

The Signalling Role of Fiscal Austerity

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Abstract

I build a model where creditworthy countries use fiscal austerity to communicate their ability to repay sovereign debt. I show that the signalling channel is active only for high levels of asymmetric information. The model generates *ceteris paribus* a negative association between the amount of public information (provided by the rating agencies) and fiscal tightness. Informed by the model predictions, I run panel data regressions on 58 OECD and emerging market economies since 1980 and find evidence of the signalling channel.

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1 Introduction

In this paper I investigate the role of fiscal austerity as a signal to communicate credibly a sovereign's ability to pay back its debt. Austerity has been at the forefront of the debate on public policies in the aftermath of the European sovereign debt crisis. It refers to a combination of measures aimed to reduce a country's deficit. The reduction of the government deficit also implies a consolidation of the debt burden. Most of the discussion about austerity measures has indeed revolved around the issue of debt sustainability (Blanchard, 1990, Corsetti and Roubini, 1991, Afonso, 2005, ECB, 2012, Contessi, 2012, Polito and Wickens, 2011). After 2010, a number of countries that engaged in sizeable austerity were considered to be in the safe European 'core'. For instance, Germany announced plans to reduce the budget deficit by 80 billion euros by 2014. The UK embarked on the biggest cuts in state spending since World War II and the Netherlands also went through several austerity packages in spite of a relatively low ratio of debt to GDP.¹ The argument advocated by policymakers was that such measures reassured the markets about the country's creditworthiness and helped maintain access to international lending. In the words of Angela Merkel, the German Chancellor, *'austerity measures are adopted in order to send a very important signal'*;² or, as the British Chancellor of the Exchequer George Osborne put it: *'we have to convince the world that we can pay our way in the world.'*³

The objective of this paper is to study whether countries reduce their debt strategically to signal their creditworthiness. I build a model of sovereign debt that incorporates a signalling role for fiscal austerity and test the implications driven by the model in a panel of 58 countries since the 80s. Countries differ in their ability to repay their sovereign debt. The key feature is that the ability to pay is unobservable, hence it determines different types of countries that are not distinguishable to the lenders. For example, one could think of these types as different political preferences of the citizens regarding the trade-off between public spending

¹'EU austerity drive country by country', BBC News, 21 May 2012.

²'Merkelettes' Siren Song Sounds Very German', The Wall Street Journal, 12 July 2011.

³'Sterling hits two-year low after Moody's UK downgrade', The Telegraph Investor, 25 February 2013.

and debt repayment. Certain countries have been more resilient than others to accept tax increases or expenditure reductions. Anecdotal evidence tells us that attempts to cut public wages and reform the pension system were met with social protest in Portugal and had to be abandoned.⁴ Similar measures have been successfully implemented in other countries, like Italy or Spain. An alternative way to view these types is related to a country's degree of tax evasion. Sovereigns might not be equally efficient in levying taxes and fighting evasion from their tax payers and this limits their ability to pay.

The economic mechanism is similar to Spence's signalling model of education (Spence, 1973), in which a more able individual has a lower cost of doing an action (getting education) and uses this choice to convey information about its ability. However, debt is endogenous in my model. I derive the conditions that satisfy the single-crossing property, which enables me to find a separating equilibrium as in Spence (1973). The separating equilibrium outcome is the following: more creditworthy countries choose to issue less debt than the optimum level under full information. A sufficient amount of austerity prevents less able countries to imitate this strategy, hence, the market rewards austerity with a lower risk premium on sovereign debt.

The model admits multiple equilibria. Selection is done using the undefeated equilibrium refinement by (Banks and Sobel, 1987). This concept is particularly useful to analyze the welfare properties of equilibria (Sobel, 2009). In my model, this refinement delivers a sharp empirical prediction: the nature of the equilibrium that prevails - separating or pooling - is uniquely determined by the amount of information about the country type. In a couple of extensions, I show how the perception about creditworthiness is affected by the information on sovereign ratings and, extending the set-up to multiple periods, how less informative ratings are linked to increases in austerity for signalling purposes.

In the empirical section I focus on two indicators of the amount of information about a country creditworthiness: the cross-sectional correlation between sovereign yields and

⁴'Portugal court rules public sector pay cut unconstitutional', BBC News, 6th July 2012.

sovereign ratings over time and a dummy for extreme sovereign yield changes conditional on the rating category. A large body of empirical literature has documented that the informativeness of the credit ratings changes over time (Partnoy, 2006, Kiff et al., 2012, Bussiere and Ristiniemi, 2012, De Santis, 2012). I abstract from the various explanations advanced to motivate the change in informativeness.⁵ and link the changes in the two information indicators along the time dimension and clustered at the rating category level to changes in the austerity performed by a country at a certain time. I exploit the panel dimension of the data to determine how the changes in deficit are associated with time and rating-varying information indicators. I also use the fact that the overall informativeness of the ratings is not likely to be affected by an individual country choice of fiscal policy.

I measure fiscal austerity with the following variables: the cyclically adjusted primary balance (CAPB), the government net borrowing, the net primary balance, the public spending and a dummy variable for fiscal consolidations based on the narrative approach by Devries et al. (2011). I find that the correlation between sovereign yields and ratings is negatively associated with all my measures of fiscal austerity. The coefficient remains significantly different than zero after controlling for other variables that are usually used in the literature estimating fiscal rules (Gali and Perotti, 2003, Favero and Monacelli, 2005, Baldacci et al., 2013). Further robustness checks discuss alternative hypothesis and favour the signalling channel as the most compelling explanation of the evidence.

Other papers have considered incomplete information in a model of sovereign debt. Both Sandleris (2008) and Drudi and Prati (2000) study how a sovereign default can be informative about the risk of a government to incur in default again in the future. Drudi and Prati (2000) model two types of government, one of which is always committed to repay its debt. They describe a case where the committed government runs a balanced primary budget and departs from perfect taxation smoothing. Fostel et al. (2013) argue that a weaker

⁵A non-exhaustive list of contributions include Bar-Isaac and Shapiro (2013), Holden et al. (2012), Manso (2013), Mathis et al. (2009), White (2010), Skreta and Veldkamp (2009), Josepson and Shapiro (2014), Opp et al. (2013) and Cole and Cooley (2014).

sovereign can experience a sudden stop without a formal default taking place. Dellas and Niepelt (2014) take one step further and endogeneize the government choice of debt. They provide a formal definition of austerity in the context of incomplete information as “the shortfall of consumption from the level desired by a country and supported by its repayment capacity”. In my set-up, this ‘consumption gap’ maps into a ‘debt gap’. In contrast, Dellas and Niepelt (2014) consider an environment with investment, in which austerity is compatible with an increase in the debt position. I depart from Dellas and Niepelt (2014) in three important aspects. Firstly, I consider a country’s amount of debt to be more observable than public investment or consumption, which are easier to hide or become known with a lag. Secondly, my treatment of the selection of equilibria is addressed through a refinement of the equilibrium definition, thus allowing the set of equilibria to be endogenously selected. Lastly, I perform an empirical analysis, based on an extension of my model that incorporates the sovereign ratings. To the best of my knowledge, this is the first empirical evidence of the signalling channel in fiscal policy.

The rest of the paper is organised as follows. In the next section I present the model and in Section 3 I characterise the equilibrium set. Sovereign credit ratings are introduced in Section 4.1, while Section 4.2 extends the full-fledged model to multiple periods. Section 5 is devoted to the empirical analysis. Section 6 concludes.

2 Model

Environment. Consider a two-period small open economy, where a sovereign borrower issues debt to the foreign lenders in order to maximize its citizens welfare.⁶ The sovereign country has limited commitment and defaults whenever it is not able to fully repay its debt. Depending on its ability to repay, the sovereign can be of two types, indexed by $i \in \{A, B\}$ with probability p and $1 - p$ respectively. Foreign lenders do not know the type of the

⁶Sovereign debt in the model is equivalent to external debt. Domestic debt does not play a role because the government has enough instruments to allocate consumption intertemporally for its citizens.

borrower.

Lenders' problem. Lenders are risk-neutral. They lend the amount qD_2 in period 1 to the sovereign, where q is the price of debt in period 1. If there is no default, they receive D_2 in period 2. In case of default, there is no partial repayment. The lender profit function is:

$$\Pi = -qD_2 + \beta' D_2[1 - \lambda(D_2, \mu)], \quad (2.1)$$

where β' is the lenders' discount factor, μ the probability that the borrower is of type A and $\lambda(D, \mu) = [\mu\lambda(D, 1) + (1 - \mu)\lambda(D, 0)]$ represents the expected sovereign's default probability at (D, μ) and will be precisely defined below. Lenders compete à la Bertrand over lending conditions driving profits to zero. As a result, the price function satisfies:

$$q(D_2, \mu) = \beta'[1 - \lambda(D_2, \mu)]. \quad (2.2)$$

Sovereign debt price responds to the amount of debt issued and the lenders' belief about creditworthiness. The higher the price is, the more advantageous are the borrowing terms for the sovereign.

Sovereign's problem. The problem solved by the sovereign government is to maximise citizens' expected discounted utility $c_1 + \beta\mathbb{E}[c_2]$, where β is the discount factor. The representative citizen has endowment ω_1 in period 1, and a random endowment ω_2 in period 2, which is drawn from an exponential distribution $f(\omega_2)$ with support $[\underline{\omega}, \infty)$, hazard rate h and cumulative function $F(\omega_2)$.⁷ Given the initial level of debt D_1 , the sovereign government chooses the debt level D_2 and taxes T_1, T_2 to satisfy the government budget.

⁷The exponential function $f(\omega) = he^{-h\omega}$ features a constant hazard rate, which is helpful in order to obtain a closed form solution for the equilibrium debt level.

Each country, of type $i = A, B$, that repays its debt satisfies the following constraints:

$$c_t \leq \omega_t - T_t, \quad \text{for } t = 1, 2; \quad (2.3)$$

$$T_1 \geq D_1 - q(D_2, \mu)D_2 \quad \text{and} \quad T_2 \geq D_2. \quad (2.4)$$

$$c_t \geq \underline{c}^i \quad \text{for } t = 1, 2. \quad (2.5)$$

Constraint (2.3) is the budget constraint of the respective citizens. Constraints (2.4) represent the government budget constraint in $t = 1, 2$. The initial level of debt D_1 is exogenous and $D_3 = 0$ since in the last period debt cannot be rolled over. It is easy to see that both (2.3) and (2.4) will be satisfied with equality. Hence, once the choice of D_2 is taken, taxes and consumption in $t = 1$ are fully pinned down under repayment. Constraint (2.5) introduces heterogeneity in the ability to pay across countries. It states that the sovereign government must guarantee to its citizens a consumption level of \underline{c}^i every period. Differences in the guaranteed level of consumption are the only source of ex-ante heterogeneity across countries.

We assume

$$\underline{c}^A < \underline{c}^B. \quad (A1)$$

Constraint (2.5), together with the budget constraint (2.3), imposes a cap on the ability to tax. Since \underline{c}^B is higher than \underline{c}^A , country B is less able to repay the outstanding debt than country A for the same level of income. Stated differently, all other things being equal, country B is less creditworthy.

In order to always guarantee the existence of a feasible allocation we assume the following

$$\underline{\omega} \geq \underline{c}^B. \quad (A2)$$

I assume away strategic default. Since $\omega_2 \in [\underline{\omega}, \infty)$, in the first period, a country will never default. Default will occur in period 2 for $\omega_2 \leq D_2 + \underline{c}^i$. If the second period endowment

realisation does not suffice to cover both the commitments versus foreign lenders and the domestic commitments on citizens' required consumption, the country defaults on its debt. Otherwise the country complies with its commitment. The probability of default for country $i = A, B$, with debt level D_2 is hence $F(D_2 + \underline{c}^i)$.

Our analysis will be confined to the range of parameters that satisfy

$$\underline{c}^B > \frac{\omega_1 - D_1 + \beta' \underline{\omega}}{1 + \beta'}. \quad (\text{A3})$$

This condition guarantees that type B debt is risky⁸ and it rules out the uninteresting case in which the two types have the same probability of default.⁹ By assumption (A1), $F(D_2 + \underline{c}^A) \leq F(D_2 + \underline{c}^B) \forall D_2$ and, by (A3), the inequality is strict. For any given debt level, a type A country is less prone to default. This predisposition to default is driven by unobservable fundamentals of the country - \underline{c}_i - but the type that actually defaults depends on the equilibrium choices and, ultimately, the endowment realisation.

In case of default, the citizens consumption is assumed to be \underline{c}^i and the lenders do not receive any repayment. The difference between the endowment realisation and consumption after default, $\omega_2 - \underline{c}^i$, is a deadweight loss. This assumption makes the lenders' pricing function more tractable. Finally, I assume

$$\beta' > \beta \cdot \frac{F(D_2 + \underline{c}^A)}{F(D_2 + \underline{c}^B)} = \beta \cdot e^{h(\underline{c}^B - \underline{c}^A)}. \quad (\text{A4})$$

Since $e^{h(\underline{c}^B - \underline{c}^A)} > 1$, it implies that the discount factor abroad β' is higher than the domestic discount factor β by a wedge that is high enough to compensate for the difference in risk premia across types. External lenders are willing to finance a type B sovereign at a rate that is attractive domestically for both types. This makes a sovereign country *willing to increase*

⁸The maximum level of debt that allows country B to be risk free in the second period is $D_2 = \underline{\omega} - \underline{c}^B$. Assume that this level (or a lower one) would be infeasible in the first period at the risk-free price β' : $\underline{c}^B > \omega_1 - D_1 + \beta'(\underline{\omega} - \underline{c}^B)$, or reformulated, $\underline{c}^B \geq \frac{\omega_1 - D_1 + \beta' \underline{\omega}}{1 + \beta'}$. Assumptions (A3) and (A2) are compatible as long as $\underline{\omega} \geq \omega_1 - D_1$.

⁹When both types are risk free there is no problem of asymmetry of information.

period 1 consumption and finance it by issuing new debt.¹⁰ What remains to be determined is how much new debt the country wants to issue, once it internalises that issuing debt changes the relative price of debt versus repayment. And this choice can be made contingent on the type.

Single crossing. Combining the previous ingredients, the discounted expected utility of sovereign i is:

$$U^i(q, D_2) := \omega_1 - D_1 + qD_2 \tag{2.6}$$

$$+ \beta \left[F(D_2 + \underline{c}^i) \underline{c}^i + (1 - F(D_2 + \underline{c}^i)) (\mathbb{E}[\omega_2 | \omega_2 \geq D_2 + \underline{c}^i] - D_2) \right].$$

The first line of the right-hand side is the citizens' consumption in the first period: the endowment ω_1 plus the net borrowing of the period. The second line is the expectation of consumption in period 2 discounted by β : with probability $F(D_2 + \underline{c}^i)$, the country defaults and consumption is \underline{c}^i , and with the complementary probability, consumption is the result of the endowment, noticing that ω_2 can only be a realisation compatible with repayment, minus the debt outstanding.

Expression (2.6) can be used to define the indifference curves in the space of two key variables (D_2, q) . Those indifference curves are represented in figure 1 for the two types of countries.

As explained below, for all D_2 , the slope of type B's indifference curves in (D_2, q) is larger than that of type A. A decrease from D_2 to D'_2 , as depicted in figure 1, needs to be compensated with an increase from q to q'_A for type A and from q to q'_B for type B. This implies that any two curves of A and B can cross at most once in the space (D_2, q) . The reason behind it is that default occurs when a country cannot afford repayment and, as this depends only on solvency, B can do it more often.¹¹ Hence, a type B country benefits

¹⁰I choose to motivate the willingness to issue debt by making international credit relatively cheap domestically. Other authors achieve the same result with different assumptions: for example, assuming the government *has to* finance an investment project that pays in the future (Sandleris, 2008) or that office-motivated politicians *like* debt (Acharya and Rajan, 2011).

¹¹Note that the penalty for default is higher for type A, $\underline{c}^A - \omega_2 - D_2 < \underline{c}^B - \omega_2 - D_2 \forall D_2$. However, the

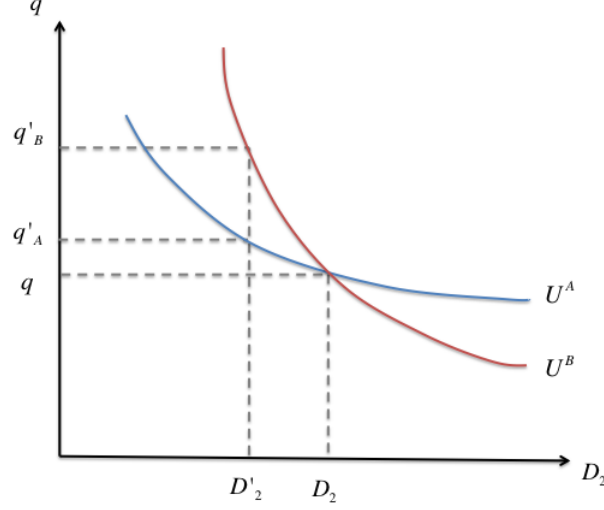


Figure 1: *Single crossing property* of the preferences.

more from debt because it anticipates that it has to pay back less. A formal proof of the *single-crossing* property can be found in Appendix A.

3 Equilibrium analysis

3.1 Full information

As a benchmark, let's describe the equilibrium of the model when the type of the country is observable. The full information equilibrium allocation is a price and a debt level for each type. In this case, the lenders know type i 's probability of default for each level of debt and charge the actuarially fair price $q^i(D_2) = \beta' [1 - F(D_2 + \underline{c}^i)]$. The sovereign faces the price

single crossing property does not require heterogeneous penalty across types. The penalty could be made equal, provided it is not high enough to prevent any default, and type B would still default in more states than A because default is not strategic.

schedule $q^i(D_2)$ and maximises the discounted expected utility (equation (2.6)):

$$\max_{D_2} \quad \omega_1 - D_1 + q^i D_2 + \beta \left[F(D_2 + \underline{c}^i) \underline{c}^i + (1 - F(D_2 + \underline{c}^i)) \left[\mathbb{E}(\omega_2 | \omega_2 \geq D_2 + \underline{c}^i) - D_2 \right] \right] \quad (3.1)$$

$$\text{subject to} \quad q^i(D_2) = \beta' [1 - F(D_2 + \underline{c}^i)].$$

The first order condition (FOC) with respect to D_2 is the following:

$$\frac{\partial q^i(D_2)}{\partial D_2} D_2 + q^i(D_2) - \beta (1 - F(D_2 + \underline{c}^i)) = 0. \quad (3.2)$$

The first term in (3.2) represents the change in cost that every infra marginal unit of debt experiences when an additional unit is issued. The second term is the gain from bringing consumption to the present at the current price $q^i(D_2)$. Finally, the third term represents the cost of the repayment promise: each unit of debt will be repaid in the next period only if there is no default, which happens with probability $1 - F(D_2 + \underline{c}^i)$.

Substituting the price schedule $q^i(D_2)$ in the FOC, after some transformations, we obtain:

$$D_2^i = \frac{\beta' - \beta}{\beta'} \left[\frac{F'(D_2^i + \underline{c}^i)}{1 - F(D_2^i + \underline{c}^i)} \right]^{-1}. \quad (3.3)$$

And, recalling that h is the hazard rate of the endowment exponential distribution $f(\cdot)$, equation (3.3) simplifies to:

$$D_2^A = D_2^B = \frac{\beta' - \beta}{\beta' h}. \quad (3.4)$$

See Appendix B for a proof. Call the full information equilibrium debt level D_2^{FI} . D_2^{FI} is positive because of assumption (A4). It means that the country issues a positive amount of debt in order to take advantage of the favourable lending conditions. Despite D_2^{FI} is the same for both types, in equilibrium, different types face a different price. Price is lower

for type B because this type defaults more than the other, so its debt carries a higher risk premium:

$$\begin{aligned} q^B(D_2^{FI}) &= \beta' [1 - F(D_2^{FI} + \underline{c}^B)] \\ &< \beta' [1 - F(D_2^{FI} + \underline{c}^A)] = q^A(D_2^{FI}). \end{aligned}$$

3.2 Incomplete information

Consider a game where the type of sovereign is unobservable. Nature draws a type A with probability p . A sovereign knows its type and chooses how much debt to issue, balancing the benefits of increasing present consumption and the probability of future default. In this section I introduce strategic considerations. The sovereign also takes into account that its choice of debt may reveal information about its type to the uninformed lenders and, therefore, influence their pricing decisions.

The country's strategy is a choice of debt D_2^* , which can be type dependent. The lenders' strategy is a price function that depends on the observed D_2^* as well as the lenders' beliefs about the type of the sovereign. The adopted solution concept is the Perfect Bayesian Equilibrium (PBE) in pure strategies.

Definition 3.1. *A symmetric PBE in pure strategies is a set of strategies for the sovereign and the lenders,*

$$\begin{aligned} D_2^* &: \{A, B\} \rightarrow \mathbb{R} \\ q^* &: \mathbb{R} \times [0, 1] \rightarrow \mathbb{R}_+ \end{aligned}$$

and a system of beliefs $\mu^ : \mathbb{R} \rightarrow [0, 1]$ on the country being of type A, such that:*

- *For $i = A, B$, $D_2^*(i)$ maximises expected utility U^i given the lenders' strategy $q^*(\cdot)$.*
- *$q^*(\cdot)$ is consistent with zero expected profits: $q^*(D_2, \mu) = \beta'[1 - \lambda(D_2, \mu)] \forall D_2, \mu$.*

- The system of beliefs $\mu^*(D_2)$ is consistent with Bayes' rule and the equilibrium strategies whenever possible. That gives the following equilibrium beliefs function.

Let $\mathbb{1}_{\{\cdot\}}$ be the indicator function taking the value 1 if the condition in curly brackets holds and zero otherwise.

If $p\mathbb{1}_{\{D_2^*(A)=D_2\}} + (1-p)\mathbb{1}_{\{D_2^*(B)=D_2\}} \neq 0$ then:

$$\mu^*(D_2) = \frac{p\mathbb{1}_{\{D_2^*(A)=D_2\}}}{p\mathbb{1}_{\{D_2^*(A)=D_2\}} + (1-p)\mathbb{1}_{\{D_2^*(B)=D_2\}}},$$

If $p\mathbb{1}_{\{D_2^*(A)=D_2\}} + (1-p)\mathbb{1}_{\{D_2^*(B)=D_2\}} = 0$, beliefs must be consistent with probabilities derived from some distribution over the strategy profiles.

Separating equilibria. An equilibrium is separating when a sovereign chooses a different debt level depending on its type. Let the equilibrium outcome be the vector of debt levels and prices denoted by $\{D_2^*(i), q^*(i)\}_{i \in \{A, B\}}$.

A type A country obtains debt at better market conditions because it is less prone to default. Hence, a type B sovereign might have an incentive to pretend to be of type A in order to improve its borrowing terms. To this end, it might choose to mimic type A's strategy.

Hence, the relevant incentive compatibility constraint is type B's,

$$U^B(D_2^*(B), q^*(B)) \geq U^B(D_2^*(A), q^*(A)). \quad (3.5)$$

Proposition 3.1. *There exists a separating equilibrium outcome $(D_2^*(A), q^*(A)), (D_2^*(B), q^*(B))$, where $D_2^*(B) = D_2^{FI}$, $q^*(B) = \beta' [1 - F(D_2^*(B) + \underline{c}^B)]$, $D_2^*(A) = D_2^{-B}$ is the level that satisfies (3.5) with equality and $q^*(A) = \beta' [1 - F(D_2^*(A) + \underline{c}^A)]$. This is supported by the equilibrium beliefs $\mu^*(D_2^*(A)) = 1$ and $\mu^*(D_2) = 0$ for any other D_2 .*

Proof. Appendix C. □

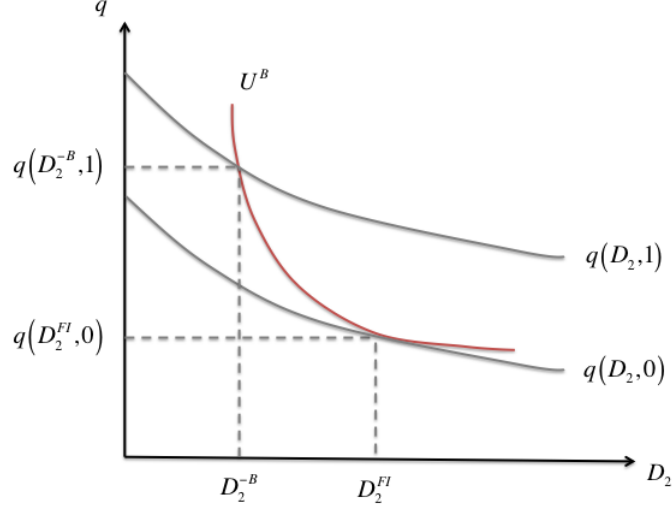


Figure 2: Sovereign B's indifference curve at the full information debt level D_2^{FI} .

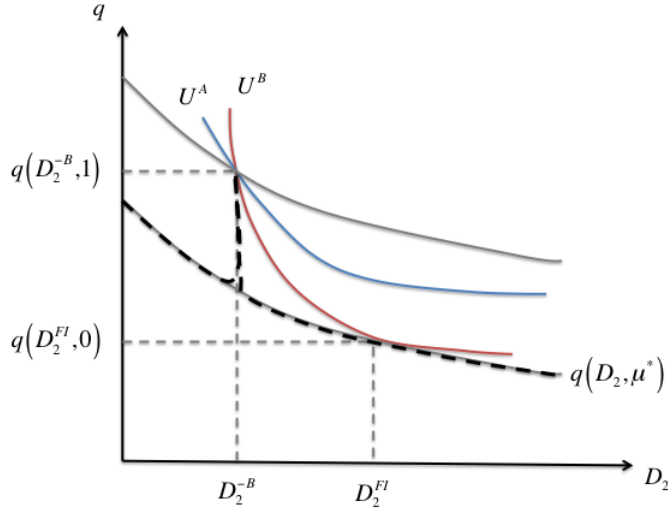


Figure 3: Separating equilibrium e^* .

The allocation $(D_2^{-B}, q(D_2^{-B}, 1))$, represented in figure 3, is preferred by A to any other allocation under the price represented by the dotted bold line. At the same time, B is indifferent between that allocation and $(D_2^{FI}, q(D_2^{FI}, 0))$ by definition.¹² The intuition is that A's isoutility curves in the space (D_2, q) are flatter than B's. Type A is willing to accept a larger debt reduction for a given change in the price of debt. It, therefore, finds attractive allocations that are not attractive to B.

¹²Its incentive compatibility constraint (3.5) is satisfied with equality.

Type A chooses $(D_2^{-B}, q(D_2^{-B}, 1))$ while B chooses its full information allocation D_2^{FI} . No type has an incentive to deviate unilaterally. But choosing a different allocation than D_2^{FI} is costly for A as well. The larger the deviation, the higher the cost for A. Since D_2^{-B} is the threshold debt level that allows separation of the types, the equilibrium e^* described in proposition 3.1 is the least cost separating equilibrium.

In a separating equilibrium, type A's equilibrium choice of debt is lower than that of the full information solution ($D_2^{-B} - D_2^{FI} < 0$). We say that the country is using *austerity for signalling purposes*. The choice of a lower level of debt improves the debt price schedule, lowering the risk premium associated to each D_2 . Summing up, reducing the amount of debt to the D_2^{-B} level has a double effect: it directly improves the risk premium, because it lowers the default probability, and it indirectly affects the perception of the type, which improves the risk premium further. If it were not for the indirect effect, though, type A would not choose to go through with austerity.¹³ Hence, signalling is the key for fiscal policy to tilt towards austerity.

Pooling equilibria. A pooling equilibrium arises if type A does not find it advantageous to reduce the amount of debt in order to obtain the benefits from revealing its type. It consists of an equilibrium debt level D_2^* and a price of debt $q^*(D_2^*, p)$, equal for both types. As a result, the lenders cannot distinguish the types from observing their debt choices and their best guess is the prior p . For example:

Proposition 3.2. *A pooling equilibrium at the full information allocation is supported by the belief system $\mu^*(D_2^{FI}) = p$ and $\mu^*(D_2) = 0$ for $D_2 \neq D_2^{FI}$. The price of debt in a pooling equilibrium equals*

$$q^*(D_2^{FI}, p) = \beta' \left(p \left[1 - F(D_2^{FI} + \underline{c}^A) \right] + (1 - p) \left[1 - F(D_2^{FI} + \underline{c}^B) \right] \right). \quad (3.6)$$

Proof. Appendix D. □

¹³The direct effect is present at the full information problem as well and type A chooses to issue more debt in equilibrium.

See figure 4, where the price schedule is again represented by the dotted bold line. The off-equilibrium threat that a country will be penalised in its risk premium if it deviates from D_2^{FI} might allow a pooling equilibrium to be sustained at the candidate D_2^{FI} . Any type of sovereign prefers to choose D_2^{FI} and be offered the pooling price under these beliefs. Beliefs are admissible because in equilibrium the pooling price satisfies Bayes' rule and off-equilibrium they are free to be any $\mu \in [0, 1]$.¹⁴

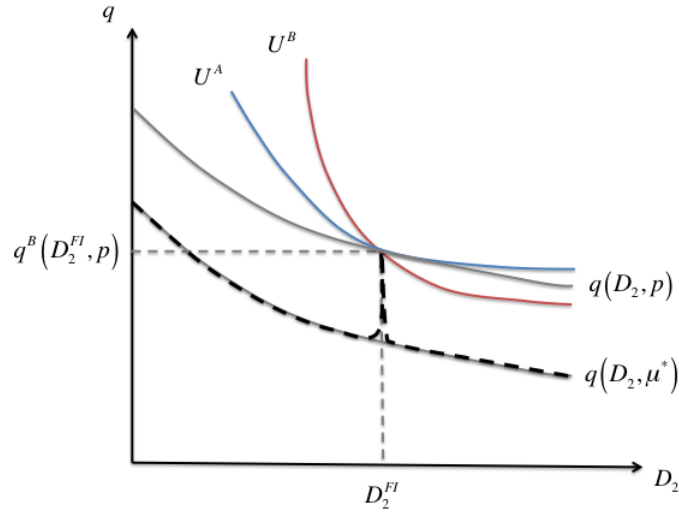


Figure 4: A pooling equilibrium at D_2^{FI} .

3.3 Refinements

A signalling game like the one presented here typically admits a multiplicity of equilibria. This is so because a large set of off-equilibrium beliefs is consistent with the equilibrium definition, making it easier to sustain a given equilibrium. In my model, proposition (3.1) and proposition (3.2) are examples of different equilibria that may coexist. To reduce the set of equilibria, I use a refinement of the PBE introduced by Mailath et al. (1993): the undefeated equilibrium (UE).

¹⁴They are set to $\mu = 0$ in this case.

The UE refinement restricts the set of admissible off-equilibrium beliefs. Beliefs about a deviation to a different allocation are admissible if the probability distribution over types is consistent with such types choosing that allocation in another equilibrium and being weakly better off by doing so. Otherwise, off-equilibrium beliefs are inconsistent. If this off-equilibrium consistency requirement restricts beliefs in such a way that they do not sustain a given equilibrium, this equilibrium is *defeated* and we say that it does not survive the refinement.¹⁵ An equilibrium is defined to be *undefeated* if it is not defeated by any other.

Unlike dominance-based refinements,¹⁶ the UE refinement focuses on the efficiency properties of the equilibrium. The consistency of an off-equilibrium strategy is evaluated on the base of which type(s) is weakly better off in an alternative equilibrium where this strategy is chosen. In any pooling equilibrium, a sovereign chooses a given D_2 irrespective of its type. For this equilibrium to be undefeated any type must be better off choosing that allocation compared to deviating to different equilibrium strategy. Thus, the UE privileges the equilibria that are efficient in a Pareto sense.

Proposition 3.3. *Applying the UE refinement to the game, equilibria of the separating and the pooling class do not coexist. For p sufficiently small there is a unique separating equilibrium where type A chooses D_2^{-B} , else there are pooling equilibria with $D_2 > D_2^{-B}$.*

As stated in the proposition, for a low value of p , $p < \bar{p}$,¹⁷ the unique equilibrium of the problem is e^* . \bar{p} is the threshold level of the prior that makes type A indifferent between the signalling allocation $(D_2^{-B}, q(D_2^{-B}, 1))$ and pooling with type B at $(D_2^*, q(D_2^*, \bar{p}))$. The line of proof goes as follows: first, notice that the least costly separating equilibrium e^* defeats any other separating equilibrium. All separating equilibria reveal the type of the sovereign but e^* does it with the smallest deviation from the full information allocation for type A. Hence, type A is strictly better off at e^* . This means that off-equilibrium beliefs at D_2^{-B} must be

¹⁵See appendix E for a formal definition of the UE refinement.

¹⁶Notably the intuitive criterion by Cho and Kreps (1987) and divinity by Banks and Sobel (1987).

¹⁷The expression for \bar{p} is $1 + \frac{\bar{U}^A - \omega_1 + D_1 + (2\beta - \beta')(1 - F(D_2 + \underline{c}_A)) - \beta(1 + \underline{c}_A + D_2 + h^{-1})}{\beta' D_2 (F(D_2 + \underline{c}_B) - F(D_2 + \underline{c}_A))}$, where $\bar{U}^A = U^A(D_2^{-B}, q(D_2^{-B}, 1))$.

$\mu = 1$ for any other separating equilibrium but those beliefs do not sustain an equilibrium at $D_2 \neq D_2^{-B}$ because such an equilibrium would be defeated by e^* . Furthermore, e^* defeats any pooling equilibrium if type A is better off signalling (that is, for $p < \bar{p}$). When choosing D_2^{-B} gives type A a higher utility, this cannot be ignored off equilibrium in any pooling equilibrium and thus it is inconsistent that A does not realize it would be better off deviating to D_2^{-B} . The pooling equilibrium is, therefore, defeated. In this case, e^* is the unique equilibrium of the model. A formal proof can be found in appendix F.

But for $p \geq \bar{p}$ both types are better off pooling and then e^* is defeated by a pooling equilibrium. The proof is in appendix G. The UE refinement allows pooling equilibria to survive.¹⁸ Pooling e' survives if there is no other pooling equilibrium in which both types are better off. Hence, undefeated pooling can be sustained at any allocation in the range $[D_2^{*A}, D_2^{*B}]$, where D_2^{*A} is the allocation preferred by type A under schedule $q(\cdot, p)$ and D_2^{*B} is the one preferred by type B.¹⁹ Pooling equilibria in allocations outside that range are defeated by other pooling equilibria within that range because they are strictly preferred by both types. Within this range moving closer to one type's preferred allocation means moving further from the other; hence, types cannot be both made better off.

Restating the result of proposition 3.3, a separating equilibrium will exist depending on the beliefs about the creditworthiness of a country. A small p reflects a prior that the country is most likely of type B, thus providing large incentives for a type A to signal and separate

¹⁸Notice that with the 'intuitive criterion' (Cho and Kreps, 1987) the separating equilibrium always eliminates all pooling equilibria and it remains the unique equilibrium in this kind of signalling game with two players and single crossing preferences. According to it, if a deviation from a candidate equilibrium is dominated for one type but not for another, this deviation should not be attributed to the type for which the deviation is dominated. Hence, no pooling equilibrium can dominate the separating equilibrium e^* because the single crossing property creates a space between the indifference curves such that any D_2 to the left of the pooling allocation would be preferred only for type A and not for B. At every such D_2 beliefs must be such that $\mu = 1$ and those off-equilibrium beliefs cannot sustain a candidate pooling equilibrium. The intuitive criterion fixes an equilibrium (e.g. e') and then restricts the off-equilibrium beliefs that are inconsistent with the dominated choices for each agent based on that equilibrium e' . Similarly, the UE fixes an equilibrium e' but the off-equilibrium beliefs at D_2 are restricted looking at another equilibrium where this allocation D_2 is an equilibrium allocation. Restrictions are established based on consistency with the type(s) that would choose D_2 in the new equilibrium, only if the type(s) are better off than at the fixed equilibrium e' . So the allocations that dominate the pooling allocation in the intuitive criterion do not exist in the UE because they are not equilibrium strategies of an alternative equilibrium. As a consequence, pooling can survive.

¹⁹In appendix H I derive the expressions for D_2^{*A} and D_2^{*B} .

itself from the uninformed pool. As p becomes larger, ex-ante beliefs of the lenders about creditworthiness are more optimistic, and both types are satisfied foregoing austerity because the potential price benefits of signalling would not be large. Once both types prefer to pool, the least preferred separating equilibrium is defeated and only a pooling equilibrium exists.

4 Public information and multiple-periods considerations

4.1 Credit rating

In the model signalling depends on the beliefs distribution over types: if lenders believe the sovereign's creditworthiness is most likely high, a country does not gain much from doing costly austerity to improve the market's perception. It is thus useful to explore how changes in the lender's views on creditworthiness affect austerity.

A Credit Rating Agency (CRA) issues sovereign ratings: they are opinions on the credit standing of a country. Credit ratings affect how the public perceives the credit standing of the country. I model a sovereign rating as a public signal: $r \in \{\bar{r}, \underline{r}\}$. The rating is imperfectly informative about the country's creditworthiness and the degree of informativeness is captured by a parameter ρ . $\rho \in [0, 1]$ is the probability that the CRA detects a type B country and assigns a low rating \underline{r} : $Prob(\underline{r} \mid B)$. Country B receives a low rating \underline{r} with probability ρ and, with probability $1 - \rho$, it receives a high rating \bar{r} . A type A country always receives a high rating.

Once ratings are assigned, the debt market becomes segmented into different markets conditional on the rating. A low rating perfectly reveals a B type and the country rated \underline{r} is removed from the complementary market \bar{r} . Hence, the rating ameliorates the asymmetry of information but does not eliminate it completely. The residual asymmetry of information de-

depends on ρ .²⁰ The empirical literature on credit ratings finds robust evidence that the ratings add information on average, measuring the impact that either ratings or new announcements have on the market (Cantor and Packer, 1996, Lee et al., 2010, Pukthuanthong-Le et al., 2007). Some papers highlight, as well, that this impact changes over time (Kiff et al., 2012, De Santis, 2012) and that the explanatory power of the ratings diminishes in times of crisis (Bussiere and Ristiniemi, 2012).

I concentrate my analysis on the \bar{r} category from now on.²¹ Recall from proposition (3.3) that the existence of an equilibrium with ‘signalling austerity’ depends on the proportion of types p . The parameter ρ , by modifying the proportion of types in each segmented market, affects the determination of the equilibrium. The posterior $\hat{p}(\rho)$ is:

$$\hat{p}(\rho) = \begin{cases} \frac{p}{1-\rho(1-p)} & \text{if } r = \bar{r} \\ 0 & \text{if } r = \underline{r}. \end{cases} \quad (4.1)$$

If ρ is set to 1 the CRA provides perfect information about the type of country and the solution is the full information one. If, instead, $\rho = 0$ we are in the baseline model with asymmetry of information from the previous section. For values between 0 and 1, the degree of informativeness affects to a lesser or greater extent the beliefs about the composition of types in the rating category \bar{r} and, thus, the equilibrium debt price of pooling in that category, which equals:

$$q^*(D_2^*, \hat{p} \mid \bar{r}) = \beta' \left[\frac{p}{1-\rho(1-p)} (1 - F(D_2^* + \underline{c}^A)) + \frac{(1-\rho)(1-p)}{1-\rho(1-p)} (1 - F(D_2^* + \underline{c}^B)) \right].$$

²⁰ ρ can take on different values $\in (0,1)$ due to a number of reasons that are not explicitly modelled here: for example, a conflict of interest due to the issuer-pays model of payment would be represented as a decrease in ρ , as we go from an investors-pay to an issuer-pays model. Similarly, the difficulties of rating an increasingly complex set of products or the lack of attention paid to sovereigns that do not pay for their ratings would also imply a decrease in the parameter ρ .

²¹That is because the \underline{r} category reveals a type B country with certainty and, thus, is of no interest for signalling. Alternatively I could model the \underline{r} rating to be imperfectly informative as well. As the analysis is analogous to that of the \bar{r} category, I opt for this simplified information structure of the signal.

Price is increasing in the prior about creditworthiness - p - and in the ratings capacity to improve the prior with new information - ρ . Both p and ρ make the lenders more optimistic about creditworthiness (weighting up the beliefs that they are in front of a type A country and down the beliefs that it is type B instead).

Let e^* be the least cost separating equilibrium defined in proposition 3.1 and \bar{p} be the threshold level of the prior that makes type A indifferent between signalling and pooling as described in the previous section.

Proposition 4.1. *If the prior p is such that $p < \bar{p}$, there exists a level of informativeness ρ^* of the rating so that for all $\rho \geq \rho^*$ all equilibria are pooling and for $\rho < \rho^*$ the unique equilibrium is e^* .*

Proof. Since the equilibrium for p is e^* , it follows that type A must prefer e^* 's equilibrium allocation to the pooling one:

$$\begin{aligned} U^A(D_2^{-B}, q(D_2^{-B}, 1)) &> U^A(D_2^*(p), q(D_2^*(p), p)) \\ &= U^A(D_2^*(\hat{p}), q(D_2^*(\hat{p}), \hat{p})) \text{ if } \rho=0. \end{aligned} \quad (4.2)$$

The last line exploits the fact that the two problems without ratings and with ratings that add no information are the same. The left-hand side of (4.2) is independent of ρ while the right-hand side is increasing in ρ because $\frac{\partial \hat{p}}{\partial \rho} |_{\bar{r}} > 0$. And for $\rho = 1 - \epsilon$, with ϵ very small, the right-hand side tends to $U^A(D_2^{FI}, q^A(D_2^{FI}))$ and the inequality is reversed. Hence, there must exist a threshold ρ^* where the equilibrium shifts from a pooling one to e^* . \square

Thus,

Corollary 4.1. *A deterioration of ratings informativeness from $\rho \geq \rho^*$ to $\rho < \rho^*$ makes ‘signalling austerity’ appear.*

A worse posterior $\hat{p}(\rho)$ about the sovereign's ability means that more type B countries are perceived to be in the \bar{r} category and the pooling price is lower for every level of debt.

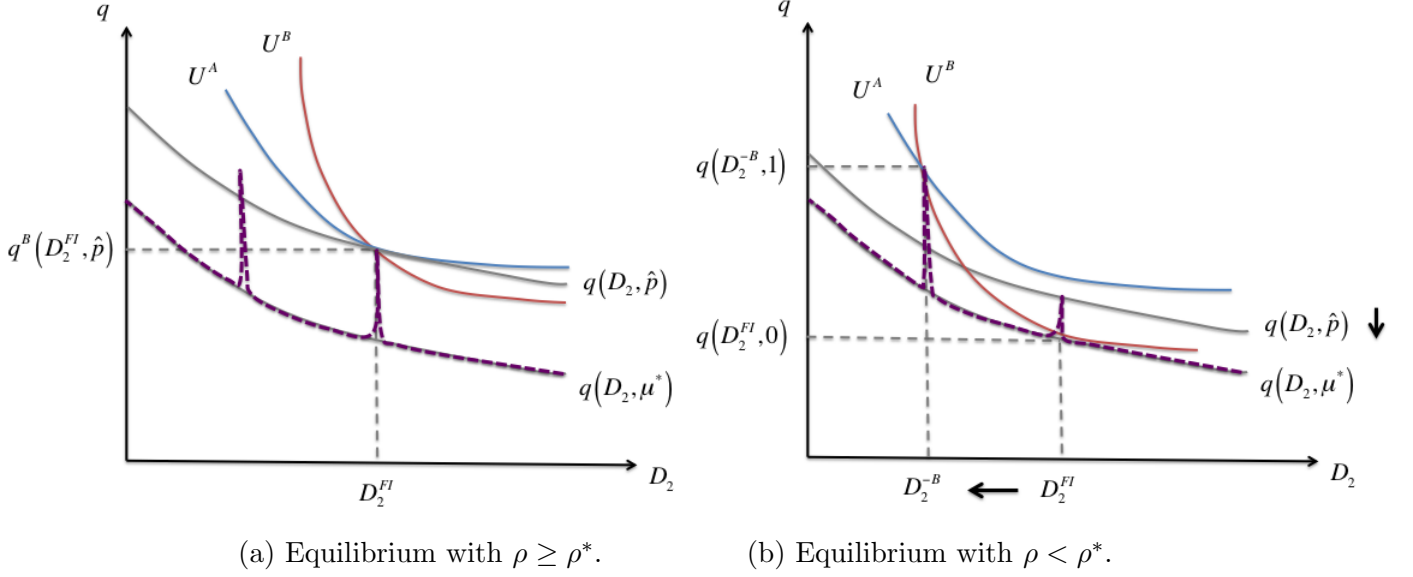


Figure 5: A change in ρ induces a shift from a pooling (left panel) to a separating (right panel) equilibrium.

Price schedule $q(D_2, \hat{p})$ shifts downwards as in the transition from figure 5a to figure 5b. If a pooling equilibrium exists, it will be on the new schedule. But, when $\rho < \rho^*$, any of the allocation on this schedule is worse off for A than the separating allocation, defeating pooling equilibria. To sum up, a worse perception of the \bar{r} -rated category makes it less attractive for A to pool with the others, because the pooling price is low, and revealing the type compensates the cost of austerity.

Think about a situation where the informativeness of the ratings was presumably high, like before the financial crisis 2008. Ratings are believed to be very informative and the markets take them at face value and react strongly to them. The prediction of the model is that all types of sovereigns would likely find it advantageous to pool at a high debt level. They don't have an incentive to signal through costly austerity in order to overcome the little residual asymmetry of information. However, if the informativeness of the ratings plummets, for instance when the reputation of the rating agencies came into question after the collapse of Lehman Brothers, the equilibrium may shift to a separating equilibrium. In this new scenario, corollary 4.1 tells us to expect 'signalling austerity' as countries benefit

from standing out as creditworthy. The effects of signalling will show in the price of debt, that becomes more responsive to the fiscal magnitudes than before. In that way, you can rationalize the surge in austerity in the European core countries in the aftermath of the crisis and the increase in the Euro area sovereign spreads. In the next section, I simulate the model for a number of periods and compare it with the time series data.

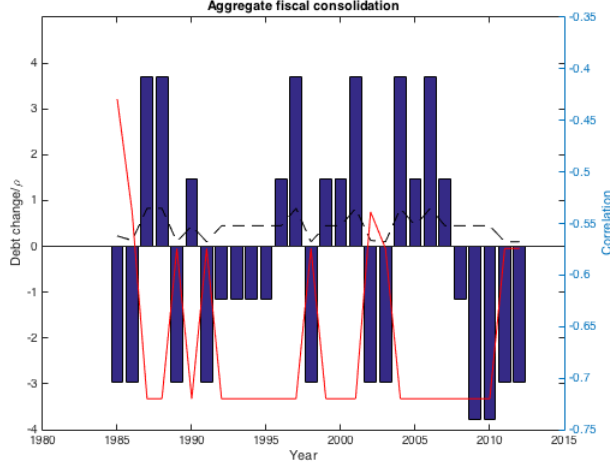
4.2 A simple multiple-period model with iid shocks to the type

In this section, I extend the model to multiple periods. There are two extreme cases: constant types over time or iid shocks to the type at the beginning of every period. With constant types, once there is a separating equilibrium, the type is revealed. From there onwards, each country chooses its optimal amount of debt under perfect information. Signalling takes place only once.

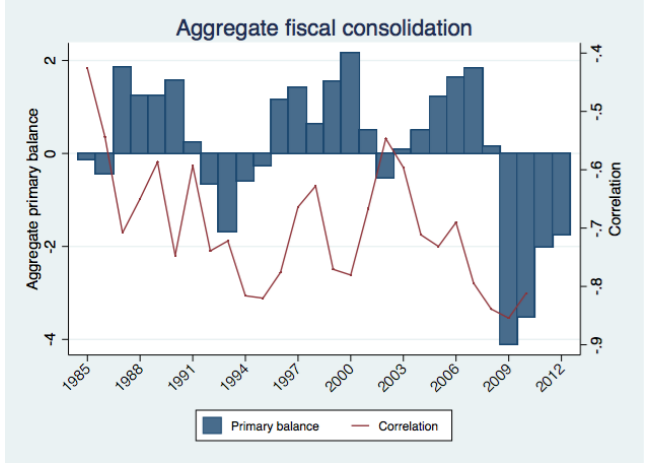
With shocks to the type drawn independently each period the solution is the same as that of a repetition of the previous two-period game over time.²² The reason is that the current realization of the type carries no information about the type in the future and the optimal choice of debt is independent from past variables. I simulate this economy during $T = 28$ to compare it with the last 28 years of data. The parameters are the following: the lender's discount factor is normalized to be $\beta' = 1$, the sovereign's discount factor $\beta = 0.6$ is lower than the lender's to satisfy assumption (A4), the minimum consumption in a type A country is normalized to $\underline{c}_A = 0$ and in a type B country is higher $\underline{c}_B = 1$. The lower bound of the support of the income distribution is $\bar{\omega} = 1$, which satisfies assumption (A2) with equality. The coefficient of the exponential distribution of income h is set to 1, so the mean income is also 1. $D_1 - \omega_1$ is set to 0 without loss of generality. Finally, the probability of being type A is chosen to be 30%.

The degree of informativeness of the CRA - $\{\rho_t\}_t$ - is exogenous and common knowledge. The sequence $\{\rho_t\}_t$ is chosen to match the correlation between debt prices (long-term

²²See appendix I for a proof.



(a) Simulated data.



(b) Actual data.

Figure 6: Negative co-movement between correlation and austerity.

sovereign yields) and sovereign ratings in the data. Figure 6a plots the time series of ρ_t , the cross-sectional correlation and the aggregate austerity implied by the model for those values of ρ_t . In figure 6b, the data shows a similar pattern for the period between 1985-2012. In the data, the debt change is measured as the primary balance of the government budgets over GDP aggregated for all countries in the sample.²³ The two variables have a negative co-movement: a high correlation between sovereign ratings and yields happens with little or no austerity while a low correlation is associated with bar spikes in austerity.

Now let us see what happens to the evolution of the sovereign yields for the same sequence $\{\rho_t\}_t$. Figure 7 depicts the aggregate debt change in bars together with the time series of sovereign bond yields. As we have seen, some values of ρ_t trigger a period of separating equilibrium, characterized by austerity, that corresponds to the troughs in the bars. At those times, the sovereign yields of the two country types diverge and a positive spread appears between sovereigns in the same rating category. The prediction for the values of ρ_t associated with a pooling equilibrium is the opposite: the debt bars spike and the spread disappears.

²³With weights correcting for the number of countries in each period. The sample is described in section 5.1 and can be found in appendix K.

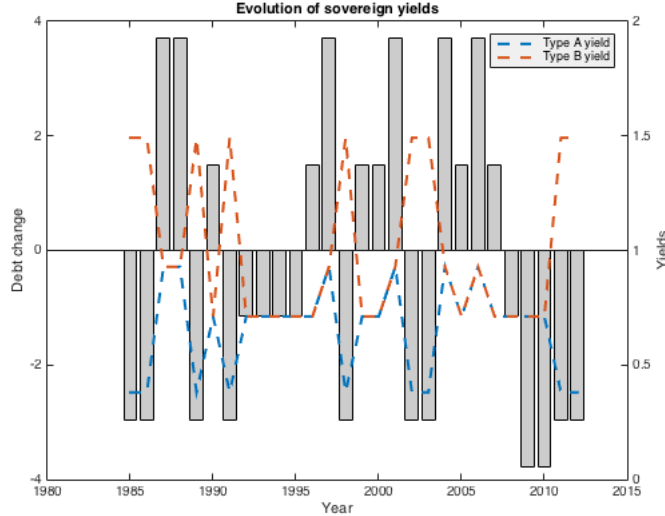


Figure 7: Simulated sovereign yields.

5 Empirical analysis

In this section I go beyond the aggregate data from the previous section and examine individual countries during three decades in a panel regression analysis. A given country's choice of fiscal policy is determined by a number of different variables that the literature has identified (Gali and Perotti, 2003, Favero and Monacelli, 2005, Baldacci et al., 2013). For instance, the stock of debt matters for debt sustainability and might affect how much austerity a country chooses to do. In order to tell apart how much austerity is owed to the signalling motive, I look at the evolution of austerity that is associated with changes in the incentives to signal, conditional on fundamentals.

Incentives to signal are measured in two ways. The first measure I use is the cross-section correlation between sovereign yields and sovereign ratings in a given period. This variable proxies the market assessment of the ratings' information. According to Corollary 4.1, the less information there is (low ρ) the more likely is a surge in austerity. This, controlling for other determinants of the fiscal stance. I now explain how the ratings' information is related to the correlation variable. Recall that $Prob(\underline{r}|B) = \rho$ and $Prob(\underline{r}|A) = 0$ and, in the setup with two ratings, it represents the information that the rating conveys to the market.

Since Cantor and Packer (1996), a large body of literature has dealt with estimating the market impact of credit ratings by regressing the sovereign yields, spreads and other measure of the market value on the sovereign ratings.²⁴ I hence estimate the equation:

$$Sovereign\ Yield_{i,t} = \rho_t Rating_{i,t} + \epsilon_{i,t},$$

using cross-sectional variation. Hence, $\hat{\rho}_t = corr_t(Sovereign\ Yield_t, Rating_t)$ estimates the changes in public information that the sovereign ratings convey over time. Each year, the correlation reflects the extent to which the sovereign yields charged by the lenders to all sovereigns are explained by the order in which they are placed in the rating scale. A larger correlation is presumed to mean a high ρ while a lower one implies a low ρ . This is what I also find in the simulation of the multiple periods economy in section 4.2 (see figure 6a).

The second way to measure the incentives to signal with austerity is spreads broadening within a given rating category. As shown in figure 7, dispersion in yields inside a category is indicative of low informativeness of the ratings and should prompt austerity in the separating equilibrium for that group of countries vis-à-vis the other groups. In the dataset I look for extreme events in the yields of a sovereign within a rating category: the variable $Yield\ Event_{i,k,t}$ represents the events in country i belonging to the rating category k in year t and takes value 1 if a large change happened and 0 if not. Rating categories have been defined more coarsely than the rating grades in order to obtain a larger number of countries in each category.²⁵ I define a yield event as extreme when the difference in demeaned log yields between two consecutive years is larger than two standard deviations of the log yields distribution in that year for that rating category.²⁶ I use log yields because, first, the distribution of yield changes is smoother (otherwise the majority of data points is concentrated around the mean) and, second, the interpretation of differences in log yields as percentage

²⁴Possibly controlling for an array of covariates.

²⁵The rating categories are: ‘Prime’ for ratings between AAA and AAA- included, ‘Subprime’ for ratings between Aa1+ and Aa3- included, ‘Investment’ between A1+ and Baa3- and ‘Non-investment’ lower or equal to Ba1+.

²⁶This is robust to small changes in the threshold of standard deviations.

changes is useful and more realistic: it has the consequence that the same difference in yield points represents a larger percentage change for lower yields than for higher ones. This feature seems particularly true for countries with good funding rates, where a change in yields may double the current rate, whereas for countries already paying higher yields the same change might represent a smaller effect. Demeaning allows me to get rid of the time trend in the time series of yields. In appendix J, I present the list of countries that experienced such events. Finally, for a given country j I aggregate the number of events in its rating category at every point in time, excluding those affecting country j itself:

$$Yield\ Shocks_{j,k,t} = \sum_{i \in k, i \neq j} Yield\ Events_{i,k,t}. \quad (5.1)$$

I obtain an indicator variable that takes a higher value when more countries in j 's rating category have price movements at the extreme of the distribution. My empirical strategy then includes these variables that proxy for the willingness to signal - the *Correlation* or the *Yield Shocks* - as a regressor $\hat{\rho}_{it}$ in an equation of the fiscal stance:

$$Austerity_{it} = \alpha + \beta \hat{\rho}_{it} + \lambda X_{it} + \xi_{it} \quad (5.2)$$

and let $\hat{\beta}$ capture the effect that changes in the public information have on austerity, beyond what can be explained by other variables included as controls in X_{it} .

Austerity is also proxied by two different variables, depending on the specification, as summarised in table 1. The first one is an indicator variable measuring whether a given country was under a consolidation program. This is determined according to the narrative approach by Devries et al. (2011). The sample goes from 1978 to 2009 for 17 countries. The second proxy for austerity is a continuous variable for the cyclically adjusted primary balance (CAPB). It is defined as 'general government balance adjusted for nonstructural elements beyond the economic cycle' and data covers 58 countries from 1980 to 2011 and is coming from the WEO database.

Table 1 recaps the main empirical specifications of equation (5.2) for different measures of austerity (consolidation dummy/ CAPB) and the market assessment of the ratings' information (correlation between yields and ratings/ yield shocks). You can also see the expected sign of the coefficient according to the implications of the model from section 4.2.

Table 1: Main empirical specifications and expected sign.

		Independent variable: MARKET ASSESSMENT RATINGS' INFORMATION	
		<i>Correlation</i>	<i>Yield Shocks</i>
Dependent variable: AUSTERITY	<i>Consolidation dummy</i>	$\hat{\beta}_c$ negative	$\hat{\gamma}_c$ positive
	<i>Cyclically adjusted primary balance</i>	$\hat{\beta}_d$ negative	$\hat{\gamma}_d$ positive

5.1 Dataset and description of the variables

The dataset contains observations at annual frequency for 58 countries during 32 years (1980–2011). Countries covered are mainly OECD and some emerging market economies. For a complete list of countries and the range of years covered see appendix K. The economic variables included in the dataset have been obtained from the World Economic Outlook (IMF) 2013 and their definitions and calculation method can be found in appendix L. They include the following fiscal variables: *Net lending/ borrowing*, *Primary surplus/ deficit*, *CAPB* and *Government expenditure*. Positive values of these variables - except expenditure - mean that the government is saving and negative values that it is borrowing. Hence, more fiscal austerity is represented by a positive change in savings/deficit or a negative change in expenditure.

The dataset has been merged with the average yield to maturity in percentage points of long-term government bonds collected by the IMF in its International Financial Statistics and with the data on fiscal consolidations programs by Devries et al. (2011). Finally, I obtained historical data on sovereign ratings by the three biggest rating agencies (Moody's,

Fitch and Standard & Poor's) for my sample of countries. The rating grades (e.g. AAA) were transformed into a numerical variable. I assigned each rating and modulation of the rating (outlook/rating watch) a number in a scale going from 0 (default) to 52 (maximum grade). The final *Rating* variable was obtained taking an annual average of the three ratings (if available). Since the sample countries got their first sovereign rating at different points in time, the resulting panel is unbalanced.²⁷

5.2 Evidence on ‘signalling austerity’

5.2.1 Results using the Correlation as the independent variable

The results presented below correspond to the first column of the specifications in table 1: ρ_t is proxied with the correlation variable throughout this section.

First, I use the consolidation episodes as a measure of austerity and I estimate equation (5.2) by probit:

$$Consolidation_{i,t} = \alpha + \beta_c Corr_t + \lambda X_{i,t-1} + \kappa_i + \tau_t + \epsilon_{i,t},$$

where $Consolidation_{i,t}$ is a dummy variable from Devries et al. (2011), that takes value 1 if the country is doing a fiscal consolidation in that year and value of 0 if it does not, $Corr_t$ is the correlation²⁸ variable estimating ρ_t and $X_{i,t-1}$ are one-period-lagged control variables (*Net lending over GDP*, *Debt over GDP*, *Squared debt over GDP*, *Log fiscal GDP*, *Log GDP per capita* and *Growth*). The specification includes country and year fixed effects.

The coefficient $\hat{\beta}_c = -13.5$ in table 2 is statistically significant. A lower correlation variable has *ceteris paribus* a positive effect on the probability that the country is doing a fiscal consolidation as expected.

²⁷However, there is no reason to believe that the initial observations for the non-rated countries are not randomly missing.

²⁸Correlations have been calculated by the Spearman method to preserve the order of the ratings without imposing a linear scale. Results using the Person correlation have also been performed and are available upon request.

Table 2: Panel probit with random effects

	Consolidation dummy
Correlation	-13.54** (6.558)
Net lending _{t-1}	-0.295*** (0.0569)
Primary surplus _{t-1} ²	-0.0156* (0.00879)
Debt _{t-1}	-0.0129 (0.0280)
Squared debt _{t-1}	0.000175 (0.000108)
Log GDP _{t-1}	3.669** (1.653)
Log GDPpc _{t-1}	-2.859 (2.853)
Growth _{t-1}	-4.587 (6.625)
Country FE	Yes
Time FE	Yes
N	369
Chi-square	102.1
Loglikelihood	-137.2

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: OLS with robust standard errors

	CAPB
Correlation	-1.809** (0.805)
CAPB _{t-1}	0.758*** (0.0461)
Debt _{t-1}	0.0575*** (0.0136)
Squared debt _{t-1}	-0.000190*** (0.0000569)
Log GDP _{t-1}	-1.055 (0.919)
Log GDPpc _{t-1}	1.267 (2.155)
Growth _{t-1}	1.992 (3.557)
Country FE	Yes
N	607
R-square	0.821
F	51.84

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

I also estimate equation (5.2), letting primary deficit be the measure of austerity, using OLS:

$$CAPB_{i,t} = \alpha + \beta_d Corr_t + \lambda X_{i,t-1} + \kappa_i + \epsilon_{i,t}. \quad (5.3)$$

The link from $Corr_t$ to $CAPB_{i,t}$ is hardly endogenous because the correlation is an aggregate measure. One country's austerity, $CAPB_{i,t}$, might affect its yields which enter the calculation of the correlation. But this variable is a measure of the relation between all yields and all ratings in the sample, hence reverse causality from a given country's austerity $CAPB_{i,t}$ to the global $Corr_t$ is unlikely. As can be seen in table 3, the estimated coefficient $\hat{\beta}_d$ is negative and significant. The effect of a 1 point decrease in the correlation implies a 1.8 percentage points increase in cyclically adjusted primary surplus over GDP. Since the correlation has been normalised to lie in the interval $[0, 1]$, this increase in austerity is difficult to interpret; hence, I use one standard deviation in the distribution of the $Corr_t$ variable as a benchmark. Such a change would be responsible for a quarter percentage point change in the deficit.

5.2.2 Robustness

I performed a series of robustness checks in order to assess whether results are consistent through changes in some measures and specifications. First, I discuss the choice about the measures of austerity. As I mentioned in the introduction, there is no clear consensus about the definition of austerity but the one I propose in this paper²⁹ requires to measure the discretionary decisions about fiscal magnitudes made by the government. I opted for the narrative approach, in which Devries et al. (2011) identify episodes of fiscal consolidations through “policymakers’ intentions and actions as described in contemporaneous policy documents”. Their focus is on fiscal actions motivated primarily by deficit reduction as a response to past

²⁹A lower debt choice than that of the full information solution due to the signalling motive (see the definition of ‘austerity for signalling purposes’ on page 15).

economic conditions. Hence this measure, by construction, is particularly well-suited for the analysis of discretionary fiscal policy. I have also showed an alternative proxy for austerity, based on a statistical measure, such as the *CAPB*. This is the most commonly used aggregate of discretionary fiscal policy. One might wonder, though, whether other fiscal variables are in line with the results as well. I present three of them in the table 4. Results are consistent with those in the previous section. The *Corr* variable co-moves negatively with austerity, represented by larger surpluses and lower expenditures. Coefficients are larger than that of *CAPB*: changes in *Corr* of one standard deviation are associated with up to 0.48pp in austerity.

I then considered additional measures in order to control for reverse causality. I replaced the $Corr_t$ by the correlation calculated over a random subsample of half the countries (J) in the sample and estimate the following regression for the other countries:

$$Y_{i,t} = \alpha + \beta Corr_t^J + \gamma X_{i,t-1} + \kappa_i + \epsilon_{i,t} \quad \forall i \notin J. \quad (5.4)$$

by OLS. In (5.4) the fiscal position $Y_{i,t}$ cannot affect $Corr_t^J$ as a consequence of the computation method because the correlation is calculated for a different subsample. Table 4 shows that the effect found in the previous regressions still holds.

Next, I instrument $Corr_t$ in (5.3) with two instruments: the annual stock prices of the company Moody's and the negative news counts about the CRAs. Moody's is the only big rating agency that is quoted since 1998 in the stock exchange with the ticker MCO. I retrieved information on its stock prices (yearly averages) from Bloomberg. I also collected the number of news items in major distribution newspapers (in English) that contain a negative view of the rating agencies from LexisNexis database³⁰.

The underlying assumption is that Moody's stock price reflects the ability of the agency to assign informative ratings and so does the opinion that experts and the media hold on the

³⁰Search key words were 'rating agencies, reputation, accuracy & criticism', 'rating agencies, credibility & mistake or error or blame', 'rating agencies, reputation & regulation' and an example article would be: 'Rating agencies: Capable or culpable?', Euromoney November 2007.

Table 4: OLS with robust standard errors

	Consolidation	Net lending	Primary surplus	CAPB	Expenditure
Correlation ^J	-1.745** (0.827)	-2.566** (1.041)	-3.492*** (1.007)	-1.547* (0.874)	1.628* (0.937)
Net lending _{t-1}		0.672*** (0.0693)			
Primary surplus _{t-1}			0.572*** (0.0908)		
CAPB _{t-1}				0.729*** (0.0791)	
Expenditure _{t-1}					0.797*** (0.0478)
Debt _{t-1}	0.0541** (0.0215)	0.0505* (0.0286)	0.0713*** (0.0266)	0.0446** (0.0185)	-0.0352 (0.0238)
Squared debt _{t-1}	-0.000102 (0.0000956)	-0.000147 (0.000156)	-0.000268* (0.000149)	-0.000122 (0.0000827)	0.0000570 (0.000126)
Log GDP _{t-1}	1.460 (1.019)	0.316 (0.960)	-0.222 (0.979)	-0.660 (1.184)	-1.673** (0.838)
Log GDPpc _{t-1}	-6.899** (2.781)	-1.976 (2.812)	-0.510 (2.816)	0.0944 (2.883)	5.574** (2.457)
Growth _{t-1}	-2.230 (5.927)	2.894 (5.141)	3.120 (5.269)	1.181 (5.891)	0.0566 (4.130)
Country FE	Yes	Yes	Yes	Yes	Yes
N	217	465	464	286	465
R-square	-	0.632	0.664	0.802	0.961
F	-	30.60	29.08	49.22	1123.1

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

rating agencies. The relevance of these variables to explain the $Corr_t$ can further be assessed by looking at the results of the first stage instrumental variables regression in the table in appendix M. On the other hand, neither Moody's stock price nor the critical opinions about the rating agencies should affect any given country's willingness to do austerity directly; it should only affect this willingness indirectly through the effect they have on the correlation via the signalling channel. In table 5 results are confirmed for several austerity measures and the magnitude of the effect is larger than in the previous estimations.

Further, I also exploit the time-series dimension of the data and substitute $Corr_t$ by its one period lag. Since the correlation at $t - 1$ is predetermined when looking at it from the current period, it can not be affected by the austerity that takes place at period t . $X_{i,t-1}$ contains the lagged dependent variable (*Net lending*, *Primary surplus*, *CAPB*, *Expenditure*), *Debt over GDP*, *Squared debt over GDP*, *Log fiscal GDP*, *Log GDP per capita* and *Growth*. In order to deal with possible error autocorrelation, regression (5.2) has been estimated using the Arellano-Bond GMM estimator.³¹ The $Corr_{t-1}$ is instrumented with further lags of the same variable. As reported in table 6, there is no autocorrelation left in the residuals. I also apply the correction for small samples. Results in table 6 confirm the previous ones and are significant. I use robust estimators to correct for heteroskedasticity.

5.2.3 Results using the Yield Shocks as the independent variable

Here I present the results of the estimation corresponding to the specifications in the second column of table 1. The independent variable in this section is the *Yield Shocks*. The following specification:

$$Y_{j,k,t} = \alpha + \gamma_d Yield\ Shocks_{j,k,t-1} + \lambda X_{j,t-1} + \kappa_j + \tau_t + u_{j,t}, \quad (5.5)$$

³¹The Arellano-Bond estimator in differences uses first differentiation to eliminate the autocorrelated fixed component of the error term.

Table 5: IV regression results

	Net lending	Primary surplus	CAPB	Expenditure
Correlation _{t-1}	-18.49*** (3.377)	-18.04*** (3.790)	-4.092* (2.418)	14.44*** (2.928)
Net lending _{t-1}	0.504*** (0.0387)			
Primary surplus _{t-1}		0.534*** (0.0393)		
CAPB _{t-1}			0.630*** (0.0382)	
Expenditure _{t-1}				0.542*** (0.0385)
Debt _{t-1}	0.0674*** (0.0194)	0.110*** (0.0208)	0.0515*** (0.0137)	-0.0514*** (0.0170)
Squared debt _{t-1}	-0.0000956 (0.0000927)	-0.000231** (0.0000957)	-0.0000983 (0.0000624)	0.0000908 (0.0000806)
Log GDP _{t-1}	-0.799 (0.728)	-2.040*** (0.747)	-1.800*** (0.495)	0.0419 (0.632)
Log GDPpc _{t-1}	5.418*** (1.768)	7.459*** (2.227)	1.602 (1.377)	-0.421 (1.522)
Growth _{t-1}	4.943 (3.914)	1.958 (4.471)	2.564 (2.899)	-3.265 (3.396)
Country FE	Yes	Yes	Yes	Yes
N	611	541	513	611
R-square	0.726	0.722	0.807	0.955
F	27.98	25.93	40.55	212.9

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: GMM with robust standard errors

	Net lending	Primary surplus	CAPB	Expenditure
Correlation _{<i>t</i>-1}	-4.788*** (1.108)	-4.454*** (1.321)	-2.573*** (0.879)	3.789*** (0.827)
Net lending _{<i>t</i>-1}	0.507*** (0.101)			
Primary surplus _{<i>t</i>-1}		0.461*** (0.134)		
CAPB _{<i>t</i>-1}			0.722*** (0.115)	
Expenditure _{<i>t</i>-1}				0.648*** (0.118)
Debt _{<i>t</i>-1}	0.220 (0.146)	0.236*** (0.0818)	0.227*** (0.0834)	-0.285** (0.128)
Squared debt _{<i>t</i>-1}	-0.000475 (0.000807)	-0.000616 (0.000557)	-0.000863 (0.000517)	0.00115 (0.000809)
Log GDP _{<i>t</i>-1}	-3.842 (6.798)	-3.769 (6.656)	1.166 (4.499)	3.236 (4.879)
Log GDPpc _{<i>t</i>-1}	11.55 (19.05)	8.179 (17.80)	-2.572 (11.63)	-9.088 (13.65)
Growth _{<i>t</i>-1}	25.82*** (8.767)	29.90*** (7.788)	8.965** (3.898)	-15.47* (8.596)
N	821	718	659	821
hansen	48.61	43.15	36.46	48.79
AR(1)	0.00182	0.0150	0.00634	0.00302
AR(2)	0.0466	0.0457	0.115	0.112
F	26.07	21.37	26.85	26.19

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

estimates how an extreme yield event in a country belonging to a rating category affects the fiscal position of the other countries in that rating category in the next period.

Table 7: Panel probit with random effects

	Consolidation dummy
Yield shocks	0.389* (0.211)
Net lending $_{t-1}$	-0.306*** (0.0527)
Squared primary surplus $_{t-1}$	-0.0112 (0.00907)
Debt $_{t-1}$	0.0152 (0.0208)
Squared debt $_{t-1}$	0.0000294 (0.000102)
Log GDP $_{t-1}$	2.066 (1.262)
Log GDPpc $_{t-1}$	-7.147** (3.216)
Growth $_{t-1}$	11.91** (6.070)
Country FE	Yes
N	335
Chi-square	83.58
Loglikelihood	-130.8

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notice that the definition of *Yield Shocks* in equation (5.1) does not include country j 's own yields events; it contains only information about other countries in the same rating category. Moreover, in order to be more careful, the independent variable is lagged one period. Finally, I also excluded from the estimation countries that experienced a yields event or a rating change between $t - 1$ and t . All this to the purpose that the yield shocks are exogenous to the countries' fiscal position $Y_{j,k,t}$ and the effect on austerity comes from

Table 8: OLS with robust standard errors

	Net lending	Primary surplus	CAPB	Expenditure
Yield shocks _{<i>t</i>-1}	0.533*** (0.154)	0.601*** (0.166)	0.294** (0.116)	-0.247** (0.118)
Net lending _{<i>t</i>-1}	0.684*** (0.0416)			
Primary surplus _{<i>t</i>-1}		0.738*** (0.0412)		
CAPB _{<i>t</i>-1}			0.725*** (0.0521)	
Expenditure _{<i>t</i>-1}				0.762*** (0.0299)
Debt _{<i>t</i>-1}	-0.00823 (0.00580)	0.0000688 (0.00586)	-0.00352 (0.00532)	0.0120** (0.00552)
Log GDP _{<i>t</i>-1}	-1.467** (0.682)	-1.981*** (0.727)	-2.267** (0.963)	1.089* (0.640)
Log GDPpc _{<i>t</i>-1}	0.714 (1.466)	2.430 (1.640)	3.098* (1.823)	1.329 (1.361)
Growth _{<i>t</i>-1}	5.198 (3.792)	0.501 (4.170)	5.121 (6.206)	-4.315 (3.534)
Rating _{<i>t</i>-1}	-0.0837** (0.0372)	-0.0776* (0.0431)	-0.0684* (0.0380)	0.0418 (0.0341)
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	885	772	653	885
r ²	0.838	0.831	0.870	0.978
F	45.85	40.75	99.59	783.4

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

the change in information alone. $X_{j,t}$ includes the usual controls and the lagged ratings.³²

The regression results for this specification are presented in tables 7 and 8. Notice that, when more countries in your rating category are subject to a yield event, it means a larger number in the variable $Yield\ Shocks_{i,k,t}$. Hence, an increase in the explanatory variable is associated with more austerity (an increase in the probability of a fiscal consolidation, $\hat{\gamma}_c > 0$, or higher values in the primary surplus, $\hat{\gamma}_d > 0$) as expected. This approach confirms the results from previous sections. Experiencing a yield shock in your rating category increases the austerity over GDP in the order of one half percentage points of net borrowing or primary deficit and about one quarter of CAPB. For example, the primary deficit over GDP would go from 3.5% to 3%.

5.3 Alternative explanations

There could be alternative theories that explain the empirical results. I attempt to list and discuss some of them in this section.

First, in order to rule out that austerity is due to criteria of budget sustainability, I have controlled in all the regressions above for a set of individual characteristics that the literature has identified as important (Gali and Perotti, 2003, Favero and Monacelli, 2005, Baldacci et al., 2013).

However, there might still be missing unobservable characteristics. This is a problem insofar the omitted variable is correlated with $Corr_t$. Imagine that we are estimating this regression:

$$Y_{i,t} = \alpha + \beta Corr_t + \gamma X_{i,t-1} + \kappa_i + \epsilon_{i,t}, \quad (5.6)$$

where in reality $\epsilon_{i,t} = Z_t + u_{i,t}$ and $Corr(X_{i,t-1}, Z_t) \neq 0$. Then, $Corr(X_{i,t-1}, \epsilon_{i,t}) \neq 0$ and estimation by OLS would produce biased coefficients. Concerns about omitted variables,

³²This is trying to control for any other domestic reason that affects the fiscal stance.

e.g. global uncertainty, are addressed by including country and time fixed effects in the last specification (5.5). The effect of changes in information on austerity remains after those omitted variables are controlled for.

Notice that regression (5.5) deals with omitted variable bias even if it has asymmetric effects on different rating categories because the category performing higher austerity changes every time (depending on the category that experienced the yields shock). But there could also be omitted variables that affect only some countries and not others. Particularly problematic is the case when an omitted variable affects the countries in some particular category only. In this case the effects could be confounded with the effects of the yield events operating at the level of the rating category and we would be unsure whether we were capturing the correct effect. For example, think about precautionary savings by countries within a rating category triggered by uncertainty clustered at the category level. Notice, though, that the precautionary motive should be homogenous in all countries within a given category. But austerity by category shows high dispersion. This indicates that austerity is not performed by every country, as would be consistent with the precautionary motive, but only by some countries that belong in the category affected by a price change, as consistent with the signalling motive.

The results obtained here could also be attributed to contagion. A shock to a country is transmitted to others, even though they are not directly hit by it. By the nature of contagion, it cannot be captured by controlling for the fundamentals of the country as I did before. In order to detect contagion among countries, the literature usually relies on price co-movements, thus implying that contagion should matter-of-factly show in the price of debt. Controlling for the country's own lagged log yields and the lagged rating in specification (5.5), as I do in appendix O, I still find an effect of changes in the ratings information content.

One issue that remains is that we cannot predict what each type do because types are not observable (neither in theory nor in the data). But we can work around that in the following ways: one is to use regional sub-samples. I repeat the same regression (5.2) on the

sample split by regions (OECD countries, European Union countries, peripheral European countries named ‘PIIGS’ and emerging market economies). The effect of a decrease in the correlation is qualitatively the same, however, it becomes less significant for the group of PIIGS and it is not significant for emerging markets (see appendix N for further details). According to the model, this would be expected if there were a higher proportion of type B countries in these two groups relative to the OECD and EU groups.

Another way is to use a two-stage strategy. In a first stage, I find the proximity to being a ‘good type’ based on past observable information, where ‘good’ is defined tautologically as those countries which overshoot austerity from that predicted by the fitted regression (5.5). In the second stage I can use the predicted proximity to good type/ austerian to explain the CAPB. It turns out that the more the observable variables predict a country to behave as a ‘good’ type in a certain year, the higher its out of sample austerity really is.³³

Table 9: OLS with robust standard errors

	CAPB
Predicted good type	1.201*** (0.177)
Standard errors in parentheses	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$	

6 Conclusion and policy discussion

In this paper I have shown that a sovereign may use fiscal policy as a signal to communicate to the lenders its high ability to repay. In the empirical analysis I find that sovereigns are prone to adopting a more austere fiscal policy when the ratings are less capable of improving the market perception about a country. This result is robust to different empirical strategies, specifications and variables that measure austerity. I consistently find evidence that favours the signalling motive over other alternative explanations.

³³The first stage regression uses years 1980 to 2000 and the out of sample prediction 2000 to 2011.

The findings in this paper are relevant for policymakers who aim at implementing austerity programs to reduce the risk of a sovereign default. A measure that has been proposed during the recent debt crisis in Europe has been a common debt ceiling. For instance, the Fiscal Compact has introduced the rule of fiscal budget balance in its Article 3 of Title II.³⁴ In the model this policy is equivalent to setting an exogenous debt limit that is the same for any country type. This policy has an effect only when the debt ceiling \bar{D}_2 is lower than type B's full information allocation D_2^{FI} as in figure 8 in appendix P. Suppose the equilibrium is the separating one e^* . Once the debt ceiling is introduced, type B is not allowed to choose its optimal debt level because it would violate the rule. In a separating equilibrium under the new debt ceiling rule, type B chooses the highest amount of debt possible, \bar{D}_2 , as depicted in figure 9. But this gives type B a lower utility, thereby forcing type A to choose an even lower amount of debt than D_2^{-B} . Type A needs to do more austerity in order to avoid imitation from B because the outside option for B has become worse. Both types are worse off, even though the riskiness of debt improves because the sovereigns have a lower default probability.

But it might well be that the introduction of a debt limit lets the separating equilibrium be defeated. For instance, the pooling equilibrium at \bar{D}_2 in figure 10 makes both types better off, thus defeating the separating equilibrium. Compared with the initial equilibrium e^* in figure 8, however, every country type loses. This can be seen by comparing the utility levels of type A and B with the equilibrium allocations from figure 8 represented by the dotted lines. Moreover, type B's default premium decreases but A's increases, as the black arrows on the vertical axis show, leaving open the possibility that the overall probability of default increases or decreases. It is, therefore, possible that the introduction of a debt ceiling makes all countries worse off and also fails to improve the riskiness of debt. A 'one-size-fits-all' austerity programme such as the Fiscal Compact may backfire when countries are trying to

³⁴*The Contracting Parties shall apply the rules set out in this paragraph in addition and without prejudice to their obligations under European Union law: (a) the budgetary position of the general government of a Contracting Party shall be balanced or in surplus; [...] (e) in the event of significant observed deviations from the medium-term objective or the adjustment path towards it, a correction mechanism shall be triggered automatically.'*

signal with austerity.³⁵

In the current debate on austerity, it is important to understand all the different roles that austerity might play. In this paper I have stressed one of these roles, which complements others that have been studied more extensively in the literature.

³⁵In a different set-up with homogeneous countries and limited commitment, introducing a debt ceiling could instead be useful to overcome the commitment problem.

APPENDIX

A The single crossing property

The *single crossing condition* is defined as a ranking of the slopes of the indifference curves $U^i(D_2, q)$ such that $\Delta^A < \Delta^B$, where $\Delta^i = -\frac{\frac{\partial U^i(D_2, q)}{\partial D_2}}{\frac{\partial U^i(D_2, q)}{\partial q}}$. Let us show that the indifference curves of country type A are flatter than those of country type B for the relevant range of D_2 . First, let us define the relevant range of D_2 . Let \underline{D}_2^i be the threshold level of debt that satisfies constraint (2.5) for $t = 1$ for each type:

$$\underline{D}_2^i = \frac{\underline{c}^i - \omega_1 + D_1}{\beta' [1 - F(\underline{D}_2^i + \underline{c}^i)]}. \quad (\text{A.1})$$

Substituting $F(\cdot)$ for its functional form, we obtain:

$$\underline{D}_2^i = \frac{\underline{c}^i - \omega_1 + D_1}{\beta'} e^{h(\underline{c}^i - \underline{\omega})} e^{h\underline{D}_2^i}. \quad (\text{A.2})$$

Since $e^{h\underline{D}_2^i}$ is bounded between 0 and 1, $\underline{D}_2^i > 0$. Moreover, since $\underline{c}^A < \underline{c}^B$, $\underline{D}_2^A < \underline{D}_2^B$. Thus, the relevant range of D_2 is $[\underline{D}_2^B, \infty)$.

Next, let us compute Δ^i for each type. Total differentiation of equation (2.6) gives:

$$\begin{aligned} 0 = D_2 \cdot dq + \\ + [q + \beta F'(D_2 + \underline{c}^i) \underline{c}^i - \beta F'(D_2 + \underline{c}^i)(D_2 + \underline{c}^i) + \beta F'(D_2 + \underline{c}^i) D_2 - \beta (1 - F(D_2 + \underline{c}^i))] \cdot dD_2 \end{aligned}$$

and, simplifying,

$$0 = D_2 \cdot dq + [q - \beta (1 - F(D_2 + \underline{c}^i))] \cdot dD_2.$$

Therefore, $\Delta^i = -\frac{q - \beta(1 - F(D_2 + \underline{c}^i))}{D_2}$ and $\Delta^A < \Delta^B$ if $\Delta^i < 0$, which is the case for all $D_2 \in [\underline{D}_2^B, \infty)$ given assumption (A4). \square

B Full information optimal allocation

Let us show that the optimal level of debt under full information D_2^{FI} is a local maximum.

Differentiating the FOC (3.2) with respect to D_2 and rearranging gives:

$$F''(D_2 + \underline{c}^i) \left[-\beta' D_2 - \beta' \frac{F'(D_2 + \underline{c}^i)}{F''(D_2 + \underline{c}^i)} + (\beta' - \beta)h^{-1} \right]. \quad (\text{B.1})$$

In order to sign the previous expression, substitute $F(\omega)$ for its functional form $1 - e^{-h\omega - \underline{\omega}}$.

$F'''(\omega) < 0$ and for equation (B.1) to be negative it must be that

$$-\beta' D_2 - \beta' \frac{F'(D_2 + \underline{c}^i)}{F''(D_2 + \underline{c}^i)} + (\beta' - \beta)h^{-1} > 0,$$

therefore,

$$D_2 < \frac{\beta' - \beta}{\beta' h} + \frac{1}{h}. \quad (\text{B.2})$$

The derivative of the FOC is negative when (B.2) holds. Since $D_2^{FI} = \frac{\beta' - \beta}{\beta' h}$ and $h > 0$, the expression (B.1) is negative at D_2^{FI} and D_2^{FI} is a local maximum. \square

C Separating equilibrium

We need to show that a separating equilibrium exists at allocation $((D_2^{-B}, q(D_2^{-B}, 1)), (D_2^{FI}, q(D_2^{FI}, 0)))$ under beliefs $\mu^*(D_2^{-B}) = 1, \mu^*(D_2) = 0$ for any other D_2 . Recall that D_2^{-B} is the debt level that satisfies type B's incentive compatibility constraint (3.5) with equality:

$$U^B(D_2^{-B}, q(D_2^{-B}, 1)) = U^B(D_2^{FI}, q(D_2^{FI}, 0)), \quad (\text{C.1})$$

and denote $D_2^{A,B}$ A's preferred allocation under the price schedule $q(D_2, 0)$.

Now let us define $\mathbf{q}_i(D_2, U)$ as the indirect function that gives the price of debt necessary

to keep type i 's utility constant at U for a given debt D_2 . $\mathbf{q}_i(\cdot)$ is continuous and one-to-one. If $\bar{U} = U^B(D_2^{FI}, q(D_2^{FI}, 0))$ is the utility level of country B in the full information equilibrium, $\mathbf{q}_B(D_2^{FI}, \bar{U})$ is equal to the price $q(D_2^{FI}, 0)$ by definition. On the other hand, we know that $q(D_2, 0) < q(D_2, 1) \quad \forall D_2$ and, in particular, for D_2^{FI} . Therefore,

$$\mathbf{q}_B(D_2^{FI}, \bar{U}) = q(D_2^{FI}, 0) < q(D_2^{FI}, 1).$$

Hence, $\mathbf{q}_B(D_2^{FI}, \bar{U})$ lies below $q(D_2^{FI}, 1)$. Now let us check how these two functions behave to the left of D_2^{FI} :

$$q(\underline{D}_2^B, 1) = \beta' [1 - F(\underline{D}_2^B + \underline{c}^A)]$$

is positive and bounded and $\lim_{D_2 \rightarrow \underline{D}_2^B} \mathbf{q}_B(D_2, \bar{U}) = +\infty$.

In the limit $\mathbf{q}_B(D_2, \bar{U})$ is above $q(D_2, 1)$. Since $q(\cdot, 1)$ is continuous in D_2 and so is $\mathbf{q}_B(D_2, \bar{U})$ for $D_2 \neq 0$, $\mathbf{q}_B(D_2, \bar{U})$ and $q(D_2, 1)$ must intersect at some D_2 between \underline{D}_2^B and D_2^{FI} . Hence, there exists a $D_2^{-B} \in [\underline{D}_2^B, D_2^{FI}]$ such that the isoutility curve of B going through $(D_2^{FI}, q(D_2^{FI}, 0))$ crosses the price schedule $q(D_2, 1)$.

It remains to be proved that type A prefers choosing D_2^{-B} and having the price of debt $q(D_2^{-B}, 1)$ to choosing $D_2^{A,B}$ and having the price $q(D_2^{A,B}, 0)$. First, notice that at the full information allocation type B is at its maximum, hence, it is its highest isoutility curve under the $q(D_2, 0)$ schedule. It follows that the price schedule $q(D_2, 0)$ must lie below B's isoutility curve going through the full information allocation for all $D_2 \neq D_2^{FI}$. So, in order to satisfy the tangency condition of $D_2^{A,B}$ for type A, $(D_2^{A,B}, q(D_2^{A,B}, 0))$ must be below the isoutility curve of B going through $(D_2^{FI}, q(D_2^{FI}, 0))$. And, given that the isoutility curves of A in (D_2, q) are steeper than those of B for any D_2 , the two of them can only cross to the right of $D_2^{A,B}$. Since they cannot cross to the left of $D_2^{A,B}$ it is impossible that $(D_2^{A,B}, q(D_2^{A,B}, 0))$ is on a higher isoutility curve of A than $(D_2^{-B}, q(D_2^{-B}, 1))$. Otherwise, it would be preferred by B as well and that is a contradiction to (C.1). \square

D Pooling equilibrium at D_2^{FI}

In order to show that there can be a pooling equilibrium at the full information debt level notice that B's utility pooling at $(D_2^{FI}, q^*(D_2^{FI}, p))$ must be higher than the full information allocation $(D_2^{FI}, q^*(D_2^{FI}, 0))$ because the debt level is the same but the price is better. Since $\mu^*(D_2) = 0$ for any $D_2 \neq D_2^{FI}$, type B's optimal choice of $D_2^*(B)$ is D_2^{FI} . At the same time, A's utility at $(D_2^{FI}, q^*(D_2^{FI}, p))$ also needs to be higher than at its preferred allocation under the $q(D_2, 0)$ schedule, $(D_2^{A,B}, q(D_2^{A,B}, 0))$. By contradiction, for $(D_2^{A,B}, q(D_2^{A,B}, 0))$ to be preferred, U^A going through it must cross $q(\cdot, p)$ at some point between $D_2^{A,B}$ and D_2^{FI} . At $D_2^{A,B}$, $q(D_2^{A,B}, p) > q(D_2^{A,B}, 0)$ and, as $D_2 \rightarrow \infty$, the $\lim_{D_2 \rightarrow \infty} q(D_2, p) > 0$ and the indifference curve going through $(D_2^{A,B}, q(D_2^{A,B}, 0))$ goes to 0. Continuity and monotonicity of $q(D_2, p)$ is straightforward and of the indifference curve has been shown in appendix B. Hence, they cannot cross to the right of $D_2^{A,B}$, and D_2^{FI} is type B's optimal choice. To sum up, D_2^{FI} is the optimal choice of both A and B given the system of beliefs and, therefore, by Bayes' rule, $\mu = p$ at D_2^{FI} . \square

E Definition of the Undefeated Equilibrium refinement

Let e^* and e' be two equilibria of the game and $\{(D_2^*(i), q^*; \mu^*(\cdot))\}_{i \in \{A, B\}}$ and $\{(D_2'(i), q'; \mu'(\cdot))\}_{i \in \{A, B\}}$ its respective outcomes. If:

1. D_2' is a non-equilibrium outcome in e^* .
2. $\Theta = \{\{A\}, \{B\}, \{A, B\}, \{\emptyset\}\}$ is the set of types that choose strategy D_2' in e' .
3. Denoting $U^i(e)$ the utility of type i under equilibrium e :

$$U^i(e') \geq U^i(e) \forall i \in \Theta,$$

with the inequality being strict for at least one $i \in \Theta$.

4. The off-equilibrium beliefs after observing D'_2 in e^* , $\mu^*(D'_2)$, are positive for the type(s) with a strict inequality and zero for the type(s) not belonging to Θ ,

then, whenever $\mu^*(D'_2)$ do not support e^* , e^* is *defeated* by e' .

F Selection of the separating equilibrium e^*

For e^* to be the unique equilibrium it must be that: a) e^* is undefeated and b) it defeats all other equilibria.

- a) e^* is defeated if there is an equilibrium e' whose μ' at D'_2 is not consistent with e^* . Notice that this can only happen:

- To the right of D_2^{-B} if $\forall D_2 \in [\underline{D}_2^B, D_2^{-B}] \quad q(D_2, \mu) > q(D_2, 1)$, which is impossible according to the definition of PBE.
- To the left of D_2^{-B} any possible equilibria are of the pooling type. Hence, equilibrium beliefs are $q(D_2, \mu) = q(D_2, p)$ and $q(D_2, p)$ needs to be above A's isoutility curve going through $(D_2^{-B}, q(D_2^{-B}, 1))$.

Thus, $q(D_2, p) < \mathbf{q}(D_2, \bar{U}^A)$, where $\bar{U}^A = U^A(D_2^{-B}, q(D_2^{-B}, 1))$, is the condition for e^* to survive.³⁶ The condition holds for a sufficiently low p :

$$p < 1 + \frac{\bar{U}^A - \omega_1 + D_1 + (2\beta - \beta')(1 - F(D_2 + \underline{c}_A)) - \beta(1 + \underline{c}_A + D_2 + h^{-1})}{\beta' D_2 (F(D_2 + \underline{c}_B) - F(D_2 + \underline{c}_A))}.$$

- b) Now, take e^* that is undefeated. This means that $U^i(e^*) \geq U^i(e') \forall i$, with strict inequality for at least one i , for any other equilibrium e' . On the other hand, off-equilibrium beliefs in equilibrium e' must be $\mu'(D_2) \neq 1 \forall D_2 \neq D'_2$ in order to be able to sustain e' . But, since $\Theta = \{A\}$ for D_2^{-B} in e^* and $U^A(e^*) > U^A(e')$, $\mu'(D_2^{-B}) = 1$ and any e' is defeated by e^* . □

³⁶ $\mathbf{q}(\cdot)$ has been defined as the function that maps (D_2, \bar{U}^A) to q : $\mathbb{R} \times \mathbb{R} \rightarrow \mathbb{R}_+$.

G Selection of the pooling equilibria

Let us show that a pooling equilibrium e' can defeat the least cost separating equilibrium e^* . e' will defeat e^* if $U^A(e') \geq U^A(e^*)$ and $U^B(e') > U^B(e^*)$. D'_2 is not an equilibrium strategy for A in e^* but both types choose D'_2 in e' , hence $\Theta = \{A, B\}$. Off-equilibrium beliefs about the type(s) that choose D'_2 in e^* need to be positive for both A and B. Hence,

$$\mu^*(\cdot) = \begin{cases} p & \text{if } D'_2 \\ 1 & \text{if } D_2^{-B} \\ 0 & \text{otherwise.} \end{cases}$$

Condition $U^B(e') > U^B(e^*)$, i.e. $U^B(D_2^{FI}, q^*(D_2^{FI}, p)) > U^B(D_2^{FI}, q^*(D_2^{FI}, 0))$, is clearly true. And for its A counterpart, $U^A(D_2^{FI}, q^*(D_2^{FI}, p)) \geq U^A((D_2^{-B}, q^*(D_2^{-B}, 1)))$, it suffices to choose a p that is close enough to 1. Take, for example, $1 - \epsilon$, where ϵ is very small. Notice that

$$U^A(D_2^{FI}, q^*(D_2^{FI}, p)) = p [U^A(D_2^{FI}, q^*(D_2^{FI}, 1))] + (1 - p) [U^A(D_2^{FI}, q^*(D_2^{FI}, 0))]$$

and that

$$U^A(D_2^{FI}, q^*(D_2^{FI}, 1)) > U^A(D_2^{-B}, q^*(D_2^{-B}, 1)),$$

because it is the full information solution. Thus, using $p = 1 - \epsilon$,

$$\begin{aligned} U^A(D_2^{FI}, q^*(D_2^{FI}, p)) &= (1 - \epsilon) [U^A(D_2^{FI}, q^*(D_2^{FI}, 1))] + \epsilon [U^A(D_2^{FI}, q^*(D_2^{FI}, 0))] \\ &> U^A((D_2^{-B}, q^*(D_2^{-B}, 1))). \end{aligned}$$

□

H Pooling debt allocation preferred by $i \in \{A, B\}$

Recall the FOC of the country's problem, equation (3.2), is:

$$\frac{\partial q(D_2, \mu)}{\partial D_2} D_2 + q(D_2, \mu) - \beta (1 - F(D_2 + \underline{c}^i)) = 0.$$

Given that we are focusing on pooling equilibria, the price schedule in equilibrium is

$$q(D_2, p) = \beta' [p (1 - F(D_2 + \underline{c}^A)) + (1 - p) (1 - F(D_2 + \underline{c}^B))] .$$

Plugging this into the FOC equation, we obtain:

$$\begin{aligned} -\beta' [p F'(D_2 + \underline{c}^A) + (1 - p) F'(D_2 + \underline{c}^B)] D_2 + \beta' [p (1 - F(D_2 + \underline{c}^A)) + (1 - p) (1 - F(D_2 + \underline{c}^B))] - \\ - \beta (1 - F(D_2 + \underline{c}^A)) = 0. \end{aligned}$$

Hence,

$$D_2^{*i} = h^{-1} - \frac{\beta(1 - F(D_2^{*i} + \underline{c}^A))}{\beta' [p F'(D_2^{*i} + \underline{c}^A) + (1 - p) F'(D_2^{*i} + \underline{c}^B)]} \quad \forall i \in \{A, B\}.$$

I Multiple-period model

Recall the two-period sovereign problem:

$$\max_{D_2} \quad c_1 + \beta \mathbb{E}_\omega[c_2] \tag{I.1}$$

$$\text{subject to} \quad c_1 \geq \omega_1 - D_1 + q(D_2, \mu) D_2$$

$$c_2 \geq \begin{cases} \underline{c}^i & \text{if } \omega_2 \leq D_2 + \underline{c}^i \\ \omega_2 - D_2 & \text{if } \omega_2 > D_2 + \underline{c}^i \end{cases}$$

$$q(D_2, \mu) = \beta' [\mu (1 - F(D_2 + \underline{c}^A)) + (1 - \mu) (1 - F(D_2 + \underline{c}^B))] .$$

Now, extend it another period. At the end of $t = 2$, nature draws again a country type, independently, from the same distribution of types P with support $\{A, B\}$ and probability p of A and $1 - p$ of B . Then, the country can borrow again, issuing D_3 . At $t = 3$ a new realization ω_3 is obtained from the income distribution $f(\omega)$ and the country defaults if it becomes insolvent, $\underline{c}_3^i \geq \omega_3 - D_3$.

All together, the problem reads:

$$\begin{aligned}
& \max_{D_2, D_3} \quad c_1 + \beta \mathbb{E}_\omega[c_2] + \beta^2 \mathbb{E}_{\omega, P}[c_3] \tag{I.2} \\
& \text{subject to} \quad c_1 \geq \omega_1 - D_1 + q(D_2, \mu_2)D_2 \\
& c_2 \geq \begin{cases} \underline{c}_2^i + q(D_3, \mu_3)D_3 & \text{if } \omega_2 \leq D_2 + \underline{c}_2^i \\ \omega_2 - D_2 + q(D_3, \mu_3)D_3 & \text{if } \omega_2 > D_2 + \underline{c}_2^i \end{cases} \\
& c_3 \geq \begin{cases} \underline{c}_3^i & \text{if } \omega_3 \leq D_3 + \underline{c}_3^i \\ \omega_3 - D_3 & \text{if } \omega_3 > D_3 + \underline{c}_3^i \end{cases} \\
& q(D_t, \mu_t) = \beta' [\mu_t (1 - F(D_t + \underline{c}^A)) + (1 - \mu_t)(1 - F(D_t + \underline{c}^B))] \text{ for } t = 1, 2.
\end{aligned}$$

Notice that every period the default decision happens before the issuance of new debt. This makes the default probability be $\lambda_t = F(D_t + \underline{c}_t^i) \forall t$.

If we focus on the problem between $t = 2$ and $t = 3$,

$$\begin{aligned}
& \max_{D_3} \quad c_2 + \beta \mathbb{E}_\omega[c_3] \\
& \text{subject to} \quad c_2 \geq \omega_2 - D_2 + q(D_3, \mu_3)D_3 \\
& c_3 \geq \begin{cases} \underline{c}_3^i & \text{if } \omega_3 \leq D_3 + \underline{c}_3^i \\ \omega_3 - D_3 & \text{if } \omega_3 > D_3 + \underline{c}_3^i \end{cases} \\
& q(D_3, \mu_3) = \beta' [\mu (1 - F(D_2 + \underline{c}^A)) + (1 - \mu)(1 - F(D_2 + \underline{c}^B))] ,
\end{aligned}$$

we can directly see that it is the two-period problem I.1 with different initial conditions: $\omega_2 - D_2$. However, initial conditions affect only the level of the indifference curves. The full information optimal debt level is unchanged and neither is the ratio of the slopes of the indifference curves. The solution to the problem between $t = 2$ and $t = 3$, D_3^* , is, hence, the same as the solution to problem I.1.

Now, from the perspective of period 1, the problem I.2 can be rewritten as

$$\max_{D_2} \omega_1 - D_1 + q(D_2, \mu_2)D_2 + \beta \left[F(D_2 + \underline{c}_2^i) \underline{c}_2^i + (1 - F(D_2 + \underline{c}_2^i)) (\mathbb{E}_\omega[\omega_2 | \omega_2 \geq D_2 + \underline{c}_2^i] - D_2) \right] \\ + \beta \mathbb{E}_{\omega, P} [V_2(D_3^*)],$$

where the last element is the only difference with the original I.1 model. But

$$V_2(D_3^*) = q(D_3^*, \mu_3)D_3^* + \\ + \beta p \left(F(D_3^* + \underline{c}_3^A) \underline{c}_3^A + (1 - F(D_3^* + \underline{c}_3^A)) (\mathbb{E}_\omega[\omega_3 | \omega_3 \geq D_3^* + \underline{c}_3^A] - D_3^*) \right) + \\ + \beta (1 - p) \left(F(D_3^* + \underline{c}_3^B) \underline{c}_3^B + (1 - F(D_3^* + \underline{c}_3^B)) (\mathbb{E}_\omega[\omega_3 | \omega_3 \geq D_3^* + \underline{c}_3^B] - D_3^*) \right)$$

is not dependent on D_2 nor on the type at $t = 1$. Hence, the problem I.2 from $t = 1$ is also the same as problem I.1 up to a constant, $\beta \mathbb{E}_{\omega, p} [V_2(D_3^*)]$.

Finally, setting the initial parameters to $\omega_1 - D_1 = 0$ without loss of generality, and extending to $t = T$ periods, the solution to the problem

$$\max_{D_t} V_t = q(D_t, \mu_t)D_t + \beta \left[\mathbb{E}_t[\underline{c}_{t+1}^i] + \mathbb{E}_t \sum_{t+1}^T V_{t+1}(D_{t+1}) \right] \\ \text{subject to } q(D_t, \mu_t) = \beta' [\mu_t(1 - F(D_t + \underline{c}^A)) + (1 - \mu_t)(1 - F(D_t + \underline{c}^B))] \quad \forall t \in [1, T]$$

is the same as the solution to T consecutive I.1 problems.

J Yield Events

NEGATIVE				POSITIVE			
Country	Year	Country	Year	Country	Year	Country	Year
Czech Republic	2003	Pakistan	1992	Cyprus	2006	New Zealand	1992
Greece	2010	Portugal	2011	Ethiopia	1987	Norway	1993
Honduras	1994	South Africa	1988	Honduras	1997	Norway	2004
Honduras	1996	Sri Lanka	1991	Italy	1984	Norway	2009
Iceland	2008	Switzerland	1994	Japan	1992	Pakistan	2003
Jamaica	1985	Switzerland	1999	Japan	1997	Seychelles	2003
Jamaica	1990	Switzerland	2003	Japan	1998	Singapore	2007
Japan	1990	Thailand	2004	Japan	2001	Slovenia	1993
Japan	1999	Uganda	1984	Japan	2007	Slovenia	1994
Lithuania	2009	Uganda	1985	Korea	1981	Solomon Islands	2004
Luxembourg	2006	Uganda	1986	Korea	1982	Solomon Islands	2005
Malawi	1995	Uganda	1989	Korea	1983	Switzerland	2000
New Zealand	1996	United States	2005	Latvia	2011	Switzerland	2002
Norway	1998			Lithuania	2010	Switzerland	2008
				Luxembourg	1988	Switzerland	2011
				Mexico	2001	Thailand	1987
				Namibia	2001	Vanuatu	1989
				Nepal	1991	Vanuatu	2008

K Dataset: the ratings geography and time span

Country	Moody's	Fitch	S&P	Country	Moody's	Fitch	S&P
Australia	1980	1996	1980	Malawi	-	2003-09	-
Austria	1980	1995	1980	Malta	1994	1997	1994
Belgium	1980	1995	1989	Mexico	1991	1996	1993
Botswana	2001	-	2001	Morocco	1999	2007	1998
Bulgaria	1997	1998	1999	Netherlands	1986	1995	1989
Canada	1980	1995	1980	New Zealand	1980	2000	1980
Cyprus	1996	2002	1994	Norway	1980	1995	1980
Czech Republic	1993	1996	1994	Pakistan	1995	-	1995
Denmark	1980	1995	1981	Papua New Guinea	1999	1999	1999
Estonia	1998	1998	1998	Philippines	1994	1999	1994
Fiji	1997	-	2007	Poland	1995	1996	1995
Finland	1980	1995	1980	Portugal	1987	1995	1989
France	1980	1995	1980	Romania	1996	1996	1996
Germany	1986	1995	1984	Russia	1997	1997	1997
Ghana	-	2004	2004	Seychelles	-	2010	2007-09
Greece	1991	1996	1989	Singapore	1990	1999	1989
Guatemala	1998	2006	2002	Slovak Republic	1995	1997	1994
Honduras	1999	-	2009	Slovenia	1996	1997	1996
Hungary	1990	1996	1992	South Africa	1995	1995	1995
Iceland	1989	2000	1989	Spain	1988	1995	1989
India	1988	2000	1991	Sri Lanka	2011	2006	2006
Ireland	1988	1995	1989	Sweden	1980	1995	1980
Italy	1987	1995	1989	Switzerland	1982	1995	1989
Jamaica	1998	2007	2000	Thailand	1990	1998	1989
Japan	1982	1995	1980	Trinidad and Tobago	1993	-	1996
Korea	1987	1996	1989	Uganda	-	2005	2009
Latvia	1998	1998	1997	United Kingdom	1980	1995	1980
Lithuania	1997	1997	1997	United States	1980	1995	1980
Luxembourg	1990	1995	1995	Venezuela	1980	1998	1980

L Dataset: definition of variables

General government gross debt (*Debt*, % GDP): Gross debt consists of all liabilities that require payment or payments of interest and/or principal by the debtor to the creditor at a date or dates in the future. This includes debt liabilities in the form of SDRs, currency and deposits, debt securities, loans, insurance, pensions and standardised guarantee schemes, and other accounts payable (World Economic Outlook 2013, WEO13).

General government net lending/borrowing (*Net lending*, % GDP): Net lending (+)/borrowing (-) is calculated as revenue minus total expenditure. It is also equal to net acquisition of financial assets minus net incurrence of liabilities (WEO13).

General government primary net lending/borrowing (*Primary surplus*, % GDP): Primary net lending/borrowing is net lending (+)/borrowing (-) plus net interest payable/paid (interest expense minus interest revenue) (WEO13).

General government structural balance (*CAPB*, national currency): The structural budget balance refers to the general government cyclically adjusted balance adjusted for nonstructural elements beyond the economic cycle. These include temporary financial sector and asset price movements as well as one-off, or temporary, revenue or expenditure items. The cyclically adjusted balance is the fiscal balance adjusted for the effects of the economic cycle (WEO13).

General government structural balance (*CAPB*, % potential GDP): The structural budget balance refers to the general government cyclically adjusted balance adjusted for nonstructural elements beyond the economic cycle. These include temporary financial sector and asset price movements as well as one-off, or temporary, revenue or expenditure items. The cyclically adjusted balance is the fiscal balance adjusted for the effects of the economic cycle (WEO13).

General government total expenditure (*Expenditure*, % GDP): Total expenditure consists of total expense and the net acquisition of non-financial assets (WEO13).

GDP corresponding to fiscal year, current prices (*GDP*, billions of national currency):

Gross domestic product corresponding to fiscal year is the country's GDP based on the same period during the year as their fiscal data. In the case of countries whose fiscal data are based on a fiscal calendar (e.g., July to June), this series would be the country's GDP over that same period. For countries whose fiscal data are based on a calendar year (i.e., January to December), this series will be the same as their GDP in current prices (WEO13).

GDP growth (*Growth*, %): author's own calculation applying the formula $\frac{GDP_t - GDP_{t-1}}{GDP_t}$ to the GDP series corresponding to fiscal year (current prices).

GDP per capita, constant prices (*GDPpc*, units of national currency): GDP is expressed in constant national currency per person. Data are derived by dividing constant price GDP by total population (WEO13).

M First stage IV regressions

Table 10: OLS with robust standard errors

	$Corr_{t-1}$	$Corr_{t-1}$	$Corr_{t-1}$	$Corr_{t-1}$
News _{t-1}	0.00222*** (0.000268)	0.00213*** (0.000285)	0.00214*** (0.000290)	0.00222*** (0.000267)
MCO _{t-1}	-0.000394* (0.000237)	-0.000365 (0.000249)	-0.000480* (0.000258)	-0.000383 (0.000237)
N	611	541	513	611
R-square	0.539	0.567	0.547	0.540
F	11.35	12.01	11.39	11.37

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

N Regression by country groups

Table 11: OLS with robust standard errors

	(1)	(2)	(3)	(4)
Effect of a 1 unit change in $Corr_t$ in:	OECD	EU	PIIGS	EM
Net lending/borrowing	-0.0284*** (0.00885)	-0.0350*** (0.0112)	-0.0770** (0.0333)	-0.0249 (0.0233)
N	535	397	93	96
R-square	0.823	0.765	0.741	0.761
F	45.38	33.02	14.59	45.21
Primary balance	-0.0258*** (0.00863)	-0.0315*** (0.0107)	-0.0722** (0.0319)	-0.0272 (0.0222)
N	534	396	92	96
R-square	0.752	0.712	0.733	0.731
F	39.80	32.87	13.86	44.28
Potential structural balance	-0.0107* (0.00645)	-0.0105 (0.00856)	-0.0574** (0.0243)	-0.0220 (0.0182)
N	535	397	93	96
R-square	0.848	0.852	0.857	0.853
F	59.24	43.61	22.59	70.95
Government spending	0.0246*** (0.00906)	0.0278** (0.0122)	0.0425 (0.0282)	0.0246 (0.0310)
N	535	397	93	96
R-square	0.942	0.928	0.840	0.975
F	399.3	249.0	62.09	302.8

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

O Robustness check for contagion

Table 12: OLS with robust standard errors

	Net lending	Primary surplus	CAPB	Expenditure
Yield Shocks _{t-1}	0.459*** (0.157)	0.468*** (0.166)	0.249** (0.122)	-0.265** (0.128)
Net lending _{t-1}	0.724*** (0.0426)			
Primary surplus _{t-1}		0.753*** (0.0410)		
CAPB _{t-1}			0.720*** (0.0554)	
Expenditure _{t-1}				0.770*** (0.0344)
Debt _{t-1}	0.0198 (0.0123)	0.0510*** (0.0133)	0.00951 (0.0107)	0.00266 (0.0123)
Square debt _{t-1}	-0.000161*** (0.0000470)	-0.000249*** (0.0000498)	-0.0000845* (0.0000488)	0.0000686 (0.0000477)
Log GDP _{t-1}	-1.784** (0.816)	-2.430*** (0.812)	-2.424** (1.150)	1.177 (0.794)
Log GDPpc _{t-1}	1.881 (1.635)	4.002** (1.894)	2.876 (2.042)	0.858 (1.585)
Growth _{t-1}	5.182 (3.936)	2.142 (4.450)	8.253 (6.371)	-5.805 (3.930)
Rating _{t-1}	-0.116** (0.0473)	-0.0976* (0.0550)	-0.0594 (0.0479)	0.0781* (0.0431)
Log yields _{t-1}	0.00670 (0.455)	0.617 (0.535)	0.827 (0.583)	0.441 (0.407)
Country	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	748	658	598	748
R-square	0.849	0.845	0.846	0.979
F	41.58	43.36	.	661.5

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

P Introduction of a common debt limit

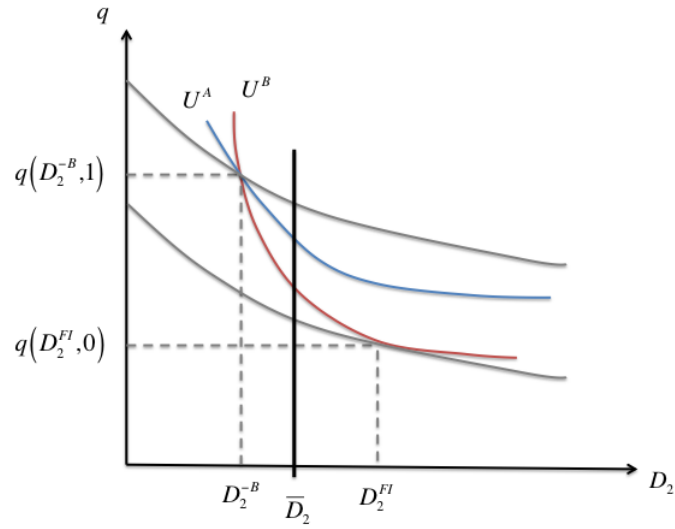


Figure 8: A common debt ceiling at \bar{D}_2 .

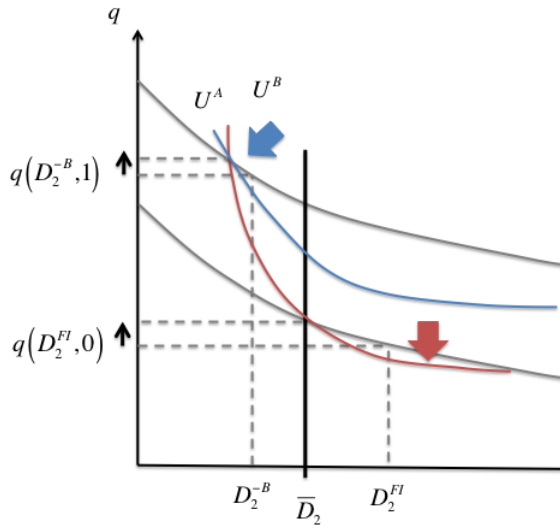


Figure 9: Separating equilibrium with a common debt ceiling.

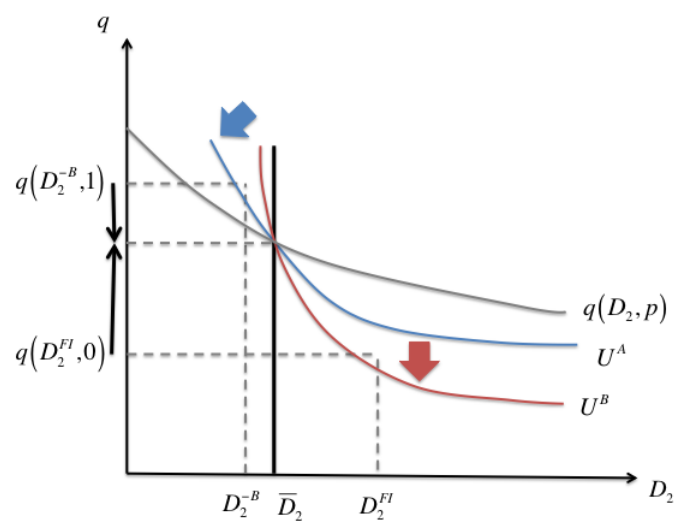


Figure 10: Pooling equilibrium with a common debt ceiling.

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