al. (2016) also studies the effect of political risk on government bond yields in 35 countries, of which 11 are EMU countries and 24 emerging markets. The study finds evidence that country-level political risk raises the risk premia of countries with higher political risk, but also that positive change in country-level political risk leads to lower risk premia in the future (Duyvesteyn et al. 2016: 510-511). As a measure of political risk, the study uses indexes by the Political Risk Services department of International Country Risk Guide, which are similar to those used in Mauro (1995) to study corruption. While corruption is one of the measures used in the indexes, it makes up only 6% of the score a country is given. Measures such as government stability and socioeconomic conditions make up the majority of the score. (Duyvesteyn et al. 2016: 499-500.)

Interestingly this conclusion appears to be in line with the findings of both Barrios et al. (2009) and Alfonso et al. (2015) in suggesting that investors seem to become more concerned with the economic and political stability of bond-issuing countries during periods of global unrest. This is, however, a finding disputed by Ciocchini et al. (2003) which finds little to no change in the sensitivity of sovereign bond yields to corruption during the Asian financial crisis.

5. DATA AND METHODOLOGY

In this section, the data used in the study is described and examined in detail. Also introduced is the model and methods used to study the data. The methods used are determined based on data diagnostics, which are described towards the end of the section. The data diagnostics are performed to ensure that the methodology used in the analysis fits the data. The expected results of the study are described at the end of the section.

The dataset used in the study contains observations that chronologically range from January 1995 to October 2016. This range of dates was chosen due to consistent and reliable data for many countries in the study becoming available from the beginning of 1995. The dataset is analysed first as a whole and then in two separate periods, which are defined based on the status of the global financial crisis. The periods are the period preceding the global financial crisis, and the period after the beginning of the global financial crisis. The period preceding the financial crisis is defined as the period from January 1995 to July 2007, which Alfonso et al. (2015: 14) defines as the month preceding the beginning of the global financial crisis. The period succeeding the beginning of the financial crisis lasts from August 2007 to October 2016. The separation into two distinct periods is done to make it possible to study whether corruption has a different effect on sovereign bond yields in the time preceding the global financial crisis and the time after its beginning.

Geographically the data used in the study is limited to the European Union. The geographical limitation is used due to a lack of previous studies focusing on the effects of corruption on bond yields in the EU. The EU is also especially interesting from the point of view of this study as corruption has in recent years been a major focus of the European Commission (2014: 1). Sovereign bond yields have also fluctuated widely in the EU since the beginning of the European sovereign debt crisis, which is evident in figure 1.

Included in the dataset are observations from all countries which were EU members in the beginning of 2017, with the notable exception of Estonia. Estonia is excluded from the study due to the view of the European Central Bank (2017b) that no currently existing Estonian long-term sovereign bonds are comparable to those of other EU countries and the definition of long-term interest rates used by the European Central Bank. With the exclusion of Estonia, the number of countries in the dataset is 27.

5.1. Model

In order to study the effects of corruption on the yields of sovereign bonds in the EU, a regression model of the form

$$(6) \quad spread = \alpha + \beta_1 cpi + \beta_2 dbt + \beta_3 gdp + \beta_4 ds + \beta_5 in + \beta_6 cr + \beta_7 vix$$

is used, where spread is the monthly average of the yield of the sovereign 10-year bonds of a country minus the 3-month Euribor rate, α is the constant term, cpi is the annual corruption index score of a country, debt is the monthly average of a country's public debt as a percentage of GDP, gdp is the annual percentage-denominated change in a country's GDP, ds is the country's budget deficit or surplus, in is a country's annual inflation rate, cr is the residual of a country's credit rating index, vix is the monthly average of the global volatility index score and β_i is the coefficient of variable i. The model utilized is similar to those used in Ciocchini et al. (2003), Connolly (2007), Huang et al. (2015) and Duyvesteyn et al. (2016).

5.2. Data

The dependent variable of the study is long term sovereign bond yield spread against the three-month Euribor rate. The sovereign bond yields used in the study are monthly averages of interest rates for government issued, Euro-denominated bonds with a maturity of ten years. The data is from the European Central Bank (2017a) Statistical Data Warehouse. The yields range from -0,15% (Germany, July 2016) to 29,24% (Greece, February 2012). Figure 1 clearly shows that the spread between yields of more stable and less stable economies in the EU has risen significantly after February 2009, which Alfonso et al. (2015: 22) defines as the starting point of the European sovereign debt crisis. This change is also evident in table 1, where minimum spread, average spread, maximum spread as well as the standard deviation between spreads are all on average largest in the countries of Eastern Europe and the Mediterranean. This is most clearly evident in the average spread, with the only countries with an average spread higher than the average spread of the entire data, 2,35%, are countries in Eastern Europe and by the Mediterranean Sea.

As figure 1 shows, European sovereign bond yields are steadily trending downward throughout the observed period. To account for this persistent trend, the spread between

the yield of a country's long-term sovereign bond yield and a three-month interbank offered rate is used as the dependent variable instead of the direct yield. Specifically, the three-month Euro Interbank Offered Rate (Euribor) is used as the comparison for the sovereign bond yields after the advent of the euro in 1999. Before 1999 the three-month London Interbank Offered Rate (Libor) is used in place of the Euribor interest rate as the two rates are quite similar both in function and in the size of their offered yields. An interbank rate is used to calculate the sovereign bond yield spread instead of a benchmark country's yield because the Euribor and to a degree the Libor rate are provided by non-governmental European entities. This allows them to simultaneously reflect EU-area sovereign debt conditions and have minimum direct dependence with the sovereign bond yield of a single country in the EU.

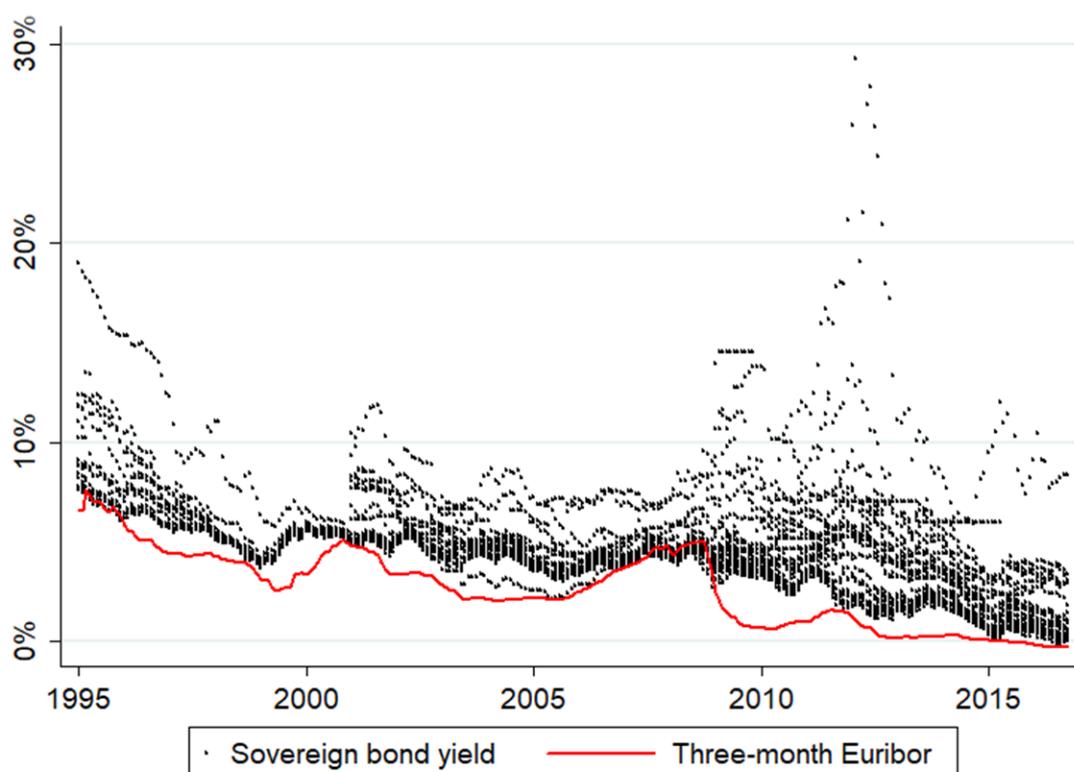


Figure 1. Scatterplot of Sovereign bond yields with 3-month Euribor rate

As figure 1 shows, the three-month Euribor follows country-level bond yields quite closely, generally at a slightly lower level. The Euribor rate also reflects short-term changes in sovereign bond yields with a slight lag. The exception to this seems to be the large drop in the Euribor in October 2008. Within six months the Euribor rate fell from 5,11% in October 2008 to 1,42% in April 2009. In October 2009, the Euribor rate was at 0,74%. Although the sovereign bond yields of many EU countries also fell slightly during

this time, the decrease in the Euribor was not a reflection of prior fluctuation in sovereign bond yields as most sizeable fluctuations in the Euribor seem to be.

As can be seen in table 1, sovereign bond yield spreads in the EU during the observed time period fluctuate between -1,54% (Sweden in October 2008) and 28,19% (Greece in February 2012) with the average value across all observations at 2,35%.

Table 1. Descriptive statistics of bond yield spread and corruption data by country

Country	Min. spread	Avg. spread	Max. spread	Yield data from	Min. CPI	Avg. CPI	Max. CPI	Corruption data from
Austria	-0.78%	1.27%	3.09%	01/1995	69.0	77.4	87.0	01/1995
Belgium	-0.65%	1.43%	3.36%	01/1995	52.5	69.6	77.0	01/1995
Bulgaria	-0.30%	2.99%	6.91%	01/2003	29.0	37.0	43.0	01/1998
Croatia	0.41%	3.80%	7.90%	12/2005	27.0	38.0	51.0	01/1999
Cyprus	-0.51%	3.41%	6.81%	01/2001	53.0	60.6	66.0	01/2003
Czech Republic	-0.60%	1.63%	4.44%	01/2001	37.0	47.3	56.0	01/1997
Denmark	-0.68%	1.30%	2.90%	01/1995	90.0	94.3	100.0	01/1995
Finland	-0.78%	1.32%	3.63%	01/1995	89.0	93.6	100.0	01/1995
France	-0.93%	1.26%	2.84%	01/1995	63.0	69.3	75.0	01/1995
Germany	-1.23%	0.98%	2.58%	01/1995	73.0	79.3	82.7	01/1995
Greece	-0.32%	5.78%	28.19%	01/1995	33.9	43.5	53.5	01/1995
Hungary	1.92%	4.86%	10.01%	01/2001	41.2	50.3	55.0	01/1995
Ireland	-0.56%	2.18%	10.85%	01/1995	69.0	76.2	85.7	01/1995
Italy	-0.33%	2.31%	6.12%	01/1995	29.9	45.5	55.0	01/1995
Latvia	0.25%	3.31%	13.08%	01/2001	27.0	41.3	57.0	01/1998
Lithuania	-0.24%	3.16%	13.78%	01/2001	38.0	47.4	61.0	01/1999
Luxembourg	-0.43%	1.03%	3.51%	01/1995	80.0	84.8	90.0	01/1998
Malta	-0.30%	2.23%	3.83%	01/2001	52.0	62.3	68.0	01/2004
Netherlands	-0.88%	1.14%	2.81%	01/1995	83.0	87.5	90.3	01/1995
Poland	0.87%	3.66%	7.51%	01/2001	34.0	48.2	62.0	01/1995
Portugal	-0.55%	2.92%	12.63%	01/1995	55.6	63.2	69.7	01/1996
Romania	2.10%	4.88%	10.60%	04/2005	26.0	35.2	48.0	01/1997
Slovakia	-0.34%	2.26%	4.58%	01/2001	35.0	42.7	51.0	01/1998
Slovenia	-0.45%	2.75%	6.48%	03/2002	52.0	60.4	67.0	01/1999
Spain	-0.64%	2.17%	6.29%	01/1995	43.1	62.7	71.0	01/1995
Sweden	-1.54%	1.47%	4.34%	01/1995	87.0	91.5	95.0	01/1995
United Kingdom	-0.59%	1.71%	3.36%	01/1995	74.0	82.2	87.0	01/1995
Full Data	-1.54%	2.35%	28.19%	01/1995	26.0	62.6	100.0	01/1995

Transparency International's CPI is used as a measure of corruption. Although used as a measure of corruption, the CPI is essentially a measure of the lack of corruption, meaning that a higher value in the CPI reflects a lower prevalence of corruption in a country. Therefore, an increase in CPI is evidence of a decrease in corruption. Due to a lack of early data for select countries in the study (most notably Cyprus and Malta, where data is first available from 2003 and 2004 onwards, respectively) the first available observation is used for all preceding time periods. This is justifiable as, unlike sovereign bond yields, the prevalence of corruption tends to change gradually. Corruption scores in the EU are significantly better in the economically more stable countries of Central and Western Europe as well as Scandinavia. As table 1 shows, all of the countries with an average CPI score that is higher than the average of the entire dataset (62,2), with the exception of Malta (62,3), Portugal (62,9) and Spain (63,2) are situated in Central or Western Europe. The prevalence of corruption is lowest in Northern Europe, namely in Finland, Sweden and Denmark, all of which have an average CPI score higher than 90. The CPI scores used in the data are from Transparency International (2017).

The indebtedness of a country is used to approximate financial stability. The metric used is the annual country-level total government debt per GDP. The amounts of total government debt and GDP are both from the European Central Bank's statistical data warehouse. Indebtedness in the data ranges from 6,50% of GDP in Luxembourg in 2000 to 179,70% of GDP in Greece in 2014. The average indebtedness in the data is 56,41%. The debt data is obtained from the European Central Bank (2017).

Interestingly, as table 2 shows, the average debt is consistently lower in the countries which joined the EU after 1995 than in the countries which joined the EU in or before 1995. Although partly due to the excessively high debt in Greece in the 2010s, there are many other old EU countries with high amounts of debt throughout the data. In the 2010s, for example, Italy, Portugal, Ireland, Belgium and Greece all had public debts exceeding their GDP during multiple years. Among the countries which joined the EU after 1995 only Cyprus had debts higher than GDP during the 2010s. During the 1990s, Italy and Belgium were the only countries in the data which had public debts that were consistently higher than GDP.

Table 2. Descriptive statistics by country group

Variable		Obs.	Mean	Std. Dev.	Min.	Max.
Yield spread (%-points)	(0)	6061	2.35	2.26	-1.54	28.19
	(1)	3929	1.88	2.21	-1.54	28.19
	(2)	2132	3.20	2.11	-0.60	13.78
CPI	(0)	7074	62.65	19.42	26.00	100.00
	(1)	3930	74.71	15.99	29.90	100.00
	(2)	3144	47.57	10.95	26.00	68.00
Debt (% of GDP)	(0)	6636	56.41	31.10	6.50	179.70
	(1)	3720	67.87	32.60	6.50	179.70
	(2)	2916	41.79	21.53	6.60	107.50
GDP growth (%)	(0)	6750	2.50	3.37	-14.81	25.57
	(1)	3822	2.07	3.03	-9.10	25.57
	(2)	2928	3.07	3.71	-14.81	11.93
Deficit /surplus (% of GDP)	(0)	6966	-2.94	3.51	-32.10	6.90
	(1)	3930	-2.47	3.93	-32.10	6.90
	(2)	3036	-3.55	2.76	-15.10	3.20
Inflation (%)	(0)	6528	3.54	8.28	-1.70	154.90
	(1)	3660	1.93	1.25	-1.70	7.90
	(2)	2868	5.59	12.10	-1.60	154.90
Credit rating residual	(0)	6348	0.00	11.64	-37.30	25.41
	(1)	3612	7.84	6.62	-18.94	25.41
	(2)	2736	-10.35	8.27	-37.30	20.63
VIX	(0)	7074	20.51	7.78	10.42	59.89
	(1)	3930	20.51	7.78	10.42	59.89
	(2)	3144	20.51	7.78	10.42	59.89

Values presented separately for (0) all countries, (1) countries which joined the EU in January 1995 or earlier and (2) countries which joined the EU after January 1995.

Annual GDP growth is used as a control variable to account for economic progress and the overall annual economic situation of a country. The GDP growth is denominated in percentages and the values are from the European Central Bank (2017). Annual GDP growth values were selected instead of quarterly or monthly figures in order to avoid seasonal fluctuation, which could differ from country to country. GDP growth is expected to have a negative correlation with sovereign bond yields.

The sizes of annual GDP growth in the dataset ranges from -14,81% in Lithuania in 2009 to 25,57% in Ireland in 2015. While the range between the highest and lowest values is high, there are only two instances in the entire data where a country's GDP has fallen more than 10% in a year and seven instances where it has grown more than 10% in a year. If Ireland's 2015 GDP growth is ignored, both the largest negative and positive change in GDP across the entire data as well as during both of the separately observed periods are from the countries which joined the EU after January 1995. As table 2 shows, the average GDP growths in all cases are quite similar in both groups of countries, with the average GDP growth of the countries which joined the EU after January 1995 consistently at or near 1%.

Annual inflation rate is used as a control variable to account for prevailing macroeconomic conditions. Inflation rates are denominated in percentages and range from -1,70% in Ireland in 2009 to 154,90% in Romania in 1997. The data is from the European Central Bank (2017).

To account for annual changes in a country's public-sector finances, the public deficit or surplus is used as a control variable. The measure is denominated in percentages and the data is from the European Central Bank (2017). The values range from a deficit of 32,1% in Ireland in 2010 to a surplus of 6,9% in Finland in 2000. Like GDP growth, the public-sector deficit is expected to have a negative correlation with sovereign bond yields. As table 2 shows, on average the public sectors of EU countries have experienced a steady deficit, which was only slightly larger on average in new EU countries.

To account for credit conditions that may affect sovereign bond yields, error term residuals of country-level foreign currency credit ratings by Standard and Poor's (2017) are used as a control variable. The original credit ratings range from D to AAA with bonds from issuers with ratings between CC and BB being considered speculative grade investments and those from issuers with ratings between BBB and AAA considered investment grade. An issuer with a D or SD rating is either in default or in selective default, respectively, meaning that it is incapable of meeting all or some of its debt obligations. In addition to plain ratings a plus or a minus can be used to show a country's relative standing within a rating category. Also, a country's rating can have either a negative, positive or neutral outlook, which reflects expectations of how the country's credit rating will change in the near future. (Standard and Poor's 2016.)

In order to make the credit rating variable as nuanced and descriptive as possible, the credit rating data from Standard and Poor's is converted to a numeric index that ranges from 0 to 59 and takes into account a country's general rating as well as its standing within the general rating category and future expectations. To fit the monthly dataset, a country's credit rating at the end of each month is used for the numerical index. The index consists of foreign currency ratings due to more consistent rating data availability in comparison to local currency ratings as well as a very high overall similarity between the two ratings. (Standard and Poor's 2016.)

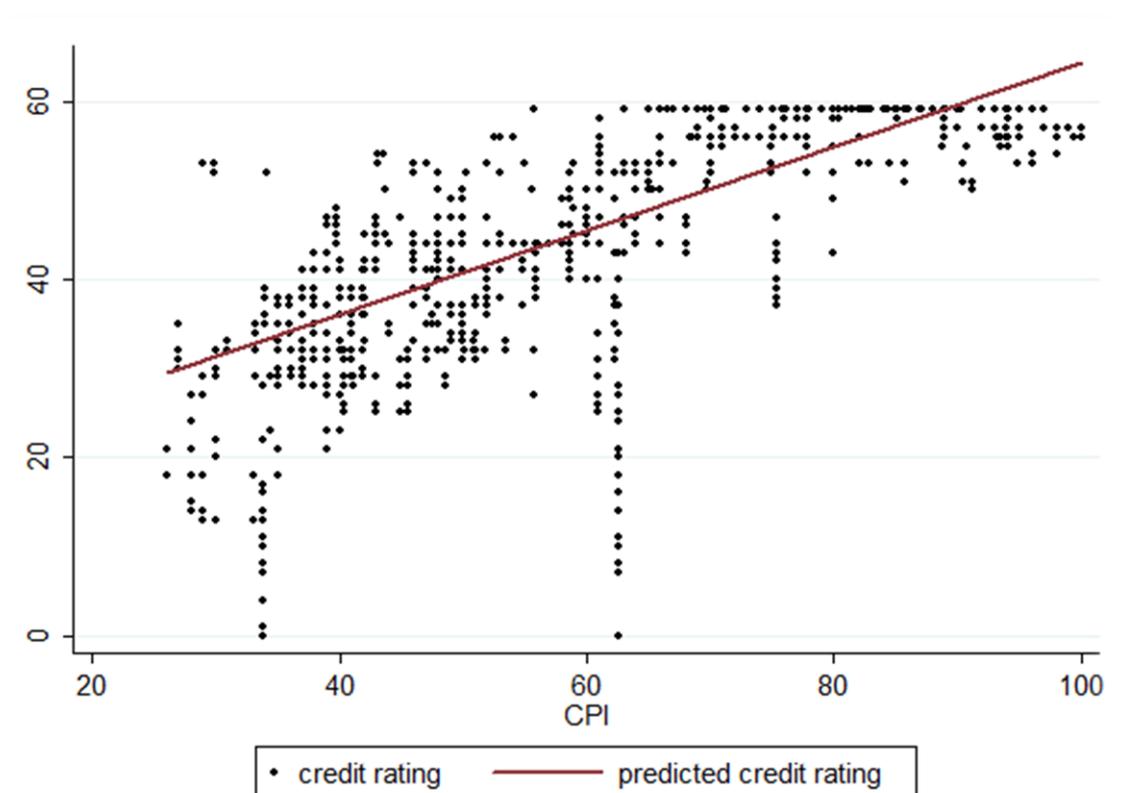


Figure 2. Scatterplot of corruption in relation to credit ratings

Credit ratings are used as an approximation of the stability of a country's finances as well as a measure of how likely a country is to be able to borrow money. A country's credit rating is expected to be negatively correlated with sovereign bond yields, as in Alfonso et al (2015). A single-variable analysis of corruption's effect on credit ratings shows the two variables to be highly positively correlated. As is visible in figure 3, the correlation between corruption and credit ratings appears to be quite high.

A country's credit rating is determined based on multiple factors. As figure 3 shows, one of these factors appears to be corruption. Due to the high correlation, the credit rating index cannot be used as a control variable itself. Instead, a regression analysis is performed on the credit rating index with the CPI, the change in a country's GDP and a country's government debt per GDP as control variables. The error term residuals of that regression are then used as a control variable in the study. This way the effect of the factors that influence a country's credit rating in addition to the ones already present in the study can be taken into account. As table 3 shows, all of the control variables in the credit rating index regression are statistically significant and account for 38,80% of the credit rating index. All of the variables also have a correlation coefficient that is easy to justify. The correlation between the credit rating and the CPI is positive, which means that higher corruption leads to a lower credit rating. This is understandable as corruption can be expected to lead to uncertainty, which can be expected to lead to a lower credit rating. The change in GDP also has a positive correlation with the credit rating. This is logical as well as an increase in GDP can be a sign of economic stability, which can be a reason to increase a country's credit rating. The effect is only significant at a 10% confidence level. A country's debt is negatively correlated with credit ratings, which means that a higher debt leads to a lower credit rating. This is also understandable, as higher debt leads to a lower chance of a country being able to repay its debts.

Table 3. Regression results for credit rating index analysis

	CPI	GDP change	Debt	Within R ²	Obs.	F	p > F
Credit rating 1995-2016	0,148*** (0,029)	0,102* (0,052)	-0,222*** (0,015)	0,388	6348	99,15	0,000

Driscoll-Kraay standard deviations are shown in parentheses under coefficients.
Significance levels: * = 10%, ** = 5%, *** = 1%.

To account for prevailing global credit market conditions that are not country-specific, the Chicago Board Option Exchange's Volatility Index (VIX) is employed. The monthly average VIX rates used in the study are from the Chicago Board Options Exchange (2017a) The VIX is a measure for stock market volatility that has been calculated since 1993. It has been calculated from Standard and Poor's S&P 500 index since 2003, but was originally calculated from the S&P 100 index. Although a measure of stock market volatility, the VIX is not calculated using direct stocks, but stock options. The VIX is calculated using stock option strike prices, which signify the price at which an investor can claim their option by either buying the underlying stock in the case of a call option,

or conversely sell the underlying stock in the case of a put option (Bodie et al. 2009: 46). More specifically the VIX is calculated from

$$(7) \quad \sigma^2 = \frac{2}{T} \sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T} \left[\frac{F}{K_0} - 1 \right]^2$$

where $\sigma = \text{VIX}/100$, T is an option's time to expiration, F is the desired forward index level from index option prices, K_i is the strike price of option i , K_0 is the first strike price below F , R is the general risk-free interest rate to expiration and $Q(K_i)$ is the midpoint of the bid-ask spread for options with a strike rate of K_i . ΔK_i is defined as

$$(8) \quad \Delta K_i = \frac{K_{i+1} - K_{i-1}}{2}$$

which is to say its value depends on the strike prices of the options with a slightly lower strike price and slightly higher strike price than i . (Chicago Board Options Exchange 2017b: 2-4.)

Although the VIX measures the overall 30-day expected volatility of the S&P 500 stock index, it is calculated using stock options, not stocks themselves. This is because stock option prices better reflect investor expectations of future stock market volatility. The VIX is included as a control variable that reflects global credit market conditions because higher volatility in the stock market leads to lower returns on stocks, which in turn raises the desirability of bonds by contrast (Chicago Board Options Exchange 2017b: 4.)

A US stock market index is used instead of a European one to better capture global stock market volatility conditions. Using a similar measure from a European country's stock market would likely have a different or more direct impact on the bond yield of that country's sovereign bonds than other countries in the study. Since the stocks that make up the S&P 500 index are widely traded globally, they can be thought of as alternative investments to European sovereign bonds in the eyes of investors, and therefore a shift in their volatility would also have an effect on the demand for European sovereign bonds. The VIX is also used as a control variable in Ciocchini et al. (2003: 526).

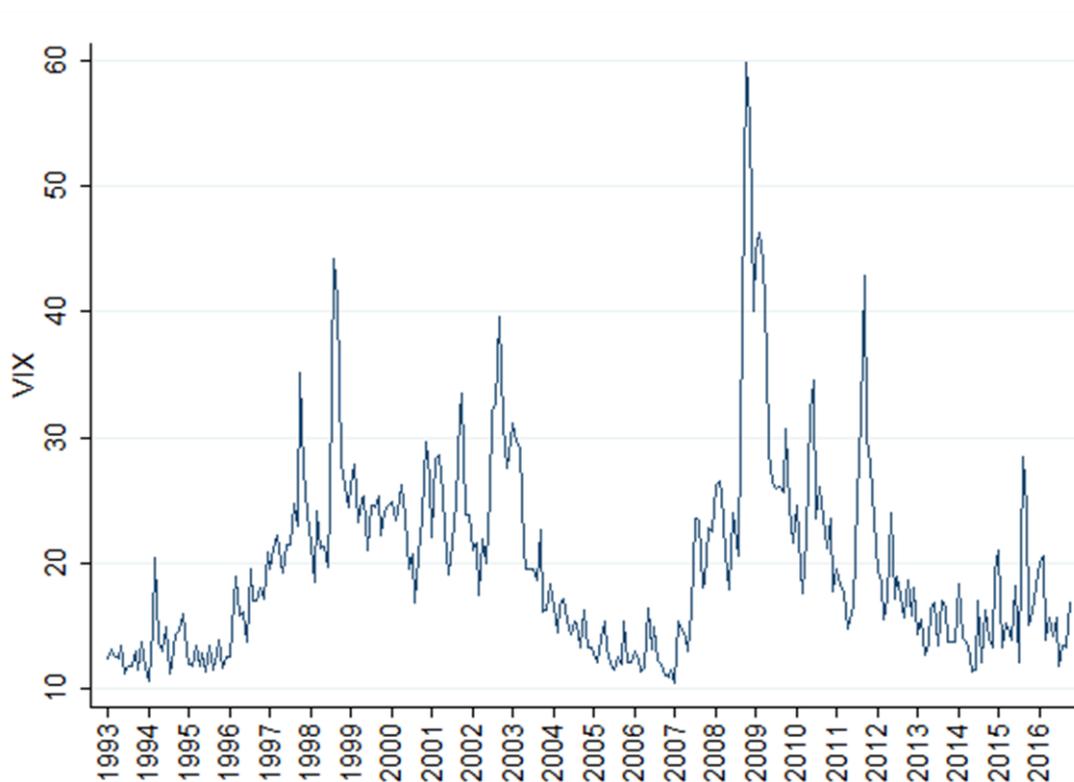


Figure 3. VIX monthly averages from January 1993 to October 2016

As figure 4 shows, stock market volatility was at its highest in the beginning of the financial crisis in 2008 and 2009. Smaller spikes are also apparent between 1997 and 1998, in 2002 and in 2011. Specifically, the VIX peaked at 59,89 in October 2008, with smaller spikes of 44,28 in August 1998, 42,96 in September 2011 and 39,69 in September 2002. Many of these spikes can be seen as reactions to global economic phenomena. A smaller spike of 35,09 in October 1997 as well as the larger spike in August 1998 coincide closely with the Asian financial crisis which began in late 1997 (Cioccini et al. 2003: 513–516). The spike in October 2008 occurs more than a year after the beginning of the global financial crisis, which Alfonso et al. (2015: 14) suggests began in August 2007. However, in October 2008 the VIX had already risen steadily since 2007, so it can be assumed that the conditions that led to the spike were related to the beginning of the financial crisis. The spike in September 2011 coincides with the European sovereign debt crisis, as it is followed by large fluctuations in bond yields that are visible in figure 1. Shortly after the spike in February 2012 Greece's sovereign bonds were first rated at default, which led to their yields peaking.

5.3. Data diagnostics

To determine the correct type of regression to use with the model proposed in the study, the Hausman test and the Breusch-Pagan test are run on the model. The Hausman test is performed in order to test whether a fixed effects or a random effects regression model should be utilised in the analysis and the Breusch-Pagan test is performed in order to find out whether or not heteroskedasticity must be taken into account in choosing the regression model.

5.3.1. Hausman test

The Hausman test is commonly used to test whether a fixed effects or a random effects regression model is best for use with the data supplied. More specifically it tests whether the error terms of a regression are correlated with its variables. The Hausman test is calculated using a random effects model and a fixed effects model. The underlying assumption of the test is that the random effects model is both consistent and effective and the fixed effects model is consistent regarding the error terms if the null hypothesis is not rejected and the error terms are found not to be correlated with the variables. If on the other hand the null hypothesis is rejected and the error terms are found to be correlated with the variables, the fixed effects model remains consistent while the random effects model is neither consistent nor effective. (Mátyás & Sevestre 2008: 80-81.)

Table 4. Results of Hausman test with fixed effects and random effects models

	Fixed	Random	Difference /Overall
CPI	-0,039	-0,015	-0,024
Debt	0,029	0,031	-0,002
GDP growth	-0,235	-0,234	-0,002
Deficit/Surplus	-0,099	-0,098	-0,000
Inflation	0,013	0,020	-0,006
Credit rating residual	-0,165	-0,150	-0,014
VIX	-0,012	-0,012	-0,001
χ^2 (7)			224,68
$p > \chi^2$			0,000

The models used for the Hausman test are linear fixed effects and random effects models based on equation 7. As table 4 shows, with $\chi^2 = 224,68$ at seven degrees of freedom the p-value of the test (0,0000) is clearly small enough that the null hypothesis must be rejected. This means that the study is best served by utilizing a fixed effects regression model rather than a random effects model.

5.3.2. Breusch-Pagan test

To test whether heteroscedasticity in the data must be considered when deciding on what type of statistical model would best serve analysis, the Breusch-Pagan Lagrangian multiplier test is used. Heteroscedasticity means that the estimation residuals of a model are not consistent over time, either in the whole data or for some subjects. While the prevalence of heteroscedasticity in a regular pooled OLS model for analysing panel data can make the results erroneous, a correctly specified model takes heteroscedasticity into account and provides results that are controlled for the inconsistent residuals. (Hoechle 2007: 282-283.)

The Breusch-Pagan test utilizes residuals from a supplied linear regression model to test for common types of heteroscedasticity in the data. The regression used in the test is the same fixed effects regression that was used to calculate the Hausman test. The test finds the model to be heteroscedastic at the 5% significance level. To take this heteroscedasticity into account a robust Driscoll-Kraay pooled OLS model is used in the analysis. The model is specified in Hoechle (2007: 283-285) where it is proposed mainly for use with medium to large econometric data with possible inherent temporal and cross-sectional dependence of the residuals.

5.4. Expected results

The expectation of the study is that greater corruption in a country is linked with greater sovereign bond yields. A single variable analysis of corruption and sovereign bond yields seems to support this assumption, as it shows corruption to have a clear effect on the size of sovereign bond yields. As is apparent in figure 2, the amount of extraordinarily high yields is larger in countries with high corruption and very low bond yields are more common in less corrupt countries. The linear prediction plot also shows a slight downward trend in yields as a country's CPI score increases, which signifies that the correlation apparent in the graph is not purely the product of outliers. Although an

interesting visualisation of the data, the single variable analysis is not robust enough that significant conclusions can be drawn from it. Instead, it shows a correlation that will be tested later with a more robust model including multiple variables.

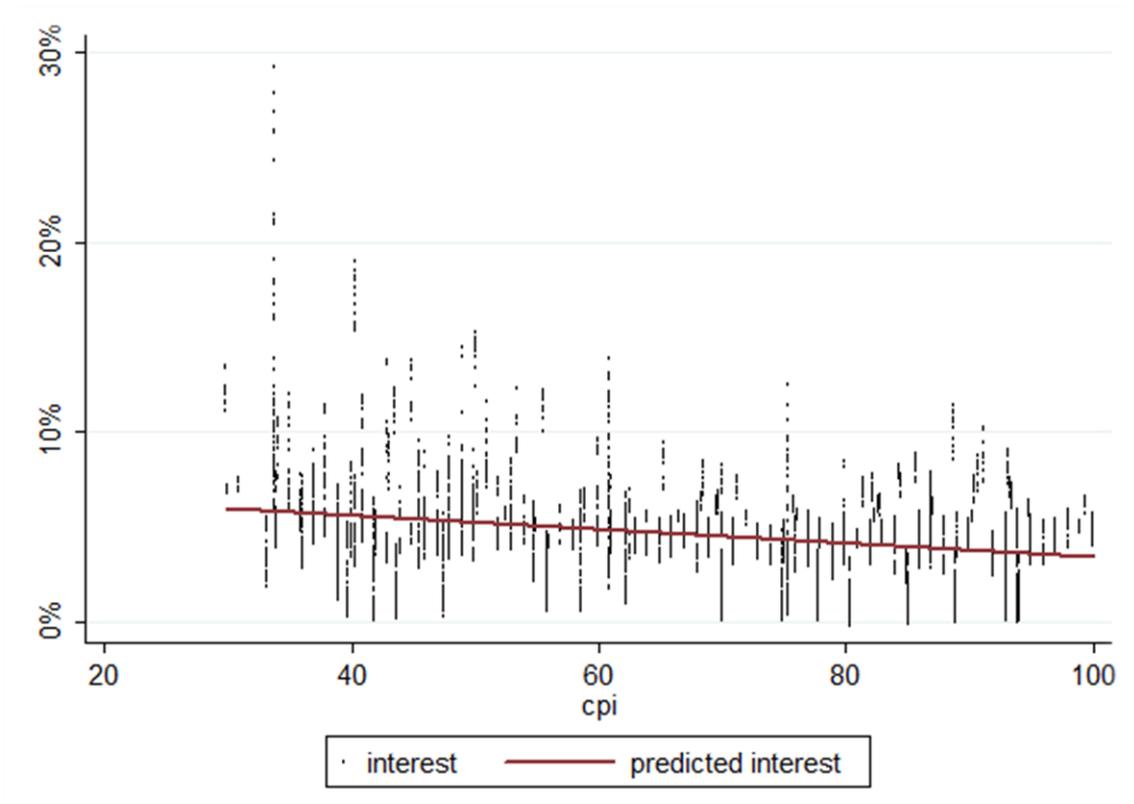


Figure 4. Scatterplot of corruption and bond yields with linear prediction plot

6. EMPIRICAL ANALYSIS

The data is first studied as a whole, and later analysed by time period in chronological order. Each regression analysis is first performed with all of the EU countries in the study included and later separately with one regression only analysing the countries which joined the EU in January 1995 or before it and one regression only analysing the countries which joined the EU after January 1995. In the analyses, these groups of countries will be referred to as old EU countries and new EU countries, respectively.

6.1. Full period analysis

Studying the effects of corruption on sovereign bond yields in all current EU countries between 1995 and 2016, the results of the regression analysis confirm the expectations of the study as far as the relationship between corruption and sovereign bond yields is concerned. The findings show that one point in the CPI of a country corresponds with a decrease of approximately 0,039 percentage points in the country's sovereign bond yields. The result is statistically significant at a 1% confidence level. This means that a lower CPI score, which equates to a higher prevalence of corruption, is linked with a lower sovereign bond yield spread. Therefore, higher corruption is found to correspond with higher sovereign bond yield spread.

While the correlation coefficient is quite small, the differences between the prevalence of corruption in EU countries is high. Assuming that the correlation is both continuous and linear, in a purely theoretical situation where one country was as thoroughly corrupt as is possible (i.e. had a CPI score of 0) and another country had no perceived corruption at all, (i.e. a CPI score of 100) the difference in the sovereign bond yields of the two countries would be 3,90 percentage points based solely on the difference in their CPI scores. While both Finland and Denmark have had CPI scores of 100, no EU country has had a CPI score that was close to 0. The largest difference in the CPI scores of two EU countries between 1995 and 2016 was in 1997, when the CPI score of Latvia was 27,0 and the CPI score of Denmark was 99,4. This difference of 72,4 points would have accounted for a difference of 2,82 percentage points in the sovereign bond yields of the two countries solely based on the difference in the CPI scores of the countries.

The relationship between corruption and sovereign bond yield spread is also notable in the case of long-term change in the CPI score of a single country. Of all the countries in

the data, the largest decrease in corruption occurred in Latvia, where the CPI score increased from 27 in 1998 to 57 in 2016. Assuming again that the correlation between corruption and bond yields is both linear and continuous, this shift of 30 points in CPI would account for a decrease of 1,17 percentage points in bond yields. This is assuming all else stayed equal and the decrease in corruption had no indirect effect on the sovereign bond yield spread. While the decrease in the prevalence of corruption in Latvia is the highest in the data, it is not the only case of a country seeing a notable change in its CPI score. In fact, eight current EU countries saw changes of 20 points or more in their CPI scores between 1995 and 2016. Of these countries, Italy, Latvia, Poland and Spain saw changes of 25 points or more in their CPI scores.

Table 5. Regression results for the period between January 1995 and October 2016

	All countries (0)	Old EU members (1)	New EU members (2)
CPI	-0,039*** (0,006)	-0,045*** (0,011)	-0,062*** (0,009)
Debt	0,029*** (0,005)	0,035*** (0,004)	0,021*** (0,004)
GDP growth	-0,235*** (0,028)	-0,137** (0,040)	-0,279*** (0,022)
Deficit/surplus	-0,099*** (0,017)	-0,113*** (0,019)	-0,179*** (0,025)
Inflation	0,013 (0,059)	0,178** (0,080)	-0,033 (0,053)
Credit rating residual	-0,165*** (0,019)	-0,213*** (0,029)	-0,094*** (0,011)
VIX	-0,012 (0,012)	-0,013 (0,013)	-0,013 (0,009)
Within R ²	0,534	0,519	0,656
F-Statistic	52,71	36,28	78,74
p > F	0,000	0,000	0,000
Observations	5479	3491	1988

Driscoll-Kraay standard deviations are shown in parentheses below correlation coefficients. Significance levels: * = 10%, ** = 5%, *** = 1%. Included are separate analyses for (0) all countries, (1) countries which joined the EU in January 1995 or earlier and (2) countries which joined the EU after January 1995.

Of the control variables in the study, debt, GDP growth, public sector deficit as well as the credit rating residual also have statistically significant coefficients which are in line with the assumptions of the study. A debt the size of 1% of GDP is linked with an increase of 0,029 percentage points in sovereign bond yields. The result is statistically significant at a 1% confidence level. This result is intuitive as a larger amount of debt increases the risk of a country not being able to repay all of its debtors, which in turn increases the profit investors demand for investing in the country's bonds. Although the correlation coefficient is quite small, its effect on sovereign bond yields is quite high due to the values being high as well. The average debt per GDP in the data is 56,41%. This means that, on average, the sovereign bond yield of a country is 1,64 percentage points larger than it would be in the case of no debt.

Also intuitive is that there is a negative correlation between GDP growth and bond yields, as economic growth signals stability to investors. An annual increase of 1% in GDP is linked with a decrease of 0,235 percentage points in sovereign bond yield spread. The relationship between GDP growth and yields is significant, as large fluctuations in GDP are not unprecedented. In the data time period encompassed by the data, the largest annual economic growth reported by a country was a 25,6% increase in Ireland's GDP in 2015. In addition, Latvia, Lithuania and Slovakia have had annual increases in GDP of over 10% and both Latvia and Lithuania have reported decreases in GDP which were larger than 10%. According to the result a 10% increase in GDP is linked with a 2,35-percentage-point decrease in bond yield. The result is statistically significant at a 1% confidence level.

A country's annual public sector deficit is also negatively correlated with sovereign bond yields. A 1% deficit is linked with a 0,099 percentage-point increase in sovereign bond yields. The result is statistically significant at a 1% confidence level. This correlation between a country's deficit or surplus and its sovereign bond yield is understandable, as a deficit must be financed either with new debt or by using existing savings. This increase in debt or decrease in savings is reason for investors to seek a higher yield when investing in a country's sovereign bond yields.

An increase of one point in the credit rating index residual is found to be linked with a decrease in sovereign bond yield spread by 0,165 percentage points. The result is statistically significant at a 1% confidence level. This result shows that credit ratings contain valuable information about sovereign bond valuation even when corruption, debt and economic growth are controlled for. Although both inflation and the VIX have

correlation coefficients which are in line with the expectations of the study, neither of them was statistically significant even at a 10% confidence level.

6.1.1. Old EU members between 1995 and 2016

Analysing only the countries which joined the EU in January 1995 or earlier yields results which differ slightly from those of the full data analysis. While the correlation between corruption and sovereign bond yields is again found to be negative as per the expectations of the study, the correlation coefficient is slightly higher than in the analysis of the full data. An increase of one point in the CPI score of a country is found to be linked with a decrease of 0,045 percentage points in sovereign bond yields. The result is statistically significant at a 1% confidence level and the coefficient is 0,006 larger than in the analysis of all current EU countries.

The largest country-level change in CPI in the old EU countries is in Spain, where the CPI score rose from 43,1 in 1996 to 71,0 in 2002. Assuming a continuous and linear correlation, this improvement of 27,9 points would account for a decrease of 1,26 percentage points in sovereign bond yields. This is a significant amount, as the average sovereign bond yield spread for the countries which joined the EU by January 1995 for the entirety of the data is 1,88%.

The difference between the most corrupt and the least corrupt old EU countries during a single year was in 1995, when the CPI score of Italy was 29,9 and the CPI score of Denmark was 93,2. This difference of 63,3 points in CPI scores would account for a spread of 2,85 percentage points in sovereign bond yields of the two countries, assuming that the correlation was linear and continuous.

Similar to the analysis of all current EU countries during the full time period, all of the control variables used in the study have a correlation coefficient that is in line with the expectations of the study. With the exception of the VIX, all of the correlations between control variables and sovereign bond yield spreads are also found to be statistically significant.

An increase of one percentage point in a country's debt per GDP is linked with an increase of 0,035 percentage points in sovereign bond yield spreads. The result is statistically significant at a 1% confidence level and the coefficient is 0,006 larger than in the analysis

of all current EU countries in the same time period. While statistically significant, the difference is not large enough for further conclusions to be drawn from it at this point.

While GDP growth is again found to be negatively correlated with sovereign bond yield spread, the magnitude of the correlation is significantly lower than in the analysis of all current EU countries. A growth in GDP of 1% is linked with a decrease in sovereign bond yield spread of 0,137 percentage points. This result is statistically significant at a 1% confidence level and the coefficient is 0,098 smaller than in the previous analysis. Since including only old EU countries in the analysis led to a significant decrease in the magnitude of the correlation between GDP growth and sovereign bond yield spreads, it can be assumed that GDP growth is a less significant factor for sovereign bond valuation in the old EU countries than in the new ones. This assumption will be tested further in the analysis of new EU countries.

A country's budget deficit is also a statistically significant predictor of sovereign bond yield spreads. A government surplus of 1% is linked with a 0,113-percentage-point decrease in the sovereign bond yield spread. The effect is statistically significant at a 1% confidence level and the coefficient is 0,014 larger than in the analysis of all current EU countries. Although the difference between the correlation coefficients in the two analyses is not negligible, conclusions about the differences in importance of government deficit as a determinant of sovereign bond yield spreads between old EU countries and new EU countries will have to be made based on further analyses.

As in the previous analysis, inflation again has a positive correlation with sovereign bond yield spread. While in all current EU countries the correlation is found not to be statistically significant, when analysing only the old EU countries the correlation is significant at a 5% confidence level. A 1% inflation rate is found to correspond with an increase in sovereign bond yield spread of 0,178 percentage points. It is interesting that inflation is a statistically significant determinant of sovereign bond yield spread in the analysis of the old EU countries but not in the analysis of all current EU countries.

The credit rating index residual is again found to be negatively correlated with sovereign bond yield spread, with one point of the residual being linked with a 0,213-percentage-point decrease in the spread. The result is statistically significant at a 1% significance level. Although the correlation between the credit rating index residual and sovereign bond yields is quite sizeable in the analysis of all current EU countries, the correlation coefficient is 0,048 larger in the analysis of the early EU countries. As in the analysis of

all current EU countries, the correlation between the VIX and sovereign bond yield spread is found not to be statistically significant in the analysis of the old EU members.

6.1.2. New EU members between 1995 and 2016

The correlation between corruption and sovereign bond yield spreads is again found to be negative when studying new EU countries. This result is similar to those in the the analysis of all current EU countries, as well as the analysis of the old EU countries. One point in a country's CPI score is found to be linked with a decrease of 0,062 percentage points in long term sovereign bond yield spreads. The correlation coefficient is 0,017 larger than in the analysis if old EU members, which is evidence that corruption is a more significant determinant of sovereign bond yield spread in new EU countries than old ones. The correlation is again statistically significant at a 1% confidence level.

The largest difference in the CPI scores of two new EU countries at any point in the study was in 2002, when Romania had a CPI score of 26 and Malta had a CPI score of 68. Assuming all else was equal, this difference of 42 points in itself would have been linked with a spread of 2,60 percentage points between the sovereign bond yields of the countries. This is evidence that the terms at which less corrupt new EU countries are able to borrow money are significantly better than those of more corrupt countries.

New EU countries would also appear to benefit more from anti-corruption measures than old EU countries, as the relationship between corruption and sovereign bond yields is more significant due to the higher correlation coefficient. As mentioned in the analysis of all current EU countries, the CPI score of Latvia rose by 30 points between 1995 and 2016. According to the results of the analysis of only new EU countries, this change in itself would have corresponded with a decrease of 1,86 percentage points in Latvia's sovereign bond yield spread. While this change in the prevalence of corruption took place over the span of more than two decades, it still indicates that anti-corruption measures may significantly affect a country's sovereign bond yield spread. In addition, it is not rare for countries to see more rapid increases in CPI score than those of Latvia. For example, the CPI score of Poland increased by 28 points between 2005 and 2015, and the CPI score of Romania increased by 22 points between 2002 and 2016.

As in the previous analyses, all statistically significant correlations between control variables and sovereign bond yield spreads are in line with the expectations of the study.

Also, similar to the analysis of all current EU countries, both inflation and the VIX were correlated with sovereign bond yield in a statistically insignificant way.

A level of indebtedness the size of 1% of GDP in the new EU countries is linked with an increase of 0,021 percentage points in sovereign bond yield spreads. The result is statistically significant at a 1% confidence level. Interestingly, the correlation coefficient is 0,014 smaller than in the analysis of old EU countries. This would appear to indicate that the level of a country's indebtedness is a more significant determinant of sovereign bond yield in old EU countries than new ones. This may partly be a result of the average debt per GDP of new EU countries being significantly smaller than that of old EU countries. As table 2 shows, the average debt per GDP of new EU countries is 41,79%, whereas the same measure for old EU countries is 67,87%. In countries where the amount of debt is consistently low it would seem logical for investors to be less concerned with differences in debt than in countries where debt is consistently high.

An increase in annual GDP of 1% is linked with a decrease of 0,279 percentage points in sovereign bond yield spread. The correlation is statistically significant at a 1% confidence level and the coefficient is 0,143 larger than in the analysis of old EU countries. This result confirms the previously mentioned assumption that GDP growth is a less significant factor for sovereign bond valuation in old EU countries than in new ones. It would therefore seem likely that investors are significantly more concerned with changes in the GDP of new EU countries than old ones.

A government budget surplus of 1% in the new EU countries is linked with a decrease of 0,179 percentage points in sovereign bond yield spread. The correlation is statistically significant at a 1% confidence level and the coefficient is 0,066 larger than the same figure for old EU countries. This difference would suggest that investors are more concerned about the deficit or surplus of new EU countries than old ones.

The correlation between the credit rating index residual and sovereign bond yield spreads in new EU countries is negative and statistically significant at a 1% confidence level, but also much smaller in scale than in old EU countries. One point in the residual in new EU countries is linked with a 0,094-percentage-point decrease in sovereign bond yield spread, an effect which is 0,119 percentage points smaller than in the old EU countries. There are two possible explanations for this. The first is that investors find credit ratings to be less important for valuing the sovereign bonds of new EU countries. The other possible explanation is that the variables which have been controlled for in the credit rating,

namely corruption, GDP growth and debt, are more important in credit rating formation in the new EU countries and therefore the credit rating residual is less significant. The latter explanation is at least partly supported by the findings of this study, as corruption and GDP growth are both significantly more notable determinants of sovereign bond yield spreads in new EU countries than in old ones.

Inflation and the VIX are found not to be statistically significant determinants of sovereign bond yield spreads in new EU countries. While the VIX has not had a statistically significant correlation with sovereign bond yield spreads in prior analyses either, the correlation between inflation and sovereign bond yield spread in old EU countries is statistically significant. This supports the previously made assumption that inflation is a more significant determinant of sovereign bond yield spreads in old EU countries than in new ones.

6.2. Before the financial crisis

The first period to be analysed separately is the period before the international financial crisis. The period, which ranged from January 1995 to July 2007, was characterised by long term sovereign bond yields which were quite stable and trended downward. The exception to this is Greece, where sovereign bond yields were at 19,0% in January 1995, and where yields continued to be high until the early 2000s. This is visible in figure 1, where Greece's sovereign bond yields are clear outliers in the graph throughout the 1990s and also less prominently during the early 2000s.

While the yields in the data were, with the exception of outliers, mostly quite similar in size between countries, this may not be exclusively due to a homogenous credit market at the time. There is a lack of long term sovereign bond yield data for many Eastern European and Mediterranean countries from the late 1990s and early 2000s. Data for most Central, Western and Northern European countries is available from 1995 or earlier, but 12 of the 27 countries in the study only have sovereign bond yield data from 2001 or later. These beginning dates for the bond yield data coincide for the most part with the date of a country's future entry into the EU. While all of the old EU countries, which joined the EU in or before January 1995, had bond yield data from January 1995 onwards, 8 of the 10 countries which became EU members in 2004 only have bond yield data from 2001 onwards. The two exceptions are Estonia, which is excluded from the study due to a lack of comparable long-term sovereign bonds, and Slovenia, for which there is bond yield

data from 2002 onwards. Of the countries which became EU members in 2007, Bulgaria has bond yield data from 2003 onwards and Romania from 2005 onwards. Croatia, which became a member of the EU in 2013, has bond yield data from 2005 onwards. This lack of data is not necessarily due to a lack of sovereign bonds being issued by the countries in question, but a lack of bonds which comply with the ECB's definition of long term sovereign bonds to the point where they are considered comparable instruments to the bonds of other EU countries. (European Central Bank 2017, European Union 2017.)

The results of the regression analysis for the period preceding the financial crisis differ only slightly from the full period analysis. Before the financial crisis one point in the CPI of a country was linked with a decrease in the sovereign bond yield spread of the country by 0,042 percentage points. The correlation is significant at a 1% confidence level and the coefficient is 0,003 larger than in the analysis of the full period.

Between 1995 and 2007 the largest decrease in corruption in any single country was in Spain, where the CPI score increased from 43,10 in 1996 to 71,00 in 2002. Assuming a linear and continuous correlation between corruption and bond yields, this increase of 27,90 points in CPI would account for a decrease of 1,17 percentage points in sovereign bond yields. This is again evidence that changes in a country's CPI score could have had a significant effect on the terms at which the government of the country is able to borrow money.

While it would appear that anti-corruption measures could have influenced the sovereign bond yields of current EU countries, the prevalence of corruption again had an even larger role in influencing the difference between the sovereign bond yields of more corrupt and less corrupt countries before the financial crisis. The largest difference between the highest and lowest CPI scores during any year in the period preceding the financial crisis was, as mentioned in the full period analysis, in 1997, when the CPI scores of Latvia and Denmark were 27,0 and 99,4, respectively. This difference of 72,4 points would in itself be linked with a difference of 3,04 percentage points in the sovereign bond yield spreads of the two countries. This is an especially large figure considering how small the spreads between the sovereign bond yields of countries were for the most part before the financial crisis.

Table 6. Regression results for the period between January 1995 and July 2007

	All countries (0)	Old EU members (1)	New EU members (2)
CPI	-0,042*** (0,008)	-0,035*** (0,011)	-0,060*** (0,019)
Debt	0,043*** (0,005)	0,042*** (0,008)	0,055*** (0,019)
GDP growth	-0,069** (0,028)	-0,043 (0,035)	-0,083* (0,046)
Deficit/surplus	-0,150*** (0,029)	-0,144*** (0,033)	-0,162*** (0,040)
Inflation	0,128*** (0,128)	0,198** (0,097)	0,114*** (0,040)
Credit rating residual	-0,223*** (0,019)	-0,214*** (0,028)	-0,165*** (0,030)
VIX	-0,002 (0,011)	-0,004 (0,011)	0,009 (0,013)
Within R2	0,364	0,327	0,452
F-statistic	40,65	21,07	194,43
p > F	0,000	0,000	0,000
Observations	2825	2025	800

Driscoll-Kraay standard deviations are shown in parentheses below correlation coefficients. Significance levels: * = 10%, ** = 5%, *** = 1%. Included are separate analyses for (0) all countries, (1) countries which joined the EU in January 1995 or earlier and (2) countries which joined the EU after January 1995.

Most control variables also behaved similarly in the full period analysis and the pre-crisis analysis. A debt the size of 1% of a country's GDP was linked with an increase of 0,043 percentage points in sovereign bond yields, which makes the correlation coefficient 0,014 larger than in the full period analysis. The correlation is statistically significant at a 1% confidence level. This would seem to indicate that a country's debt rate had a more significant relationship with sovereign bond yield spread before the financial crisis than in the full period. This assumption will, however, need to be confirmed by the post-crisis analysis.

The correlation between GDP growth and sovereign bond yield spread was significantly smaller in scale in the period before the financial crisis than in the full period analysis.

An annual GDP growth of 1% was linked with a decrease of 0,069 percentage points in sovereign bond yield spreads, making the correlation coefficient 0,166 smaller than in the full period analysis. The correlation was also statistically significant at a 5% confidence level, whereas the correlation in the full period analysis was statistically significant at a 1% confidence level. Based on this result it is possible to propose that GDP growth was a less significant determinant of sovereign bond yields before the financial crisis than during it, although this assumption will need to be tested in the analysis of the period during the financial crisis.

While GDP growth appeared to be a less significant predictor of sovereign bond yields in the pre-crisis analysis than in the full period analysis, government budget deficit conversely appeared to have a more significant relationship with sovereign bond yields before the financial crisis. A budget surplus of 1% was linked with a decrease of 0,150 percentage points in sovereign bond yield spreads, which means that the correlation coefficient is 0,021 larger than in the full period analysis. The correlation is statistically significant at a 1% confidence level.

An annual inflation rate of 1% before the financial crisis was linked with an increase of 0,128 percentage points in sovereign bond yield spreads. The correlation is statistically significant at a 1% confidence level. This is interesting as the correlation between inflation and sovereign bond yield spread was not statistically significant in the full period analysis. It would appear that inflation was a more significant predictor of sovereign bond yields before the financial crisis, though this hypothesis will need to be confirmed in the analysis of the period during the financial crisis.

The correlation between a country's credit rating index residual and its sovereign bond yield spread was negative both in the pre-crisis analysis and the full period analysis, but the correlation coefficient was larger in size in the pre-crisis analysis. Before the financial crisis an increase of one point in the credit rating index residual corresponded with a downward shift of 0,223 percentage points in the country's sovereign bond yield spread. This correlation coefficient is 0,058 larger than in the full period analysis and the correlation is statistically significant at a 1% confidence level. Based on this result it would seem that the residuals of credit ratings had a larger impact on sovereign bond yield formation before the financial crisis than in the full period. However, it remains to be seen whether or not this impact is diminished in the period during the financial crisis. As in previous analyses, the VIX was not a statistically significant determinant of sovereign bond yield spreads during the financial crisis.

6.2.1. Old EU members before the financial crisis

The results of the analysis of old EU countries before the financial crisis are very similar to the analysis of all current EU countries during the same period. A large reason for this is the fact that the availability of data for this period is significantly better for old EU countries than new ones. This is visible in table 6, where 2025 of the 2825 observations in the analysis of all countries are from old EU countries. While mostly small, some differences can be found between the results.

Contrary to the full period analysis, the scale of the correlation between corruption and sovereign bond yield spread in old EU countries before the financial crisis was slightly smaller than the same effect in the analysis of all countries during the same time period. One point in a country's CPI score was linked with a decrease of 0,035 percentage points in sovereign bond yield spreads. The correlation coefficient is 0,007 smaller than in the analysis of all countries and the correlation is statistically significant at a 1% confidence level. The result is similar enough to the full period analysis that no clear conclusions can be drawn from it.

An increase of one percent in a country's indebtedness was linked with an increase of 0,042 percentage points in the country's sovereign bond yield spread. The correlation coefficient is 0,001 smaller than in the analysis of all EU countries and the correlation is statistically significant at a 1% confidence level.

Contrary to the analysis of all EU countries, GDP growth in old EU countries was not correlated with sovereign bond yield spread in a statistically significant way before the financial crisis. It is reasonable to assume that investors at the time were not concerned with GDP growth when investing in the sovereign bonds of old EU countries, as annual decreases in GDP were rare between 1995 and 2007. In fact, only Portugal and Germany experienced a decrease in GDP during the time period. In 2003 the GDP of Portugal decreased by 0,94% and the GDP of Germany decreased by 0,75%. While the high prevalence of GDP growth is reason in itself for investors to not value changes in GDP as highly, this result also seems to indicate that the magnitude of a country's GDP growth was not significantly linked with sovereign bond yield spread.

Like corruption and debt, the government budget deficit also had a very similar correlation coefficient in the analysis of all EU countries and the old EU countries. A budget surplus of 1% was linked with a decrease of 0,144 percentage points in sovereign

bond yields. This result is statistically significant at a 1% confidence level and the correlation coefficient is 0,006 smaller than in the analysis of all EU countries.

Before the financial crisis, an inflation rate of 1% corresponded with an increase of 0,198 percentage points in sovereign bond yields in old EU countries. The correlation is statistically significant at a 5% confidence level and the coefficient is 0,070 larger than in the analysis of all EU countries. This makes it the only statistically significant control variable to have a significantly different correlation coefficient in the analysis of all EU countries than in the analysis of old EU countries. It would also seem to indicate that inflation was a more significant determinant of sovereign bond yield spreads in old EU countries than in new EU countries. However, this assumption will need to be tested in the analysis of new EU countries.

Similar to corruption, debt and the budget deficit, the credit rating residual behaved very similarly in the analysis of old EU countries before the financial crisis as it did in the analysis of all current EU countries before the financial crisis. One point in the credit rating index residual was linked with a decrease of 0,214 percentage points in sovereign bond yield spread in old EU countries before the financial crisis. The result is statistically significant at a 1% confidence level and the correlation coefficient is 0,009 smaller than in the analysis of all countries. The VIX did not have a statistically significant effect on sovereign bond yield spreads in old EU countries before the financial crisis.

6.2.2. New EU members before the financial crisis

Similar to the previous analyses, a country's CPI score was again significantly correlated with sovereign bond yield spread in new EU countries before the financial crisis. One point in a country's CPI score was linked with a decrease of 0,060 percentage points in sovereign bond yield spread. The correlation is statistically significant at a 1% confidence level and the coefficient is 0,025 larger than the same measure in the analysis of old EU countries.

The correlation coefficient between the CPI and sovereign bond yield spreads was only very slightly smaller in the pre-crisis analysis than in the full period analysis. Before the financial crisis, the relationship between the CPI and sovereign bond yield spread in new EU countries was 0,002 percentage points smaller than the same measure in the full period analysis. However, the difference between old EU members and new EU members is larger in the pre-crisis analysis than in the full period analysis. The difference between

the correlation coefficients of the two groups of countries in the full period analysis is 0,017 percentage points, 0,008 percentage points lower than in the pre-crisis analysis. While the differences between the periods are not very large, the results would seem to imply that before the financial crisis corruption was more important as a determinant of sovereign bond yield spreads in new EU countries than old ones.

The control variables used in the study were for the most part similarly correlated with sovereign bond yield spreads in new EU countries as in the analysis of all countries before the financial crisis. Still, some differences in the magnitudes of these correlations were apparent. For example, a government debt the size of 1% of GDP was linked with an increase of 0,055 percentage points in sovereign bond yields. The correlation is statistically significant at a 1% confidence level and the coefficient is 0,013 larger than in old EU countries.

Interestingly, while the correlation between GDP growth and sovereign bond yield spread was not statistically significant in the analysis of old EU countries, the same correlation is statistically significant, although only at a 10% confidence level, in new EU countries. An annual increase in GDP of 1% was linked with a decrease of 0,083 percentage points in sovereign bond yield spread. The same measure in the full period analysis was 0,279 percentage points, and there it was statistically significant at a 1% confidence level. This would seem to imply that while correlated with sovereign bond yield spread, GDP growth was a notably less significant predictor of sovereign bond yield spread before the financial crisis, both in new and old EU countries.

A 1% government surplus was linked with a decrease of 0,162 percentage points in sovereign bond yield spreads in new EU countries before the financial crisis. The correlation is statistically significant at a 1% confidence level and the correlation coefficient is 0,018 larger than in old EU countries.

In the new EU countries, an inflation rate of 1% was correlated with an increase in sovereign bond yield spreads of 0,114 percentage points before the financial crisis. The result is statistically significant at a 1% confidence level and the correlation coefficient is 0,084 smaller than in old EU countries. This would appear to confirm the previously made assumption that inflation is a more significant predictor of sovereign bond yield spread in old EU countries than in new ones.

The credit rating index residual was again negatively correlated with sovereign bond yield spreads. One point in the residual was linked with a 0,165-percentage-point decrease in sovereign bond yield spread. The correlation is statistically significant at a 1% confidence level and the correlation coefficient is 0,049 smaller than in the old EU countries. Based on this result it would seem that before the financial crisis the variables influencing credit ratings, aside from corruption, GDP growth and debt, were more significant as determinants of sovereign bond yield spread in old EU countries than new ones. As corruption, GDP growth and debt were all correlated to a larger magnitude with sovereign bond yield spread in new EU countries, it is again possible that the difference is a result of the variables being controlled for. This would diminish the significance of the credit rating residual more in new EU countries than old ones. The VIX was not statistically significant as a determinant of sovereign bond yield spread in new EU countries before the financial crisis.

6.3. During the financial crisis

The second period to be analysed separately is the period after the beginning of the global financial crisis, which ranges from August 2007 to October 2016. This period is slightly shorter than the pre-crisis period used in the study, at 9 years and 3 months compared to the 12 years and 7 months before the financial crisis.

While the global financial crisis is an interesting subject for study in itself, even more interesting from the perspective of sovereign bond yields is the period after the financial crisis mutated to the European sovereign debt crisis in March 2009. During the financial crisis period, the EU saw its lowest sovereign bond yield spread, (-1,54% in Sweden, October 2008) while the European sovereign debt crisis brought with it the highest sovereign bond yield spread (29,24% in Greece, February 2012) in the data. This is unsurprising as the sovereign debt crisis is by definition closely related changes that occurred in European sovereign bonds and their markets.

The beginning of the financial crisis was marked by uniformly low sovereign bond yields and even a period where it was not uncommon for the three-month Euribor rate to exceed the long-term sovereign bond yields of select EU countries. This changed as the financial crisis morphed into the European sovereign debt crisis and differences in the sovereign bond yields of EU countries grew significantly. At the same time, the three-month Euribor rate decreased significantly, further raising the sovereign bond yield spreads of all EU

countries. By 2016 the sovereign bond yields of EU countries had, with the notable exception of Greece, reached rates lower than those before the beginning of the financial crisis.

Although the European sovereign debt crisis is more significant to the study than the global financial crisis, the entire period from August 2007 to October 2016 will be referred to as the period during the financial crisis going forward. This is done for the sake of clarity and because the global financial crisis is an integral part of the beginning of the European sovereign debt crisis.

Similar to previous analyses, corruption was again found to be positively correlated with sovereign bond yields during the financial crisis. A one-point increase in the country's CPI score corresponded with a 0,114-percentage-point decrease in sovereign bond yields. This correlation is statistically significant at a 1% confidence level and the correlation coefficient is 0,072 larger or 2,71 times as large as the same measure in the pre-crisis analysis. This result heavily indicates that the financial and European sovereign debt crises caused corruption to become a much more significant determinant of sovereign bond yield than it was before the beginning of the financial crisis.

During the financial crisis, the largest change in the prevalence of corruption in a country was in Poland where the country's CPI score rose from 42 in 2007 to 62 in 2016. This increase of 20 points in the CPI score would account for a decrease of 2,28 percentage points in the country's sovereign bond yields by itself assuming a linear and continuous correlation throughout the data. Although the sovereign bond yields for many countries were high during the financial crisis, this measure would still account for a significant portion of the interest a country pays on its sovereign debt.

The largest difference in the CPI scores of two countries at any given time during the financial crisis was in 2011 when the CPI score of Bulgaria was 33,29 and the CPI of Finland was 94,04. According to the results of the analysis, this difference of 60,75 points would account for a spread of 6,93 percentage points between the sovereign bond yields of the countries. Although spreads of this size between the sovereign bond yields of countries were not unheard of in 2011, they were not common either. In 2011, the largest spread between the sovereign bond yields of Finland and Bulgaria, for example, was 2,95 percentage points in September.

Table 7. Regression results for the period between January 1995 and July 2007

	All countries (0)	Old EU members (1)	New EU members (2)
CPI	-0,114*** (0,013)	-0,153*** (0,031)	-0,106*** (0,019)
Debt	0,040*** (0,007)	0,043*** (0,009)	0,019*** (0,006)
GDP growth	-0,289*** (0,026)	-0,214*** (0,039)	-0,309*** (0,020)
Deficit/surplus	-0,178*** (0,020)	-0,241*** (0,025)	-0,208*** (0,034)
Inflation	-0,015 (0,072)	0,266** (0,105)	-0,117* (0,059)
Credit rating residual	-0,147*** (0,029)	-0,216*** (0,048)	-0,086*** (0,013)
VIX	-0,016 (0,013)	-0,016 (0,015)	-0,015 (0,010)
Within R2	0,572	0,522	0,724
F-statistic	116,54	34,68	92,13
p > F	0,000	0,000	0,000
Observations	2654	1466	1188

Driscoll-Kraay standard deviations are shown in parentheses below correlation coefficients. Significance levels: * = 10%, ** = 5%, *** = 1%. Included are separate analyses for (0) all countries, (1) countries which joined the EU in January 1995 or earlier and (2) countries which joined the EU after January 1995.

Of the explanatory variables, most are in line with the previous analyses. A government debt rate of 1% is linked with a 0,040-percentage-point increase in sovereign bond yield spread during the financial crisis. The correlation is statistically significant at a 1% significance level and the correlation coefficient is 0,003 smaller than before the financial crisis.

Change in a country's GDP is again negatively correlated with sovereign bond yield spread during the financial crisis. A 1% annual increase in a country's GDP corresponds with a 0,289-percentage-point decrease in bond yields. The correlation is statistically significant at a 1% confidence level and the correlation coefficient is 0,220 percentage points larger than or 4,19 times as large as the same measure in the pre-crisis analysis,

where the correlation was only statistically significant at a 5% confidence level. This result clearly indicates that the link between sovereign bond yield spread and GDP growth was significantly stronger during the financial crisis than before it.

The government budget deficit of a country is again negatively correlated sovereign bond yield spread. A government budget surplus the size of 1% of GDP is linked with a 0,179-percentage-point decrease in sovereign bond yield spread. The effect is statistically significant at a 1% confidence level and 0,028 percentage points larger than before the financial crisis.

While the scale of the correlation between GDP growth and sovereign bond yield spread grew significantly from the period preceding the financial crisis to the period during it, the opposite is true for inflation. The correlation between inflation and sovereign bond yield spread in EU countries during the financial crisis is not statistically significant. This is interesting as the same correlation was statistically significant at a 1% confidence level before the financial crisis. Based on this result, it would seem that inflation ceased to be a determinant of sovereign bond yield spread once the financial crisis began, implying that investors no longer considered inflation to be important for sovereign bond valuation.

In accordance with the assumptions of the study, a country's credit rating residual is negatively correlated with sovereign bond yield spread during the financial crisis. A one-point increase in the credit rating residual is linked with a decrease of 0,147 percentage points in bond yields. This result is statistically significant at a 1% confidence level and the correlation coefficient is 0,076 smaller than before the financial crisis. This would appear to indicate that credit ratings are less significant as predictors of sovereign bond yield spreads during the financial crisis than before it. As in previous analyses, the correlation between the VIX and sovereign bond yield spread was not statistically significant.

6.3.1. Old EU countries during the financial crisis

During the financial crisis, the magnitude of the correlation between corruption and sovereign bond yield spread is found to be significantly higher in old EU countries than in all EU countries. One point in the CPI score of a country is found to be linked with a decrease of 0,153 percentage points in sovereign bond yield spread. The correlation coefficient is 0,118 percentage points larger than in the pre-crisis analysis and 0,039

percentage points larger than in the analysis of all EU countries during the financial crisis. The correlation is also statistically significant at a 1% confidence level.

The largest country-level change in CPI score in old EU countries during the financial crisis was in Greece, where the CPI score decreased from 47,0 in 2008 to 33,9 in 2011. The difference in CPI score of 13,1 points would have accounted for a decrease of 2,00 percentage points in sovereign bond yield spreads assuming a linear and continuous correlation. Although it is unclear to what extent the globally publicised sovereign debt crisis in Greece influenced the opinions of the participants of the studies from which Transparency International calculates the CPI, the difference of 2,00 percentage points is quite a small part of the 17,92 percentage points that the sovereign bond yield spread of Greece grew in all during the same period. It is therefore plausible to assume that increased corruption could have resulted in an increase of 2,00 percentage points in bond yield spread had all else remained equal.

The relationship between corruption and sovereign bond yields is again more significant when used to explain the differences in sovereign bond yields of countries. The largest annual difference between the CPI scores of two countries in the analysis was in 2011 between Greece and Finland. The CPI score was 33,9 in Greece and 94,0 in Finland. This difference of 60,1 in CPI scores could by itself be linked with a difference of 9,20 percentage points in the sovereign bond yield spreads of the two countries. Again, although the figure is quite high, it is plausible as the differences in sovereign bond yields between countries grew significantly once the European sovereign debt crisis began in 2009. While spreads of this magnitude were not necessarily common even in 2011, they were not unheard of either. For example, the largest difference in sovereign bond yields between Finland and Greece in 2011 was 18,62 percentage points in December.

Although the correlation between corruption and sovereign bond yields in old EU countries saw a significant change once the financial crisis began, not all control variables were similarly affected. A government debt the size of 1% of a country's GDP is linked with an increase of 0,043 percentage points in sovereign bond yield spread during the financial crisis. The correlation coefficient is only 0,001 percentage points smaller than in the pre-crisis analysis. As in the-crisis analysis, the correlation is again significant at a 1% confidence level.

Conversely, the relationship between GDP growth and sovereign bond yield spread in old EU countries saw a significant change after the financial crisis began. An annual GDP

growth rate of 1% is linked with a decrease of 0,214 percentage points during the financial crisis. Whereas the correlation between GDP growth and sovereign bond yield spread was not statistically significant before the crisis, during the crisis it is statistically significant at a 1% confidence level. This is evidence that GDP growth became a much more significant determinant of sovereign bond yield spread during the financial crisis than it was before the crisis.

The correlation between a country's budget deficit and sovereign bond yield spread is also significantly larger in magnitude during the crisis than before it. In old EU countries during the financial crisis a surplus the size of 1% of GDP is linked with a decrease of 0,241 percentage points in sovereign bond yield spread. This correlation is statistically significant at a 1% confidence level and the correlation coefficient is 0,097 larger than before the financial crisis.

Interestingly, while inflation is not a statistically significant determinant of sovereign bond yield spread in the analysis of all EU countries during the financial crisis, the correlation is statistically significant at a 5% confidence level when analysing only old EU countries. An inflation rate of 1% is found to be linked with an increase in sovereign bond yield spread of 0,266 percentage points, which makes the correlation coefficient 0,068 larger than in the pre-crisis analysis.

Along with debt, the credit rating index residual is the only statistically significant control variable which did not see a notable change in terms of its correlation with sovereign bond yield spread when the financial crisis began. One point in the credit rating residual is linked with a decrease of 0,216 percentage points in sovereign bond yield spread during the financial crisis. This makes the correlation coefficient 0,002 larger than in the pre-crisis analysis. The correlation is statistically significant at a 1% confidence level. The correlation between the VIX and sovereign bond yield spread was not statistically significant in old EU countries during the financial crisis.

6.3.2. New EU countries during the financial crisis

Interestingly, unlike in the full period analyses or the pre-crisis analyses, in the financial crisis analyses the correlation between corruption and sovereign bond yield spread is larger in magnitude in old EU countries than in new EU countries. In new EU countries during the financial crisis one point in the CPI score of a country corresponded with a decrease of 0,106 percentage points in its sovereign bond yield spread. The correlation is

statistically significant at a 1% confidence level. The correlation coefficient is 0,047 smaller than in old EU countries but also 0,046 larger than in new EU countries in the pre-crisis analysis. This result implies that while correlation became a more significant determinant of sovereign bond yield spread in new EU countries during the financial crisis, it was still a more notable determinant of sovereign bond yield spread in old EU countries.

The largest country-level change in corruption in new EU countries during the financial crisis was in Poland, where the CPI score increased from 42,0 in 2007 to 62,0 in 2015. This increase of 20,0 points in CPI would have accounted for a decrease of 2,12 percentage points in the sovereign bond yield spread of Poland, assuming the correlation is linear and continuous and that all else remained equal. This is evidence that, especially during the financial crisis, successful anti-corruption measures could have had a notable effect on the terms by which a country can borrow money.

The largest difference in country-level CPI scores in new EU countries during the financial crisis was in 2008 when the CPI score of Bulgaria was 36 and the CPI score of Slovenia was 67. Assuming that the correlation is both linear and continuous across the entire period, this difference of 31 points would have corresponded with a spread of 3,29 percentage points in the sovereign bond yields of the two countries. This is a notable difference, especially considering that there is significantly less variation in the CPI scores of new EU countries than old ones.

Similar to the analyses of the old EU countries, the correlation coefficients of control variables changed drastically in most cases in new EU countries from the period before the financial crisis to the period during the financial crisis. A government debt the size of 1% of GDP is linked with an increase of 0,019 percentage points in sovereign bond yield spread during the financial crisis. The same measure before the financial crisis was 0,055 percentage points, which is 0,036 percentage points larger than during the financial crisis. This means that while the correlation between debt and sovereign bond yield spread in old EU countries stayed similar between the two separately observed periods, its magnitude was diminished significantly in the case of new EU countries. The correlation is statistically significant at a 1% confidence level.

Conversely, the correlation between GDP growth and sovereign bond yield spread during the financial crisis in new EU countries grew significantly in scale when compared to the pre-crisis analysis. During the financial crisis, an annual GDP growth of 1% was linked

with a decrease of 0,309 percentage points in sovereign bond yield spread. The correlation coefficient is therefore 0,226 larger than the same measure before the financial crisis. The correlation is also statistically significant at a 1% confidence level, whereas the corresponding correlation before the financial crisis was only statistically significant at a 10% confidence level. While the same phenomenon is visible in the analyses of old EU countries, the correlation coefficient in new EU countries during the financial crisis is still 0,095 larger than in old EU countries. This indicates that while GDP growth became a much more significant determinant of sovereign bond yield spread in all current EU countries, the increase in significance was highest in new EU countries.

In comparison to most of the control variables in the study, the correlation between a country's government deficit or surplus and its sovereign bond yield spread changed quite little in new EU countries when comparing the periods before and during the financial crisis. During the financial crisis, a government budget surplus the size of 1% of GDP is linked with a decrease of 0,208 percentage points in sovereign bond yield spread. The correlation is statistically significant at a 1% confidence level and the correlation coefficient is 0,046 larger than the corresponding coefficient before the financial crisis.

The largest difference in the control variables when comparing the periods before and during the financial crisis is in the correlation between country-level inflation rate and sovereign bond yield spread. An inflation rate of 1% during the financial crisis in new EU countries is found to be linked with a decrease of 0,117 percentage points in sovereign bond yield spread. Although only statistically significant at a 10% confidence level, this measure is significantly different from the increase of 0,114 percentage points before the financial crisis. This result would appear to imply that larger inflation is linked with improvement in the terms at which a country was able to borrow money during the financial crisis. Interestingly this is not the case in old EU countries, where the correlation coefficient between inflation and sovereign bond yield spread remained positive and even grew from the pre-crisis analysis.

The correlation between sovereign bond yield spread and the credit rating residual was somewhat diminished during the financial crisis from what it was before the financial crisis. During the financial crisis one point in the credit rating residual was linked with a decrease of 0,086 percentage points in sovereign bond yield spread. This result is statistically significant at a 1% confidence level and the correlation coefficient is 0,079 smaller than before the financial crisis.

The correlation between the VIX and sovereign bond yield spread was not found to be statistically significant in new EU countries during the financial crisis. It can therefore be concluded that stock market volatility did not appear to influence the sovereign debt markets of EU countries in either of the separate periods or groups of countries examined in the study.

7. CONCLUSIONS

This study examines the relationship between corruption and the cost of borrowing money for the governments of EU countries and whether or not the global financial crisis or the period during which a country has joined the EU affects this relationship. This is achieved by statistically analysing the link between sovereign bond yields and corruption. The regression analysis used in the study is performed with a robust Driscoll-Kraay pooled OLS model to account for temporal and cross-sectional dependence in the residuals of the model.

The main finding of the study is that there is a statistically significant negative correlation between the Corruption Perceptions Index (CPI) and sovereign bond yield of a country when major macroeconomic variables are controlled for. As higher CPI scores imply less corruption, this finding means that higher corruption is linked with higher sovereign bond yields. Therefore, more corrupt countries must on average pay higher interest on their sovereign debt. The results are statistically highly significant. The control variables used in the study consist of measures of government debt, GDP growth, government budget deficit, inflation, country-level credit rating and global stock market volatility.

The finding that higher corruption is linked with higher sovereign bond yields was present regardless of which period or group of countries was analysed. The magnitude of the dependence was higher in all cases during the financial crisis than before it. Interestingly, while before the financial crisis the level of the dependence between corruption and sovereign bond yields was higher in the countries which joined the EU after January 1995 than in the countries which had joined the EU by January 1995, the opposite was true during the financial crisis. While the degree of correlation between corruption and sovereign bond yields rose sharply in all of the analyses when the financial crisis began, the effect was significantly larger in old EU countries than in new ones. This indicates that while there was a significant relation between corruption and sovereign bond yields before the financial crisis, this relation increased in magnitude significantly after the beginning of the financial crisis, especially in old EU countries.

While no clear causality can be attributed to the results of this study, it does seem likely that higher corruption is viewed by sovereign debt investors as a risk, and therefore these investors demand higher premiums for investing in the sovereign debt of more corrupt countries. Assuming then that a higher prevalence of corruption leads to higher sovereign bond yields, it would appear that anti-corruption measures would be beneficial for all EU

countries for either acquiring or maintaining good terms for the sovereign bonds they issue. During economically stable times and in the long run this is especially the case in newer EU countries, while during times of economic crisis the role of corruption for sovereign bond yield formation is more significant in older EU countries.

Another possible implication of the findings of this study is that more corrupt countries are impacted to a greater degree by economic instability than less corrupt countries. This means that while anti-corruption measures are valuable in the long run for securing good terms for sovereign debt, they are even more significant for protecting a country from the adverse effects of economic crises on sovereign bond yields. Sovereign debt investors appear to value corruption more highly as a source of risk during the financial crisis, which directly leads to higher interest rates for sovereign debt and therefore higher costs associated with debt during a period which is by already definition economically difficult for a country.

The finding that the relationship between corruption and sovereign bond yields was more significant during the financial crisis than before it is in line with previous studies which have found country-level variables to be more significant determinants of bond yields during the financial crisis (Barrios et al. 2009, Alfonso et al. 2015, Duyvesteyn et al. 2016). This finding is, however, only partly echoed by the control variables in the study. While GDP growth was more significantly linked with sovereign bond yields during the financial crisis, the opposite is true for inflation. Government debt and budget deficit were both similarly related to sovereign bond yields before and during the financial crisis.

From the point of view of EU nations, the results of this study imply that corruption is a significant threat to financial stability. Corruption should therefore be considered as such in policymaking and combatted to prevent the aforementioned negative effects it can entail. The effect of corruption on sovereign bond yields can be observed in all three types of periods analysed by this study: in the long run, during times of stable economic growth, and especially during periods of economic crisis. This indicates that the negative effects of corruption on sovereign debt are not limited to a certain set of circumstances, but are constantly observable. Therefore, both EU-level and government-level anti-corruption measures should also be consistently implemented and enforced in order to improve or at least maintain the terms at which a country can borrow money from the sovereign debt market.

While there appears to be a significant link between corruption and sovereign bond yields, it is important to note that many other variables affect bond yields as well. Of the control variables in the study government debt and budget deficit as well as sovereign credit ratings are consistently linked with sovereign bond yields in a statistically significant way. GDP growth and inflation are both found to have statistically significant and notable relationships with sovereign bond yields in certain situations. Of the variables controlled for, only stock market volatility is found not to have a statistically significant association with sovereign bond yields. Although corruption may not be the most significant single determinant of sovereign bond yields, its impact on sovereign bond yields does appear to be very persistent across the countries and time periods analysed. This persistence, coupled with the fact that the costs of corruption for a society are yet fairly unknown, makes corruption an issue which requires attention from both government legislation and academia.

Although corruption is highly prevalent all around the world, its effect on the economies of developed countries has not been studied nearly as thoroughly as its effect on developing countries. There is an especially apparent lack of prior studies on the financial and humanitarian effects of corruption on European nations. Future research on the subject could for example focus on the possible correlation between corruption and private sector bond yields in EU countries. It would be especially interesting to see if the bonds issued by EU-based companies were affected by corruption in their home country in a way similar to that which sovereign bonds are.

Another possible topic for further study would be to analyse how large-scale national corruption scandals affect sovereign bond yields. A country's CPI score mainly reflects the prevalence of everyday corruption which is visible to the average citizen, and does not necessarily accurately capture the prevalence of grand corruption. While the prevalence of petty corruption is undoubtedly correlated with the prevalence of grand corruption in a country, a relative absence of petty corruption does not necessarily mean that grand corruption does not exist hidden in a country's power structures. If the CPI is biased in some way, it can be assumed to show countries with less petty corruption as less corrupt overall than they really are. A study analysing the relationship between grand corruption and sovereign bond yields would complement the findings of this study.

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