Public Debt Sustainability in Advanced Economies: A Stochastic Simulation of Fiscal Spaces after the 2008 Financial Crisis

Sébastien Pommier
CREM - CNRS & University of Rennes 1 *

First Draft

February 2015

Abstract: The large increase in public debt after the 2008 financial crisis raises concerns about the sustainability of fiscal policy. In this paper, we first analyze the extent to which both fiscal reaction functions and determinants of growth-adjusted interest rates have been affected during the post 2008 period. Second, we compute levels of debt limits over which the growth of debt becomes explosive and we simulate fiscal spaces (distance between debt limits and projected debts) implied by the estimated empirical model. Results show (i) in average, primary balances fall down while the effective cost of public debt increases from 2008 onwards; (ii) as a consequence, debt limits decrease of more than 10 percent of GDP (iii) Japan, Greece, Iceland and Hungary do not have any fiscal spaces; (iv) Italian and Portuguese fiscal spaces are likely to get exhausted over the next few years.

Key words: Sustainability, Fiscal Fatigue, Cost of Debt, Stochastic Simulations

JEL codes: E62 H63 H68

1 Introduction

The financial crisis that hit most advanced economies in 2008, and the subsequent "Great Recession" have lead to a large and rapid growth of debt-to-GDP ratios. In the set of advanced economies, the increase in debt ratios from 2007 to 2013 reaches more than 10 points of percentage in average and about 40 points in the UK and in the US, 60-70 points in Greece and Portugal. The extent to which this fast increase could have increased

*7 place Hoche 35065 Rennes, FRANCE. Contact: *sebastien.pommier@univ-rennes1.fr*.

risks for sustainability of public debts becomes a major matter of concern, notably after the partial default on Greek public bonds. Many countries planned programmes of debt consolidation: in the EU, the 2013 Stability and Convergence Programmes forecast an increase in government balances by 2.6% of GDP until 2013. Others, like the US, seem to postpone the consolidation: such restrictive policies may be costly in terms of economic growth when they are implemented during slowdowns (Batini et al. (2012)).

Prior to 2008, fiscal policies in advanced countries were looked sustainable in most academic papers. Contradictory results have been reported by Afonso (2005) on European countries and Ballabriga and Martinez-Mongay (2007) who highlighted likely troubles for the Greek debt sustainability. The Japanese case has raised a particular attention for decades because the impressive level of debt (183% of GDP in 2006) may be unsustainable, but does not lead to default so far.

The rather unexpected sovereign crisis in the EU questions the accuracy of sustainability analysis. On the one hand, we may consider that conclusions from the literature still hold true. Thus, current risks for unsustainability are largely overestimated. There are little rationales for redirecting fiscal policy towards consolidation plans. On the other hand, the determinants of sovereign risk premium, as well as the occurrence of large-scale macroeconomic shocks could have been overlooked in usual measures of sustainability, leading to overestimate the soundness of public finances in several developed countries.

In this paper, we attempt to provide a reassessment of the public debt sustainability before and after the 2008 financial crisis for 31 countries. Our definition of sustainability is tied to recent developments of the literature. Following Gosh and al. (2013), the sustainability of public debt corresponds to the convergence of debt ratio towards a stable and finite level, conditionaly to not exceeding a debt limit above which the debt dynamics becomes explosive. Risks for sustainability can be measured by fiscal spaces i.e. spreads between the debt limit and the current or projected debt ratios. Therefore, we try to address the following questions: how did the 2008 financial crisis affect the debt limits? In which extent fiscal spaces will get exhausted over the following years?

Our contribution to the empirics of public debt sustainability is three-fold. Frist, the debt limits are computed as a solution of a system of 2 equations: a fiscal reaction function that determine primary surpluses and a regression explaining the effective cost of debt (i.e. the growth-adjusted interest rate on public debt). While the effective cost of debt is generally considered as exogenous, we will provide original estimates of the relationship between the debt ratio and the effective cost of debt. Thus, we try to make a junction between two strands of literature: one focusing on the fiscal reaction function, and the other dealing the determinants of sovereign bond yields. Second, we argue that our empirical model is sufficiently tractable for modelling the effect of the financial crisis and to account for country specficities. This is done by allowing structural breaks in the regressions and by

calibrating a small set of exogenous variables with data from the pre-crisis period and the post-crisis period. Third, the estimated equations are used to simulate the distribution of the future debt ratios and the corresponding fiscal spaces, instead of using debt projections available from international institutions like the IMF.
The remaining of the paper is organised as follows. The next section presents the underlying theory of debt limits and fiscal spaces as measures of sustainability. In section 3, we develop the econometric approach used in order to estimate the debt limit and its change after the 2008 financial crisis. Section 4 presents simulations of fiscal spaces from 2014 to 2020. The section 5 concludes.

2 Measures of fiscal spaces

Empirical studies address the issue of public finance sustainability using mainly two kinds of approach. On the one hand, tests for stationarity and cointegration on various sets of relevant fiscal variables are implemented to check whether governments fulfill their intertemporal budget constraint or not. This method is notably employed by Afonso (2005) and Afonso and Rault (2014) on European countries. On the other hand, the ability of time series properties to accurately reveal cases of unsustainability has been criticized by Bohn (2007)[1]. Thus, a second way of investigating the question of public debt sustainability relies on the estimation of fiscal reaction functions. The primary surplus, reported to GDP, ought to correct (i.e. to react positively) the debt-to-GDP ratio in order to entail a convergence of the public debt ratio towards a finite and stable level.
This section presents rationales for this approach and extensions provided by Gosh et al. (2013) who have found robust evidences of a so-called "fiscal fatigue" phenomenon. The ability of governments to thwart the evolution of public debt is mitigated when the debt ratio reaches a high level. A condition for maintaining sound public finances is then to let the primary balance react to the debt, conditionally to not achieving a finite limit of the debt ratio. As long as current or projected debt-to-GDP ratios remain lower than this debt limit, governments keep a room to maneuver to mitigate the evolution of the debt. On the contrary, when the debt ratio tends to go up to the limit, risks of unsustainability urge for a dramatic change of the usual behavior of fiscal authorities in favor of a consolidation policy. Fiscal spaces measure the spread between the debt limit and the current or future debt-to-GDP ratio and provide a synthetic measure of risks for sustainability.

[1]The main critical argument points out that the intertemporal budget constraint is satisfied if the debt variable is stationary after arbitrary sequences of differencing operations. Moreover Bohn (2007) exhibits various stochastic processes that verify the intertemporal budget constraint although they are not stationary nor cointegrated.

2.1 Fiscal reaction functions and public debt sustainability

The sustainability of public debt defines the ability of governments to repay and/or to re-issue maturing bonds. This condition is satisfied if the evolution of public debt durably respects the intertemporal budget constraint (IBC):

$$\Delta d_t = d_t - d_{t-1} = \frac{r-g}{1+g} d_{t-1} - s_t \tag{1}$$

Neglecting the stock-flow adjustment, the one-year increase in the debt-to-GDP ratio (d_t) is given by the difference between the debt service (the growth-adjusted interest rate ($(r-g)/(1+g)$) on the previous debt ratio) and the current primary balance (s_t). Respecting the IBC year after year leads to re-write (1) as:

$$\left(\frac{1+g}{1+r}\right)^n d_{t+n} = d_t - \sum_{j=1}^{n} \left(\frac{1+g}{1+r}\right)^j s_{t+j} \tag{2}$$

Governments cannot access to borrowing without constraint and the long-term respect of the IBC implies that the ratio of debt, in any given year, equalizes the discounted market value of expected future primary surpluses.

$$d_t = E\left(\sum_{j=1}^{\infty} \left(\frac{1+g}{1+r}\right)^j s_{t+j}\right) \tag{3}$$

as long as:

$$\lim_{n\to\infty} \left(\frac{1+g}{1+r}\right)^n d_{t+n} = 0 \tag{4}$$

The transversality condition (4) is then equivalent to the equality between the debt ratio and the discounted value of expected future primary surpluses (3). Both imposes $r > g$. Bohn (1995, 1998) shows that such a condition does not hold historically on the US data. In a stochastic model, low public debt interest rates remain consistent with dynamic efficiency inasmuch as public bonds are supposed to be free of risk. Bohn (2008) states that the standard transversality condition (4) does not accurately express the restriction for avoiding that governments run Ponzi schemes, as it is generally claimed. A preferable version of a non-Ponzi condition would simply impose that the ability to access borrowing is constrained by other agents' willingness to lend. Hence, this would impose that expected future debt ratios reach a finite limit. A sufficient condition for such a definition of sustainability is a feedback rule for the primary surplus i.e. a rule requiring that the primary surplus positively reacts to the initial debt ratio. Canzoneri et al. (2001) also argue that such a rule provides a sufficient condition for a sustainable fiscal policy. The fiscal rule simply defines a systematic response of the primary surplus to the lagged debt:

$$s_t = \mu_t + \beta d_{t-1} \tag{5}$$

with μ_t capturing other stationary determinants of primary surpluses but the debt level. The debt dynamics is still driven by $d_t = (1+\phi)d_{t-1} - s_t$ where $\phi = (r-g)/(1+g)$ according to equation (1). Taking into account the flow of primary surpluses given by the fiscal reaction function, the dynamics of debt follows:

$$d_t = (1+\phi-\beta)d_{t-1} - \mu_t \tag{6}$$

The debt ratio is convergent towards a finite limit when $|1+\phi-\beta| < 1$, that is when one of the following alternative conditions holds true:

$$\phi \quad < \beta < \quad \phi + 1 \tag{7}$$

$$\phi - 1 \quad < \beta < \quad \phi \tag{8}$$

As in Bohn (1998), the convergence condition may only impose $\beta > 0$ for plausible values of ϕ but it does not require to meet the standard transversality condition $\phi > 0$.
It is worth noting that in this very mere example, the stable limit of the debt is given by:

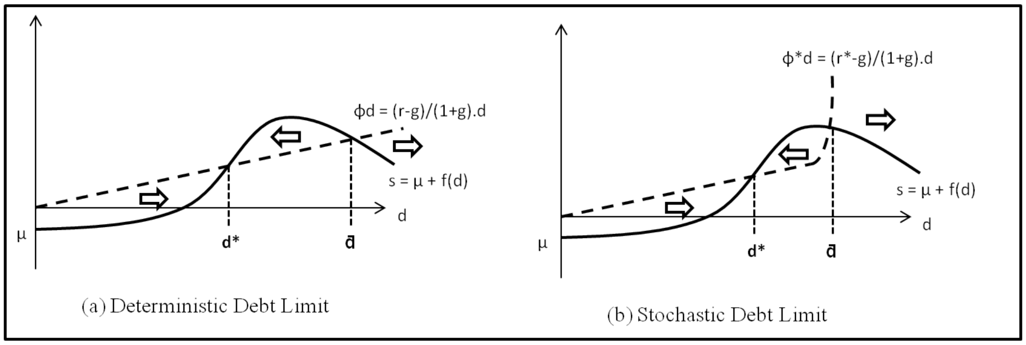
$$d^* = \frac{\mu}{\phi - \beta} \tag{9}$$

with $\mu = E(\mu_t)$. An interesting feature may arise when μ is negative, representing expectations of structural primary deficits. If $\phi > 0$ the debt stabilisation requires $\beta > \phi$. The debt ratio is converging towards a positive primary balance because the government limits the evolution of debt. If $\phi > 0$ the government is benefiting from a growth rate higher than the interest rate. Even a small positive β will limit the evolution of debt, and the government will not run a Ponzi scheme.
Historical data on the growth adjusted interest rate (below or close to zero) lead Bohn (1998) to look sustainability as self reliable as long as the government provides a sufficient corrective response to changes of the debt ratio. Collignon (2012) provides a more complex treatment of conditions for stabilizing the debt ratio. The sustainability of public debt still remains the outcome of an interaction between the "economic environment" (ϕ) and the flow of primary balances given by the fiscal reaction function. Collignon (2012) concludes that the sustainability of European public debt is not threatened so far, but he argues for a more credible response to the increasing public debt, that will accelerate the convergence of debt levels to their steady state. He also points out the importance of bringing the economic environment to usual and predictable states. The contrary may re-inforce pessimistic expectations.

2.2 Non linearities: A case for fiscal fatigue and debt limits

Numerous empirical papers have attempted to estimate fiscal reaction functions: Favero (2002), Ballabriga and Martinez-Mongay (2002), Gali and Perotti (2003) or Celasum et

Figure 1: Fiscal Fatigue and Debt Limits à la Gosh et al. (2013)



al. (2007) among others. The coefficient associated with the lagged debt ratio is found to be positive and significant. When they used the estimated fiscal reaction function to simulate the evolution of debt, Celasum et al. (2007) found that some countries face fast inscreasing debt ratios (in Argentina and Turkey) while others (South Africa and, in a lesser extent, Brazil) have seen the debt ratio declining. Recent contributions also look for structural breaks (Baldi and Staehr, 2013) or non-linearities (Legrenzi and Milas, 2013) in the coefficients of the fiscal reaction functions. Gosh et al. (2013) document robust empirical evidence of "fiscal fatigue" that relies on nonlinear reaction of the primary balance to changes in the debt ratio. The fiscal reaction function is given by:

$$s_t = \mu_t + f(d_{t-1}) + \epsilon_t \tag{10}$$

ϵ_t represents unexpected shocks on the current primary surplus. The correction of debt involved in $f(d)$ is supposed to decline with high levels of debt ratio and even become negative. This behavior captures the idea that, when the government faces high debt burden, its ability to mitigate the growing debt thanks to a corrective response of the primary surplus is weakened [2]. The evolution of debt defined by (1) and (10) can be simply illustrated by Figure 1. In addition to a stable debt level towards which the economy converges d^*, the debt trajectory implies a second unstable equilibrium representing the debt limit $\bar{d}$.

Graph (a) depicts debt equilibria (d^*,$\bar{d}$) assuming constant growth-adjusted interest rate ϕ. Gosh et al. (2013) emphasize that the debt service may rise strongly when the economy gets closer to the debt limit because markets charge a risk premium on public bonds (Graph (b)). This stochastic process of interest rate leads to a smaller debt limit. Nevertheless the computation of debt limits still supposes that the growth rate (g) remains constant and exogenously determined whatever changes of fiscal variables: debt-to-GDP ratios and

[2] Gosh et al. (2013) state that very high debt ratio must imply a response of the primary surplus that exceeds the GDP.

primary surplus ratios.
At this point, our approach diverges from the one by Gosh et al. (2013) in two mains aspects. First, the growth-adjusted interest rates (named "economic condition" in Collignon (2012)) is supposed to be dependent on other fiscal variables. Hereafter, we refer to ϕ_t as the "effective cost of debt". This effective cost of debt is given by a nonlinear function of the debt level.

$$\phi_t = \lambda_t + g(d_{t-1}, s_t) + \eta_t \tag{11}$$

where λ_t represents country-specific and other non fiscal determinants of the effective cost of debt. η_t stands for i.d.d. shocks. The $g()$ function captures the impact of both debt and primary surpluses on the effective cost of debt. This specification allows to refer to the important literature on the determinants of sovereign bond rates that does not necessarily lead to clear-cut answers about the impact of fiscal variables on the debt service (inter alia Codogno et al. (2003), Ardagna et al. (2007), Baldacci and Kumar (2010)). We shall discuss these results below.
Second, the model described by equations (1), (10) and (11), contains some country specific determinants μ_t and λ_t. The first one represents the intercept of the fiscal reaction function while the second entails specific components to the slope of the debt cost. These determinants can be affected by external changes faced by the economy, in particular they may summarize country specific responses to an event such as the 2008 financial crisis. In the empirical part of this paper, we seek for the most parsimonious specifications of those country-specific effects and we calibrate them with data from the pre-crisis period (2002-2007) and the post crisis period (2008-2013).

3 Econometric approach

We now turn to the ready-to-estimate forms of equations (10) and (11). We present the dataset, econometric methods and the results.

3.1 Data

The dataset consists in a panel of 31 countries over the period 1980-2013. Countries include Australia, Austria, Belgiuum, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Repulic, Slovenia, Spain, Sweden, Switzerland, United Kingdom and the United States. Various sources of data had been used mainly the *World Economic Outlook* database from the IMF, and the *Economic Outlook* database form the OECD. For some European countries the *AMECO* database helped us to fill up the data over the larger range of available observations.

3.2 Fiscal Reaction Function (FRF)

The specification of $f(d)$ is the same as in Gosh et al. (2013), the nonlinear response of primary balance to lagged debt is captured by a cubic expression:

$$s_{i,t} = \alpha_{1,i} + \beta_1 d_{i,t-1} + \beta_2 d_{i,t-1}^2 + \beta_3 d_{i,t-1}^3 + X_{i,t}B + \epsilon_{i,t} \quad (12)$$

$$\epsilon_{i,t} = \rho\epsilon_{i,t-1} + \nu_{i,t} \quad (13)$$

Country specific factors include an individual fixed effect $\alpha_{1,i}$ and other control variables $X_{i,t}$. These notably include the output gap in order to capture the cyclical reaction of primary balances. The error term $\epsilon_{i,t}$ follows an AR(1) process and is justified by the degree of inertia that characterize series of primary balances. Celasum and Kang (2006) show that fixed effects estimates are quite relevant when one wishes to capture the reaction of the primary balance to debt-to-GDP.

Table 1 presents the results for various specifications and methods of estimations. Columns (1) and (2) report the results of estimates. Control variables include the expenditure gap[3], the degree of openness, the inflation rate, the oil price, the commodity price, the US exchange rate and the future age dependency ratio provided by the U.N. database. Control variables influence the primary balance intuitively. The expenditure gap reduces the primary balance, hence, temporary expenditures are mainly financed by borrowing. The future age dependency ratio also tends to decrease primary balances. The cyclical component of fiscal policy, captured by the coefficient of the output gap, is significant and positive. Fiscal policy appears contra-cyclical. The cubic relation between lagged debts and primary balances cannot be rejected.

Columns (3) and (4) address the issue of potential endogeneity biases in the FRF. We follow the method of Meideros (2012). Instruments are used to estimate coefficients of lagged debt terms and the output gap. In addition to the lagged exogenous variables, the list of instruments includes lagged expenditure gap, degree of openness, inflation, oil price, commodity price, USD exchange rate and future age dependency ratio. This approach leads to a more parsimonious version of the fiscal reaction function and will limit the number of hypothesis concerning regressors when we shall compute the debt limit and simulate the debt path implied by the model. The cubic slope of the FRF leads to results rather close to those of Meideros (2012). The reaction of primary balance is positive for low debt ratios (around 20%), starts to decline when the debt ratio rises about 75% and turns to negative when the public debt exceeds 125% of GDP. Even though some countries of the panel never faced such a high level of debt, there is few reason to believe that they would not experiment "fiscal fatigue" in such a situation. Moreover, Mendoza and Ostry (2008) provide robust evidence of homogenous slopes in the fiscal reaction functions across

[3] Difference between current and long term primary expenditures. Long term primary expenditures are estimated using the HP filter.

Table 1: Panel Fiscal Reaction Functions

	(1) AR(1)	(2) AR(1)	(3) AR(1) IV	(4) AR(1) IV
Lagged Debt	-0.104**	-0.07	-0.133	-0.178
	(0.046)	(0.051)	(0.112)	(0.112)
Lagged Debt Squared	1.630E-3***	1.297E-3**	4.289E-3***	4.671E-3***
	(4.96E-4)	(5.46E-4)	(1.43E-3)	(1.43E-3)
Lagged Debt Cubic	-5.3E-6***	-4.1E-6**	-2E-5***	-2.1E-5***
	(1.5E-6)	(1.6E-6)	(2.3E-5)	(1.3E-5)
Output gap	0.295***	0.287***	0.469***	0.509***
	(0.040)	(0.044)	(0.053)	(0.054)
Expenditure gap	-0.395***	-0.365***		
	(0.040)	(0.042)		
Openness	-0.013	-0.005		
	(0.015)	(0.016)		
Inflation	0.073***	0.075***		
	(0.018)	(0.019)		
Oil Price	1.7E-4	0.022**		
	(0.008)	(0.011)		
Commodity Price		-0.020**		
		(0.009)		
US Exchange Rate		-0.002		
		(0.003)		
Age Dependency Ratio		-0.204***		
		(0.059)		
Fiscal Rule		0.285*		0.524***
		(0.151)		(0.150)
Crisis				-2.714***
				(0.354)
ρ	0.787***	0.760***	0.709***	0.677***
	(0.026)	(0.030)	(0.033)	(0.033)
N	791	718	739	697
$\bar{R}^2$	0.749	0.760	0.704	0.724

Dependent Variable: Primary balance to GDP in percent.

Country Fixed Effects not reported

Standard-errors in parentheses, significance levels: * 10%,**5% and ***1%.

IV denotes Instrumental Variables Estimator.

Instruments include lagged exogenous variables and controle variables form column (2)

countries.
The fourth specification will be the one used in the following of the paper. It introduces an index of fiscal rules. Among various indexes available from the IMF, we choose the "number of numerical rules" which summarizes all types of constraints in the use of fiscal policy (debt rule, balanced budget rule, expenditure rule...) Our preference for this indicator is due to the heterogeneity in the total number of rules that each country is subjected to. Results show that the more rules a country faces, the higher primary balance. The sign and significance of institutional constraints are robust when other indicators such as binary dummy variables for balanced-budget rules or debt rules are used.
The regression also allows for a shift in the average primary surplus after the 2008 financial crisis. CRISIS is a dummy variable that equals unity in each country form 2008 to 2013. Primary balances have been reduced by 2.7% of GDP in average. One may argue that the impact of the financial crisis has not been the same in every country. Nevertheless, the crisis effect in our model is reprensented as a homogeneous shift in the heterogeneous intercepts of the FRF (individual fixed effects).

3.3 Determinants of Effective Cost of Debt

Computing the debt limits requires to modelize the effective cost of debt ϕ. We do not follow the approach of Gosh et al. (2013) that consists in modelling the interest rate as depending on a calibrated expected risk of default and that assumes constant rate of growth. We refer to the literature that attempts to explain how the debt cost is linked to the outstanding amount of debt. We then estimate the following equation:

$$\phi_{i,t} = \alpha_{2,i} + \gamma_1 d_{i,t-1} + \gamma_2 d_{i,t-1}^2 + \gamma_3 s_{i,t} + Y_{i,t}\Gamma + \eta_{i,t} \tag{14}$$

The effective cost of debt is given by:

$$\phi_{i,t} = \frac{r_{i,t} - g_{i,t}}{1 + g_{i,t}}$$

where $r_{i,t}$ stands for the implicit nominal interest rate of the public debt[4] and $g_{i,t}$ represents the growth rate of nominal GDP. Following Ardagna et al. (2007) and Baldacci and Kumar (2010), we introduce an individual fixed effect $\alpha_{2,i}$, a quadratic term of the lagged public debt and the primary balance among regressors. Thus, the effective cost of debt is depending on levels of accumulated debt as well as changes in debt level approximated by primary balances.
Control variables included in vector $Y_{i,t}$ are standard. We introduce the short term interest rate and the rate of inflation in order to take into account changes in monetary policy and the inflation premium charged by investors. We also introduce the output gap as the

[4]When non available, we used the 10-year public bond rate as another proxi for the cost of public debt

business cycle may affect the needs for borrowing of fiscal authorities.
Estimates of equation (14) may face endogeneity biases, inasmuch as the debt ratio may be affected by changes in the cost of public debt. The primary balance among the regressors may also be correlated with the error term $\eta_{i,t}$ because of its cyclical component. We address this issue by using two sets of instruments. We estimate a just-identified model where fiscal variables are instrumented by one lagged value. We also estimate an over-identified model where fiscal variables are instrumented by two lags.

Results are reported in table 2. Columns (1) to (3) depict the estimates of equation (14). Subsequent columns present results of estimates when the effective cost of public debt is broken down between the implicite interest rate (column (4)) and the rate of nominal growth (column (5)). Changes in monetary policy affect significantly the effective cost of public debt. A rise of the short run interest rate increases the effective cost of public debt as it raises the implicit interest rate and reduces the rate of growth. The rate of inflation appears to reduce the cost of public debt. This effect is driven by the positive impact of inflation on the nominal growth rate that mitigates the positive but non-significant effect of inflation on the implicit interest rate. Indeed, inflation helps government to dampen the cost of borrowing. The output gap influences negatively the interest rate and positively the nominal growth rate. Consequently, increasing output gap diminishes the effective cost of debt. This result is in line with those of Baldacci and Kumar (2010) and Klepsch and Wollmershauser (2011)[5]. During good times, government revenues increase, the need for borrowing as well as the default risk are reduced, leading to smaller effective cost of debt. The quadratic specification of the debt-to-GDP ratio is significant. In the regression with the implicit interest rate as the dependent variable (column (4)), the effect of debt is concave. A higher level of debt dampens the increase in interest rates. The relation is decreasing when debt exceeds about 110% of GDP[6]. Governments take advantage of low interest rates when they issue growing amounts of public bonds. As we also obtain a concave relation between debt and economic growth, the relation between the debt-to-GDP ratio and the effective cost of public debt turns to be convex. Hence, when the debt ratio exceeds 110%-130%, the effective cost of debt is increasing. This effect might be reinforced inasmuch high debt levels decrease the primary surpluses that increase the effectif cost of debt . Non linear effects of the primary balance were not significant and are not reported.
The regression entails a dummy variable from 2008 onwards that captures the effect of the financial crisis. Both the rate of growth and the implicit interest rate on public bonds decreased after the crisis. Indeed, in response to the crisis, monetary authorities have

[5] Ardagna et al. (2007) and Caporale and Williams (2002) found the opposite: cyclical activity increases interest rates.

[6] In Baldacci and Kumar (2010) the decreasing relation between debt and interest rates starts around 90%.

Table 2: Determinants of the Effective Cost of Public Debt

	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS OI	2SLS OI	2SLS OI
Dependent variable	$\phi_{i,t}$	$\phi_{i,t}$	$\phi_{i,t}$	$r_{i,t}$	$g_{i,t}$
S.R. Interest Rate	0.005***	6.632E-3***	6.60E-3***	0.543***	-0.115***
	(0.000)	(5.31E-4)	(5.2E-4)	(0.023)	(0.0267)
Inflation	-0.011***	-0.011***	-0.011***	0.030	-1.088***
	(0.001)	(0.001)	(0.001)	(0.020)	(0.030)
Lagged Debt	-5.12E-4***	-4.55E-4***	-4.29E-4***	0.0168**	0.0482***
	(1.71E-4)	(1.63E-4)	(1.77E-4)	(0.007)	(0.0148)
Lagged Debt Squared	2E-6***	2E-6***	1.48E-6***	-7.5E-5***	1.87E-4***
	(1E-6)	(1E-6)	(1E-6)	(2.9E-5)	(6.9E-5)
Primary Surplus	1.184E-3***	-3.53E-4	-5.64	-0.108***	-0.037
	(4.44E-4)	(4.27E-4)	(4.99E-4)	(0.021)	(0.039)
Output gap	-0.003***	-3.62E-3***	-3.61E-3***	-0.088***	0.325***
	(6.79E-4)	(6.2E-4)	(6.36E-4)	(0.020)	(0.039)
Crisis		0.0248***	0.0242***	-1.331***	-3.576***
		(0.003)	(0.003)	(0.125)	(0.264)
N	761	761	761	761	765
$\bar{R}^2$	0.692	0.723	0.728	0.823	0.792
J-Hansen			5.63	4. 07	8.658
p-value			[0.131]	[0.354]	[0.034]

Country Fixed Effects not reported

Standard-errors in parentheses, significance levels: * 10%,**5% and ***1%.

2SLS: lagged debt and primary balance instrumented by their lagged values

2SLS OI: Over identified list of instruments: 2 lags for fiscal variables.

reacted by implementing non conventional measures, thus, the short term interest rate has fallen down close to the zero bound. Portfolio reallocations, after the partial default of Greece, might have provided largest borrowers with a liquidity premium reducing the interest rate on their bonds. Finally, the effective cost of debt increased after the financial crisis. The decrease in implicit interest rates is more than compensated by the sharp decrease in the nominal GDP growth rate. In the remaining of the paper we use results from column (3).

3.4 The 2008 Financial Crisis' Impact on Debt Limits

The accounting equation (1) and estimates of equations (13) and (14) lead to the following system:

$$\begin{cases} d_{i,t-1} = (1+\hat{\phi}_{i,t})d_{i,t-1} - \hat{s}_{i,t} \\ \hat{s}_{i,t} = \hat{\mu}_{i,t} + \hat{f}(d_{i,t-1}) \\ \hat{\phi}_{i,t} = \hat{\lambda}_{i,t} + \hat{g}(d_{i,t-1}, \hat{s}_{i,t}) \end{cases} \tag{15}$$

Solutions are given by $\hat{\phi}_{i,t}d = \hat{s}_{i,t}$. There are two solutions of interest[7]. One corresponds to the stable equilibrium d^* and satisfies:

$$(\hat{\mu}_{i,t} + \hat{f}(d^*)) = (\hat{\lambda}_{i,t} + \hat{g}(d^*, \hat{s}))d^* \quad with \quad d < d* \rightarrow \Delta d > 0 \quad and \quad d > d* \rightarrow \Delta d < 0$$

The other solution defines the debt limit $\bar{d}$ which is the unstable solution:

$$(\hat{\mu}_{i,t} + \hat{f}(\bar{d})) = (\hat{\lambda}_{i,t} + \hat{g}(\bar{d}, \hat{s}))\bar{d} \quad with \quad d < \bar{d} \rightarrow \Delta d < 0 \quad and \quad d > \bar{d} \rightarrow \Delta d > 0$$

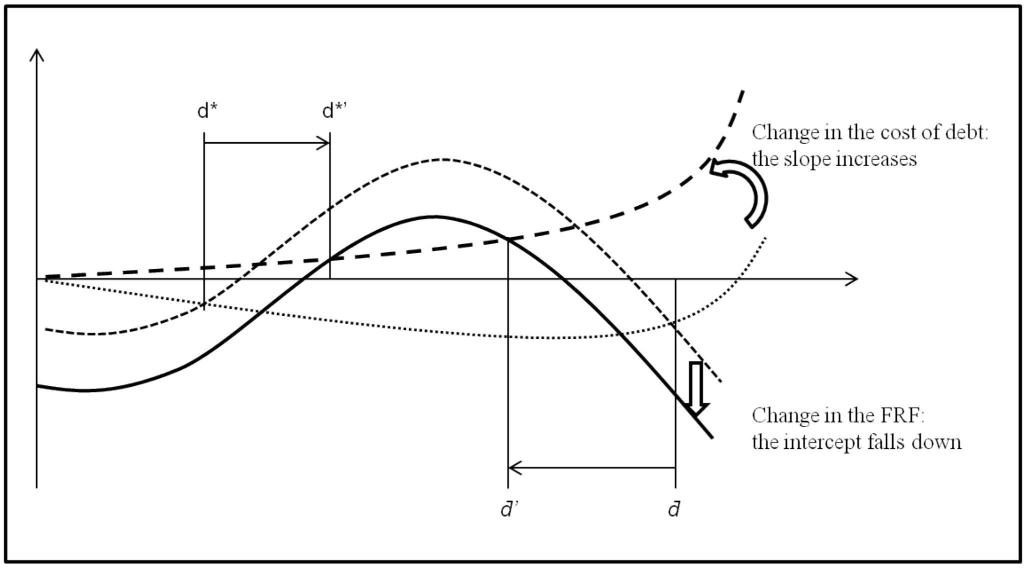
In system (15), $\hat{f}()$ and $\hat{g}()$ stand for the estimated coefficients of cubic terms of debt in the fiscal reaction function (13) and the quadratic terms of debt and primary balance in the determinants of the effective cost of public debt (14), respectively. The computation of solutions $\{d^*; \bar{d}\}$ requires assumptions on the other predetermined variables $\hat{\mu}_{i,t}$ and $\hat{\lambda}_{i,t}$. We use a set of two alternative values for predetermined variables representing the economic and budgetary situation before and after the 2008 financial crisis. The pre-crisis period is modelled assuming:

$$\hat{\mu}_{i,t1} = \hat{\alpha}_{1,i} + \hat{\beta}_{fr} FR_{i,T1}$$
$$\hat{\lambda}_{i,t1} = \hat{\alpha}_{2,i} + \hat{\gamma}_{sri}\overline{SRI}_{i,t1} + \hat{\gamma}_{inf}\overline{INF}_{i,t1}$$

with FR, SRI and INF denoted respectively the fiscal rule index used in FRF estimates and short-run interest rates and inflation rate used in the estimates of the effective cost of public debt. $t1$ represents the pre-crisis period $t1 = [2002 - 2007]$. We use the average of

[7](15) defines a 3-order equation and a third solution is possible that corresponds to a negative debt. When the stable solution is also negative, we consider the economy converges to a 0 debt ratio

Figure 2: Financial Crisis, Stable Debt $d*$ and Debt Limit $\bar{d}$



SRI and INF along this period, for FR we use the end period value in $T1 = 2007$.
The post-crisis period is modelled as:

$$\hat{\mu}_{i,t2} = \hat{\alpha}_{1,i} + \hat{\beta}_c CRISIS_{i,t} + \hat{\beta}_{fr} FR_{i,T2}$$
$$\hat{\lambda}_{i,t2} = \hat{\alpha}_{2,i} + \hat{\gamma}_c CRISIS_{i,t} + \hat{\gamma}_{sri}\overline{SRI}_{i,t2} + \hat{\gamma}_{inf}\overline{INF}_{i,t2}$$

Hence, country fixed effects are shifted by the *CRISIS* dummy variable. Averages of exogenous variables are computed over $t2 = [2008 - 2013]$ and $T2 = 2013$. Note that the output gap included in equations (13) and (14) could have been considered as a predetermined variable requiring a particular value. We follow Gosh et al. (2013) and consider an output gap equal to 0 for computing solutions of the system.
The financial crisis has increased primary deficits: this effect has been captured by the decrease in the intercept of the FRF after 2008. At the same time, the effective cost of debt has gone up as a consequence of the severe economic slowdown in several countries. Hence, the slope of the cost of debt becomes higher. The increase in this slope remains heterogeneous among countries due to the specific evolution of short run interest rates (their decline dampens the increase in debt cost) and of inflation rates (a lower inflation increases the cost of debt). As an example, figure 2 displays changes of $d*$ and $\bar{d}$ when the fiscal reaction function moves downwards and the slope of debt cost goes up. The debt limit is expected to decrease, then fiscal space diminishes and risks for sustainability become higher. Higher (smaller) primary deficits (surpluses) increase the needs for borrowing. With a lesser ability to restrain deficits, debt limits are reached at smaller levels.

This effect is strengthened by the higher effective cost of debt. The stable debt ratio increases inasmuch as larger needs for borrowing at higher costs entail a convergence towards a greatest level of debt. The "space" between the stable debt (a proxy for expected future debt ratios) and the debt limit falls down. In that case, risks for unsustainability get worse as macroeconomic shocks can shift the debt ratio from close to the stable equilibrium level to over the limit level.

Table 3 displays the results. Before the 2008 crisis, debt limits were about 176% of GDP in average, almost all countries got positive fiscal spaces as the Debt-to-GDP ratios in 2007 remain well below the limits. The only exception was Japan whom public debt already looked unsustainable. The unsustainability of the Japanese debt is largely documented in the literature (*inter alia* Doi et al. (2011) and IMF (2011)) and is mainly explained a long-lasting period (from the early 90's) during which Japan combines persistent primary deficits with small and volatile rate of growth. Among European countries, all of them were far below the debt limit and provided with a likely sufficient fiscal space to avoid their debt from following an explosive path. Greece and Italy had the smallest fiscal spaces: 60% and 50% of GDP respectively. Worries for Greece had been pointed out early by Ballabriga and Martinez Mongay (2007).

The financial crisis has lead to a large increase in debt ratios in a majority of countries: from 2007 to 2013, the rise of debt ratios has been comprised between 6 points of percentage in Korea to 98 points in Ireland. Debt limits decreased of about 15 points of GDP in average, from -5.4 points in Finland to - 31.1 in Ireland -35.8 points in Portugal. Consequently, fiscal spaces measured by the difference between the debt limit and the current 2013 debt ratio falls down. In Greece, Hungary, Iceland and Japan the debt evolution becomes explosive as primary balances remain below the effective cost of debt. Italy had no longer fiscal spaces and remaining rooms for maneuver in Portugal decrease to less than 5%. Fiscal spaces are under 50% in Belgium, Canada, Ireland and in the US.

Those results must be taken with caution as they depend on the way the effects of the financial crisis have been modelled. For instance, the Spanish situation seems quite sound as the remaining fiscal space in 2013 is evaluated at 56,2%. This may be due to the fact Spain has emplemented a sizable policy of debt consolidation since 2009. Hence the average situation in 2008-2012 is a mix of the crisis impact and of the early responses to that shock. More generally, the debt limits computed in table 3 represent point estimates and are a complex combination of coefficients that have been estimated for the fiscal reaction functions and for the determinants of the effective cost of debt. The next section attempts to provide more convenient measures of risks for sustainability by taking into account the uncertainty around the estimated coefficients and to provide projections for the future.

Table 3: Stable Debt $d*$ and Debt Limit $\bar{d}$ Before and After the Financial Crisis

	Pre-Crisis Period: 2002-2007			**Post-Crisis Period: 2008-2013**		
Countries	$d_{i,2007}$	$d*$	$\bar{d}$	$d_{i,2013}$	$d*$	$\bar{d}$
Australia	9.7		190.2	28.8	48.1	178.6
Austria	60.2	61.1	171.8	74.2	82.9	158.1
Belgium	84.0	64.5	167.9	99.8	91.1	149.4
Canada	66.5	76.2	162.5	89.1	115.2	129.9
Czech Republic	27.9	43.4	190.2	47.9	74.4	167.2
Denmark	34.3	42.2	176.5	55.2	71.6	162.7
Estonia	3.7		205	10.0	37.3	186.5
Finland	35.2	44.9	175.6	57.0	61.1	170.2
France	64.2	49.2	177.1	93.9	74.6	162.1
Germany	65.2	71.7	164.3	78.4	94.9	148.4
Greece	107.2	78.8	167.6	173.8		
Hungary	73.3	54	176.9	89.4		
Iceland	28.5	54.9	169.8	90.2		
Ireland	24.9	54.4	181.4	122.8	95.4	147.3
Israel	74.6		178.8	67.8	44.8	178.5
Italy	116.5	70	165.8	145.5	102	141
Japan	183.0	100.2	148.7	243.2		
Korea	30.7		192.1	36.7		185.2
Luxembourg	6.7		193.4	23.1	50.5	182.2
Netherlands	51.5	63.1	171.8	86.2	90.4	152
New Zealand	17.2		182.4	35.9	48	175.6
Norway	50.5		195.8	29.5		185.4
Poland	50.4	63.4	174.4	63.8	90.4	154.2
Portugal	68.4	68.8	168.8	128.8	111.2	133
Slovak Republic	29.8	53.3	188.1	55.4	81.4	164.4
Slovenia	23.1	72.8	166.2	73	93.6	152.2
Spain	36.3	56.4	179	93.9	91	150.1
Sweden	48.2	38.7	178.2	47.1	65.7	166.2
Switzerland	55.6	63.4	167.1	49.4	63.7	176.5
United Kingdom	43.7	52.1	175	90.1	70.1	167.2
United States	63.8	71.1	167.1	104.3	94.9	148.8
Median	50.4	62.1	175.6	74.2	81.4	162.7
Mean	52.7	61.2	176.4	80.1	77.8	162
Standard Error	35.6	13.6	11.5	46.9	20.9	15.7

4 Simulated Fiscal Spaces

We aim at computing probabilities of future fiscal spaces implied by the estimated model of section 3. To that end, we still consider the above computed debt limits as given and we simulate the debt path from 2013 onwards, as implied by the model. This exercise allows to take into account shocks that may hit the FRF and the effective cost of public debt as well. Repeated simulations will provide us with the overall distribution of fiscal spaces at different time spans.

4.1 Methods of simulation: Monte Carlo Experiments vs Bootstraped Errors

Debt limits had been computed using results of estimates of the system (15). The simulation methodology uses the same results and introduces shocks on the fiscal reaction functions and on the effective cost of public debt. Similar approaches had been followed by Celasum et al. (2007), Meideros (2012), Berti (2013) and Melou et al. (2014) in order to build fan-charts for the debt trajectory.

Projections of debt ratios are computed as follows:

$$\begin{aligned}
\hat{\epsilon}_{i,h} &= \hat{\rho}\hat{\epsilon}_{i,h-1} + \nu^*_{i,h} \\
\hat{s}_{i,h} &= \hat{\alpha}_{1,i} + \hat{\beta}_1 \hat{d}_{i,h-1} + \hat{\beta}_2 \hat{d}^2_{i,h-1} + \hat{\beta}_3 \hat{d}^3_{i,h-1} + \hat{\beta}_C + \hat{\beta}_{og} O\hat{GAP}_{i,h} + \beta_{fr} F\hat{R}_{i,T2} \\
\hat{\phi}_{i,h} &= \hat{\alpha}_{2,i} + \hat{\gamma}_1 \hat{d}_{i,h-1} + \hat{\gamma}_1 \hat{d}_{i,h-1} + \hat{\gamma}_2 \hat{d}^2_{i,h-1} + \hat{\gamma}_3 \hat{s}_{i,h} + \hat{\gamma}_C + \hat{\gamma}_{og} O\hat{GAP}_{i,h} + \hat{\gamma}_{sri} S\hat{R}I_{i,h} + \hat{\gamma}_{inf} I\hat{N}F_{i,h} + \eta^*_{i,h} \\
\hat{d}_{i,h} &= (1 + \hat{\phi}_{i,h})\hat{d}_{i,h-1} - \hat{s}_{i,h}
\end{aligned}$$

with $h = [2014, 2020]$. The first equation stands for the AR(1) process followed by shocks of the fiscal reaction function, the second and the third equations represent the estimated fiscal reaction fonction and the estimated determinant of the effective cost of debt, respectively. The fourth and last one is the accounting relation that expresses the debt dynamics. Hat variables denote projections and hat coefficients their estimates from table 1 and 2.

Additionnal assumptions are required about the projected values of exogeneous variables. The index of fiscal rule FR introduced in the fiscal reaction function is supposed to remain unchanged over the next 7 years and is still be given by its end-period value in $T2 = 2013$. The short run interest rate SRI (in log), the rate of inflation INF and the output gap $OGAP$ are forecasted from unrestricted VARs estimated country-by-country over 1980-2013 with an intercept, a break from 2008 and two lags.

There are two kinds of shocks in the model: $\nu^*_{i,h}$ stands for shocks on the primary balance and $\eta^*_{i,h}$ represents shocks on the effective cost of debt. Two alternative methods are used to draw randomly these series of shocks. First, we implement a Monte-Carlo simulation by assuming that shocks are normally distributed with estimated variances $\hat{\sigma}^2_\nu$ and $\hat{\sigma}^2_\eta$ from regressions (12-13) and (14), respectively. Second, in order to overtake weaknesses from the normality hypothesis, we draw series of shocks from bootstrapped estimated residuals. This method allows to take into account the overall distribution of historical disturbances that hit primary balances and the effective cost of debt. If the distribution of shocks is skewed and exhibits fat tails, the bootstrapping technic could improve the accuracy of our results. Moreover, the couple of bootstapped residuals are drawn randomly at the same date, thus any cross correlations between shocks are kept into simulations.

4.2 Results of simulations

Table 4 summarizes results from simulations. It displays the probability that a country gets various levels of fiscal spaces (0, 20, 50, 100 percent of GDP) in 2020. This presentation follows the one by Gosh et al. (2013) although estimated models and simulation techniques are rather different.

Results follow up the same, regardless the method of simulation. Bootstrapped estimated residuals tend to lower the estimated probability of getting any additional fiscal spaces than when disturbances are assumed normally distributed. In Greece and Japan, simulations failed since the debt path was quickly explosive. In Hungary and Iceland it was not possible to compute the debt limit after the crisis, instead, we used the pre-crisis debt limit to compute the simulated fiscal spaces.

A majority of countries still have any sufficient and positive fiscal space, even if fiscal space fluently ends below 100% of GDP. Results for the Hungarian economy seem odd, it is the only case in which methods of simulation surprisingly diverge. The bootstrapping simulation suggest that the country has no longer fiscal space. Among other European countries, the simulations reveal smaller probability of any positive fiscal space in Portugal and Italy. The Italian case looks particularly worrying: the probability of any fiscal space is only about 34% and these scarce rooms to maneuver are also tiny and must not exceed 20% of GDP. In portugal, the remaining fiscal space is below 50% of GDP with a probability of 86%.

5 Conclusion

According to the most recent literature the sustainability of the debt-to-GDP ratio can be defined as its convergence towards a stable finite level. The dynamics of public debt depends on the interaction between the flow of future primary balances and the effective cost of public debt i.e. the growth adjusted interest rate paid on the accumulated debt ratio. While a positive reaction to the lagged debt ratio is fluently considered as a sufficient condition to entail a sustainable evolution of the public debt (Bohn, 2008), empirical investigations have supported the idea of a "fiscal fatigue" phenomenon that might weaken the ability of government to correct the debt evolution when the public debt burden reaches

Table 4: Probability of Projected Fiscal Spaces in 2020

	Monte Carlo Simulations				Bootstrapping Simulations			
Countries	FS>0	FS>20	FS>50	FS>100	FS>0	FS>20	FS>50	FS>100
Australia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Austria	1.00	1.00	1.00	**0.10**	1.00	1.00	1.00	**0.11**
Belgium	1.00	1.00	0.93	**0.00**	1.00	1.00	0.90	**0.00**
Canada	1.00	***0.84***	**0.00**	**0.00**	1.00	***0.81***	**0.00**	**0.00**
Czech Republic	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.97
Denmark	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Estonia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Finland	1.00	1.00	1.00	0.98	1.00	1.00	1.00	0.96
France	1.00	1.00	1.00	**0.48**	1.00	1.00	1.00	**0.50**
Germany	1.00	1.00	1.00	**0.00**	1.00	1.00	1.00	**0.00**
Hungary	1.00	1.00	0.99	**0.23**	**0.00**	**0.00**	**0.00**	**0.00**
Iceland	0.90	***0.78***	**0.36**	**0.00**	***0.83***	***0.77***	***0.62***	**0.00**
Ireland	1.00	1.00	0.98	***0.66***	0.99	0.98	0.94	**0.42**
Israel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Italy	0.86	***0.61***	**0.04**	**0.00**	**0.34**	**0.02**	**0.00**	**0.00**
Korea	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Luxembourg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Netherlands	1.00	1.00	1.00	**0.28**	1.00	1.00	1.00	**0.00**
New Zealand	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Norway	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poland	1.00	1.00	1.00	**0.01**	1.00	1.00	1.00	**0.00**
Portugal	1.00	0.97	***0.52***	**0.00**	0.86	**0.42**	**0.00**	**0.00**
Slovak Republic	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spain	1.00	1.00	1.00	**0.06**	1.00	1.00	1.00	**0.00**
Sweden	1.00	1.00	1.00	0.74	1.00	1.00	1.00	0.76
Switzerland	1.00	1.00	1.00	0.86	1.00	1.00	1.00	0.83
United Kingdom	1.00	1.00	1.00	**0.19**	1.00	1.00	1.00	**0.20**
United States	1.00	1.00	0.76	**0.00**	1.00	1.00	0.72	**0.00**

Probabilities of fiscal spaces (FS) in percent of GDP, from 5000 random draws.

Figures below 50% in bold and between 50% and 85% in bold and italic.

high levels (Gosh et al., 2013, Meideros, 2012). As a consequence, the debt ratio may converge towards a stable finite level, conditionnally to not exceed a debt limit above which the evolution of debt turns to explode. Fiscal spaces, computed as differences between the debt limit and current or projected debt levels provide the measure of sustainability.
Following these approaches, we estimate a fiscal reaction function (FRF) that explains the primary balance and allows for "fiscal fatigue". In addition to the FRF, we estimate the effective cost of public debt in line with empirical contributions dealing with determinants of sovereign bond yields. The stable level of debt as well as the debt limit are computed as the roots of the system of these two estimated equations. The impact of the 2008 financial crisis is captured by structural breaks in the estimates and by calibrating the small set of exogenous variables by means from the pre-crisis period (2002-2007) and the post-crisis period (2008-2013). Last, we simulate the debt ratio implied by the model and we compute the probability that a country still has any given level of fiscal space up to 2020.
Our results show that the financial crisis has lead to a large and persistent increase in the needs of public fundings that durably lowers primary balances. The crisis had also pushed up the effective cost of public debt: the decrease in long term nominal interest rates that could have reduced the cost of public debt had been offset by the strong reduction of both the economic growth rate and the rate of inflation in the years following the crisis. Fiscal spaces have been reduced since the debt limits fall down from 176% of GDP to 162% in average. Risks for sustainability increased inasmuch as the stable level of debt and the debt limit became closer. We find that Greece, Japan, Hungary and Iceland had no longer any positive fiscal space and could be urged to undertake programs for debt consolidation quite soon. Simulations also raise concerns about Portugal and Italy where fiscal spaces are likely to fall down to less than 50 percent of GDP during the next seven years.

References

Afonso, A. (2005). "Fiscal Sustainability: the Unpleasant European Case", *FinanzArchiv*, 61 (1), 19-44.

Afonso, A. and Rault, C. (2014). "Multi-step analysis of public finances sustainability", *Economic Modelling*, forthcoming.

Ardagna, S., Caselli, F. and Lane, T. (2007). "Fiscal Discipline and the Cost of Public Debt Service: Some Estimates for OECD Countries", *BE Journal of Macroeconomics*, 7 (1), Art. 28.

Baldacci, E. and Kumar, M. S. (2010). "Fiscal Deficits, Public Debt, and Sovereign Bond Yields, *IMF Working Paper*, 10/184.

Baldi, G. and Staehr, K. (2013). "The Europe Debt Crisis and Fiscal Reaction Function in Europe 2000-2012", *DIW Discussion Paper* 1295.

Ballabriga, F. and Martinez-Mongay, C. (2002). "Has EMU Shift Policy", *European Economy*, 166, European Commission.

Ballabriga, F. and Martinez-Mongay, C. (2007). "A Further Inquire about the Sustainability of Fiscal Policy in the EU", *European Economy*, 297, European Commission.

Batini, N., Callegari, G. and Melina, G. (2012); "Succesful Austerity in the United States, Europe and Japan", *IMF Working Paper*, 12/190.

Berti, K. (2013). "Stochastic Debt Projections Based on the Historical Variance-Covariance Matrix Approach for UE Countries"', *European Economy*, 480, European Commission.

Bohn, H. (1995). "The Sustainability of Budget Deficits in a Stochastic Economy", *Journal of Money, Credit and Banking*, 27 (1), 257-271.

Bohn, H. (1998). "The Behavior of U.S. Public Debt and Deficits. *The Quarterly Journal of Economics*, 113 (3), 949-963.

Bohn, H. (2007). "Are stationarity and cointegration restrictions really necessary for the intertemporal budget constraint?", *Journal of Monetary Economics*, 54, 1837-1847.

Bohn, H. (2008). "The Sustainability of Fiscal Policy in the United States", in *Sustainability of Public Debt* by Neck, R. and Sturm, J.-E. (eds), 15-49. Cambridge (MA), MIT Press.

Canzoneri, M., Cumbi, R. and Diba, B. (2001). "Is the Price Level Determined by the Needs of Fiscal Solvency?", *American Economic Review*, 95 (1), 1221-1238.

Caporale, G. M. and Williams, G. (2002). "Long-Term Nominal Interest Rates and Domestic Fundamentals", *Review of Financial Economics*, 11, 119-130.

Celasum, O. and Ostry, J. D. (2006). "On the Property of Various Estimators for Fiscal Reaction Functions" *IMF Working Paper*, 182.

Celasum, O., Debrun, X. and Ostry, J. D. (2007). "Primary Surplus Behavior and Risks to Fiscal Sustainability in Emerging Market Economies: A Fan Chart Approach", *IMF Staff Paper*, 53 (2), 401-425.

Codogno, L., Favero, C. and Missale, A. (2003). "Yield spreads on EMU Government Bonds", *Economic Policy*, 18 (37), 505-532.

Collignon, S. (2012), "Fiscal Policy Rules and the Sustainability of Public Debt in Europe", *International Economic Review*, 53 (2),539-567.

Doi, T, Hoshi, T. and Okimoto, T. (2007). "Japanese Government Debt and Sustainability of Fiscal Policy", *NBER Woking Paper*, 17305.

Favero, C. A. (2002). "How do European Monetary and Fiscal Authorities Behave", *CEPR Discussion Paper*, 3884.

Gali, J. and Perotti, R. (2003). "Fiscal Policy and Monetary Integration in Europe" *Economic Policy*, 18 (37), 533-572.

Gosh, A. R., Kim, J. I., Mendoza, E. G., Ostry, J. D. and Qureshi, M. S. (2013). "Fiscal Fatigue, Fiscal Space and Debt Sustainability in Advanced Economies", *Economic Journal*, 123 (566), 4-30.

IMF (2011). *Japan Sustainability Report 2011*.

Klepsch, C. and Wollmershäuser (2011). "Yield Spreads on EMU Government Bonds - How the Financial Crisis Has Helped Investors to Rediscover Risk", *Intereconomics*, 46 (3), 169-176.

Legrenzi, G. and Milas, C. (2013). "Modelling the Fiscal Reaction Function of the GIPS Based on State Varying Thresold", *CESifo Working Paper* 4385.

Meideros, J. (2012). "Stochastic Debt Simulation using VAR Models and a panel fiscal reaction function: Results for a Selected Number of Countries", *European Economy*, 459, European Commission.

Melou, M., Sumlinski, M. and Geiregat, C. (2014). "An Application of the "Fan-Chart Approach" to Debt Sustainability in Post-HIPC Low-Income Countries", *IMF Working Paper*, 14/102.

Mendoza, E.G. and Ostry, J. D. (2008). "International Evidence on Fiscal Solvency: Is Fiscal Policy "Responsible"?", *Journal of Monetary Economics*, 55 (6), 1081-1093.