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Macroeconomic Determinants of Sovereign Risk: A Debt Sustainability Analysis

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Abstract

This paper analyses the effect of the debt sustainability indicator on sovereign risk. This stochastic indicator uses simulations of real interest and growth rates to capture uncertainty and combines this with the expected fiscal response of changes in debt levels. A two-variable VAR model is used for the Monte Carlo simulations of real interest and growth rates. The expected fiscal response is determined using long time series of eighteen countries. The results suggest that the indicator has a significant and positive relationship with sovereign CDS spreads. A one percentage point increase of relative deviation of upper-bound debt levels with respect to the median paths leads to an increase of 26.68 bps on average of 5-year sovereign CDS spreads over the subsequent five years. Lastly, inflation, trade-to-GDP and Export-to-Import have a significant effect on sovereign CDS spreads as well.

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1 Introduction

Since the Euro crisis, the sustainability of sovereign debt on the medium and long-term has been frequently discussed by both academia and policy makers. Although countries that are part of the EMU agreed to follow criteria regarding public finances, these may have not been adequate criteria given the European debt crisis which followed after the financial crisis in 2008. Recently, the ECB (2017) reported that there is more uncertainty about debt sustainability, which impacts the financial markets. Assessing this uncertainty regarding the sustainability of sovereign debt is important for determining sovereign risk premiums. In 2013, the Netherlands Bureau for Economic Policy Analysis (CPB) published an article, which led to a publication in 2016, in which they describe a stochastic indicator that has been developed to function as a Debt Sustainability Indicator (DSI) for sovereign risk. This indicator has several advantages over assessing the sustainability of sovereign debt (Lukkezen & Rojas-Romagosa, 2016).

The stochastic indicator forecasts the future path development of simulated debt-to-GDP levels for a period of five years. This stochastic indicator uses simulations of real interest and growth rates to capture uncertainty and combines this with the expected fiscal response of changes in debt levels. A two-variable VAR model is used for the Monte Carlo simulations of real interest and growth rates. The expected fiscal response is determined using long time series of eighteen countries. The indicator is defined as the 97.5% upper-bound of the simulated debt-to-GDP ratios with respect to the median debt-to-GDP levels. This deviation of the upper-bound simulated debt levels with respect to the median path debt levels is referred to as upward risk. The article suggests that the indicator could be used as a determinant of sovereign credit default swaps spreads, referred to as sovereign CDS spreads onwards, as more upward risk implies more sovereign risk.

Sovereign CDS spreads, explained more in depth in section 2.2, remain an interesting topic within macroeconomics and financial economics. The market for sovereign CDS has increased from 2004 and onwards. Whereas the total CDS market was roughly 10 trillion USD in 2004, where data regarding sovereign CDS started being reported on a structural basis, it grew to 60 trillion USD in 2008 and remained consistently around 25 trillion after the crisis. There has been a lot of empirical research within macroeconomics about determinants of sovereign default risk as well. Sovereign CDS spreads appear to be a good proxy for measuring the market perception of sovereign default risk (Aizenman, Hutchison, & Jinjarak, 2013). Furthermore, research suggests that CDS spreads are determined by macroeconomic conditions (Amato, 2005). Cecchetti, Mohanty, & Zampolli (2001) illustrate how fiscal indicators influence the CDS spreads in advanced economics. Yet, it is not clear which macroeconomic factors are determinants of sovereign CDS spreads.

This research focuses on the question whether the Debt Sustainability Indicator, as developed by the CPB, could possibly be a determinant of sovereign CDS spreads. This leads to the following research question:

What is the effect of the Debt Sustainability Indicator on the sovereign credit default swap spreads?

My main results suggest that the Debt Sustainability Indicator is a robust indicator for sovereign risk, as it explains changes in sovereign CDS spreads. A one percentage point increase of relative deviation of upper-bound debt levels with respect to the median paths leads to an increase of 26.68 bps on average of 5-year sovereign CDS spreads over the subsequent five years. Secondly, inflation, trade-to-GDP and Export-to-Import are macroeconomic determinants of sovereign CDS spreads as well. Lastly, the results suggest that ten out of the eighteen countries in this paper have a significant positive fiscal response towards changes in debt levels after controlling for business cycles and temporary expenditures. This implies that the remaining eight countries may be more vulnerable to fluctuations in real interest rates, i.e. an increase could potentially lead to more vulnerability regarding sustainable debt levels.

This paper is structured as followed. Firstly, in section 2, the literature about sovereign default and macroeconomic determinants of sovereign CDS spreads will be discussed, as well as the Debt Sustainability Indicator. After an overview of the literature, a theoretical framework for the sustainability of sovereign debt will be developed. Section 3 will focus on the data used in this research. Afterwards, the methodology will be discussed in section 4, elaborating on the empirical methods used to determine the DSI and the methods to measure the impact on the sovereign CDS spreads. In section 5, the results will be presented. In section 6, the most important results will be summarized, the research question will be answered and possible limitations and suggestions for future research will be discussed.

2 Theoretical Framework

2.1 Sovereign Default and Sovereign Debt Sustainability

Financial crises leading to sovereign default have often occurred throughout history. Usually, there are remarkable similarities with experiences from other countries and from history. Reinhart & Rogoff (2009) conclude that there is one thing that many of the crises have in common, which is the accumulation of excessive debt. They do not specify what kind of debt accumulation, as debt accumulation in any given sector, e.g. consumers or corporations, often tends to lead to greater systemic risks.

Throughout history, there seem to be recurring patterns regarding sovereign default on external debt. Sovereign default is the occurrence of a government defaulting on debt owed to external parties. The literature mentions a correlation between banking crises and default. These crises could lead to a higher probability of default through several channels. For instance, world growth could experience a significant drag, which effects the exports negatively. Furthermore, banking crises could lead to declining world commodity prices, which impacts export earnings and consumption (Hoffman, Jacks, Levin, & Lindert, 2005). Besides banking crises, the literature mentions inflation as a recurring pattern regarding sovereign default on external debt. Sovereign defaults occur often in countries experiencing long periods of high inflation. Inflation can be regarded as a form of partially defaulting, as government liabilities are not (fully) indexed to changes in price levels (Boughton, 1991). Problems with inflation is integrally related to problems of external and domestic default. A government which decides to default on its debt can merely be relied on that they can maintain the value of their currency. Those episodes of high inflation are strongly correlated with exchange rate collapses. Just as banking crises, inflation also has persistent adverse consequences on the economy (Reinhart & Rogoff, 2009).

As mentioned before, excessive debt accumulation is assumed to be the most important systemic risk, which could lead to sovereign default. However, debt accumulation itself is not considered to be the fundamental problem. The difference with excessive debt accumulation is the sustainability of the debt levels. While the sustainability of debt has been discussed from early on, it remains a concept with little consensus. Although it is generally agreed upon that sustainable policy should eventually prevent crises, there is no clear definition which defines sustainable debt levels. Reinhart & Rogoff (2010) suggest a debt threshold of

90 percent of GDP, as their research shows that median growth rates tend to decrease above 90 percent. However, this has been heavily criticized, as more econometrically sophisticated research does not find an indication of any threshold effects (Ash, Basu, & Dube, 2017). Defining and assessing debt sustainability remains difficult. The literature has proposed several methods to do this, looking at both different time horizons and the choice of factors impacting debt sustainability (Neck & Sturm, 2008).

While there are several methods to define debt sustainability, we take the government's intertemporal budget constraint as a starting point. This constraint discusses the least requirements for a government to maintain debt levels. Assume a government borrows for one period, i.e. now and the future, which pays an interest rate of $i_t > 0$ for the borrowed amount in period t. Government spending and tax revenues in period t are respectively denoted as G_t and T_t. Lastly, let D_t denote the amount borrowed in period t, which is equal to the debt. The following constraint holds for the government's public finances:

$$(1 + i_t)D_{t-1} + G_t = D_t + T_t \tag{1}$$

For debt sustainability, our main variable of interest is the debt-to-GDP ratio. Let gs_t, τ_t and d_t respectively be the levels of government spending, tax revenues and debt to GDP in period t. The constraint remains a one period model, thus debt issued in the beginning must equal debt at the end of period t. Rewriting the previous equation yields:

$$ps_t + \frac{1+i_t}{1+g_t}d_{t-1} = d_t \tag{2}$$

Where ps_t is the primary surplus level, equal to the difference between $gs_t - \tau_t$ and g_t is the notation of the growth rate of GDP. Equation (2) suggests two ways of increases in debt levels. First of all, debt levels increase when there is a deficit, as expenses are higher than revenues and must be compensated by issuing debt. Secondly, debt levels increase when the interest rate is higher than the GDP growth, as the debt component of the debt-to-GDP ratio increases at a higher level than the GDP component of the ratio (Neck & Sturm, 2008).

If expenses exceed revenues, a government can issue debt to finance this deficit. However, a government cannot stick to a policy which issues debt to finance old debt. This would imply that the present discounted value of government debt should be equal to zero, as deficits financed by debt must be compensated by surpluses in the future. Including this condition in equation (2), the budget holds the following constraint:

$$\sum_{t=1}^{\infty}\left(ps_t \prod_{p=1}^{t} \frac{1+i_t}{1+g_t}\right) + d_0 = 0 \tag{3}$$

Where the current debt ratio is denoted by d_0. To achieve sustainable fiscal policy, assuming that debt sustainability implies that there is no default risk, a government must meet the constraint of equation (3) (Neck & Sturm, 2008).

2.2 Sovereign Credit Default Swaps

Due to the lack of an instrument for creditors to insure themselves against sovereign default risk, the credit default swaps (CDS) were developed to meet the demand for allocating risk. These efficient vehicles are used to manage, but also transfer risk regarding sovereign default, as well as to provide new instruments for investment opportunities (Augustin, 2012). This asset allocates default risk on many sovereign countries with a broad range of maturities, ranging from 6 month to 30 years, however the 5-year maturities tend to be the most liquid in the market (Zhang, 2014). Besides managing the risk of default that arises from holding sovereign debt, sovereign CDS can be used as an instrument for other purposes as well. Sovereign CDS allows investors to profit from changes in CDS spreads by speculating. Lastly, sovereign CDS can be used for common arbitrage strategies (Zhang, 2014), which are often not socially desirable.

But what exactly is a credit default swap? The credit default swap can be regarded as a financial instrument with a fixed income characteristic. It provides insurance for the buyer of the derivative in the case of sovereign default. As it is a derivative, the underlying asset is the debt issued by a government. The buyer of the instrument pays a premium to the seller of the instrument. The buyer can pay this premium in different time horizon bases, e.g. monthly, quarterly or yearly and this premium is based on the notional amount insured.

If a sovereign country is not able to pay the interest on their debt or repay the old debt, the event is regarded as a credit event which is what the credit default swap is for. If this event occurs, the seller of the instrument pays the buyer the difference between the notional amount insured for and the loss upon default of the debt owed by a sovereign country which the buyer can no longer expect due to the credit event.

As sovereign CDS spreads represent the payments that must be paid by the buyer of CDS to the seller of the instrument, it can function as an excellent proxy for default risk pricing based on the outcome of the fincial markets (Packer & Suthiphongchai, 2001). A variety of papers has analysed the determinants of those CDS premiums. Whereas the early literature tended to focus on government bond yield spreads, which can be used as a proxy as well, e.g. Edwards (1984), the literature included examining the CDS spreads as a proxy for default risk later, such as Aizenman et al. (2013).

2.3 Determinants of sovereign CDS spreads

The global CDS market has increased exponentially and attracted large institutional investors such as banks and hedge funds. The market offers the opportunity for investors to manage sovereign risk. Thus, it is essential for investors to understand spreads in the sovereign CDS market. However, there has been debate on the factors determining sovereign CDS spreads. There appears to be little consensus on the question of whether global factors or local factors are determinants of sovereign CDS spreads. It is CDS premiums that a country must pay, so it is valuable to understand what drives these spreads and how a country can decrease their sovereign risk.

2.3.1 Global and Local factors as determinants of sovereign CDS spreads

Collin-Dufresne, Goldstein, & Martin (2001) find that financial leverage and volatility of the underlying firm are useful variables for models explaining changes in corporate CDS. In an analogous manner, sovereign CDS spreads should depend on a country's leverage, i.e. debt-to-GDP, the fluctuations in a country's assets, and the interest rate. Other studies, with a focus on global financial factors, find empirical evidence suggesting that consumption growth, macroeconomic uncertainty, e.g. variance of the GDP growth rate, and fiscal space, i.e. public debt/tax and fiscal deficit/tax, are determinants of sovereign CDS spreads (Ang & Longstaff, 2011; Augustin & Tedongap, 2011; Aizenman et al., 2013). These factors imply that changes in sovereign CDS spreads are related to global factors.

Although there has been much research based on either a global or local perspective as determinants of sovereign CDS spreads, there is empirical research that suggests that both factors are relevant for changes in sovereign CDS spreads. Country-specific factors examined in these studies focus on fundamentals such as market liquidity, e.g. bid-ask spreads, debt-to-GDP, and its exports and imports (Altman & Rijken, 2011; Sgherri & Zoli, 2009; Zhang, 2003). In earlier years, it appears that changes in CDS spreads were mostly determined by country factors, whereas global factors, such as the TED spread, are found to have an increasing explanatoray power for sovereign CDS spreads in more recent years, especially during the global financial crisis (Zhang, 2003). The TED spread is the spread between the interest rates on banks lending to each other and on the interest rates on T-bills. This variable is often used to proxy banking liquidity and appears to have an effect on sovereign CDS spreads (Hilscher & Nosbusch, 2010; Sgherri & Zoli, 2009). Besides using the TED spread as a global factor, research tends to include the global risk aversion indicator as well. This indicator is published daily by the European Central Bank. It is a financial market liquidity indicator which measures global risk aversion in the Euro area. An analysis by Caceres & Segoviano (2010) shows that global risk aversion is a significant determinant of sovereign CDS spreads.

2.3.2 Macroeconomic factors as determinants of sovereign CDS spreads

Research regarding sovereign CDS are relatively new. This paper tends to follow the perspective of the macro finance literature, where macroeconomic factors of sovereign default risk are considered to be the factors that explain CDS spreads. This is based on empirical evidence, suggesting that macroeconomic circumstances influence these spreads (Amato, 2005). Aizenman et al. (2013) conduct research about the relationship between risk of European sovereign debt defaults and fiscal space. They find empirical evidence which suggests that Tax-to-GDP, trade openness, with Trade-to-GDP as a proxy, and inflation are important determinants of sovereign CDS spreads. Furthermore, Hilscher & Nosbusch (2010) find that the terms of trade, i.e. Export-to-Import, and debt-to-GDP are important macroeconomic determinants of CDS spreads as well.

Furthermore, the unemployment rate may impact a country's economic growth potential negatively, influencing the overall health of the macroeconomy and leading to higher sovereign risk (Figlewski, Frydman, & Liang, 2006). Besides the unemployment rate, consumption, proxied by consumption growth, is considered a macroeconomic fundamental of sovereign CDS spreads. Declines in consumption have a negative effect on sovereign CDS spreads, as they indicate higher sovereign risk (Reinhart & Rogoff, 2009; Augustin, 2014).

2.4 Debt Sustainability Indicator

As described earlier in this paper, there are several macroeconomic determinants of sovereign CDS spreads. However, my paper considers the effect of the Debt Sustainability Indicator (DSI) as the main variable of interest on determining sovereign CDS spreads. Lukkezen & Rojas-Romagosa (2016) developed a stochastic indicator, the DSI, to assess government debt sustainability. This indicator is split in two components, which together make the indicator. The first part is the simulation of real interest and growth rates of a sovereign country using a two variable VAR model. The second part is the expected fiscal response which is an institutional variable that provides information regarding a country's behavior towards changes in debt levels. This indicator provides information regarding the question whether a country has sustainable debt levels. This implies that the debt levels can be considered sustainable only if they do not accumulate and strictly increase over the long term, i.e. only if the simulated debt levels are bounded (Hall, 2013). The DSI assesses the upward risk associated with the distribution of the simulated future debt levels. It measures the deviation of the upper-bound with respect to the median of the simulated debt-to-GDP ratios. Downward risk is not considered in this paper, as this would not necessarily lead to default. Default occurs when a country cannot sustain its public finances. This leads to the following hypothesis:

A wider deviation of the upper-bound with respect to the median of the simulated debt-to-GDP ratios has a positive effect on the sovereign CDS spreads.

2.5 Fiscal Reaction Functions and Debt Sustainability

Fiscal policy rules describing the relationship between the primary balance and the levels of public debt are often used to analyse fiscal sustainability. Based on the research of Bohn (1998), he finds that there is a signficant positive effect of changes in debt-to-GDP ratios to the primary public balance to debt-to-GDP ratios, as this fiscal policy tends to imply sustainability of public finances. Bohn (1998) regards fiscal policy to be sustainable when debt is sustainable, i.e. when the debt-to-GDP ratio is stationary and mean-reverting over time. It is necessary to check for stationarity for the evolution of the debt-to-GDP ratios. Bohn (1998) uses two equations to determine the evolution. Firstly, he describes an accounting equation for a sovereign country's debt. Secondly, he describes a behavioral equation for the relationship between the primary balance surplus and the debt-to-GDP ratio. The first accounting equation is:

$$D_{t+1} = (1 + r_t)(D_t - PS_t) \tag{4}$$

This equation implies that public debt (D) should be equal to the debt during $t - 1$ minus the primary balance surplus (PS) times the real interest rate factor $(1 + r_t)$. To assess the relationship with debt-to-GDP, equation (4) can be divided by GDP, for the GDP-ratio form:

$$\frac{D_{t+1}}{Y_{t+1}} = (1+r_t)\,\frac{Y_t}{Y_{t+1}}\left(\frac{D_t}{Y_t} - \frac{PS_t}{Y_t}\right) \tag{5}$$

This ratio can be simplified (see Appendix A) to:

$$d_{t+1} = \frac{1 + r_t}{1 + g_t}\,(d_t - ps_t) \tag{6}$$

Where d_{t+1} is the net debt-to-GDP ratio in $t + 1$, r_t stands for the ex-post real interest rate and the growth rate of real GDP is denoted as g_t. Furthermore, the real interest rate is equal to the nominal interest rate i_t minus inflation π_t, yielding $r_t = i_t - \pi_t$. Furthermore, the nominal interest rate is equal to the expected real interest rate $\tilde{r}_t$ plus the expected inflation π_t^e, thus we can substitute $r_t = \tilde{r}_t + \pi_t^e - \pi_t$ into equation (6), yielding:

$$d_{t+1} = \frac{1 + \tilde{r}_t + \pi_t^e - \pi_t}{1 + g_t}\,(d_t - ps_t) \tag{7}$$

From this equation, it can be observed that the debt-to-GDP rate in $t + 1$ depends on several factor and can be reduced through different channels (Buiter & Rahbari, 2012). Firstly, one could practice fiscal austerity, which is increasing ps_t by reducing government spending or increasing tax revenues, e.g. increasing tax rates. This approach however is both harmful in the short-term and not popular amongst citizens. Secondly, one could reduce the effective nominal interest rates on the public debt by influencing the equilibrium rates in the financial markets. A recent example is the monetary policy conducted by the European Central Bank called Quantitative Easing. Another way of influencing the market equilibrium interest rate is, if possible, through access to the concessional and conditional funding of external official entities such as the IMF and the EFSF. Thirdly, one could pursue policies that could potentially increase the rate of inflation π_t, thus leading to a decrease in d_{t+1}. As a fourth measure, raising the growth rate of real GDP (g_t), is a painless deleveraging policy. This however, is more difficult than fiscal policy for example. Whereas fiscal policy can be actively approached, growth is an outcome. The last option is default, but this has been discussed in section 2.1 already.

The second behavioural equation for the primary surplus and the debt-to-GDP ratio is used to determine a sovereign country's fiscal response towards changes in debt levels.

$$ps_t = \alpha + \rho d_t + \beta Z_t^{"} + \varepsilon_t \tag{8}$$

Where ρ is the fiscal reaction function (FRF) parameter, which is the parameter to assess whether changes in debt levels lead to a government to conduct policy to change its primary surplus; $Z_t^{"}$ is a vector of two other determinants of the primary surplus which are necessary to include for the mean-reverting process of debt-to-GDP; and ε_t is the error term.

ρ is an institutional variable, which represents a structural relationship between the debt-to-GDP ratio and the primary surplus ratio. One could argue that this parameter is not constant over time, as it is merely based on policy. However, because of the potential omitted variables problems, vector $Z_t^{"}$ is included in the empirical analysis based on a theoretical model of fiscal policy, the tax-smoothing model of Barro (1979), which says that the primary surplus has nondebt components, which are captured by vector $Z_t^{"}$ in equation (8), which includes the level of temporary government spending, GVAR, and an indicator for business cycles, i.e. cyclical fluctuations in output, YVAR. These variables will be addressed in section 3.1.1. Including these variables in the empirical analysis should address potential omitted variable bias concerns about the FRF parameter, as this tax model implies stationarity of government debt. It is further assumed that this parameter is constant over time.

Substituting equation (8) in equation (6), which captures real interest rates, gives the model which describes how the debt-to-GDP levels will develop over time (Lukkezen & Rojas-Romagosa, 2016):

$$d_{t+1} = \varphi_t (1 - \rho) d_t - \varphi_t (\alpha + \beta Z_t^{"} + \varepsilon_t) \tag{9}$$

Where φ_t is a variable that summarizes the real growth rates with respect to the real interest rates:

$$\varphi_t = \frac{1 + r_t}{1 + g_t} \tag{10}$$

By simulating the evolution of debt-to-GDP, given by equation (9), the Debt Sustainability Indicator (DSI) can be determined at last. Equation (10) is simulated by forecasting a VAR model with Monte Carlo simulations (see section 4.1.2). Positive and significant fiscal responses, estimated using equation (8), affect the debt-to-GDP evolution, reducing the spread of the simulated debt levels. This deviation of the distribution of debt levels is captured by the DSI, which is defined as follows:

$$DSI = d_{t+5}^{97.5\%} - d_{t+5}^{50\%} \tag{11}$$

Where $d_{t+5}^{97.5\%}$ stands for the 97.5 percentile debt-to-GDP in $t + 5$ of the simulated distribution of d_{t+5} and $d_{t+5}^{50\%}$ is the median of the distribution. Therefore, the DSI measures only the development of the debt levels, which can be regarded as upward risk, of deviating from the median debt level in $t + 5$. Lukkezen & Rojas-Romagosa (2016) suggest that the DSI could be used as an indicator for debt sustainability to assess potential risk, by simulating the development of the debt-to-GDP path and measuring this deviation of thos simulated paths. The question remains whether this indicator could be a determinant of sovereign risk and could function as a useful tool to assess debt sustainability.

3 Data

In this paper, data are used for two purposes. Firstly, section 3.1 will focus on the data used in this paper that are required to estimate the Debt Sustainability Indicator. Secondly, section 3.2 will focus on the data used for the OLS regressions for macroeconomic determinants of CDS spreads.

3.1 Debt Sustainability Indicator

This paper focuses on the assessment of debt sustainability of eighteen countries. These countries are: Argentina (ARG), Austria (AUS), Belgium (BEL), Denmark (DEN), Spain (ESP), Finland (FIN), France (FRA), United Kingdom (GBR), Germany (GER), Ireland (IRL), Iceland (ISL), Italy (ITA), Japan (JAP), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Sweden (SWE), and United States (USA). These countries have time series of at least 60 years, except for Germany which I only have data from 1960 onwards, and are chosen based on the availability of the data. Within this sample, at least 70 years of data up until 2016 are used from the post-war period for eight countries, to estimate the fiscal reaction functions. The fiscal reaction functions are estimated with data up until 2011 for the remaining countries, due to the availability of the data. Due to the Second World War, many countries do not have data from before 1945, thus the post-war period is selected for the sample.

The following time series are used for measuring the DSI: both nominal and real GDP, the GDP deflator to determine inflation rates, public debt, primary surplus, and government expenditures. YVAR, which measures cyclical fluctuations in output, is a variable that can be obtained using the real GDP of each country and GVAR, which measures temporary government spending, from government spending with respect to GDP. Bohn (2008) takes log real GDP and uses an HP-filter ($\lambda = 100$) in order to extract the trend component and defines this variable as YVAR, which is the gap between the actual value and this trend with respect to GDP. The same method is applied for GVAR, but differs by using not the trend component of real GDP but rather the cyclical component of government spending. Each of the time series is tested for stationarity using an Augmented Dickey-Fuller test including a trend. The results are presented in Appendix C. The time series appear to be stationary, except for debt-to-GDP. However, as discussed extensively by Bohn (1998), standard unit-root tests cannot detect the mean reverting process of debt-to-GDP and therefore have a bias. He discussed that debt-to-GDP is in fact a stationary variable.

Figure 1 in Appendix B plots the post-war debt-to-GDP and Primary Surplus ratios of the eighteen countries. As can be observed, Spain, US, UK and The Netherlands start with relatively high debt-to-GDP ratios from the post-war sample. However, Portugal, Italy and Belgium tend to have increasing debt-to-GDP ratios, where Italy and Portugal have increasing debt over time and Belgium relatively high debt ratios during 1980-2000. United Kingdom appears to have relatively low and stable debt ratios since 1980. As can be observed from the Primary Surplus, there seem to be relatively little fluctuations over time, except for Ireland, Italy and Portugal. If we look at the correlation over time between debt-to-GDP and the Primary Surplus, this varies a lot. Whereas countries such as Belgium, Italy, Netherlands, Denmark and Sweden appear to have a high correlation, countries such as Iceland, Japan, Portugal and France have very little correlation.

These observations seem to be in line with the summary statistics of table 1. Belgium appears to have the highest debt-to-GDP ratio on average, which could be attributed to the high debt levels during 1980-2000. Spain on the contrary appears to have the lowest debt ratios on average, which could be attributed to the low debt levels in the post-war period. This is interesting, as Spain is currently regarded as a riskier country than Belgium. It is also interesting given the long-term real interest rates, with almost the same rates for Belgium and Spain on average. Also, the average debt-to-GDP of Iceland seems remarkably low, which is not representative for the current situation. The low average is due to the very low debt-to-GDP levels near the post-war period, whereas the debt-to-GDP has increased over time as can be observed in figure 1. Furthermore, some countries tend to have structural primary deficits, such as United Kingdom and Germany, whereas France and Belgium have a primary surplus on average, which can also be observed based on figure 1 in appendix B.

Moreover, when observing the real interest and growth rates, there seems to be some correlation. For example, Portugal has the highest real growth rates, but it is among the highest real interest rates as well. The same applies to Iceland, with even higher interest rates than Portugal. Countries such as Netherlands, Norway, Sweden and Germany tend to have the lowest real interest and growth rates, and are also perceived as less risky countries.

Lastly, there is much variety between the primary budget in this sample. Almost half of the countries have a primary deficit on average, which is partly policy based. This makes it more interesting to observe and understand how a country's fiscal response to changing debt levels influences sovereign risk.

Table 1: Summary Average Statistics DSI Variables

	ARG	**AUS**	**BEL**	**DEN**	**ESP**	**FIN**	**FRA**	**GBR**	**GER**
	1950-2011	1950-2011	1949-2016	1954-2011	1946-2016	1950-2011	1950-2011	1946-2016	1960-2016
Fiscal Reaction Functions									
Debt/GDP	39.24	39.10	87.60	36.12	39.90	23.06	38.25	86.41	44.09
	(32.72)	(22.56)	(26.09)	(22.72)	(23.26)	(16.94)	(19.20)	(57.99)	(20.99)
Primary Surplus	0.78	0.25	0.61	3.19	-2.27	2.24	3.28	-2.68	-1.99
	(2.54)	(1.70)	(3.19)	(2.96)	(2.90)	(3.39)	(1.31)	(3.06)	(1.79)
VAR Simulation									
Real interest rates	0.062	0.053	0.062	0.073	0.060	0.065	0.057	0.064	0.055
Real growth rates	0.034	0.042	0.042	0.038	0.072	0.047	0.037	0.021	0.033
	IRL	**ISL**	**ITA**	**JAP**	**NLD**	**NOR**	**PRT**	**SWE**	**USA**
	1950-2011	1946-2011	1946-2016	1950-2011	1949-2016	1950-2011	1946-2016	1950-2011	1946-2016
Fiscal Reaction Functions									
Debt-to-GDP	59.27	23.49	71.88	68.09	65.30	34.53	44.00	38.27	65.41
	(23.88)	(15.77)	(37.19)	(67.42)	(21.83)	(10.17)	(31.83)	(17.87)	(19.68)
Primary Surplus	-1.04	1.56	-6.20	0.12	-1.78	6.82	-1.52	0.01	-2.29
	(5.28)	(2.20)	(4.89)	(3.26)	(4.53)	(4.89)	(2.64)	(3.63)	(2.74)
VAR Simulation									
Real interest rates	0.054	0.079	0.063	0.031	0.061	0.062	0.078	0.069	0.046
Real growth rates	0.075	0.098	0.050	0.013	0.045	0.066	0.077	0.052	0.050

Notes: Standard deviations are in parentheses. Primary Surplus is denoted in % of GDP. Real interest and growth rates are denoted in %. Time series for VAR Simulation run from 1987-2011.

3.2 Macroeconomic determinants of CDS spreads

Daily 5-year CDS spreads are retrieved from Datastream for each of the eighteen countries from 2008 until 2016. Those observations are transformed into five year averages, measuring the average sovereign CDS spreads five years after the debt sustainability forecast, starting from January 1st 2008 until December 31st 2010 and onwards, up until January 1st 2014 and December 31st 2016, yielding five CDS spreads averages for each country. Those five year averages will be regressed on the upward risk ratio five years prior, which will be elaborated on in section 4. The same transformations are applied on the following yearly time series for the same timeframe: Inflation, Trade-to-GDP, Export-to-Import, debt-to-GDP, Unemployment, Consumption Growth, TED spread and Global Risk Aversion. These time series are retrieved from IMF Database, Eurostat, Federal Reserve Bank, World Bank, ECB and OECD. Observations between 2009 and 2012 are left out for South-European countries, i.e. Portugal and Spain, since CDS spreads in South-European countries were not representative for debt sustainability. Due to the lack of a lender of last resort, the spreads would not be a valid proxy for sovereign risk (Grauwe, Paul, & Yuemei, 2012). The surging spreads between 2010 to roughly halfway of 2012 can be considered as the results of deteriorating fundamentals. Furthermore, economic uncertainty can have dramatic effects on spreads as well. The spreads can deteriorate from the underlying fundamentals, similar to bubbles in stock markets.

Trade-to-GDP is defined as the sum of aggregate imports and exports divided by GDP. Debt-to-GDP is the outstanding public debt divided by GDP. Inflation is measured using the GDP deflator. Unemployment and Consumption Growth are yearly time series denoted in percentages. Global Risk Aversion measures financial market liquidity, and is published daily by the European Central Bank.

Table 2 provides averages, and standard deviations in parentheses, to summarize the most important characteristics of the dataset used for the OLS estimation. Average sovereign CDS spreads between 2008 and 2016 are the highest for respectively Argentina, Portugal, Iceland and Ireland, which are the countries with the highest government finances concerns currently. This suggests that the spreads appear to be a good proxy, as has been mentioned in section 2. The International Swaps and Derivatives Association (ISDA) is the association that focuses on the swaps and derivatives market. They declared Argentina in default in 2014, which explains the high sovereign CDS spreads during 2008-2016. Inflation is relatively high in the Western-European countries, i.e. Belgium, Germany and The Netherlands. Trade-to-GDP is the highest for respectively Ireland, Belgium and Netherlands, whereas Argentina, United States and Japan have the lowest levels. Unemployment also tends to be higher for countries with higher CDS spreads, such as Portugal and Ireland. Lastly, most countries experience an increase in consumption, except for Spain and Iceland, which are also regarded as countries with financial concerns.

Table 2: Summary Average Statistics Macroeconomic Determinants 2008-2016

	ARG	AUS	BEL	DEN	ESP	FIN	FRA	GBR	GER
Sovereign CDS spreads	1762.31	44.16	68.50	37.39	141.75	33.67	48.87	47.79	23.06
	(1040.99)	(33.98)	(60.32)	(34.80)	(101.35)	(17.50)	(32.52)	(27.32)	(16.56)
Inflation	9.78	1.85	2.10	1.58	0.65	1.57	1.12	-0.01	1.94
	(1.46)	(1.00)	(1.00)	(1.15)	(0.96)	(1.53)	(1.02)	(1.72)	(1.89)
Trade/GDP	31.11	110.85	158.81	100.61	58.27	75.98	57.77	59.94	82.47
	(5.63)	(5.57)	(9.47)	(5.13)	(5.87)	(6.15)	(3.91)	(5.32)	(4.99)
Export/Import	112.90	108.22	102.00	109.89	98.67	101.67	92.78	94.44	113.11
	(14.96)	(2.11)	(1.12)	(1.76)	(8.25)	(3.61)	(1.39)	(1.01)	(1.17)
Unemployment	7.35	5.16	7.95	6.42	20.80	8.19	88.07	6.74	5.84
	(0.64)	(0.62)	(0.59)	(1.29)	(4.49)	(0.87)	(9.90)	(1.26)	(1.27)
Debt/GDP	54.57	71.99	100.85	41.10	78.32	52.52	88.07	79.48	75.19
	(5.86)	(3.53)	(6.22)	(3.83)	(22.89)	(9.92)	(9.90)	(12.43)	(5.68)
Consumption Growth	3.36	0.48	0.99	0.21	-0.74	1.00	0.69	0.71	1.05
	(5.64)	(0.53)	(0.76)	(1.45)	(2.51)	(1.81)	(0.64)	(1.87)	(0.68)
	IRL	**ISL**	**ITA**	**JAP**	**NLD**	**NOR**	**PRT**	**SWE**	**USA**
Sovereign CDS spreads	223.68	270.08	151.10	43.31	44.45	21.18	319.34	28.67	31.15
	(227.04)	(208.99)	(100.26)	(18.91)	(29.43)	(9.30)	(309.42)	(25.80)	(15.24)
Inflation	0.71	5.39	1.67	0.31	1.40	2.25	1.24	0.96	1.34
	(2.56)	(4.19)	(1.00)	(1.22)	(1.89)	(0.96)	(1.49)	(1.40)	(1.82)
Trade/GDP	193.27	98.70	54.09	32.3	145.00	69.28	74.24	86.81	29.13
	(18.79)	(7.24)	(3.38)	(4.10)	(12.66)	(2.27)	(6.67)	(3.10)	(1.93)
Export/Import	120.75	112.53	102.33	97.10	111.78	114.78	92.44	114.11	98.97
	(5.95)	(13.78)	(6.60)	(8.79)	(1.09)	(6.04)	(11.50)	(0.93)	(2.31)
Unemployment	11.48	5.42	10.01	4.13	5.46	3.50	12.18	7.72	7.28
	(2.96)	(1.66)	(2.22)	(0.70)	(3.21)	(0.67)	(2.79)	(0.72)	(1.79)
Debt/GDP	95.18	93.17	123.19	228.88	64.08	52.49	111.21	45.89	98.44
	(28.21)	(10.38)	(9.15)	(15.83)	(3.21)	(2.80)	(23.18)	(7.34)	(12.30)
Consumption Growth	0.29	-0.45	-0.61	0.34	0.07	2.23	-0.19	1.74	1.57
	(3.15)	(5.91)	(1.80)	(1.47)	(1.31)	(1.08)	(3.05)	(1.17)	(1.59)

Notes: Standard deviations are in parentheses. Sovereign CDS spreads in bps. Inflation, Trade/GDP, Export/Import, Unemployment, Debt/GDP, and Consumption Growth are in %.

4 Methodology

4.1 Estimating the Debt Sustainability Indicator

Within this paper, two different estimation techniques are required to assess whether the DSI is a useful indicator for the sustainability of sovereign debt. Section 4.1 is split in two subsections, which will elaborate on the methodology used for the estimation of the DSI. This estimation requires two approaches. First, the fiscal reaction functions have to be estimated, which will be elaborated on in section 4.1.1. Section 4.1.2 will focus on the VAR estimation technique using Monte Carlo simulations to simulate real interest and growth rates.

4.1.1 Fiscal Reaction Functions (FRF)

To estimate the FRF, this paper follows the methodology of Bohn (1998) methodology. He described the relationship between Primary Surplus and debt-to-GDP ratios as mentioned in section 2. To estimate the FRF parameter, Primary Surplus is regressed on debt-to-GDP using Newey-West with a lag window of size 1. YVAR and GVAR are added as control variables for the linear regression. Besides the control variables, d_t^2 – a squared term for the debt levels - and $d_{max,60}$ – which is a dummy variable that is equal to '1' when debt-to-GDP is over 60% – are added to control for non-linearity (Lukkezen & Rojas-Romagosa, 2016). The model is described in the following equation:

$$ps_t = \alpha + \rho d_t + \beta_1 YVAR_t + \beta_2 GVAR_t + \beta_3 d_t^2 + \beta_4 d_{max,60} + \varepsilon_t \tag{12}$$

Where ps_t is the Primary Surplus, d_t is the debt-to-GDP, YVAR measures cyclical fluctuations in output and GVAR measures temporary government expenditures, from government expenditures with respect to GDP, in time t.

4.1.2 Simulating real interest and growth rates

The probability distribution for the development of debt-to-GDP ratios depends on several factors. First, the fiscal response influences the width of the distribution. It is necessary to keep the government debt under control (Bohn, 1998), thus the fiscal response parameter narrows the deviation of the upper-bound of future debt-to-GDP levels. Secondly, the distribution depends on future growth and interest rates, as their volatility influences the future debt levels (Budina & Wijnbergen, 2008). Lukkezen & Rojas-Romagosa (2016) combine the methodology used by Bohn (1998) and Budina & Wijnbergen (2008) to estimate future debt-to-GDP levels, depending on the factors mentioned above. Simulated real interest and real growth rates are inserted in equation (13):

$$d_{t+1} = \varphi_t (1 - \rho) d_t - \varphi_t \alpha \tag{13}$$

Where $\mathrm{E}(Z_t^{"}) = \mathrm{E}(\varepsilon_t) = 0$ by construction, thus equation (13) remains. To obtain a path for future debt-to-GDP levels d_t, equation (13) is simulated 10,000 times using Monte Carlo simulations. Each step uses the interest and growth rates, obtained from a two variable VAR model including real interest and growth rates, which captures historic fluctuations:

$$\begin{pmatrix} r_t \\ g_t \end{pmatrix} = \alpha_0 + \sum_{j=1}^{\infty} A_j \begin{pmatrix} r_{t-j} \\ g_{t-j} \end{pmatrix} + \eta_t \tag{14}$$

$$var(\eta_t) = \mathbf{V}$$

Where r_t stands for the real interest rate in period t and r_{t-j} in period $t-j$, g_t is the real growth rate in period t and g_{t-j} in period $t-j$. η_t is a vector of error terms. Within this model, interest and growth rates are assumed to be correlated over time and within the same time period. The models above describe how one path of the development of the debt-to-GDP ratios is estimated. By repeating this procedure 10,000 times, I obtain a whole distribution of the development of 10,000 debt-to-GDP levels. Higher volatility in interest and growth rates are thus reflected in covariance matrix V as larger values, thus increasing the width of the distribution, and thus the upper-bound. So, the spread of the distribution may grow without bounds over time. This could be the result of a lack of or a weak a fiscal response towards changes in debt levels. Furthermore, this could be due to high volatility in either growth or interest rates. This would imply that the distribution is not bounded and thus the debt levels are not stationary (Hall, 2013).

The procedure mentioned above is used to generate a debt-to-GDP path for the period $[t, t+5]$ starting with $t = 2008$ until $t = 2012$. I run the simulations for two situations: one with the estimated FRF parameter, ρ, and one without the FRF parameter. As mentioned in Lukkezen & Rojas-Romagosa (2016), equation (14) is estimated from 1987 and onwards, as interest rates before 1987 are not representative due to fincancial repression. The number of lags is equal to 1 based on the selection-order criteria (see Appendix D for details).

4.2 OLS Regression for Macroeconomic Determinants of CDS spreads

The main variable of interest within this paper is the DSI. This indicator has been simulated and transformed, as described in section 4.1. To assess the usefulness of this stochastic variable as an indicator for sovereign risk, I run an OLS regression. First, I use sovereign CDS spreads as a proxy for sovereign default risk, which has been justified in section 2. Furthermore, I will regress these spreads on the indicator and other macroeconomic fundamentals derived by following the literature about macroeconomic conditions influencing CDS spreads. I will run the following regression:

$$CDS_{t,t+5} = \alpha + \beta DSI_t + \theta X^{"}_{t,t+5} + \varepsilon_{t,t+5} \tag{15}$$

Where $CDS_{t,t+5}$ stands for sovereign CDS spread, t for year and $t+5$ for the subsequent five years. DSI_t is the main variable of interest, defined as the upper-bound divided by the median of the distribution of debt levels. This ratio is referred to as the upward risk ratio from now on. $X^{"}_{t,t+5}$ is a vector of other macroeconomic determinants of sovereign CDS spreads. The vector includes inflation, trade openness (Trade/GDP), terms of trade (Export/Import), unemployment, public debt (Debt/GDP) and consumption growth.

The dependent and independent variables, except for DSI, are the averages of period $[t, t+5]$ and DSI is estimated in period t. DSI is measured as follows: in period t, the DSI is equal to: DSI $= d^{97.5\%}_{t+5} - d^{50\%}_{t+5}$. This implies that the upper-bound is given for period $t+5$. Two variables from the literature are added to control for global factors. This is the TED spread, which measures banking liquidity, and the Global Risk Aversion Index, which measures global risk aversion. Lastly, a dummy variable is made for each time period, where '0' equals 2007, '1' equals 2008, '2' equals 2009, '3' equals 2010 and '4' equals 2011. This factor variable controls for each time period.

The upward risk ratio increases as the upper-bound deviates more from the median path, which could be due to higher volatility captured by the VAR model or a lack of or weak fiscal response. This is in line with my hypothesis described in section 2, namely:

A wider deviation of the upper-bound with respect to the median of the simulated debt-to-GDP ratios has a positive effect on the sovereign CDS spreads.

This implies that the outcome of the OLS regression expects the upward risk ratio to be significantly positive, i.e. higher deviation of upper-bound with respect to the median of the distribution results in higher CDS spreads on average in the subsequent five years and thus implying higher sovereign risk.

5 Results

This section will elaborate on the estimated fiscal reaction functions parameters for the eighteen countries used in this paper in section 5.1. Section 5.2 will provide a brief overview of the estimated upper-bounds and medians of the simulated debt-to-GDP. Section 5.3 shows the results of the OLS regression for CDS spreads and the DSI.

5.1 Results of Fiscal Reaction Functions

Table 3 presents the outcome of the OLS regression of equation (12). It appears that 11 out of the 18 countries in this sample have a positive and significant fiscal response towards changes in debt levels, whereas the rest of the countries do not, after controlling for business cycles and temporary expenditures. Furthermore, when looking at the non-linear regressions, it seems that less than half the countries, i.e. Spain, Iceland, Japan, Netherlands, Norway, Portugal and United States, have significant values for square debt. From these countries, only Netherlands, Norway and Sweden have a positive sign. Those values indicate that fiscal responses are stronger for increasing debt levels.

These results support findings of previously done research. Firstly, when comparing this to Lukkezen & Rojas-Romagosa (2016), the nine OECD countries within their sample have similar results, both the significance levels and sign. It appears that this has not changed using data past the financial crisis. The fiscal response is robust. This is also consistent with the results of Bohn (1998), where a positive and significant fiscal response towards changes in debt levels is found. These results are also in line with research of Berti, Colesnic, Desponts, Pamies, & Sail (2016). They conduct research on fiscal reaction functions for European Union countries. They find that most EU countries positively adjust their fiscal policy to rising levels of debt. The results are similar to their research in the sense that the signs and significance levels are in line. However, when looking at the level of the fiscal response function, this is not always the same. Whereas I find a 0.053 fiscal response for Denmark, they find 0.056, which is remarkably close to each other. However, when looking at Netherlands, they find a 0.023 fiscal response parameter, whereas my research suggests a stronger fiscal response, namely 0.086. Those differences could be explained by the use of different methodologies, whereas I include the same set of control variables, they also include other variables, such as inflation and lagged time series of debt. Other research within this field regarding the countries used in this sample find similar results, except for the size of the parameter. It seems to depend on the methodology used, but the robustness of the significance and sign appears to be present in all papers. Very few results are significantly different in size regarding this paper. For example, Fincke & Greiner (2012) find a 0.10 value for France and 0.15 for Denmark, whereas this paper finds remarkably different values (respectively -0.034 and 0.053). But besides these small differences, the results in table 3 seem to be in line with the literature (Lukkezen & Rojas-Romagosa, 2016; Fincke & Greiner, 2011; Schoder, 2014; Legrenzi & Milas, 2013; Mauro, Romeu, Binder, & Zaman, 2015).

Table 3: Summary of fiscal reaction function estimates of eighteen countries in the post-war period

	ARG 1950-2011	**AUS** 1946-2011	**BEL** 1946-2016	**DEN** 1950-2011	**ESP** 1949-2016	**FIN** 1950-2011	**FRA** 1946-2016	**GBR** 1950-2011	**GER** 1946-2016
Estimated coefficients from linear regression									
ρ	0.036***	0.091	0.060***	0.053***	0.006	0.025	-0.034***	0.020***	0.002*
YVAR	0.118*	0.202**	0.622***	0.797***	0.191*	0.591***	0.310**	0.391**	0.290**
GVAR	0.372	-0.124*	-0.103**	0.031	-0.094**	0.096**	-0.066***	-0.248***	-0.107**
Estimated coefficients from control variables (non-linear regression)									
d^2	-0.082	-0.036	0.101	0.094	-0.026**	0.165	0.011	0.010	0.092
$d_{max,60}$	0.118*	0.202**	0.622***	0.797***	0.191*	0.591***	0.310**	0.391**	0.290**
	IRL 1950-2011	**ISL** 1946-2011	**ITA** 1946-2016	**JAP** 1950-2011	**NLD** 1949-2016	**NOR** 1950-2011	**PRT** 1946-2016	**SWE** 1950-2011	**USA** 1946-2016
Estimated coefficients from linear regression									
ρ	0.032	-0.020	0.000	-0.032***	0.086***	0.031***	-0.017	0.087***	0.031*
YVAR	0.615*	0.203**	0.355	0.146	0.513**	0.073***	0.020	0.559**	0.377**
GVAR	-0.321*	-0.093***	-0.084*	-0.198***	-0.085*	-0.008	-0.129***	-2.06***	-0.118***
Estimated coefficients from control variables (non-linear regression)									
d^2	0.108	-0.114**	-0.043	-0.021***	0.157***	0.075**	-0.084***	0.232**	-0.132**
$d_{max,60}$	0.003	-0.050***	0.340***	0.041***	-0.038***	0.045***	-0.039***	0.026**	0.003

*Notes: Significance levels: *** p<0.01, ** p<0.05, * p<0.10. Standard errors are computed using heteroscedasticity- and autocorrelation-consistent standard errors with Newey-West with a 1 lag period.*

Countries with no or a weak significant fiscal response parameter may experience concerns regarding the maintenance of the debt at at sustainable levels (Lukkezen & Rojas-Romagosa, 2016). This applies to seven countries, including five countries that have financial concerns, i.e. Spain, Ireland, Iceland, Italy and Portugal. The lack of significant fiscal responses towards changes in debt levels imply difficulties to maintain sustainable debt levels and are likely to cause financial concerns, implying higher sovereign risk. Lastly, the information acquired from the OLS estimation, i.e. the fiscal response parameter, is used for the stochastic indicator as it will be combined with a VAR analysis and Monte Carlo simulations to generate future debt level paths.

5.2 Results of Simulations

The debt projections are influenced by fiscal policy in two ways. First, fiscal responses lower the expected future debt levels, narrowing the debt deviation of the simulated debt levels. Secondly, a higher fiscal response coefficient implies that real interest and growth rates are reduced by the impact.

This section presents a summary results of the simulations ran from 2012 until 2016. In table 4, the first column, which is the most relevant column, represents the relative upper-bound level of the upper-bound level with respect to the median debt path, also referred to as the upward risk ratio. The upper-bound level is defined as the 97.5 percentile of the simulated debt-to-GDP paths. The upward risk ratios range from 5.80 (Belgium) to 40.42 (Argentina) percentage points. Similar results are found in Lukkezen & Rojas-Romagosa (2016) and Berti et al. (2016). There seems to be a correlation between the upward risk ratios and sovereign risk. Whereas Netherlands, Belgium, and Austria have relatively low sovereign CDS spreads, but also relatively low upward risk ratios, countries such as Portugal, Ireland and Argentina, whom have relatively high sovereign CDS spreads, are among the highest upward risk ratios. It indicates what kind of relationship can be expected from the OLS regression in section 5.3. This distinction can also be expected based on the volatility of the real growth and interest rates. Ireland, Portugal and Argentina have higher volatile real growth and interest rates, whereas Netherlands, Belgium and Austria have relatively stable and non-volatile real growth and interest rates. This effect is directly captured by the VAR model, where higher volatility leads to higher deviations of the median debt path, implying higher upward risk ratios and thus indicating higher sovereign CDS spreads.

It is interesting finding that Japan has relatively high debt levels, including the upper-bound, yet the upward risk ratio is relatively low (14.20), whereas Argentina has average debt levels, but with relatively high upper-bound levels (40.42) with respect to the median debt levels. Japan has relatively low sovereign CDS spreads compared to Argentina. It suggests that the debt levels itself do not necessarily imply debt sustainability. Lastly, I ran the simulations with no fiscal response ($\rho = 0$). The relative upper-bound levels are close to the values including a fiscal response. Even though the median and upper-bound debt paths differ, the upward risk ratios do not differ much. Assuming $\rho = 0$, the simulated debt levels appear to be higher for every country, except for a few countries with a negative ρ. Figure 2 in Appendix B plots the DSI values over time for each country. Overall, the DSI values tend to increase from 2007 until reaching its peak in 2009, where it starts decreasing. If the indicator is a useful indicator for debt sustainability, this would suggest that debt sustainability was a relatively big concern for most countries during 2009. This seems to be consistent with the financial crisis, reaching its peak in 2009. Argentina has consistently scored relatively high upward risk ratios between 39 and 42 percentage points. This may have been an indication of its debt sustainability concerns, which may have given information regarding the default in 2014. Overall, the upward risk ratios have decreased after the peak in 2009.

Table 4: Summary of average simulation outcomes during 2012-2016

	Upward Risk Ratio	Median Debt	Upper-bound Level	Median Debt $\rho = 0$	Upper-bound Level, $\rho = 0$
Netherlands	12.00	42.63	48.70	63.94	73.04
Belgium	5.80	77.56	82.36	90.64	96.25
Germany	12.99	70.43	81.09	80.34	92.51
United Kingdom	11.86	60.79	69.40	76.52	87.36
United States	11.01	58.82	67.52	88.25	101.31
Italy	12.02	81.08	92.36	118.34	134.82
Spain	17.70	51.46	63.71	52.77	65.32
Portugal	22.45	91.22	117.89	88.97	114.98
Iceland	20.26	79.56	99.70	72.05	90.30
Ireland	38.48	96.52	183.10	113.31	214.97
Argentina	40.42	52.91	89.02	61.28	103.08
France	9.84	90.09	100.02	76.18	84.57
Denmark	9.64	28.65	31.78	37.57	41.67
Sweden	15.92	22.45	26.64	35.34	41.94
Japan	14.20	284.64	332.23	243.16	283.81
Norway	9.64	31.25	40.44	36.62	47.39
Finland	28.40	34.18	47.84	38.70	54.16
Austria	9.39	67.61	74.79	70.73	78.24

Notes: Equation (13) is simulated 10,000 times using Monte Carlo simulations in a VAR model framework. The DSI is estimated for $t + 5$, with 2007 as a starting point and repeated up until 2011, generating five observations for each country. The averages of the median (50%) simulated debt levels in t+5, and upper-bound levels (97.5%) in t+5 are given in this table. Relative upper-bound levels are in % points. Median debt and upper-bound levels are in % of GDP.

5.3 Results of OLS Macroeconomic Determinants

This section presents the outcomes of the OLS estimation of equation (15) with various models in table 5. The results are used to test the hypothesis, which expects a significant and positive effect of the upward risk ratio to sovereign CDS spreads.

Model (1) to (7) are univariate regressions, of sovereign CDS spreads on each macroeconomic determinant, including the upward risk ratios. These determinants are considered fundamentals and are chosen based on the available literature on this topic. Based on these models, it appears that the upward risk ratio has a significant and positive effect on sovereign CDS spreads. Furthermore, three other macroeconomic fundamentals have a significant effect. Model (2) presents the outcome of the regression including inflation. This has a positive effect which is in line with Reinhart & Rogoff (2009). Periods of hyperinflation tend to be correlated with defaults. Therefore, an increasing inflation could lead up to a higher probability of default, implying more sovereign risk and thus higher spreads. A one percentage point increase of inflation leads to an increase of 3.15 bps on average of sovereign CDS spreads over the subsequent five years. Whereas inflation has a positive effect, Trade-to-GDP, also referred to as trade openness, and Export-to-Import, also referred to as Terms of Trade, have a significant and negative effect on sovereign CDS spreads. These results are in line with Aizenman, Jinjarak, & Park (2016) and Hilscher & Nosbusch (2010). Debt-to-GDP appears not to have a significant effect. A possible interpretation is that debt-to-GDP is already captured by the indicator, thus debt-to-GDP should not have a significant effect.

Also, debt-to-GDP does not say anything regarding the sustainability of the debt levels, so this should not have a significant effect as expected. Lastly, unemployment and consumption growth appear not have a significant effect either, which is not necessarily in line with the literature, as this does suggest a relationship. This relationship however is not found in this paper.

In model (8), all macroeconomic fundamentals are included within the multivariate regression. Similar results are found compared to the univariate regressions. The relative upward risk ratio has a similar coefficient, standard error and p-value as with the univariate regressions. Inflation, Trade-to-GDP and Export-to-Import yield a significant effect with similar coefficients, standard errors and p-values. The other macroeconomic fundamentals remain insignificant. So far, the model has not controlled for global factors. This is included in the multivariate regression in model (9). TED Spread appears to have a positive sign, which is consistent with the literature, but its effect is insignificant. The same applies for Risk Aversion. Although the sign is as expected, according to the literature, its effect remains insignificant. This is interesting, as the macroeconomic fundamentals appear to have a significant effect, whereas global factors do not. Furthermore, controlling for global factors does not yield different results, as the upward risk ratio has a similar coefficient compared to the other models.

Besides controlling for global factors, I control for year effects as well. Model (10) includes dummy variables for each year. It can be observed that there are almost no changes to the significant macroeconomic fundamentals. The results are almost the same as in model (9). There is no significant effect of a dummy variable within this model, implying that there are no higher spreads in particular for a specific year. Furthermore, the R^2 increases each time by controlling for global factors and year effects. Including these control variables increases the R^2 from 0.381 till 0.534. Inflation, trade-to-GDP and Export-to-Import remain macroeconomic determinants of sovereign CDS spreads as well. Based on model (10), a one percentage point increase of relative deviation of upper-bound debt levels with respect to the median paths leads to an increase of 26.68 bps on average of 5-year sovereign CDS spreads over the subsequent five years

This effect is consistent with the findings of Lukkezen & Rojas-Romagosa (2016). Their research suggests that the DSI could function as an early-warning instrument. Higher upward risk ratios provide information regarding debt sustainability problems. It is also consistent with the approach of Kaminsky, Lizondo, & Reinhart (1998), whom suggest an early-warning system. This approach does reasonably well during the global financial crisis (Shi & Gao, 2010). The results in this paper suggest that the DSI does reasonably well, using data before, during and after the crisis.

Based on the results and robustness of the upward risk ratio, the hypothesis is accepted. A wider deviation of the upper-bound with respect to the median of the simulated debt-to-GDP ratios, i.e. increasing upward risk ratio values, has a robust positive and significant effect on the sovereign CDS spreads.

Table 5: Results of OLS estimation with DSI including ρ

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Macroeconomic Fundamentals										
DSI	22.86***	23.10***	23.45***	25.57***	22.63***	22.96***	22.12***	25.93***	26.07***	26.68***
	(6.68)	(6.42)	(5.72)	(7.21)	(6.54)	(6.93)	(6.23)	(6.56)	(6.66)	(6.82)
Inflation		3.15**						2.94**	2.98***	2.98***
		(1.45)						(1.15)	(1.13)	(1.11)
Trade/GDP			-2.26**					-1.81**	-1.70*	-1.65*
			(0.92)					(0.86)	(0.89)	(0.93)
Export/Import				-6.23***				-7.16*	-7.32*	-7.69**
				(2.72)				(3.70)	(3.73)	(3.76)
Debt/GDP					-0.49			-1.22	-1.09	-1.08
					(0.51)			(0.79)	(0.84)	(0.89)
Unemployment						-1.26		-2.80	-1.10	-1.26
						(5.70)		(8.26)	(8.78)	(9.56)
Consumption							21.31	11.32	19.73	22.29
Growth							(26.07)	(25.65)	(26.99)	(31.90)
Controlling for Global Factors										
TED Spread									457.29	-247.60
									(838.75)	(1016.47)
Risk Aversion									-43.14	94.02
									(191.15)	(226.31)
Year Dummy										
2008										-22.23
2009										-141.77
2010										-20.15
2011										-56.67
Constant	-202.45**	-234.24**	22.62	417.25**	-155.10*	-193.60**	-203.42**	761.62	568.40	884.88
	(90.08)	(93.19)	(74.35)	(196.58)	(90.14)	(80.93)	(87.31)	(462.23)	(544.21)	(646.16)
Observations	84	84	84	84	84	84	84	84	84	84
R^2	0.375	0.413	0.442	0.411	0.378	0.375	0.381	0.518	0.525	0.534

*Notes: These are the results of the OLS estimation of equation (15) with CDS as the dependent variable. 2007 is the base year for 'Year Dummy'. Standard errors are given in parentheses. White standard errors are used to control for heteroscedasticity. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.*

6 Conclusions

This paper has analyzed the effect of the debt sustainability indicator on sovereign risk. This stochastic indicator uses simulations of real interest and growth rates to capture uncertainty and combines this with the expected fiscal response of changes in debt levels. A two-variable VAR model is used for the Monte Carlo simulations of real interest and growth rates. The attitude of a sovereign country towards changes in debt levels, the expected fiscal response, is determined using long time series for eighteen countries, where the primary surplus is regressed on public debt and controlled for business cycles and temporary government expenditures. Sovereign CDS spreads are used as a proxy for sovereign risk and are regressed on macroeconomic fundamentals from the literature and the relative deviation of the upper-bound simulated debt levels to the median path simulated debt levels. The results suggest that the relative deviation of the indicator has a robust positive and significant effect on sovereign CDS spreads. I find that a one percentage point increase of relative deviation of upper-bound debt levels with respect to the median paths leads to an increase of 26.68 bps on average of 5-year sovereign CDS spreads over the subsequent five years.

The results suggest that the DSI is a determinant of sovereign risk and could function as a useful tool to assess sovereign risk. The indicator depends on several factors, including the historic volatility of real interest and growth rates, and the expected fiscal response. A positive fiscal response towards changes in debt levels reduces upward risk, as captured by the indicator, and could lead to a decrease in sovereign risk. I find a significant positive response for ten countries, whereas the countries that lack a significant positive response are mostly the countries with debt sustainability concerns. This is also consistent with the high upward risk ratio values for these countries. If real interest rates increase, countries with no significant positive fiscal response are less prepared to maintain debt at sustainable levels. This is captured by the indicator through more upward risk, implying higher upward risk ratios. Furthermore, the results suggest that, including the upward risk ratio, Debt-to-GDP has an insignificant effect on sovereign CDS spreads. This implies that it is not the debt levels itself that cause higher sovereign risk, but rather the sustainability of those debt levels. For example, Japan has relatively high debt levels compared to Iceland, but has remarkably lower sovereign CDS spreads. Lastly, global factors appear not to have a significant relationship with sovereign CDS spreads, as is suggested by the literature. This paper focused on macroeconomic determinants, but included global factors to control for potential omitted variable bias concerns. These control variables did not appear to determine sovereign CDS spreads. This suggests that sovereign CDS spreads tend to be more related to macroeconomic fundamentals.

Although this paper provides interesting insights in the world of macroeconomics and financial economics, there are potential limitations. One potential concern is the fiscal response variable. It could be argued that this is an institutional variable which relationship is not necessarily described by a constant parameter as assumed in this paper. This concern has been attempted to reduce by controlling for multiple factors, including temporary government expenditures and business cycles. Even though the parameter is based on long time series, its size and significance appears to be robust for different time periods based on the robustness tests of Lukkezen & Rojas-Romagosa (2016), and Berti et al. (2016). Also, as long time series are required to estimate ρ, this approach cannot be used for short-term analysis of debt sustainability, but rather for the medium and long-term. Furthermore, simulations with $\rho = 0$ yield nearly exact the same results to simulations including the fiscal response parameter, as the upward risk ratio does not change, only the absolute values which are presented in table 4. As no significant ρ is found for some countries, the outcomes of the upper-bounds including ρ in table 6 are unlikely to occur for those countries. This implies higher absolute values of upward risk, which could have been reduced by a fiscal response of the government of the particular country. The concern is addressed adequately, but remains a potential concern. A second potential concern, or rather limitation, is the use of a period of five years for the DSI. This time period is based on the research of Lukkezen & Rojas-Romagosa (2016), to assess the middle and long term relationship. However, future research could focus on different time periods, as these may yield different results, depending on the time frame.

There remain interesting insights and recommendations for future research. Besides focusing on reducing the potential limitations, this research could be applied for both policy, where debt sustainability could be measured and sovereign risk could be reduced, as well as for financial economists to determine sovereign CDS spreads. Furthermore, the results of this paper tend to shift the debate about macroeconomic fundamentals and global factors towards macroeconomic fundamentals, as these appear to have a significant relationship, whereas the global factors in this paper do not. The indicator itself is also a robust variable within the macroeconomic fundamentals field. It suggests that future research could potentially focus on macroeconomic determinants. Lastly, as the results suggest that the upward risk ratio could be used to measure debt sustainability, future research could focus on which levels of upward risk ratios would imply debt sustainability.

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Appendix

Appendix A: Simplification equation (5)

$$\frac{D_{t+1}}{Y_{t+1}} = (1+r_t)\frac{Y_t}{Y_{t+1}}\left(\frac{D_t}{Y_t} - \frac{PS_t}{Y_t}\right)$$

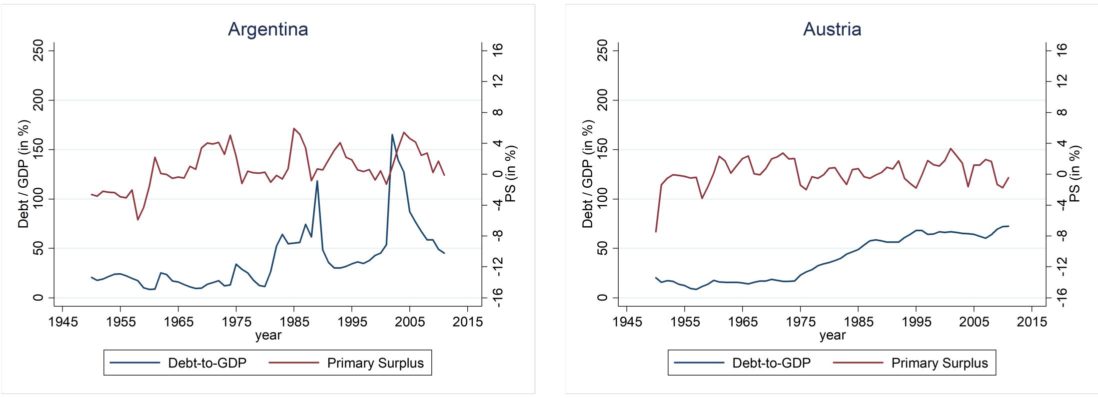
$$\left(\frac{Y_{t+1}}{Y_t}\right)\left(\frac{D_{t+1}}{Y_{t+1}}\right) = (1+r_t)\frac{D_t}{Y_t} - (1+r_t)\frac{PS_t}{Y_t}$$

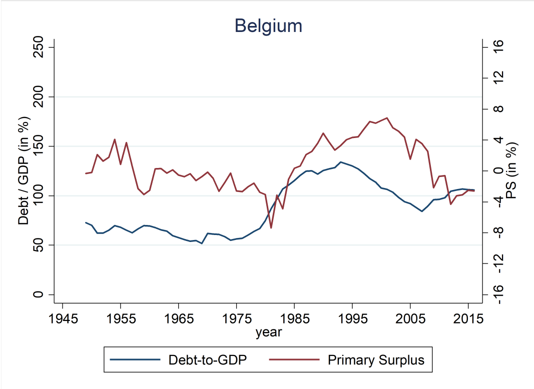
$$(1+g_t)d_{t+1} = (1+r_t)(d_t - ps_t)$$

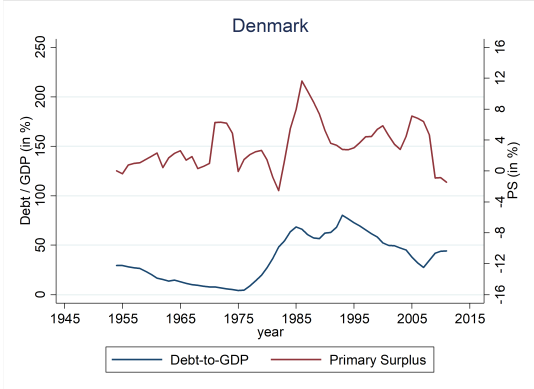
$$d_{t+1} = \frac{1+r_t}{1+g_t}(d_t - ps_t)$$

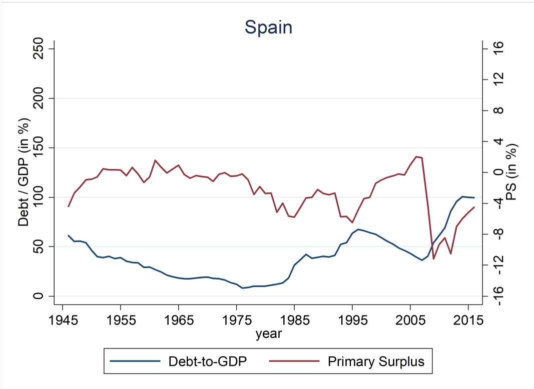
Appendix B: Figures

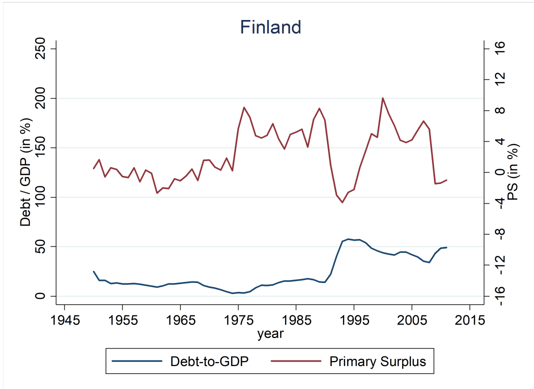
Debt-to-GDP and Primary Balance

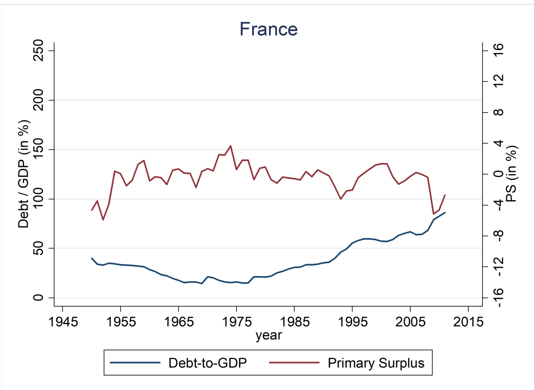


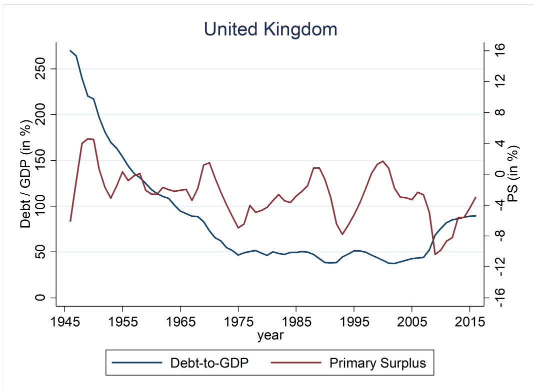

Belgium
Debt / GDP (in %)
0 50 100 150 200 250
PS (in %)
-16 -12 -8 -4 0 4 8 12 16
1945 1955 1965 1975 1985 1995 2005 2015
year
Debt-to-GDP
Primary Surplus

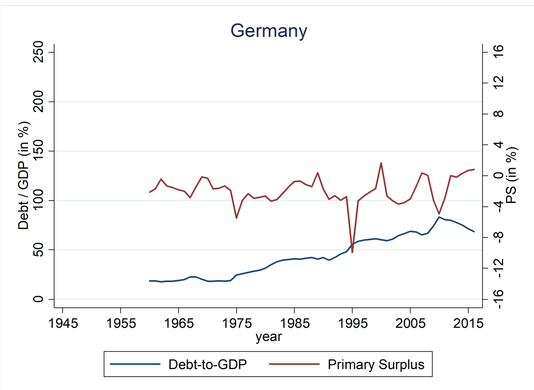

Denmark
Debt / GDP (in %)
0 50 100 150 200 250
PS (in %)
-16 -12 -8 -4 0 4 8 12 16
1945 1955 1965 1975 1985 1995 2005 2015
year
Debt-to-GDP
Primary Surplus


Spain
Debt / GDP (in %)
0 50 100 150 200 250
PS (in %)
-16 -12 -8 -4 0 4 8 12 16
1945 1955 1965 1975 1985 1995 2005 2015
year
Debt-to-GDP
Primary Surplus


Finland
Debt / GDP (in %)
0 50 100 150 200 250
PS (in %)
-16 -12 -8 -4 0 4 8 12 16
1945 1955 1965 1975 1985 1995 2005 2015
year
Debt-to-GDP
Primary Surplus


France
Debt / GDP (in %)
0 50 100 150 200 250
PS (in %)
-16 -12 -8 -4 0 4 8 12 16
1945 1955 1965 1975 1985 1995 2005 2015
year
Debt-to-GDP
Primary Surplus


United Kingdom
Debt / GDP (in %)
0 50 100 150 200 250
PS (in %)
-16 -12 -8 -4 0 4 8 12 16
1945 1955 1965 1975 1985 1995 2005 2015
year
Debt-to-GDP
Primary Surplus


Germany
Debt / GDP (in %)
0 50 100 150 200 250
PS (in %)
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1945 1955 1965 1975 1985 1995 2005 2015
year
Debt-to-GDP
Primary Surplus

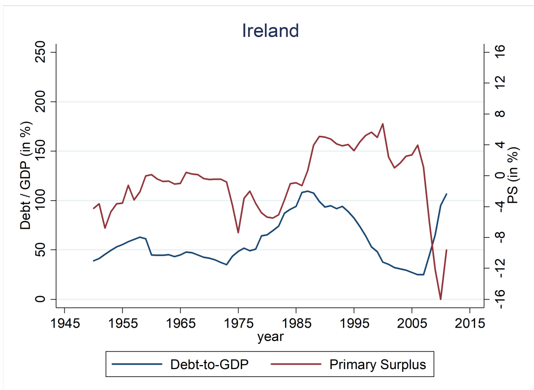
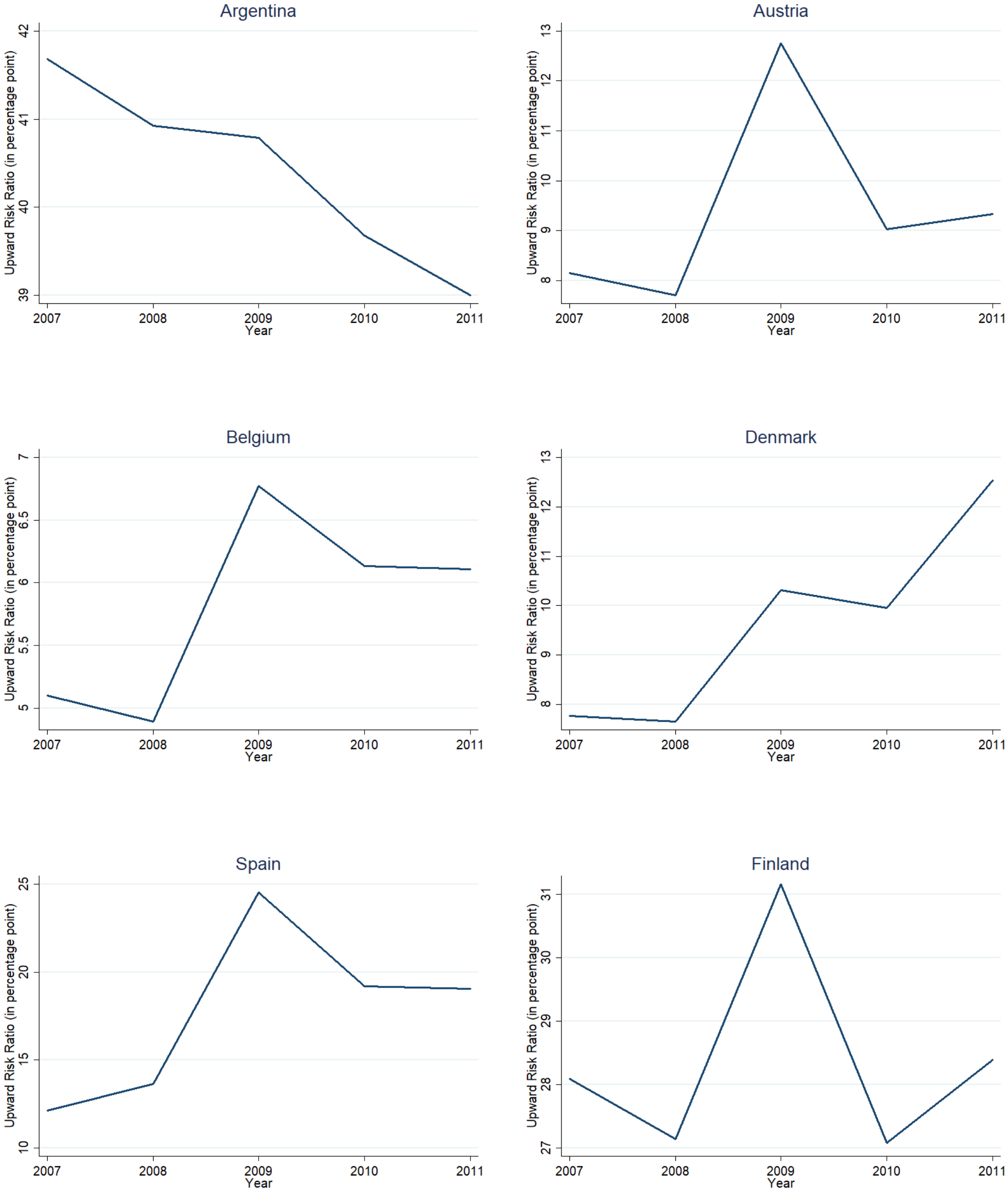
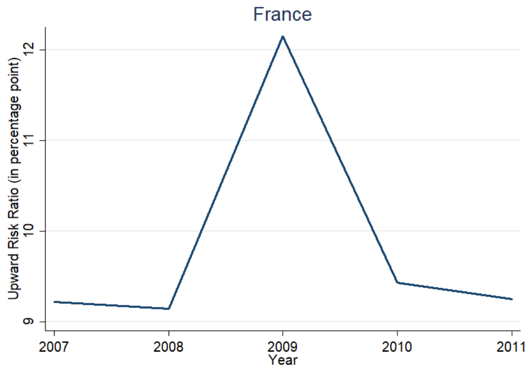
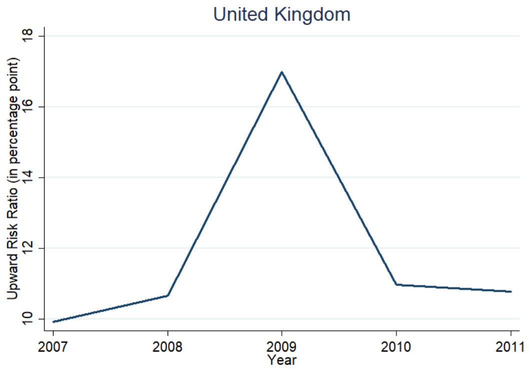

Ireland
Debt / GDP (in %)
0 50 100 150 200 250
PS (in %)
-16 -12 -8 -4 0 4 8 12 16
1945 1955 1965 1975 1985 1995 2005 2015
year
Debt-to-GDP
Primary Surplus

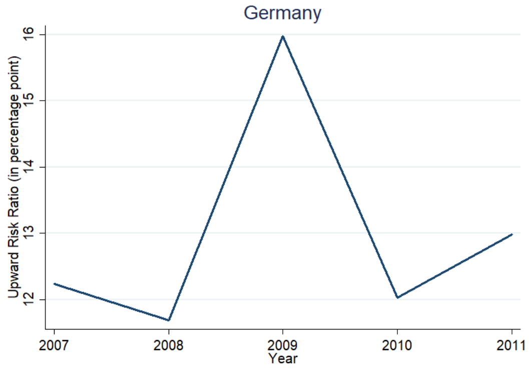
Figure 1: Post-war Debt-to-GDP and Primary Balance for eighteen countries

DSI Values over time

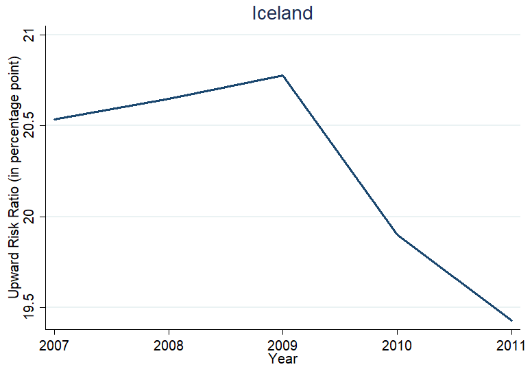


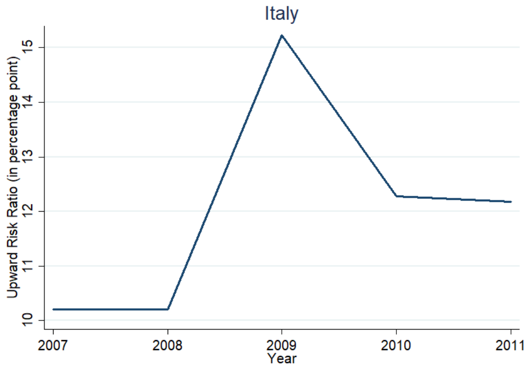

France
Upward Risk Ratio (in percentage point)
9
10
11
12
2007
2008
2009
2010
2011
Year

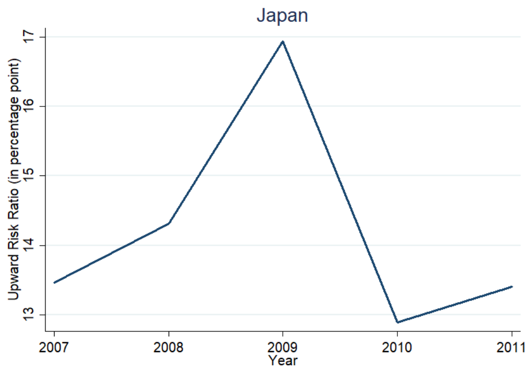

United Kingdom
Upward Risk Ratio (in percentage point)
10
12
14
16
18
2007
2008
2009
2010
2011
Year

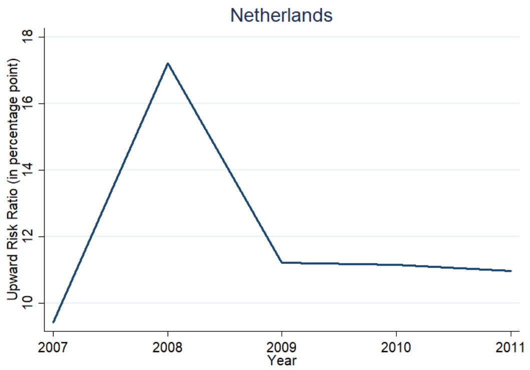

Germany
Upward Risk Ratio (in percentage point)
12
13
14
15
16
2007
2008
2009
2010
2011
Year


Ireland
Upward Risk Ratio (in percentage point)
20
30
40
50
60
2007
2008
2009
2010
2011
Year


Iceland
Upward Risk Ratio (in percentage point)
19.5
20
20.5
21
2007
2008
2009
2010
2011
Year


Italy
Upward Risk Ratio (in percentage point)
10
11
12
13
14
15
2007
2008
2009
2010
2011
Year


Japan
Upward Risk Ratio (in percentage point)
13
14
15
16
17
2007
2008
2009
2010
2011
Year


Netherlands
Upward Risk Ratio (in percentage point)
10
12
14
16
18
2007
2008
2009
2010
2011
Year

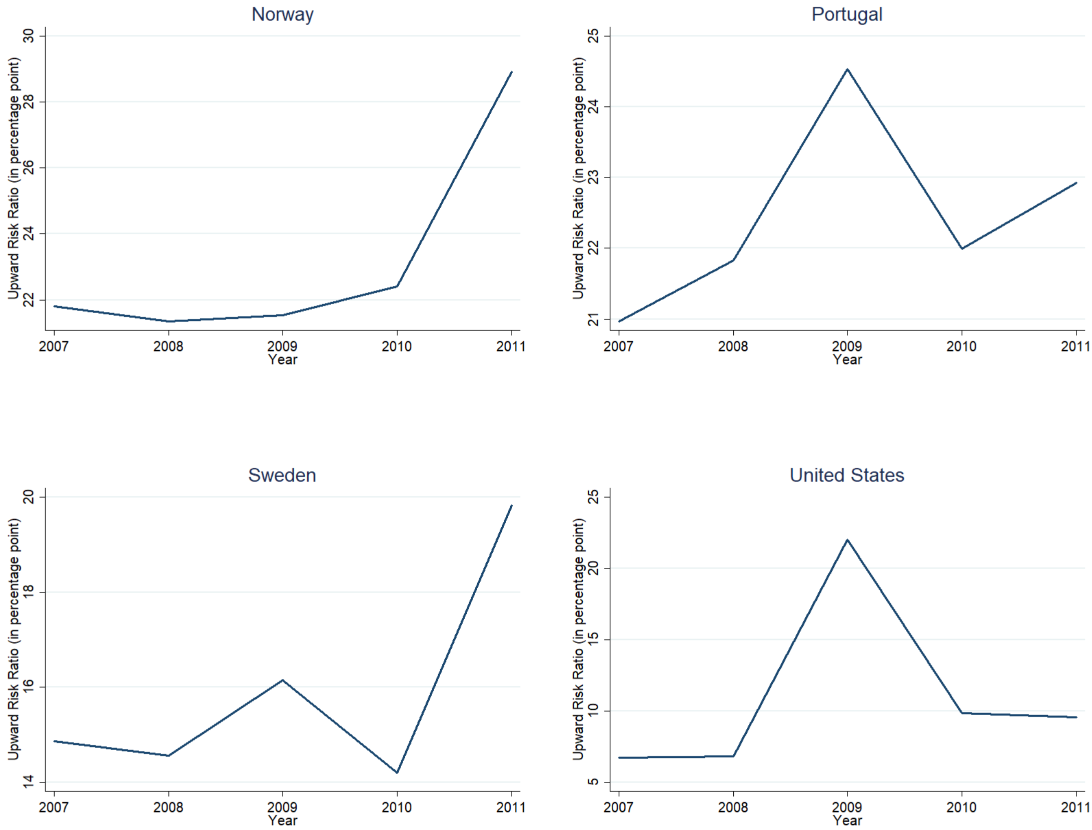


Figure 2: Upward Risk Ratio over time

Appendix C: Standard Unit-root Tests

Table 6: Augmented Dickey Fuller Unit-root Tests including trend on the post-war sample

	Debt-to-GDP	PS-to-GDP	YVAR	GVAR
Argentina	-3.40	-3.22*	-4.00***	-3.00*
Austria	-2.49	-6.10***	-4.50***	-5.48***
Belgium	-0.82	-2.27	-4.40***	-4.21***
Denmark	-0.96	-2.80**	-4.56***	-5.79***
Spain	-1.12	-3.32***	-4.12***	-5.51**
Finland	-2.18	-2.49	-3.63**	-3.90**
France	-1.07	-3.67**	-3.89**	-4.31***
United Kingdom	-2.42	-6.72**	-5.41***	-10.42**
Germany	0.10	-3.82**	-3.27***	-4.45***
Ireland	-0.76	-2.57*	-2.62	-4.89***
Iceland	-1.37	-4.00***	-3.20*	-3.36*
Italy	-0.21	-4.99**	-5.42***	-3.99*
Japan	-0.13	-1.87	-3.55***	-4.84***
Netherlands	-2.01	-5.32***	-2.46**	-2.19***
Norway	-2.46	-3.22*	-3.41**	-4.02***
Portugal	0.41	-2.24*	-5.73**	-4.41**
Sweden	-1.52	-2.17	-3.93**	-3.42**
United States	-2.28	-4.55***	-5.92***	-5.88***

*Notes: Significance levels: *** p<0.01, ** p<0.05, * p<0.10.*

Appendix D: Selection-order criteria VAR model

Table 7: Selection-order criteria VAR model

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	10.88				0.0015	-0.85	-0.82	-0.75
1	46.99	72.22*	4	0.000	0.0001*	-3.90*	-3.84*	-3.61*
2	48.10	2.23	4	0.695	0.0001	-3.63	-3.52	-3.13
3	50.92	5.64	4	0.228	0.0001	-3.52	-3.37	-2.82
4	55.33	8.82	4	0.066	0.0001	-3.56	-3.36	-2.66

Notes: This table shows the selection-order criteria of the United Kingdom. Similar results are found for each other country, justifying the use of one lag.