Early warning indicators in a debt restructuring mechanism

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This paper is written at the request of the UNCTAD working group Debt Workout Mechanism and was presented at the UNCTAD Working Group Meeting on March 19th in Buenos Aires, Argentina.[1] We propose a system of debt indicators that is constructed for nine OECD countries and could be estimated for emerging economies as well. Given the data constraints for many non-OECD countries, further research will be devoted to indicators targeted at emerging markets and least developed countries (LDCs).

1 Introduction

The UNCTAD Principles for Responsible Sovereign Lending and Borrowing (Espósito et al., 2013) encourage an orderly, timely, efficient and fair restructuring process for countries in debt distress. Restructuring is, however, a long and protracted process, whose costs for both lenders and borrowers increase the longer it takes (Furceri and Zdzienicka, 2012). Delay is often caused by disagreement on whether it is necessary to restructure at all and if so, what losses have to be acknowledged.

In this context, it is crucial to have a procedure –multilaterally agreed upon– that determines when a restructuring process must start. A central component of this procedure is the economic analysis that determines when a debt restructuring must be initiated. In other words, the main question to be addressed is: When should a country seek for debt restructuring?

We propose a two-component debt restructuring mechanism. The first component is a system of debt indicators that can adequately and timely convene when a country is positioned on a vulnerable debt path and when the fiscal position of a

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country warrants closer scrutiny. It is designed to be applicable to different categories of countries: advanced economies, emerging markets and developing countries. However, as we discuss in the paper, given the short term dynamics and the political, legal and economic sensitivities that surround debt crises, it is extremely difficult to objectively establish when a debt restructuring is inevitable. Therefore, the second component is a procedure –based on an adequately tuned analytical framework that is agreed upon broadly– to evaluate the occurrence of an unexpected negative shock that can be considered as the "triggering" event of a potential crisis. This procedure to identify a "triggering" event could then signal the start of debt restructuring talks. This will facilitate an orderly, timely, efficient and fair restructuring process.

Our methodological approach will consist of three steps. First, we make an overview of the economics of debt crises and the debt sustainability indicators in the literature proposed by other international institutions. We then evaluate the strengths and weaknesses of these indicators. This analysis provides the background for the second step, in which we propose a system of indicators to assess when public debt vulnerable and a procedure that can signal when debt should be restructured. The final step is our two-component proposal for a debt restructuring mechanism, where we combine our system of indicators with the procedure to identify debt crisis "triggering" events.

Section 2 reviews the economics of debt crises. History has shown than a debt crisis often looms for a long time before it suddenly becomes acute after begin triggered by an unexpected event. As the particular triggering event is hard to predict, economic indicators for debt restructuring should focus on assessing the likelihood of a debt crises occurring. Crucially, this likelihood depends on expectations of future debt levels, so an early warning indicator that assesses debt vulnerability should focus on the factors that impact probable future debt outcomes, such as economic uncertainty and policy responses. As sovereign debt problems are often interrelated with other economic issues, the early warning indicator should be complemented by indicators examining foreign currency and balance of payment risks, potential problems generated by the financial sector, and the capacity of the economy to withstand unexpected economic shocks.

The UNCTAD's attempt at establishing a debt workout mechanism is not the first –see Weidemaier (2013) for a historic overview– and neither is our attempt to find a suitable indicator for debt restructuring. In Section 3 we present our overview of the literature to assess debt vulnerabilities. We categorize this literature into two main branches: those papers that conduct a formal debt sustainability analysis and the literature that examines the determinants of debt crises. A debt sustainability analysis –as done for example by the IMF and the World Bank– compares the economy under various scenarios to thresholds that increase in the quality of policy making. Any variable that exceeds its predetermined threshold value is flagged and warrants further investigation. These analyses can inform policy makers on potential weaknesses in their economy. However, these analyses are less suitable in assessing probable future debt developments as the baseline scenario contains substantial judgment, alternative scenarios are prescribed and do not contain a

country-specific policy response to adverse conditions, and the likelihood of these scenarios is not taken into account. On the other hand, the literature that analysis the determinants of debt crisis aims at finding economic variables that have a high correlation with a crisis incidence indicators –i.e. variables that could serve as an early warning indicator. This literature, however, does not inform policy makers about the effects of their policies and does not advice on a sustainable debt level.

In Section 4 we propose our system of debt vulnerability indicators.This system combines the two approaches in the literature. At the core of the system is an early-warning indicator based on a debt vulnerability analysis. This Stochastic Early-warning Indicator (henceforth SEI) is constructed using country-specific stochastic simulations based on historical estimates of uncertainty in the economy and the way the government has dealt with them in the past. It relies on earlier work of ours (see van Ewijk et al., 2013; Lukkezen and Rojas-Romagosa, 2013) and builds on Celasun et al. (2006). We then apply this indicator to analyzing debt sustainability issues for a set of OECD countries. The core SEI is then complemented by indicators on the risks associated with the financial sector and the probability of a sudden stop or currency crisis. Combining the core SEI indicator with the foreign and banking components we create a system of debt indicators. This system is flexible and can incorporate the country-specific economic, institutional and political context. It can be readily implemented and applied to developed and developing countries alike.

Finally, in Section 5 we combine our system of debt vulnerability indicators, with an institutional procedure to identify debt crisis "triggering" events. We propose to use both these components as a debt restructuring mechanism. In addition, we argue that the value of an indicator for debt restructuring relies –besides its intrinsic value as a measuring device– on whether it is generally accepted as such. This is especially true for debt restructuring indicators as they depend on expectations of future debt levels. Thus it needs to have considerable institutional support and represent the consensus among lenders and borrowers. To foster acceptance, these indicators should be easy to understand and be regularly updated and maintained by an independent third party with sufficient expertise. Moreover, while no threshold for our indicator will rule out all debate – whether restructuring is necessary or not– we provide values for our main indicator that can guide the debate. However, these values will only be able to assess whether a country is on a delicate public debt dynamic (i.e. on a risky debt path), not whether restructuring is inevitable. As history has proven, it is usually an unexpected negative shock –i.e. a "triggering" effect– which ultimately renders a country unable to fulfil its debt obligations and seek for debt restructuring. Therefore, we propose a mechanism where countries that show debt vulnerability problems –assessed by our system of debt indicators– must be immediately evaluated after a negative unexpected shock is realized, and then a decision must be taken regarding the start of a debt restructuring process.

The scope of the current analysis, therefore, is to propose a mechanism for debt vulnerability assessment that can guide and be an integral part of a debt restructuring mechanism. As part of previous research work we were able to include country examples on the values and signal properties of the core SEI for nine OECD coun-

tries. Due to time constraints, however, it was not possible to gather the necessary data series, and run the simulations, estimations and calibration process required to provide country examples for additional countries.[2] Due to these limitations we only propose threshold values for our core SEI, and how it can be complemented with the future estimations of the foreign currency (SEI-X) and banking (SEI-B) components.

2 The economics of debt crises

The occurrence of government debt crisis depend primarily on expectations (Calvo, 1988). To the sovereign borrower defaults bring costs[3], which means that as long as the interest burden remains relatively low, it is in the interest of the sovereign to honour its commitments. When the interest burden becomes high, however, servicing the debt is increasingly costly and at some point it will no longer be in the interest of the borrower to pay its debt. Therefore, as the lender cannot enforce sovereign liabilities, expectations on whether the interest rates will remain low –and the debt burden limited– are of prime importance in his decision to continue lending.

The role of expectations leads to two findings for the construction of debt restructuring indicators. First, it is not necessary to distinguish between solvency and liquidity issues. In essence, they are inseparable. If the market currently believes the government will not (be able to) service its debt in the medium or long run, a solvency issue exists. Then interest rates will increase and this will trigger a liquidity problem. Similarly, if short term adverse conditions on the financial market induce an increase in the interest rates that creates a liquidity problem, then the incapacity of the government to service its debt burden in the short run is translated into a medium run solvency problem.

Second, unlike the underlying economic fundamentals, debt expectations can change overnight. This means that while the economic fundamentals may be bad for quite some time, creating some level of expectations for a future debt crisis, the market may continue to believe (and expect) that debt will be serviced and collectively coordinate on a low interest rate equilibrium. Then suddenly, some event triggers a change in expectations and the debt problems –related to the economic fundamentals– evolves into a full-blown crisis and the market coordinates on a high interest rate equilibrium. This process is described by the famous quote by Rudi Dornbusch: "The crisis takes a much longer time coming than you think, and then it happens much faster than you would have thought, and that's sort of exactly the Mexican story. It took forever and then it took a night". Therefore, the likelihood of a debt crisis depends crucially on expectations of future debt levels, so an early warning indicator that assesses debt vulnerability should focus on the factors that impact

[2] We are currently collaborating with Ortec Finance in extending our indicator to cover more countries.

[3] According to Panizza et al. (2009) these are primarily the repercussions on the domestic economy and the political consequences for the officials that allow the default and to a lesser extent costs from exclusion from the international capital market.

probable future debt outcomes, such as economic uncertainty and policy responses. Moreover, the economic fundamentals of debt sustainability are not only related to public finances and the intrinsic dynamics of public debt, but often sovereign debt problems originate and are inter-tangled with other sectors of the economy. A crisis seldom comes alone: the probability of a debt crisis conditional on a currency or banking crisis is substantially higher than the unconditional probability of a debt crisis (Eichengreen et al., 2003; Laeven and Valencia, 2013). Thus, just monitoring public finances is unfortunately not sufficient to asses debt vulnerability and all three areas should be monitored.

Using these concepts we can summarize the dynamics of debt crisis in two steps. First, there has to be a process of economic deterioration, which is reflected in adverse developments of the economic fundamentals of debt sustainability. We define this situation as debt vulnerability. In the second step, there is an unexpected adverse shock that suddenly changes expectations and triggers the debt crisis – i.e. the "triggering" event. Moreover, both steps are necessary conditions for a debt crisis, but on their own they are not sufficient conditions. This means that economic fundamentals can be negative for a relatively long period –i.e. the country has a vulnerable debt position– but it could be the case that these adverse conditions are not translated into a debt crisis.[4] On the other hand, if the economic fundamentals of debt sustainability are solid, then an adverse unexpected shock usually does not translate into a debt crisis.

These two steps can be directly related to our proposed methodology for assessing when a country should seek for debt restructuring. First, economic fundamentals and how they are related to debt vulnerability are monitored using our system of debt indicators. These indicators will measure the debt vulnerability of a given country to a full blown debt crisis. The triggering event itself, however, is often extremely hard to predict. In particular, the intrinsic nature of a triggering event is that it is unexpected. Hence, our system of debt indicators can assess the vulnerability of a given country to a debt crisis, but it cannot signal when a debt crisis is inevitable. In other words a debt indicator can assess the likelihood that a triggering event might create a crisis, i.e. that the debt level might explode in the future as a consequence of an unforeseen negative shock. But a debt indicator, on its own, cannot determine when a debt crisis is inevitable and thus, it cannot determine when a debt restructuring process should start. In Section 5 we propose a procedure that uses our system of debt indicators –in combination with a multilateral framework that can identify a triggering event– to establish when debt restructuring talks should start.

Finally, it is important to note that relying entirely on an indicator to start the restructuring process may create a dilemma of its own. In particular, for such an indicator to be used directly as a signal for restructuring, it must first be estab-

[4]However, the vulnerability of a government to debt crisis increases the longer and faster the deterioration in fundamentals occurs. In this last case, the triggering event does not need to be an extreme shock to the system. The more vulnerable the economic situation, the more likely that an -even small- adverse economic shock can become a triggering event.

lished what is the predetermined threshold value that will start restructuring talks. However, as will be clear from our analysis below, all early-warning debt indicators express either directly or indirectly mere probabilities –since they are usually based on a stochastic process to deal with the variability of the different components of debt vulnerability. As such, there is always scope for a debt crisis not occurring, even when the values of the indicator are relatively high. This fact, together with the insight that debt sustainability depends on expectations and that news can impact expectations, leads to a curious insight: it may well be the case that the indicator crossing the threshold becomes the triggering effect, even when a debt crisis could still be avoided.

3 Inventarization of current tools to assess debt restructuring

There are two approaches to assess sovereign debt issues: formal debt sustainability analyses and the literature that examines the determinants of debt crises.[5] We discuss them in order.

3.1 Debt sustainability analysis

A formal debt sustainability analysis, usually conducted by a supranational organization, is aimed at assessing the impact of specific policies on the sustainability of public debt and –usually– other aspects of the economy as well. It is also used to identify weaknesses in other sectors of the economy. These debt sustainability analysis generally follow the following structure. First, a baseline scenario for the economy and government finances is constructed based on the information available and expert judgment. Then, the outcomes of the baseline scenario are compared to predetermined threshold values and if any of the outcomes exceeds one of the thresholds, this particular characteristic is flagged and further investigation is warranted. Economic uncertainty and the impact of specific policies are investigated by examining alternative scenarios, which are evaluated against the same thresholds as the baseline.

We focus here on the debt sustainability analysis of the IMF for market access countries (mostly advanced and emerging economies) and on the joint IMF and World Bank approach for low income countries (without financial market access).

The debt sustainability of market access countries is assessed annually by the IMF in its article IV consultations and more often in its review of countries with IMF programs. The basis for its analysis is given by IMF (2002) and a user's manual for its staff by IMF (2013). It divides market access countries in two categories: emerging market (EM) and advanced economies (AE). The basic analysis consists of a baseline scenario for the economy and government finances and two alternative scenario's, one where all variables are at their historic average and one where the

[5] Panizza et al. (2009) refers to this last branch of the literature as the early-warning literature.

primary balance is unchanged. The basic analysis is performed for countries with relatively low debt levels and refinancing needs –see the thresholds in Table 1. For countries with higher debt levels, with more financing needs or who are in an IMF program, this basic analysis is extended by assessing the historical realism of the government forecast of the economy and its finances, the vulnerability of the debt profile, the sensitivity to a number of stylized macro-financial shocks and the effects of the realization of contingent liabilities. Also a fan chart is constructed that adds shocks to the central path. Whenever the economic variables or public finances exceed certain thresholds under a scenario, these are flagged and explained in the accompanying text. To reflect the fact that advanced economies are more mature and have better quality of policy making institutions, their thresholds are set higher. In addition, for advanced economies the analysis addresses the impact of specific issues on government finances, such as aging of the population, bursting real-estate bubbles and health care expenditure increases.[6]

Table 1: Thresholds for market-access countries that determine whether extended analysis is required

	Debt	Gross financing needs
Advanced Economies	60	15
Emerging Markets	50	10

Notes: Values as a % of GDP. Source: IMF (2013)

For low income countries the IMF and the World Bank (IMF and World Bank, 2005) have a joint debt sustainability framework. In this framework they construct a basic scenario for the economy, government finances and external debt and compare the public sector and the external debt-to-GDP ratio and the servicing costs-to-GDP ratio against five thresholds, which increase in value with the quality of policy making institutions in the country. The thresholds are given by Table 2. Next, alternative scenarios are constructed and compared against the same thresholds. A statistic that exceeds the threshold is again flagged.

These debt sustainability analyses can inform policy makers on potential weaknesses in their economy that warrant further investigation. They are however, less suitable in assessing future debt developments. First, the baseline scenario contains substantial judgment and alternative scenarios in the analysis are generally prescribed and not country specific, hence the likelihood of these scenarios occurring or the effect of economic volatility is not taken into account. Second, there is no endogenous response of policy to these alternatives. Third, while exceeding a threshold indicates problems in the economy, it does not imply that debt is unsustainable.[7] Finally, following the analysis from Gray et al. (2008), it is clear that these sustainability analyses do not take sufficient account of issues related to contingent liabilities by the government.

[6]For examples in the European context, see European Commission (2012a,b).

[7]As explained in Section 2, the main factor triggering debt crisis are unexpected negative shocks.

Table 2: Debt burden thresholds for low income countries

	Present Value of debt as % of:			Debt service as % of:	
	Exports	GDP	Revenue	Exports	Revenue
Weak Policy	100	30	200	15	25
Medium Policy	150	40	250	20	30
Strong Policy	200	50	300	25	35

Source: IMF and World Bank (2005)

3.2 Determinants of debt crises

This branch of the literature aims to find the economic variables that are determinants of debt crises. In particular, they seek variables that have a high correlation with a crisis incidence indicator. In contrast to the debt sustainability analysis, it does not aim at identifying potential weaknesses in the economy nor does it inform on the effect of a policy plan. As such, it also does not advice on a sustainable debt level. It employs two techniques: regressing economic variables on a crisis incidence indicator to see what prior economic variables have a high correlation with crisis incidence; and using the signals approach, which calculates the signal-to-noise ratio of a crisis prediction indicator.

The literature that regresses economic variables on a default indicator or a default risk measure originated by work of, among others, Feder and Just (1977) and Cline (1984) on developing countries. These early contributions to the literature found that high debt, large budget deficits and high debt servicing costs, and economic downturns increase the probability of a debt crisis. These findings are confirmed by Joy (2012), who estimates the probability of entry and exit from default taking into account model uncertainty. He finds that large budget deficits and high interest payments on external debt increase the probability of entering into default, while debt reduction matters the most for countries that are exiting default.

These contributions where extended into several directions. Kraay and Nehru (2006) estimate the probability of entry into default and find that besides the debt burden and unexpected shocks, the quality of policies and institutions matters. Rijckeghem and Weder (2009) find that in more stable political environments default probabilities are lower. Detragiache and Spilimbergo (2001) focus on liquidity and find that less liquid countries –i.e. who are financed with shorter maturity, with more debt service coming due on short notice and/or lower foreign exchange reserves– have a higher probability of default.

The default probability also depends on other aspects of the economy. Reinhart and Rogoff (2008), and subsequent work of these authors, use comparative statistics and a compelling narrative to show that financial crisis often precede sovereign debt crisis.[8]

[8]To incorporate the contingent liabilities appropriately a full risk-based sustainability framework is required, see Gray et al. (2008) for a proposal.

Also, Eichengreen et al. (2003) and Calvo et al. (2004) find that when debt is issued in a foreign currency, it is not only debt that matters, but also the access to foreign currency to service the debt. Even though foreign currency can be readily available at the moment, this may change whenever a country experiences a "sudden stop" in which the currency depreciates and the current account deficit disappears in relatively short period. This means that sources of foreign currency –e.g. capital inflows, exports (including tourism), remittances, and reserves held at the Central Bank– are relevant to assess the capacity of the country to repay its foreign currency debt. For instance, Celasun and Harms (2011) find that a greater share of private sector debt in total external debt is associated with a reduced likelihood of sovereign default. Manasse and Roubini (2009) reproduce this result using a regression tree approach, which shows that default risk can originate from diverse combinations of macroeconomic fundamentals, including insolvency as well as illiquidity.

Last but not least, Catão and Kapur (2006) provide evidence that differences in macroeconomic volatility are the key determinant of higher spreads. In a related study, Genberg and Sulstarova (2008) show how the right hand tail of the distribution of the debt-to-GDP ratio depends on the second moments (i.e. variability) of macroeconomic variables and then regresses these second moments on interest spreads. They find that interest spreads increase in the second moments. Daude (2012) confirms this for the default probability, which he estimates to increase in the volatility of terms-of-trade.

The signals approach, which originates from Kaminsky et al. (1998) in the context of currency crisis, proposes an early warning system based on the signal-to-noise ratio of an indicator for predicting a crisis. This approach does not attempt to explain what drives the default probability, but merely tries to make a predictor that is as accurate as possible.

In this approach a "signal" is given if the variable V exceeds the threshold T. If the event (the default) then occurs within a certain time frame, the signal was a genuine positive. If it does not, it is a false positive. Alternatively, no signal is given if the variable does not exceed the threshold. Then, if the event indeed does not occur, the signal is genuine. If it does occur, it is a false negative. The signal-to-noise ratio maximizes the number of genuine positives, A_T, to the number of false negatives, C_T, relative to the number of false positives, B_T, to genuine negatives, D_T. This can be summarized in a diagram as follows:

$$\begin{array}{lcc} & \text{crisis} & \text{no crisis} \\ V \geq T & A_T & B_T \\ V < T & C_T & D_T \end{array} .$$

Then, the signal-to-noise ratio for variable V is a function of the threshold level and given by:

$$S(V) = \max_T \frac{\frac{A_T}{A_T+C_T}}{\frac{B_T}{B_T+D_T}}.$$

Berg et al. (2005) perform a review of early-warning systems focusing primarily on the 1997 Asian crisis and report mixed results. Over the global financial crisis, Shi and Gao (2010) show the Kaminsky et al. (1998) early warning system did reasonably well during the crisis, albeit in a modified form.

Several extensions to these type of indicators have recently been made. Dobrescu et al. (2011) extend the analysis to near-default events and show that including near-default events shows that fiscal stress remains high in advanced economies. Ciarlone and Trebeschi (2005) extend the two-state approach (default, non-default) to a three-state (default, non-default and post-default) and generate an early warning system which predicts 76% of entries into crisis, with 36% false alarms. Babecký et al. (2013) focuses in the Euro area banking sector and show that a banking crisis is more likely to trigger a debt crisis whenever the banking sector is large compared to the domestic economy, financed from abroad and holds a large amount of domestic private credit. Knedlik and Schweinitz (2012) assess whether macroeconomic balances can be used as an indicator for a debt crisis and finds that a broad composite indicator has the highest predictive power.[9]

A final approach, which can loosely be classified under signals, is a complex systems approach (Adrian and Brunnermeier, 2011; Markose et al., 2010) that assesses the riskiness of the entire system instead of individual entities. As such, it does not aim to explain default of individual entities, but it aims to explain systemic failure. Nevertheless, all entities are susceptible to systemic risk; for countries with vulnerable public finances an increase in systemic risk could be a triggering event turning a looming crisis into an acute one. Then, systemic risk is used to transmit contagion, see Hurlin et al. (2013) for an application to the European debt crisis.

From the discussion in Section 2 we know that expectations on future debt levels –and how expectations affect the ability to service debt– are instrumental for a sustainable public debt. To sum up, we learn from the literature overview in this section that the main elements that have predictive power for future debt problems are: initial high public debt, large deficits, poor policy making institutions, macroeconomic uncertainty and large implicit liabilities. In addition, for countries with a relatively large share of debt issued in foreign currency, elements that influence the access to the foreign currency required to service the debt become also crucial –such as high public debt with short maturity and uncertainty in foreign currency inflows. In the next Section we propose an indicator that can incorporate these elements. However, as becomes evident from the signals or early-warning approach, no indicator will be perfect. For instance, without a triggering event, expectations may not shift from the good to the bad equilibrium. This can provide the necessary time for the potential crisis to be addressed and the actual debt crisis need not occur.

[9]Methodological extensions are made by Fuertes and Kalotychou (2007), who attach weights to false positives and negatives that depend on the policy makers preferences. Babecký et al. (2013) include model uncertainty, and Fioramanti (2008) use a non-parametric artificial neural networks approach to find the most informative indicator.

4 Proposed system of debt restructuring indicators

In this section we propose a system of indicators that takes into account the main elements of the current literature –as over viewed above– to analyse the need for debt restructuring. The core element in this system is our Stochastic Early-warning Indicator (SEI). The system of indicators should be embedded in a broader debt restructuring process framework.

In principle, our approach will be country specific, not driven purely by debt levels and will take into account uncertainty and policy responses.[10] The initial idea will be to have a "core" indicator (based on van Ewijk et al. (2013) and Lukkezen and Rojas-Romagosa (2013)) and complement it with additional factors (i.e. foreign currency access and banking sector risks) that can create additional debt sustainability risks. We then create a system of red flags –based on the definitions used by IMF (2013)– that either directly integrates or complements the information provided by the core indicator with these additional factors to determine whether restructuring should be considered.

This approach will take into account the three main areas of debt sustainability:

- Fiscal issues. Future debt levels are a function of expected future growth and interest rates, the expected future surplus and the current debt level. If the distribution of future growth and interest rates and surpluses is wide, the future debt level is likely to deviate far from its predicted path. If the upward risk is large, there is much uncertainty in the debt level and the probability that a crisis occurs rises. Therefore, a debt sustainability indicator should take into account the volatility in interest and growth rates and the expected response of policy to this volatility, as well as the policy response to other factors.

- External issues. Sudden stops to foreign currency inflows (e.g. foreign, capital inflow, exports and remittances) can have a large impact on the ability of the government to service its foreign currency debt. Analyzing debt sustainability encompasses, therefore, analyzing changes in these sources of foreign currency cash flows and linking net foreign assets with debt levels, while accounting for the availability of foreign exchange reserves and other relatively liquid foreign assets. This also involves assessing the impact of external events –e.g. international economic and/or political crises– on the particular country ana-

[10] Note that we explicitly avoid using any upper limit or critical debt level as part of our debt sustainability analysis. Several papers find that debt above a certain level has negative consequences for economic growth (Reinhart and Rogoff, 2010; Cecchetti et al., 2011; Checherita-Westphal and Rother, 2012; Égert, 2012; Baum et al., 2013). However, the causality between debt and growth is difficult to establish and critical debt levels are generally country-specific (e.g. Japan has debt levels way above any critical level mentioned in the literature, while other countries had debt crisis well below these critical levels), which makes the cross-country results from these studies not informative in an indicator when applied to different countries. Another example of a critical debt level that proved to be ineffective and non-informative was the EMU rule of debt levels below 60%.

lyzed. This external component can be evaluated using additional indicators on currency crisis from the literature (cf. Kaminsky et al., 1998).

- Banking issues. There is a contingent liability for national governments whenever they issue explicit and/or implicit financial support to their banking sector. Under these circumstances their is a positive probability that a national or international banking crisis will spill over to the government finances and trigger a debt crisis. We use existing bank risk indicators from the literature (i.e. Borio and Drehmann, 2009) to incorporate this risk into our indicator.

Implicit in this three-point analytical framework is the capacity of each country to deal and successfully absorb unexpected shocks. For instance, the susceptibility of a country to experience a currency crisis is directly related to both the inflows of foreign currency but also to the stock of foreign reserves available to the country in case it needs to buffer a negative external shock.

4.1 Core indicator

Our core sustainability early-warning indicator (SEI) provides a structured assessment on public debt sustainability in the medium term future. This indicator combines the effect of economic uncertainty –represented by stochastic simulations of interest and growth rates– with the expected fiscal response that provides information on the long-term country specific attitude towards fiscal sustainability –assessed through the econometric estimation of a long-term fiscal reaction function.

4.1.1 Debt sustainability analytical framework

Before we define our core indicator, we lay out the analytical framework it is based upon, which is based on Celasun et al. (2006). The dynamic behavior of the debt-to-GDP ratio is given by the following accounting equation:

$$d_{t+1} = \frac{1 + r_t}{1 + y_t}(d_t - s_t) \tag{1}$$

which says that d_{t+1} (the debt-to-GDP ratio at the beginning of period $t+1$) equals the debt-to-GDP ratio at the beginning of period t minus s_t (the primary surplus-to-GDP ratio over period t) times the gross interest rate factor over period t $(1+r_t)$, divided by the change in the GDP over period t $(1 + y_t)$. For our analysis we use real growth rates and the "effective" interest rates –i.e. the ratio of actual interest payments to gross debt levels.

The construction of the SEI is based on two main components. First, we follow Bohn (1998, 2008) and estimate a fiscal reaction function (FRF), which provides information on the long-term country-specific behavior of that country's government and its attitudes towards fiscal sustainability. The FRF is a behavioural equation for the primary surplus-to-GDP ratio, which tells us how the government's budget

responds to debt accumulation given a structure of shocks occurring in the background:

$$s_t = \alpha + \rho d_t + \beta \mathbf{Z}_t + \varepsilon_t \tag{2}$$

where α, β and ρ are the estimated parameters, $\mathbf{Z}$ is a set of other primary surplus determinants (including business-cycle fluctuations and temporary changes in government expenditure), and ε_t is an error term.

The most important parameter is ρ, which is the fiscal reaction coefficient that indicates whether the government has increased its primary surplus as a reaction to an increase in the debt-to-GDP ratio. A positive and significant ρ value denotes a country that has been committed to reduce or maintain steady debt-to-GDP ratios conditional on short-term economic fluctuations and temporary government expenditures.[11]

The second component employs the stochastic debt simulation method proposed by Celasun et al. (2006) and Budina and van Wijnbergen (2008). This method uses a Vector Auto Regressive (VAR) model to capture the historic volatility of effective interest and real growth rates to project them into the future.[12] The VAR model we use is given by:

$$\begin{aligned} \begin{pmatrix} r_t \\ y_t \end{pmatrix} &= \alpha_0 + \sum_{j=1}^{\infty} A_j \begin{pmatrix} r_{t-j} \\ y_{t-j} \end{pmatrix} + \theta_t, \\ \text{var}\,(\theta_t) &= \mathbf{V} \end{aligned} \tag{3}$$

where $j = 2$ is the number of lags in our model, and $\mathbf{V}$ is the covariance matrix of the error terms θ_t.

Combining equations (1) and (2) yields a simplified dynamic debt-to-GDP equation:

$$d_{t+1} = (1 + r_t - y_t)(1 - \rho)d_t + \eta_t \tag{4}$$

where η is an error term that aggregates the additional elements from the FRF.[13]

Equation (4) provides a simple and elegant summary of the main elements that determine debt dynamics. In particular, the evolution of the debt ratio is driven by three contributing channels:

1. Fiscal reactions. These are captured by the estimated coefficient (ρ) of the FRF and provide information on the historical fiscal reaction of governments (i.e. changes in primary surpluses) to changes in the debt-to-GDP ratio.

[11] In particular, a positive and significant ρ can be interpreted as a government that engages in fiscal austerity to reduce debt levels even when markets are not specifically concerned about those debt levels, nor is there international pressure (e.g. IMF, EU institutions) to reduce them. A reason for this might be that in advanced economies fiscally responsible politicians at the national level have larger re-election probabilities (Brender and Drazen, 2005, 2008).

[12] Similar approaches have been proposed by Medeiros (2012) and Berti (2013).

[13] In particular, $\eta = \alpha(1 + r_t - y_t)$, since by construction we have that $E(\mathbf{Z_t}) = 0$ and $E(\varepsilon_t) = 0$ –i.e. the fluctuations in $\mathbf{Z_t}$ and ε cancel out over time.

2. Real growth dividend. This term has a beneficial effect on the debt-to-GDP ratios when real GDP growth (y) is positive and sustained over time. Therefore, this term groups governmental policies –such as structural reforms– and external factors –such as foreign demand– on the real economy that have a medium- to long-term effect on real growth rates.

3. Real effective interest rates (r) on government debt. This is the difference between the nominal interest and the inflation rate. Thus, this category groups the monetary and financial policy instruments available to governments to reduce debt levels. It is also linked to the term "financial repression" coined by Reinhart and Sbrancia (2011), who define it as policies that depress real interest rates –while the extreme case of periods with negative real interest rates is defined as "liquidation years".

In a deterministic setting, the following holds: if economic growth y is larger than the effective interest rate r, the debt-to-GDP ratio decreases over time and a positive fiscal response is not needed to assure debt sustainability. This is also known as the "Aaron condition" (Aaron, 1966). If this condition is not met (e.g. $y < r$) then debt sustainability depends on the fiscal reaction function: primary surpluses should be sufficiently responsive to the debt-to-GDP ratio to arrive at a stationary debt-to-GDP level. In technical terms, this means that the debt level is sustainable whenever $r - y - \rho < 0$.

4.1.2 Stochastic debt simulations

However, as described in Sections 2 and 3, debt sustainability should not be assessed in a deterministic setting, but in a dynamic setting that takes into account shocks to the economy and the expected policy response to assess upward risk. To do so, we run stochastic simulations.

We estimate the FRF from equation (2) to obtain the values for ρ and α and run simulations on the VAR model of equation (3) to generate a distribution of future effective interest rates and real growth rates.[14] These data is then plugged into equation (4) to generate a distribution of future expected debt levels. When we run multiple (i.e. 10,000 times) simulations we obtain multiple projection and create fan charts that provide information on the main path (the median of the distribution) and the volatility of future debt levels, which include the tails of the distribution.

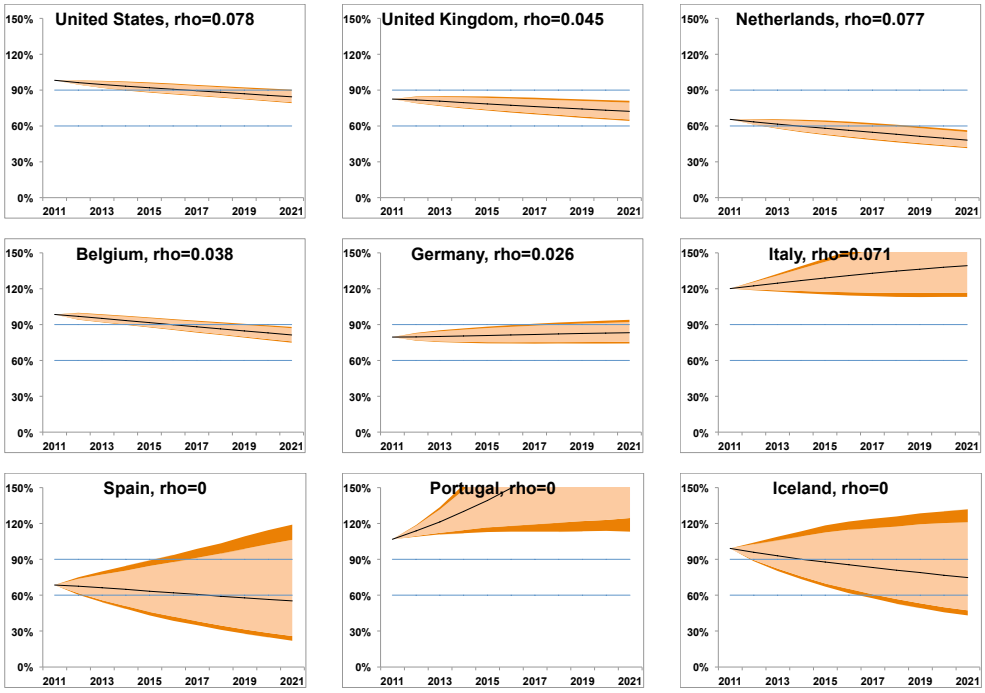
Using the data collected in Lukkezen and Rojas-Romagosa (2013) until 2011 for a set of OECD countries, we produce the stochastic debt projections shown in Figure 1. Here we observe that for the first five countries: United States, United Kingdom, the Netherlands, Belgium and Germany, projected median debt levels are decreasing (for all cases but Germany) and have relatively low variability: the 95% band width of future debt levels are close to the median values. On the other hand, the remaining countries (Italy, Spain, Portugal and Iceland) show high volatility and in the case of

[14] Cf. Lukkezen and Rojas-Romagosa (2013) for the specific details, estimation techniques and robustness analysis on the FRF and the VAR model.

Portugal, an explosive debt path. Since these results –using data until 2011– include the consequence of the Euro-area crisis, in Figure 2 we include simulations that use data until 2007 and then project debt paths until 2017. Here we observe that the bandwidth of the projected debt levels is significantly decreased as the relatively historically high effective interest rates and low real growths experienced after the 2008 global financial crisis are not included in the VAR model.

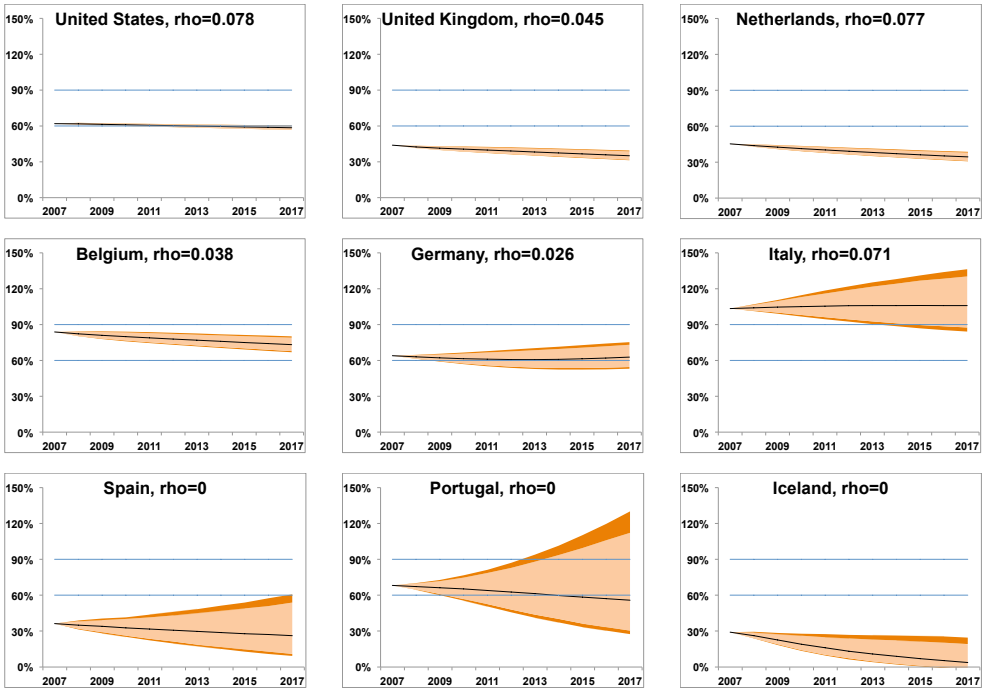
Note that for some countries the median debt levels are decreasing over time. This pattern may seem counter-intuitive following recent debt increases in these countries. But it is important to keep in mind that we are performing a medium term analysis based on the historical levels and variability of the debt-to-GDP ratios, effective interest rates and real growth rates. Therefore, the auto-correlation process implicit in the simulations are translated in the projections of these variable returning to their historical levels. This is the assumption behind debt sustainability: after a positive or negative shock to debt, changes in policy (the fiscal reaction coefficient ρ) or economic circumstance (e.g. the Aaron condition) should return government debt to their historical levels. Otherwise, if the median debt level projections are steadily increasing over time, this means that the country is an explosive debt path with very clear debt sustainability problems.

Figure 1: Stochastic debt projections for selected countries 2011 to 2021, with 25 year sample



Notes: ρ denotes the estimated fiscal response. The dark orange band with p<0.95 encompasses also the light orange band with p<0.90. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

Figure 2: Stochastic debt projections for selected countries 2007 to 2017 with 25 year sample



Notes: ρ denotes the estimated fiscal response. The dark orange band with p<0.95 encompasses also the light orange band with p<0.90. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

However, it is important to note that even in 2007 the debt projections still identify those countries that had sustainability concerns in the crisis: Italy, Spain, Portugal, from those that did not: the United States, United Kingdom, the Netherlands, Belgium and Germany. The exception is Iceland, for which there was no indication (using the 2007 projections) of the future debt crisis. This is explained by the fact that the fiscal and debt problems in Iceland were triggered by its banking crisis. Thus, this case illustrates the importance of including additional factors into the debt sustainability analysis.[15]

4.1.3 Estimation of the SEI

The core Sustainability Early-Warning Indicator (SEI) is based upon the stochastic debt simulations and it is defined as follows:

$$SEI = d_{t+10}^{97.5\%} - d_{t+10}^{50\%}, \tag{5}$$

where $d_{t+10}^{97.5\%}$ is the 97.5th percentile of the simulated distribution of d_{t+10} and $d_{t+10}^{50\%}$ is the median.[16] The SEI, therefore, denotes the upward risk of deviating from the median debt level 10 years into the future in our debt simulations. Note that SEI is based on the debt-to-GDP rations (d), and as such, it is a "normalized" value that can be compared across countries.

The advantage of this indicator is that it takes into account the impact of stochastic events on the simulated debt path, while implicitly considering the fiscal policy response – included in the value of ρ– that underlies each simulated debt path. For instance, when countries have a significant and positive fiscal reaction coefficient (ρ), the median debt path is usually lower and has narrower bands than when $\rho = 0$).

In addition, the SEI is not directly related with the country-specific debt levels, even when it implicitly includes the projected debt levels dynamics that arise from the debt levels from previous years. This feature makes the SEI a country-specific instrument (i.e. it does not rely on an arbitrarily defined debt level threshold) but it does consider the implications of the previous debt variations. For instance, a country with a high debt level that has experienced a reduction of its debt in previous years will yield a low SEI value.

Table 3 uses the previous data for nine OECD countries and shows the SEI values when using 2011 as the last year with available data and projecting the debt levels until 2021. While Table 4 is the equivalent estimations but using 2007 as the last year with available data and projecting the debt levels until 2017.

Again, it is clear from the SEI values in both tables that the group of countries that did not experience debt problems after 2008 can be easily recognized from those that did. This applies also when using the earlier 2007 data sample in Table 4.

[15] For instance, we discuss the effects of banking crisis on debt sustainability in Section 4.3.

[16] The decision to use specifically the 97.5% value is arbitrary, but the relative values of SEI and its informative value does not change if we use thresholds that are close to this value, such as 95% or 99%.

Table 3: Summary of simulation outcomes for 2021, with a 25 year sample

	2011	2021		ρ value
	debt level	debt level	SEI	
US	101.7	89.1	5.7	0.078
UK	82.5	73.2	8.4	0.045
NL	65.5	49.8	8.2	0.077
BE	98.5	83.0	6.4	0.038
DE	79.5	82.9	10.4	0.026
IT	120.1	138.0	33.4	0.071
SP	68.5	56.5	57.9	0
PT	106.8	198.9	174.3	0
IC	99.2	76.8	53.2	0

Notes: Units are percent of GDP. SEI is the estimated Stochastic Early-Warning Indicator. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

Table 4: Summary of simulation outcomes for 2017, with a 25 year sample

	2007	2017		ρ value
	debt level	debt level	SEI	
US	65.4	62.3	1.8	0.078
UK	43.9	35.9	4.1	0.045
NL	45.3	35.2	4.0	0.077
BE	83.9	74.1	6.7	0.038
DE	63.9	62.0	12.1	0.026
IT	103.4	105.9	28.0	0.071
SP	36.3	27.1	30.4	0
PT	68.3	57.1	62.6	0
IC	29.1	5.3	20.1	0

Notes: Units are percent of GDP. SEI is the estimated Stochastic Early-Warning Indicator. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

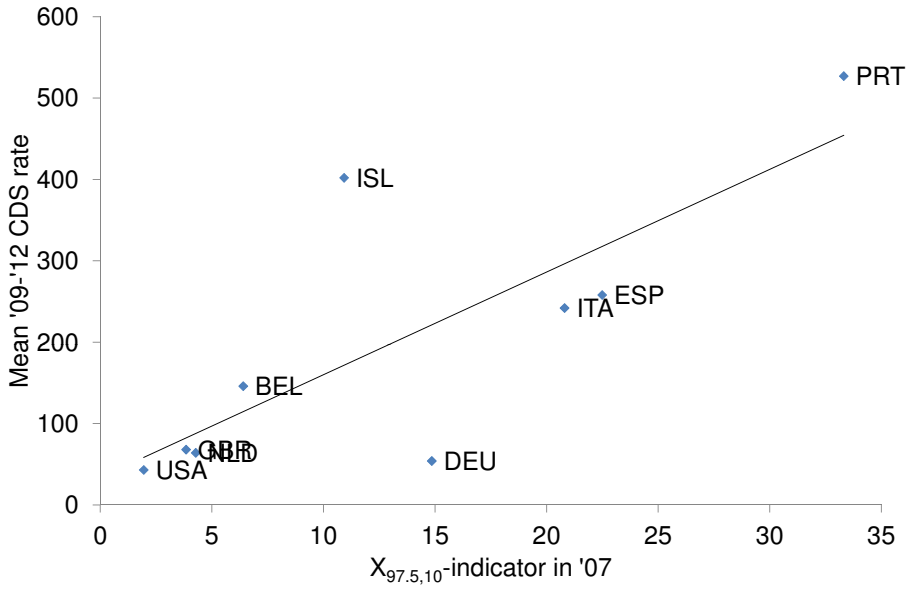
Moreover, in both tables we include the estimated ρ value, and we find that there is also a correlation between having a positive and significant fiscal reaction coefficient (i.e. with $\rho > 0$) and a low SEI value. The exception is Italy, which has a relatively high SEI value and a strong fiscal reaction coefficient. However, this may also explain in part why Italy did not have a debt restructuring even when it was under pressure by international markets.

To check whether SEI can be used as an early-warning indicator, Figure 3 plots the SEI –based on data until 2007– against the average sovereign credit default swaps (CDS) rate between January 2009 and November 2012. We find a high correlation of 0.78 indicating a strong predictive power of our sustainability indicator. While

the correlation of SEI using 2011 data has a correlation with the mean 2009-2012 CDS spread of 0.92.

On the contrary, in 2007 there was hardly any variation in sovereign CDS spreads. Hence, our indicator in 2007 was, with the benefit of hindsight, more informative than the market based data on the fiscal stress that occurred after 2008. It clearly shows that Portugal and Spain –and to a lesser extent Iceland and Italy– and Spain had relatively high SEI values in 2007 that could predict the debt sustainability problems that occurred later on.

Figure 3: CDS rates in the crisis versus SEI prior to the crisis



Source: Rates in basis points for 5 year CDS from Datastream, observation window Jan-09 to Nov-12, indicators in percentages.

Finally, using the information from Table 4 and additional robustness tests that are further explained below. We propose that a flag system can be used to guide the interpretation of the SEI values. In particular, we propose that values of SEI below 20 are given a green flag (i.e. no foreseeable problems), values between 20 and 50 are assigned a yellow flag (moderate debt sustainability problems), and values above 50 are given a red flag (serious debt sustainability issues). Recall that the SEI estimation is based on debt-to-GDP ratios, and as such the recommended thresholds of 20 and 50 are directly comparable between countries.

4.1.4 Data requirements for estimating the SEI

Even though we presented results for only nine OECD countries, in principle the SEI can be estimated for other OECD countries, emerging economies and developing countries. However, a very important element in the construction of the SEI is data availability. First, the estimation of the fiscal reaction function from equation (1) requires historical time series –spanning at least 40 years or more– to yield reliable ρ estimates (cf. Lukkezen and Rojas-Romagosa, 2013). With shorter series, ρ will not pick up the institutional attitude towards debt sustainability in a country, but most probably the medium-term responses to the business cycle and fluctuations on temporary government expenses.

Secondly, the number of years that are used to estimate the volatility in the VAR model from equation 2 is crucial for the results. Having long available time series matters. For instance, the results presented so far use a 25-year sample. In the Appendix we show that estimating the VAR model with a 15-year sample renders the debt simulation fan charts and the SEI values non-informative (see Figures 4 and 5, and Tables 5 and 6). In particular, the bandwidth of the stochastic debt projections is greatly reduced, and this results in SEI values that are relatively low for all selected countries.[17] In the case of data estimated until 2007, the bandwidths are extremely low, as well as the SEI values, reflecting the abnormal relatively low interest rates experienced by debtor countries and relatively high real growth rates brought by the different asset bubbles that busted after 2008.

On the other hand, using a longer sample of 35 years (see Figure 6 and Table 7), clearly reinforce the information about future debt problems provided by both the fan charts and the SEI values that use a 25-year sample.

In addition, given the data availability problems mentioned above, we can only use yearly data to estimate SEI. In practical terms this means that the indicator can only be estimated for a particular year with a delay –usually one or two years– depending on how fast and frequently the data sources used are updated. This also means that any SEI estimated for any particular country can hardly incorporate short-term events and this is another reason why the SEI cannot be used directly as the signal to start restructuring talks.

In the case of emerging economies and less-developed countries, data availability can become a serious constraint to the analysis. For these countries the basic data will still be necessary (i.e. debt levels, nominal and real GDP, primary surplus and interest payments) but the sample size can be shorter to focus only on macroeconomic volatility, while the fiscal reaction coefficient (ρ) can be assumed to be zero (for countries with historical debt sustainability problems) or positive otherwise (based on estimated ρ values for comparable countries).

To sum up, the availability of data becomes crucial to estimate our SEI. In particular, long time series are required on gross debt (preferably at the general government level, but central government level data is also valuable), total fiscal

[17] The exception is the United States, which experiences a surge in the bandwidth due to recent debt dynamics that moved contrary to its historical trend.

surpluses, primary surpluses (or data on interest payments), and nominal and real GDP levels (or data on the GDP deflator). Following our own estimations and robustness tests, we consider that time series of at least 25 years are required to run the VAR model and debt simulations. The estimation of the FRF requires longer data, but in its absence, assumptions about the value of ρ can be made: countries with a record of debt crisis very likely have $\rho = 0$, while countries with a long track record of debt responsibility and sustainability can be assigned a positive ρ value equal to the estimated value for other countries with similar characteristics.

4.2 External issues and currency crisis

So far, our analysis has focused mainly on fiscal issues related to fiscal policy responses, debt dynamics and the volatility in interest and growth rates. However, a large and increasing number of countries borrow in international markets. This creates additional mechanisms through which debt crisis may appear. In particular, this has been the main trigger of debt crises in the past for emerging and advanced economies.

The share of debt that is issued in a foreign currency, in particular, puts additional pressures on the economic viability of sovereign's servicing this type of debt. The government not only requires the usual interest payment and primary surpluses to pay back debt, but they need foreign currency to pay for the share of debt issued in foreign currency.[18] A special case are currency union members, such as the Euro area countries, where particular countries have debt in a currency that they do not fully control –i.e. the Central Bank functions are decentralized in an international setting in which each country cannot directly implement monetary policies on its own.

Foreign currency is available from different sources: capital inflows (both on short, medium and long term assets, including FDI), foreign reserves held by the Central Bank and/or government (including relatively liquid foreign assets), exports and remittances (including tourism services) and official international aid. The sources and relative importance of each potential source vary by country and by country category. Most advanced economies rely mainly on capital inflows of different maturities, while emerging economies are more dependent on short and medium term inflows, and exports. Relatively poor countries, on the other hand, are relatively more dependent on official aid and in some cases, remittances.

4.2.1 Expanded indicator with external variables (SEI-X)

We expand our core SEI indicator to capture the relative importance of debt denominated in foreign currency and the country-specific sources and dynamics of foreign currency availability and external unforeseen shocks. We denote this indicator as SEI-X.

[18] Accordingly, the amount of debt that is held by foreign nationals is directly related to the share of debt that has to be paid using foreign currency.

Hence, we add two variables to the dynamic debt-to-GDP equation (4) as follows:

$$d_{t+1} = (1 + r_t - y_t)(1 - \rho)d_t(1 + f_t\phi) + \eta_t \tag{6}$$

where f_t is the share of total debt d that is issued on a foreign currency in period t and ϕ is an estimated parameter that captures the probability of a country entering a currency crisis.[19] Thus, countries with no debt issued in foreign currency will have $f_t = 0$ and the estimation of future debt levels ($d_{t+1}...d_{t+j}$) will not change with respect to the simulated debt levels used in the core SEI.

However, for countries that have foreign denominated debt, then future debt levels will be conditional on the relative importance of this foreign debt and the probability of a currency crisis (ϕ). The crucial element will then be the estimation of this parameter.

One option is to use a stochastic analysis that relies on the total sum of foreign currency inflows (including all sources) plus the foreign currency reserves over time. We define this total value as X, which will include the main sources of foreign exchange by country, and thus, is able to account for country-specific particularities in the way each economy acquires foreign currency. For instance, X can be estimated as the changes in the current account balance plus the foreign exchange reserves in the Central Bank. Although adjustments and additions can also be made to account for country-specific sources of foreign currency (e.g. liquid assets in foreign exchange).

Once we have constructed a time series for X, we can associate ϕ with the fluctuations of these foreign currency values. Here we can then follow the sudden stop literature (Calvo, 1988; Calvo et al., 2004), which defines the start of a sudden stop as a one standard deviation drop in the year-on-year capital flows below the sample media, and a sudden stop episode as a period with at least one year with a drop of two standard deviations below the media. Hence, we can assign specific values of ϕ that are defined in a continuous range, such that $\phi = 0$ when the estimated value of X is above or equal to the sample mean, $\phi = 0.1$ when there is a year-on-year drop of one standard deviation, and $\phi = 0.5$ when the X drops by two or more standards deviations above the sample average.

Once the values of f and ϕ are calculated, then we proceed as before: the estimated ρ values from the FRF are combined with the r and y simulated values from the VAR model to obtain the projected debt levels, which in turn are used to estimate the new SEI-X values.

The advantage of this approach, is that again it will be country-specific and will directly target the importance of foreign debt (f) and the country-specific sources of foreign currency (X).

In this context, the interpretation of future debt levels is not the same as in the original equation 4, since the foreign/external component $(1 + f\phi)$ adds to future debt levels even when it is not directly increasing the official debt levels recorded in

[19] Alternatively, in a non-stochastic setting, ϕ can be seen as the expected depreciation of the domestic currency vis-a-vis the currency in which debt is denominated.

equation 4. Therefore, a combination of high f and/or ϕ values, will directly add pressure to the estimated future debt levels that are simulated to calculate SEI-X.

Finally, an alternative is to use the foreign/external component $(1 + f\phi)$ as an independent indicator that can be used as a "red flag" to assess the importance of currency crises on debt sustainability.

4.2.2 Data and calibration issues regarding SEI-X

In principle, it should be straightforward to construct time series to estimate SEI-X. Balance of payments and current account data are consistently compiled by national and international organizations (e.g. IMF, OECD) and these data can be directly used to construct time series for X. The share of public debt that is denominated in a foreign currency (f) is usually also available for most countries, and in this case, it is not necessary to have time series values, although it will add extra information to the analysis.

The main issue will be to have long enough X time series that allow for a proper calibration of the crisis parameter ϕ. This exercise will require the compilation of data –both X and f– for countries that have experienced currency crisis in the near past, and then define the values of the external component $(1 + f\phi)$ experienced by these countries as benchmarks that can be used to define threshold values or red flags –if the external component is used as an independent indicator– or the calibration of ϕ that produces informative values of SEI-X that are comparable with the SEI values of countries that have experienced debt sustainability issues.

4.3 Banking issues

A large and excessively leveraged banking sector constitutes is a contingent liability for government finances (Gray et al., 2008). Even when there are usually no explicit clauses or institutional frameworks on bank bailouts or large subsidies for stabilizing a financial sector in distress, the reality is that there are implicit liabilities –in addition to explicit deposit insurance and other insurance schemes. These contingent liabilities from the banking sector can exert pressure on public finances and if they materialize, they could trigger a debt crisis on its own. The recent experiences of Iceland and Ireland are clear examples of countries with relatively stable debt levels that experienced a debt crisis in the aftermath of a banking crisis.

In principle, $\mathbf{Z}$ in the estimation of the fiscal reaction function in equation (2) already captures fluctuations in temporary government expenditure ($GVAR$) that are related to unexpected events. [20] For example, in the case of the US and the UK $GVAR$ is associated with military expenditure during the war. For other countries $GVAR$ is associated with temporary increases in public expenditure related to automatic stabilizers. Thus, in so far as banking bailouts and subsidies to the banking

[20] Lukkezen and Rojas-Romagosa (2013) provide an in-depth explanation of the characteristics and calculations of $GVAR$.

sector are a "normal" part of the business cycle, this is captured. However, expenditure increases associated with banking crisis usually go beyond cyclical fluctuations in $GVAR$ and can directly trigger a debt crisis.

The critical element in the relation between banking and debt crisis is the relative size of the banking sector with respect to the rest of the economy. For instance, even when the US subprime mortgage crisis forced the US to bail-out its financial sector, which resulted in a surge in temporary government expenditure, this did not prompt public debt concerns and the effective interest rate on its debt decreased even. Actually, interest rates where low by historical standards and –as shown in our debt sustainability analysis in Section 4.1– projected debt levels are still sustainable and with low variability for the US.

4.3.1 Expanded indicator with banking variables (SEI-B)

To account for the contingent liabilities that the banking sector represent to public debt sustainability, we expand our estimation of future debt paths as follows:

$$d_{t+1} = (1 + r_t - y_t)(1 - \rho)d_t(1 + b_t\beta) + \eta_t \tag{7}$$

where b_t is a size measure of the contingent liability from the banking sector with respect to GDP in period t and β is an estimated parameter that captures the probability of a banking crisis occurrence.

Next, we proceed as before and combine the FRF estimations and the VAR simulations to estimate equation 7. The resulting projected debt path over 10 years is then used to calculate SEI-B.

Using this setting, we account for country-specific characteristics of the relative size of the banking system and the potential risks it faces, which can complement the information provided by the core SEI.

Alternatively, the banking component: $(1 + b_t\beta)$, can also be used as an independent indicator that acts as an early-warning indicator on the potential liabilities that public finances may suffer if the country experiences problems in its financial sector.

4.3.2 Data issues regarding SEI-B

To assign values to the banking parameters b and β we can use indicators already constructed in the literature. For instance, Borio and Drehmann (2009) propose indicators that asses the risk of banking crisis that can be used to assign values to β. Moreover, these authors also show that these indicators performed well out-of-sample and thus, can be used as early-warning for the risks of banking systems.[21]

Different common indicators can also be used to assign b values. Our preferred indicator will be banking sector Tier 1 capital relative to GDP. But other indicators can also be used, such as: foreign lending and private debt to GDP ratios.

[21] They also show that their indicators exhibit comparatively low noise-to-signal ratios.

As with the external component, the estimated values of $(1 + b_t\beta)$ need to be calibrated to past banking crisis in order to find threshold values than can guide policy and also, that provide SEI-B values that can be comparable to the core SEI values for countries with debt problems.

5 Application of the system of indicators and further recommendations

In this section we first propose how to apply our system of debt vulnerability indicators, then propose a mechanism to initiate a debt restructuring process and finally discuss applicability to emerging market economies.

5.1 Application of our system of debt vulnerability indicators

Based on the IMF and World Bank framework (IMF, 2013) we propose the use of "flags" to identify problems indicated by each of the three components of our system of debt indicators: SEI, SEI-X and SEI-B. This system of early-warning indicators is based on a sound economic analysis, grounded firmly in recent literature and constructed to fit country-specific circumstances and characteristics. In the case of the core SEI measure, we use as reference the results presented in Section 4.1 and propose the following thresholds: values of SEI below 20 are given a green flag (i.e. no foreseeable problems), values between 20 and 50 are assigned a yellow flag (moderate debt sustainability problems), and values above 50 are given a red flag (serious debt sustainability issues). The same system can be applied to either the integrated SEI-X and SEI-B indicators –i.e. when both the external sector and banking sector components are directly integrated into the SEI estimations– or to the use of the external and banking components as separate indicators. In both cases, and as explained above, the exact threshold values should be estimated and then calibrated to recent currency and banking crises. In addition, since our core SEI values were calibrated using only a sample of OECD countries, it should be estimated on a broader set of advanced, emerging and developing countries as well. This would enable us to assess the robustness and practicality of the threshold values we suggest above.

Once this system of debt indicators is estimated and calibrated, it must face international scrutiny and evaluation. In particular, the use of the signal-to-noise ratio –which is based on the usefulness of an indicator for predicting a crisis (see Section 3.2)– can be used to improve the performance of our system of indicators for early warning purposes.

Nevertheless, it is important to keep in mind that our indicator cannot be directly used as a signal to start debt restructuring talks. As explained above, it could become self-fulfilling and the annual frequency of the data that is used to construct it, limits its capacity to timely incorporate short-term shocks. Moreover, no early-warning debt indicator will rule out all debate on whether debt is sustainable or

if restructuring is necessary. The SEI is a vulnerability indicator that provides information on the probability of a debt crisis occurring *if* there is a triggering event. As such, it can only signal debt problems or vulnerabilities within the current debt dynamics, but it cannot be used to determine when restructuring talks should start. In this regard, the flag-system proposed here are an instrument to guide this debate, not a replacement of the debate. For instance, countries flagged as "red" using our system of indicators could eventually last several years *without* a debt crisis occurrence.

Our system of indicators, moreover, does not provide appropriate information as to *how* a restructuring process may be conducted. Our indicator is an early-warning instrument that provides information on the likelihood of a crisis occurring *ex-ante*, but is not well suited to analyse how the different components of public debt (i.e. maturity, different creditor groups, interest rates) should be restructured to assure that the *ex-post* debt path is sustainable.

5.2 Proposed procedure to start restructuring talks

As explained in Section 2 the occurrence of a debt crisis requires two elements: a country that is vulnerable to a debt crisis and an unexpected negative shock that triggers the crisis. Our system of indicators can be used to assess the first element and provide an economic assessment of the vulnerability of debt of a given country. However, as economic history has proven, it is usually the second element: an unexpected negative shock, or in other words a triggering event, which ultimately makes a debt crisis inevitable and forces a country and/or its debtors to seek debt restructuring.

A necessary complement to our system of indicators is therefore a mechanism in which countries that show debt vulnerability problems are evaluated after they have been hit by a large negative shock. This task should be done by an independent third-party institution that has the authority to make the decision to officially start a formal debt restructuring process.[22] It is important to note, that this decision is subjective and depends on the interpretation of the short-term shocks and the economic and politically implications they carry.

In this context, it is necessary to define what a "triggering" effect is. In a first approach, a triggering effect can be defined as an unexpected negative shock that has a direct negative impact on the debt level of the country or its debt servicing capacity. For example, for a country that has a relatively high SEI, which is classified as a red flag, any shocks that negatively affect public finances could be considered triggering events. Whereas for a country with a fragile banking system, a shock to international capital markets would be classified as a triggering event.

Based on recent crisis experiences, and according to the different components of our system of indicators (SEI), one can think of three main categories: internal shocks, external shocks and banking shocks. Internal shocks relate to unexpected

[22] As argued in the accompanying legal paper, the default decision should be made by the sovereign, so we focus here on the start of the restructuring process.

events in the domestic economies, such as political issues (e.g. a GDP slump created by political unrest or civil war), natural disasters (that either require unexpected government expenditures and/or cause a strong reduction in output), or fiscal negative events (sudden reduction of government revenues or increase of public expenditure, for instance, created by a need to finance pension funds in distress). External shocks are unexpected international events that directly affect a particular country – e.g. an abrupt decrease in export demand, remittances, indirect effects of global recessions or sudden stops of foreign capital flows. Finally, the third category of banking shocks includes both national banking crises and international crisis that spread into the local financial system.

Recent economic history suggests that such triggering events can be associated with precise shocks. For example, the Lehman Brothers bankruptcy in 2008 and the consequent crisis in the international banking system can be considered as a triggering event, which ultimately resulted in the debt crises in Ireland and Iceland. Another example is the announcement of the Greek government in 2009 that its published fiscal accounts did not conform to reality, triggering the Greek debt crisis in 2010. And finally, spill overs from Greece in a very risk averse market could be considered triggers for Spain and Portugal.

Both components of our proposal for a debt restructuring mechanism –i.e. our early-warning indicator SEI and identifying triggering events– are interrelated. Countries with SEI "red flags" should be the main focus of attention when evaluation the consequences of an unexpected negative shock. The higher the SEI value, the more likely a particular shock will become the triggering event. On the other hand, both components of our proposals are very different in nature. The SEI is a technical and data-based indicator that could be estimated by an independent economic organization, which also needs to be able to collect, evaluate and update the data required to estimate the SEI.[23] On the other hand, identifying a triggering event is a more subjective task that implies short-term valuations of economic and political circumstances and how they interrelate with debt sustainability. [24]

Next, the value of an early-warning indicator relies as much on its intrinsic capacity to predict debt crises, as on its acceptance among international organizations, and international lenders and borrowers. Thus, any debt restructuring mechanism to be developed that uses early-warning debt indicators should devote some time and energy developing an institutional framework that guarantees the validity, acknowledgment and consistency of these indicators. We suggest that this third-party institution should also be responsible for the system of debt vulnerability indicators. This institution should regularly update and maintain these indicators, and thus have access to sufficient data sources and economic expertise. Furthermore, our

[23] In fact, data collection is a crucial and a large task in itself.

[24] In principle, this second component is currently done *de facto* by the IMF –but without an explicit legal multilateral agreed international framework. However, given that the IMF is also the prime lender to distressed nations, there is a conflict of interests. This makes the IMF a less than ideal organization for this task.

proposal also implies that a legal structure, with directing principles and guidelines for these indicators, should be created to support the whole system.

5.3 Application to emerging market economies

Even though we have presented results for only nine OECD countries, our indicators can be estimated for emerging economies as well. Nevertheless, data availability generally is a serious constraint to the analysis. For emerging economies the basic data will still be necessary (i.e. debt levels, nominal and real GDP, primary surplus and interest payments) but the sample size can be shorter to focus only on macroeconomic volatility, while the fiscal reaction coefficient (ρ) can be assumed to be zero (for countries with historical debt sustainability problems) or positive otherwise (based on estimated ρ values for comparable countries). This, coupled with a shorter projection horizon, might allow us to draw some conclusions still.

As an example, the cases of Argentina in 2000 and Turkey in 1999 are illustrative. Celasun et al. (2006) analyse the vulnerability of sovereign debt using a stochastic simulation very similar to our approach. Using their data and estimations for Argentina, Brazil, Turkey and South Africa in 1999 and 2000, we can obtain a measure similar to our SEI indicator.[25]. This indicator has the following values: 55% for Argentina, 45% for Turkey, 25% for Brazil and 10% for South Africa. Showing debt vulnerability problems in Argentina and Turkey, with Brazil having also some upward risks.

In our proposed mechanism, Argentina and Turkey's situations would have received a red flag and Brazil's a yellow flag. Then after a triggering event, debt vulnerability should be reassessed in the first two countries and a judgment made by an independent organization whether to organize a meeting of debtors and creditors. For Argentina, the run on the banks to convert Argentinean pesos by the end of November 2001 could have been interpreted as a triggering event. Alternatively, the *corralito* on the 2nd of December or the IMF's decision not to release aid to Argentina on the 5th of December could also have been interpreted as such. This might not have stopped the default by the end of the month, but would surely have led negotiations to start earlier than they did: until three years later in January 14th, 2005. In Turkey's case, definitely less spectacular, the large quarter-on-quarter depreciations of the currency in 2000 and 2001 could have constituted a triggering event had the IMF not intervened by offering a large stabilization loan in return for a reform program.

[25] In particular, their Figure 4 on page 27 presents fan charts on debt projections, from which we can estimate a SEI indicator for 5 years in the future –instead of the 10 years we use above. This version of the SEI indicator will be defined as: $d_{t+5}^{90\%} - d_{t+5}^{50\%}$.

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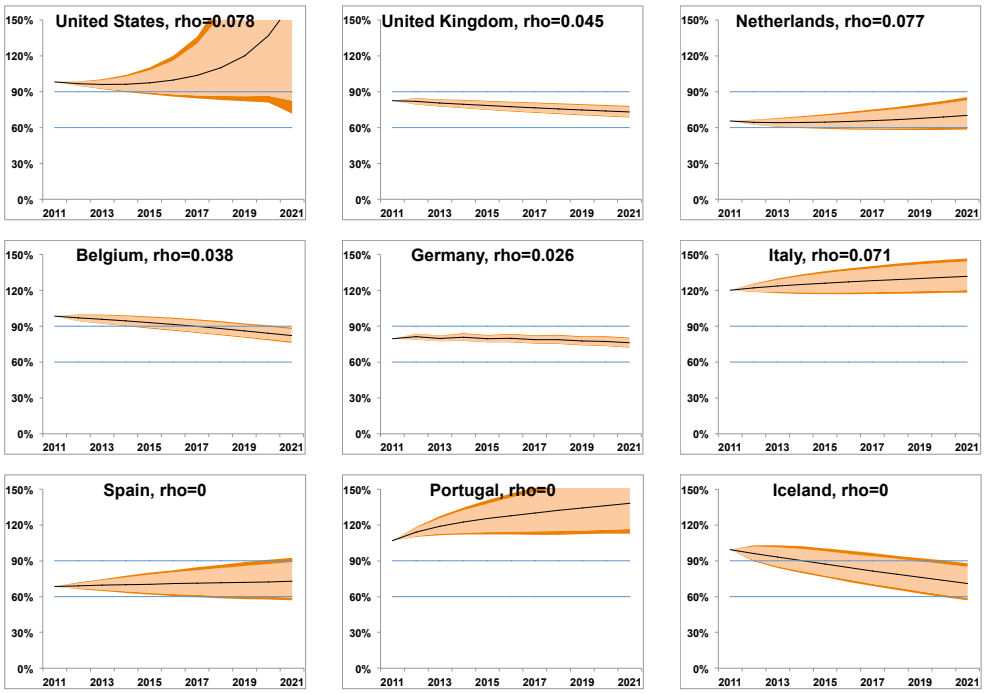
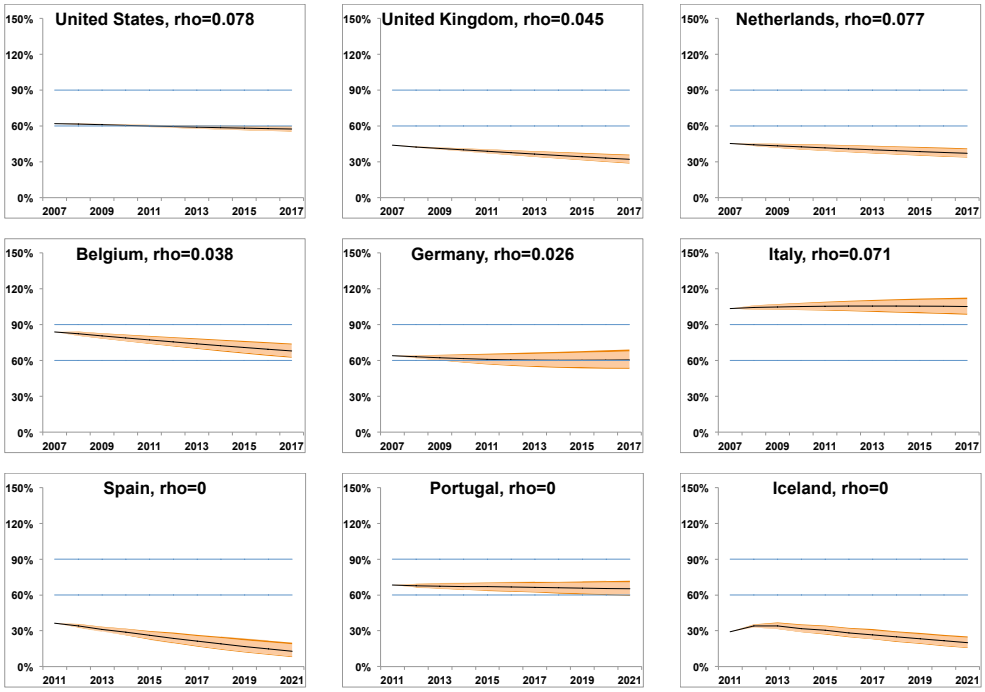
A Appendix

Figure 4: Stochastic debt projections for selected countries 2011 to 2021, with 15 year sample



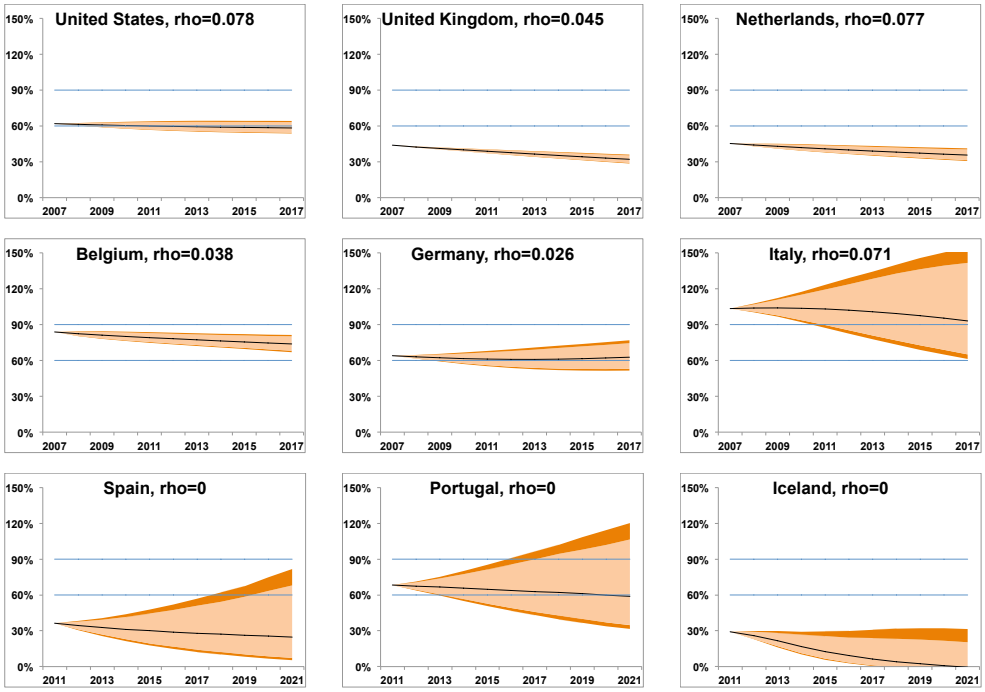
Notes: ρ denotes the estimated fiscal response. The dark orange band with p<0.95 encompasses also the light orange band with p<0.90. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

Figure 5: Stochastic debt projections for selected countries 2007 to 2017 with 15 year sample



Notes: ρ denotes the estimated fiscal response. The dark orange band with p<0.95 encompasses also the light orange band with p<0.90. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

Figure 6: Stochastic debt projections for selected countries 2007 to 2017 with 35 year sample



Notes: ρ denotes the estimated fiscal response. The dark orange band with p<0.95 encompasses also the light orange band with p<0.90. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

Table 5: Summary of simulation outcomes for 2021, with a 15 year sample

	2011	2021		ρ value
	debt level	debt level	SEI	
US	101.7	140.4	295.8	0.078
UK	82.5	73.9	5.0	0.045
NL	65.5	68.9	13.5	0.077
BE	98.5	84.2	6.5	0.038
DE	79.5	77.3	4.3	0.026
IT	120.1	130.8	14.6	0.071
SP	68.5	72.4	18.5	0
PT	106.8	136.3	28.9	0
IC	99.2	73.5	16.7	0

Notes: Units are percent of GDP. SEI is the estimated Stochastic Early-Warning Indicator. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

Table 6: Summary of simulation outcomes for 2017, with a 15 year sample

	2007	2017		ρ value
	debt level	debt level	SEI	
US	65.4	61.3	2.0	0.078
UK	43.9	33.2	3.6	0.045
NL	45.3	37.8	4.0	0.077
BE	83.9	69.4	5.9	0.038
DE	63.9	60.3	8.2	0.026
IT	103.4	105.3	6.8	0.071
SP	36.3	14.7	6.9	0
PT	68.3	65.5	6.2	0
IC	29.1	21.5	5.0	0

Notes: Units are percent of GDP. SEI is the estimated Stochastic Early-Warning Indicator. Source: Own estimations using data collected in Lukkezen and Rojas-Romagosa (2013).

Table 7: Summary of simulation outcomes for 2017, with a 35 year sample

	2007	2017		ρ value
	debt level	debt level	SEI	
US	65.4	62.0	5.7	0.078
UK	43.9	35.9	9.4	0.045
NL	45.3	36.4	5.3	0.077
BE	83.9	74.6	7.0	0.038
DE	63.9	62.1	13.3	0.026
IT	103.4	95.4	54.9	0.071
SP	36.3	25.5	49.3	0
PT	68.3	59.9	54.4	0
IC	29.1	0.7	31.4	0

Notes: Units are percent of GDP. SEI is the estimated Stochastic Early-Warning Indicator.