Signalling Creditworthiness with Fiscal Austerity

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February 2022

Abstract

Sovereign borrowers may tighten their fiscal stance in order to signal their creditworthiness to lenders. In a model of sovereign debt with incomplete information, I show that a trustworthy country may reduce its debt beyond the optimal level in order to separate itself from less reliable countries. Since austerity is costly, the gains in the price of debt from separating need to be high enough, as is the case when credit ratings provide very noisy signals. I proxy for the informativeness of the ratings with two model-implied variables and find empirical support for the existence of a signalling channel.

Keywords: signalling; fiscal austerity; sovereign debt; credit ratings.

JEL Classification: D82; E62; F34; G24.

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1 Introduction

Throughout the 2010s, austerity was at the forefront of economic debate. During the European debt crisis of 2010-2012, several countries adopted a more austere fiscal stance in response to market anxiety, while governments of diverse political orientation embraced fiscal conservatism[1]. For instance, Italy suffered a credibility crisis in the summer of 2011. Government bond spreads deteriorated rapidly[2] and three timid budget-tightening proposals in a row by the government were deemed insufficient by the markets, leading to the resignation of the Prime Minister. In November 2011, the President of the Republic appointed a temporary technocrat government with a reformist mandate to put an end to the market turmoil. One of the goals of the new government was to demonstrate that Italy was committed to honouring its debt. Other European peripheral countries also took extraordinary measures. Spain amended its constitution for only the second time in its history to include a debt ceiling clause in an effort to differentiate itself from bailed-out countries. Prime Minister Mariano Rajoy made an explicit comparison to Greece when he pointed out that "[unlike Greece] Spain was a reliable country and had a reliable government"[3]. Poland implemented several austerity measures (like raising the retirement age as well as slashing tax and pension privileges) despite being the only EU nation to keep growing during global financial turmoil[4]. Austerity is not exclusively a European measure. Outside Europe, we can find examples of countries seemingly adopting measures to signal its creditworthiness and appease the markets, as in the case of the so-called "Asian tigers" in the late 1990s[5].

Most of these episodes took place in times of economic downturns when the public finances had stoke investors' fears about the sustainability of debt. Thus, it is undeniable that austerity may have a justification as means to improve the budget balance and reign in an uncontrolled path of sovereign debt accumulation. On the other hand, though, austerity comes with a high economic and political cost. Hence, the insistence on the notion that a country may benefit from reclaiming a good reputation in the markets – which was voiced repeatedly

[1] "EU austerity drive country by country," BBC News, 21 May 2012.

[2] "Lost credibility," Il Sole 24 ore, 20 September 2011.

[3] "Rajoy: Los españoles pueden estar tranquilos ante la crisis de Grecia," La Vanguardia, 29 June 2015.

[4] "Poland, eyeing euro crisis, launches austerity drive," Reuters Business News, 18 November 2011.

[5] The adoption of structural adjustment programmes was part of the conditionality of an IMF bailout in Korea, Indonesia and Thailand.

in the media and in political statements – induces me to believe there is some inherent value in austerity, beyond relaxing the government budget constraint. This additional benefit may come from improving the government's reputation for borrowing in international markets. In the words of German Chancellor Angela Merkel, 'austerity measures are adopted in order to send a very important signal'[6]. Similarly, the European Commissioner for Economic and Monetary Affairs, Olli Rehn, said, 'In the early phase of the crisis it was essential to restore the credibility of fiscal policy in Europe because that was fundamentally questioned by market forces'[7].

In this paper I address the following questions: When do fiscal policy choices work as a signal to the lenders about sovereign creditworthiness? Is there evidence that countries engage in austerity for signalling purposes?

To answer the first question, I construct a model of sovereign debt with incomplete information that incorporates the signalling role for fiscal policy. In the model, countries differ in their ability to repay their sovereign debt. Lenders cannot differentiate between different types of countries, hence the motivation to signal creditworthiness. A country chooses the optimal level of debt weighing the costs of austerity – lower current consumption – with its benefits – a lower probability of default and, hence, a higher debt price. A trustworthy country has a higher probability of repaying its debt, thus it also has a higher expected future benefit in reducing debt. Thus, the model enjoys a single-crossing property and admits a separating equilibrium. A sufficient debt reduction with respect to the optimum level under full information, which I will call austerity, allows creditworthy countries to differentiate themselves from less able countries.

Nevertheless, equilibria without austerity also exist. I chose an equilibrium refinement, the 'undefeated equilibrium' refinement, because it always delivers a Pareto efficient equilibrium allocation. This refinement allows me to make predictions regarding the amount of austerity in equilibrium as a function of the fundamentals. I model different levels of public information by introducing a credit rating agency that provides public signals about country types. This provides a second key result, which delivers a testable prediction: When the

[6] 'Merkelettes' Siren Song Sounds Very German', The Wall Street Journal, 12 July 2011.
[7] 'EU promises less austerity as G20 debates debt,' Reuters Business News, 19 April 2013.

rating agency provides a noisy signal, in the unique equilibrium that emerges, the creditworthy countries find it profitable to undertake fiscal consolidation for signalling purposes. In contrast, when the public signal that the agency provides is very informative, the pooling equilibria emerge.

To answer the second research question, I bring empirical evidence of a signalling motive in fiscal policy choices. Using a panel of OECD countries from 1980 to 2014, I estimate an equation of the fiscal stance augmented to incorporate the signalling channel. I use two model-derived proxies for informativeness of the ratings: (i) the cross-country correlation between sovereign yields and ratings, which is a time varying variable, and (ii) the standard deviation of sovereign yields within a rating category, which varies across time and across ratings. The objective is to compare a sample of similar countries, for which controls for observable fundamentals are also considered. I allow the primary budget, adjusted for the cycle, to respond to the countries' past level of debt, gross domestic product, and to other individual characteristics of the country. I find that, in those years and in those rating categories where the measured level of informativeness is low, there is a tightening of the fiscal stance that it is not accounted for fundamentals nor the economic cycle. Interpreting the evidence in the light of my model, poorer public information about borrowers' quality induces a higher average austerity, which is driven by the sovereigns' desire to signal their creditworthiness.

Evidence that countries use austerity for signalling purposes is important for policy making. One size-fits-all measures, like the introduction of a debt ceiling, make separation more difficult, thus prompting more inefficient austerity compared to the situation where there is perfect information. Instead, policies targeted at the countries in distress, for example the ECB programmes aimed at easing the borrowing conditions for troubled countries, may help improve the perceived average quality of the pool of sovereigns and indirectly benefit the creditworthy types as well[8].

Literature review. There is vast literature on fiscal austerity and public debt sustainability (Alesina and Ardagna (1998); Ardagna et al. (2008); Ardagna (2009); Blanchard et al. (1990); Corsetti and Roubini (1991); Afonso (2005); Polito and Wickens (2012)). This paper

[8]Considerations about financing of the quantitative easing programmes are absent from this discussion.

proposes a new channel that motivates fiscal tightening: the willingness to signal creditworthiness through fiscal conservatism. None of the empirical contributions estimating fiscal rules (Gali and Perotti, 2003; Favero and Monacelli, 2005; Baldacci et al., 2013) explore the signalling channel.

My definition of signalling-induced austerity is based on the comparison between different equilibrium allocations: a reduction from the optimal debt level that would have been chosen under full information. Hence, in my framework, austerity is linked to the information structure. This view is very different from models that study fiscal austerity in a framework without information frictions. Other works consider incomplete information in a model of sovereign debt (Cole et al., 1995; Sandleris, 2008; D'Erasmo, 2008; Drudi and Prati, 2000; Catao et al., 2017; Dellas and Niepelt, 2020). They address different issues. Drudi and Prati (2000) study why a government with limited commitments may adopt pro-cyclical fiscal policies. They concentrate on optimal tax-smoothing properties. Catao et al. (2017) provide a rationale for a sudden increase in sovereign yield spreads across countries. In their framework, increased borrowing indicates a negative fiscal shock. In particular, neither of them studies how the equilibrium set depends on the amount of public information available. As explained earlier, changes in the amount of public information in the market are key in deriving the prediction that provides empirical support to my model. In others, as in Dellas and Niepelt (2020), Sandleris (2008), and D'Erasmo (2008), signalling operates through past default decisions and, in Cole et al. (1995), through debt settlements. In my model, in contrast, debt is observable to the lenders and the choice of deficit, i.e. the austerity level, is the signal that reveals information on creditworthiness.

The model is based on Spence (1973)'s signalling game with two players but it differs from the standard model in that the signal itself is payoff relevant for the receiver, the lenders in this case. I derive the conditions that imply the single-crossing property in this setup, which allows the existence of a separating equilibrium. Additionally, instead of focusing on the least costly separating equilibrium, I choose a refinement of the equilibrium that yields a more interesting empirical prediction.

The paper is organised as follows. The next section presents the economy and the problems of the agents while also defining a key property of the model, the single-crossing property

of the preferences. Section 3 characterises the equilibrium set under full information and under incomplete information and presents the refinement of the equilibrium. Credit ratings are introduced in Section 4, where I derive testable implications. Section 5 is devoted to the empirical analysis and section 6 concludes.

2 Model

Consider a two-period small open economy where a sovereign borrower issues debt to foreign lenders in order to maximise its citizens' welfare[9]. The sovereign country defaults whenever it is unable to fully repay its debt. I assume away strategic default. 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 what type of borrower the country is.

Sovereign's problem. The government seeks to maximise its 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 $F(\omega_2)$[10]. Given the initial level of debt D_1, the sovereign chooses the debt level D_2 and taxes T_1, T_2 to satisfy the government budget. The price of debt is denoted by q.

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

$$c_t \leq \omega_t - T_t, \quad \text{for } t = 1, 2; \tag{2.1}$$

$$T_1 \geq D_1 - qD_2 \quad \text{and} \quad T_2 \geq D_2. \tag{2.2}$$

$$c_t \geq \underline{c}^i \quad \text{for } t = 1, 2. \tag{2.3}$$

Constraint (2.1) is the budget constraint of the citizens. Constraints (2.2) 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 (2.1)

[9] In the model, sovereign debt is equivalent to external debt. Domestic debt does not play a role in this model, because the government is able to choose its citizens' consumption levels.

[10] The exponential function $f(\omega) = he^{-h\omega}$ features a constant hazard rate, which is helpful in obtaining the same level of equilibrium debt for both types under full information.

and (2.2) 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 (2.3) introduces heterogeneity in the ability to pay across countries. Together with the budget constraint (2.1), it imposes a limit on the ability to tax. In particular, taxation every period cannot exceed a certain threshold because consumption has a lower bound $\underline{c}^i \geq 0$ for every $i = \{A, B\}$[11].

I assume

$$\underline{c}^A < \underline{c}^B. \tag{A1}$$

Since $\underline{c}^B$ is higher than $\underline{c}^A$, for the same level of income, country B is less able to repay the outstanding debt than country A. Stated differently, *ceteris paribus*, country B is less creditworthy.

To guarantee the existence of a feasible allocation, I also assume the following

$$\underline{\omega} \geq \underline{c}^B. \tag{A2}$$

In the first period, default will not occur as long as we assume a small enough D_1:

$$D_1 \leq \omega_1 - \underline{c}^B. \tag{A3}$$

Default will occur in period 2 for $\omega_2 \leq D_2 + \underline{c}^i$. If the second period endowment realisation impedes full repayment of debt D_2 and $c_2 \geq \underline{c}^i$, the country defaults on its debt. In case of default, there is no partial repayment. Otherwise, the country complies with its promise. The probability of default for country $i = \{A, B\}$, with debt level D_2, is hence $F(D_2 + \underline{c}^i)$.

Lenders' problem. Lenders are risk-neutral. They lend the amount qD_2 in period 1 to the sovereign and receive D_2 in period 2 if there is no default. Lenders compete à la Bertrand over lending conditions driving profits to zero. Recall that there is no partial repayment. As

[11]For simplicity, in a model with lump-sum taxes, the tax limit is represented by a maximum amount of T_t that can be levied regardless of the income. It could be interpreted as the peak of the Laffer curve associated with a sovereign's heterogeneous efficiency on tax collection.

a result, the equilibrium price function satisfies:

$$q(D_2) = \beta' \left[\mu \left(1 - F(D_2 + \underline{c}^A) \right) + (1 - \mu) \left(1 - F(D_2 + \underline{c}^B) \right) \right]. \tag{2.4}$$

where β' is the lenders' discount factor, μ the probability that the borrower is of type A and the term in brackets represents the expected sovereign's default probability for each D_2 given μ. The sovereign debt price responds to the amount of debt issued and the lenders' belief about creditworthiness. The higher the price, the more advantageous the borrowing terms for the sovereign, which is not a price taker.

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

$$\underline{c}^B > \frac{\omega_1 - D_1 + \beta' \underline{\omega}}{1 + \beta'}. \tag{A4}$$

This condition rules out the uninteresting case in which the two types have zero probability of default[12]. By assumption (A1), $F(D_2 + \underline{c}^A) \leq F(D_2 + \underline{c}^B) \, \forall \, D_2$ and, by (A4), 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, citizens' consumption is assumed to decline to $\underline{c}^i$ 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. Finally, I assume that $\beta' > \beta \frac{1-F(D_2+\underline{c}^A)}{1-F(D_2+\underline{c}^B)}$. Thanks to the exponential assumption on $F(\cdot)$, we can state the previous condition as a function of exogenous parameters:

$$\beta' > \beta \cdot e^{h(\underline{c}^B - \underline{c}^A)}. \tag{A5}$$

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

[12]The 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 unfeasible 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 (A4) and (A2) are compatible as long as $\underline{\omega} \geq \omega_1 - D_1$.

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 period 1 consumption and finance it by issuing new debt*[13]. 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. This choice can be made contingent on the type.

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

$$\begin{aligned} U^i(q, D_2) := \omega_1 - D_1 + qD_2 \\ + \beta \left[F(D_2 + \underline{c}^i)\underline{c}^i + \left(1 - F(D_2 + \underline{c}^i)\right) \left(\mathbb{E}[\omega_2 | \omega_2 \geq D_2 + \underline{c}^i] - D_2\right)\right]. \end{aligned} \tag{2.5}$$

The first line of the right-hand side represents citizens' consumption in the first period: the endowment ω_1 plus the net borrowing of the period. The second line represents 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 (2.5) can be used to define the indifference curves in the space (D_2, q). For all D_2, the slope of type B's indifference curves in (D_2, q) is steeper than that of type A. This implies that any two curves of A and B can cross at most once in the space (D_2, q). This is because default occurs when a country cannot afford repayment and, as this depends only on solvency, B can default more often. Hence, a type B country benefits more from debt because it anticipates that it has to pay back less. A formal proof of the *single-crossing* property is found in Appendix A. The single-crossing property of the problem is a sufficient condition to find an equilibrium in pure strategies of the incomplete information game in Section 3.2.

[13] I 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 the country has office-motivated politicians who *like* debt (Acharya and Rajan, 2011).

3 Equilibrium analysis

3.1 Full information

As a benchmark, let us 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 debt level and charge the actuarially fair price $q^i(D_2) = \beta' \left[1 - F(D_2 + \underline{c}^i)\right]$. The sovereign faces the price schedule $q^i(D_2)$ and maximises the discounted expected utility (equation (2.5)):

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

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

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

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

The first term in (3.2) represents the change in cost that every inframarginal 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[14]:

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

Further, recalling that h is the hazard rate of the endowment exponential distribution

[14] See Appendix B for the proof.

$f(\cdot)$, equation (3.3) simplifies to:

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

The expression (3.4) is the optimal debt level under full information. Denote the full information equilibrium debt level by D_2^{FI}. D_2^{FI} is positive because of assumption (A5), which means that the country issues a positive amount of debt to take advantage of the favourable lending conditions. While D_2^{FI} is the same for both types[15], in equilibrium, different types face a different price. The price is lower for type B, because type B defaults more than type A, so its debt carries a higher risk premium:

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

3.2 Incomplete information

Assume now that 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. The sovereign also takes into account that its choice of debt may reveal information about its type to uninformed lenders, influencing their pricing decisions.

The country's strategy is a choice of debt D_2^* for each type. The lenders' strategy is a price function that depends on the observed D_2^* and 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,*

[15]The fact that D_2^{FI} is independent of the type depends on the assumption of the exponential income function. A different process would yield a different result, whereby the full information optimal debt level differs across types. This distinction is not important here as these levels are not observable when incomplete information is introduced.

$$D_2^* : \{A, B\} \to \mathbb{R};$$
$$q^* : \mathbb{R} \to \mathbb{R}_+;$$

and a system of beliefs $\mu^* : \mathbb{R} \to [0, 1]$ *that the country is 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:* $q^*(D_2) = \beta'[1-\lambda(D_2, \mu^*(D_2))]\ \forall D_2$, *where* $\lambda(D_2, \mu^*(D_2))$ *represents the probability of default.*
- *The system of beliefs* $\mu^*(D_2)$ *is consistent with Bayes' rule and the equilibrium strategies whenever possible. That is, if we let* $\mathbb{1}_{\{.\}}$ *be the indicator function taking the value 1 if the condition in curly brackets holds and zero otherwise, we have:*

  - *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* $p\mathbb{1}_{\{D_2^*(A)=D_2\}} + (1-p)\mathbb{1}_{\{D_2^*(B)=D_2\}} = 0$, *then* $\mu^* \in [0, 1]$.

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 $\{D_2^*(i), q^*(D_2^*(i))\}_{i\in\{A,B\}}$.

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,

$$U^B\left(D_2^*(B), q^*(D_2^*(B))\right) \geq U^B\left(D_2^*(A), q^*(D_2^*(A))\right). \tag{3.5}$$

Proposition 3.1. *Under assumptions A1 to A5, there exists a separating equilibrium outcome where* $D_2^*(B) = D_2^{FI}$; $q^*(D_2^*(B)) = \beta'\left[1 - F(D_2^*(B) + \underline{c}^B)\right]$; *the debt level* $D_2^*(A) = D_2^{-B}$ *satisfies* (3.5) *with equality; and* $q^*(D_2^*(A)) = \beta'\left[1 - F(D_2^*(A) + \underline{c}^A)\right]$. *This is supported by the equilibrium beliefs* $\mu^*(D_2^*(A)) = 1$ *and* $\mu^*(D_2) = 0$ *for* $D_2 \neq D_2^*(A)$.

Proof. See appendix C. □

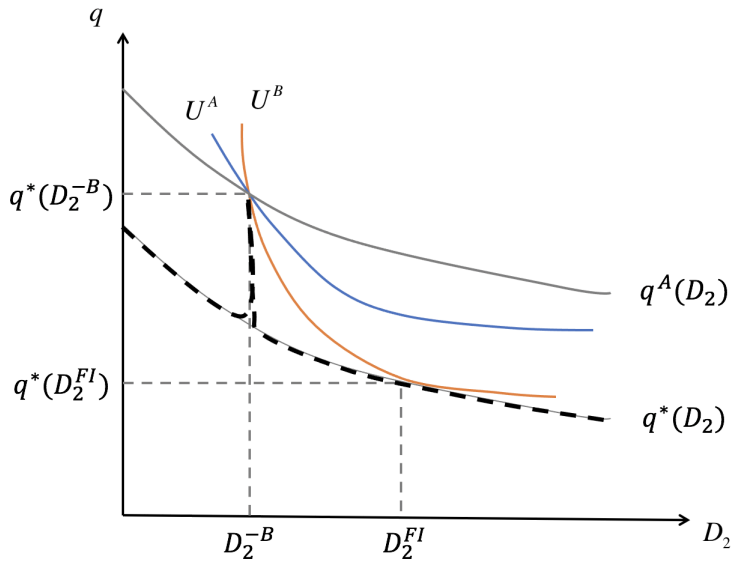

Figure 1: Separating equilibrium e^*.

Type A prefers the allocation $(D_2^{-B}, q^*(D_2^{-B}))$, represented in figure 1, to any other allocation under the price schedule represented by the dotted bold line. At the same time, B is indifferent to that allocation and $(D_2^{FI}, q^*(D_2^{FI}))$ by definition[16]. 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. A, therefore, finds attractive allocations that are not attractive to B. Type A chooses $(D_2^{-B}, q^*(D_2^{-B}))$ while B chooses its full information allocation D_2^{FI}. No type has an incentive to deviate unilaterally. However, 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 in this case the country is using *austerity for signalling purposes*. The choice of a lower debt level improves the lenders beliefs, lowering the risk premium associated with 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

[16]Its incentive compatibility constraint (3.5) is satisfied with equality.

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[17]. Hence, signalling is the key for fiscal policy to tilt toward austerity.

Pooling equilibria. A pooling equilibrium arises if, given the lender's beliefs, 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 $q^*(D_2^*)$, 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. *Under assumptions A1 to A5, 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 equals* $q^*(D_2^{FI}) = \beta' \left(p \left[1 - F(D_2^{FI} + \underline{c}^A)\right] + (1-p)\left[1 - F(D_2^{FI} + \underline{c}^B)\right]\right)$.

Proof. See appendix D. □

See figure 2, where the price schedule is again represented by the dotted bold line and $q^P(D_2)$ represents the pooling price schedule for any D_2. 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 $\mu \in [0,1]$[18].

3.3 Selection of equilibria

A signalling game, like the one presented here, typically admits a multiplicity of equilibria. This is 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

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

[18] They are set to $\mu = 0$ in this case.

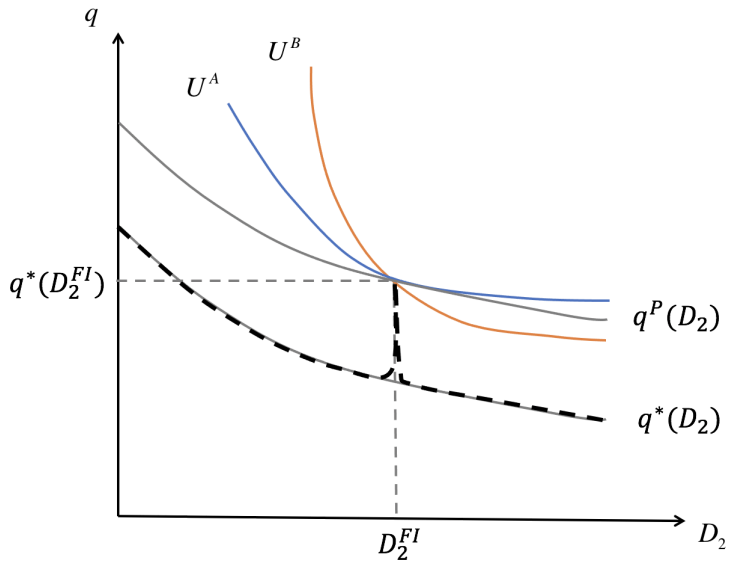

Figure 2: A pooling equilibrium at D_2^{FI}.

equilibria, I use a refinement of the PBE introduced by Mailath et al. (1993): the undefeated equilibrium (UE).

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[19]. An equilibrium is defined as *undefeated* if it is not defeated by any other.

Proposition 3.3. *Applying the undefeated equilibrium refinement, equilibria of the separating and the pooling class cannot coexist. There is a $\bar{p}$ such that for $p < \bar{p}$ there is a unique separating equilibrium where type A chooses the least costly separating equilibrium debt level D_2^{-B}, otherwise the only surviving equilibria are pooling, all with $D_2^* > D_2^{-B}$.*

Proof. See appendix F. □

As stated in the proposition, for low $p < \bar{p}$, the unique equilibrium of the problem is the least costly separating equilibrium e^*, where $\bar{p}$ is the threshold level of the prior that makes

[19]See appendix E for a formal definition of the UE refinement.

type A indifferent between the signalling allocation $\left(D_2^{-B}, q^*(D_2^{-B})\right)$ and pooling with type B at $\left(D_2^*, q^P(D_2^*)\right)$. The line of proof is as follows: first, note that the least costly separating equilibrium e^* defeats any other separating equilibrium. All separating equilibria reveal the type of the sovereign, but e^* reveals the type 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 $\mu = 1$ for any other separating equilibrium, but those beliefs do not sustain an equilibrium at $D_2 \neq D_2^{-B}$, because e^* would defeat such an equilibrium. 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 greater utility, this cannot be ignored off equilibrium in any pooling equilibrium; it is inconsistent to ignore that A would be better off deviating to D_2^{-B}. Thus, the pooling equilibrium is defeated. In this case, e^* is the unique equilibrium of the model.

If $p \geq \bar{p}$, then both types are better off pooling. Thus, e^* is defeated by a pooling equilibrium. Pooling equilibrium 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 type A prefers the allocation D_2^{*A} under the pooling price schedule and type B prefers D_2^{*B}. 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 both be made better off.

According to Proposition 3.3, a separating equilibrium may exist depending on the beliefs about a country's creditworthiness. Intuitively, a small p reflects a prior that a country issuing debt in the market is most likely of type B, thus providing large incentives for a type A to signal and separate itself from the uninformed pool. As p becomes larger, lenders become more optimistic about the average creditworthiness in the market and, hence, the potential price benefits of signalling are not large enough to induce countries to separate (via austerity measures). A key takeaway from this result is that the value of signalling depends on the improvement in the price of debt that signalling achieves.

Unlike dominance-based refinements, notably the intuitive criterion (IC) by Cho and

Kreps (1987), the UE refinement focuses on the efficiency properties of the equilibrium[20]. The consistency of an off-equilibrium strategy is evaluated on the basis of which type(s) is/are 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 a different equilibrium strategy. Thus, the UE privileges the equilibria that are efficient in a Pareto sense.

The previous result can be extended to a multiple-period problem. There are two cases in which this extension can occur without excessive complications: the case with constant types over time and the case with iid shocks to the type. With constant types, the type is fully revealed once there is a separating equilibrium. From then onward, each country chooses its optimal amount of debt under perfect information. Signalling, hence, takes place once at most. With independent shocks to the type, the problem changes in the following way: at the end of period t a new type is drawn, $\underline{c}^i_{t+1}$. Then, the income realisation ω_t is obtained and the country may default. After a default, to simplify further, I assume that there is immediate re-entry into the debt market and the country can borrow again D_{t+1}. Since the solution is the same as that of the previous two-period game[21], the current realisation of the type carries no information about the type in the future. Thanks to the linear preferences and the absence of a dynamic punishment for default, the optimal level of debt is independent of the past stock of debt. Reality is probably in between these two extremes. Persistency makes the past stock of debt informative about the current country type. Hence, the market of sovereign debt becomes segmented into different markets with different priors. Inside each market segment, lenders cannot distinguish the country type, thus providing an incentive to signal. The same forces operating in the two-period model modify the incentives of the dependable country to separate from the less trustworthy countries. Austerity is more attractive in this dynamic setup because the effect of signalling extends beyond the present period due to the persistency of the type.

[20]See appendix G for a comparison of the UE refinement and the intuitive criterion.

[21]See appendix J for a proof.

4 Testable implications

In this section, I derive some model-based implications regarding the amount of austerity for signalling purposes that countries may want to implement in equilibrium. Subsequently, in section 5, I provide evidence that they are coherent with the historical data that we observe on fiscal policy movements.

Austerity is a feature of the separating equilibrium and, as we show in Proposition 3.3, the existence of a separating equilibrium depends on the beliefs about a country's creditworthiness. Thus, changes in such beliefs are expected to trigger changes in observed austerity. Credit ratings are expert opinions on the solvency of a country and they may influence market beliefs about a country's creditworthiness. Additionally, the ratings informativeness is, to a certain extent, linked to their expertise, know-how, their workforce etc, which are independent from the business cycle. Hence, the reliability of credit ratings is a source of potential changes in a lender's beliefs about the creditworthiness of a country that is neither linked to the fundamentals of the country nor to the business cycle[22].

I model a sovereign rating as a public signal $r \in \{\bar{r}, \underline{r}\}$ that is imperfectly informative about the country's creditworthiness. The degree of informativeness is captured by the parameter $\pi \in (0.5, 1)$, which represents the probability that the Credit Rating Agency (CRA) reports the country type correctly: $\pi = Prob(\bar{r} \mid A) = Prob(\underline{r} \mid B)$. Conversely, $1 - \pi$ is the probability that the CRA makes a mistake and assigns either a high rating $\bar{r}$ to a type B country or a low rating $\underline{r}$ to a type A country.

Once ratings are assigned, the debt market is segmented into different sub-markets conditional on the rating. The introduction of ratings may ameliorate the asymmetry of information in the sub-market but it is unlikely to eliminate it completely. The empirical literature on credit ratings finds robust evidence that the ratings add information on average (Cantor and Packer, 1996; Larrain et al., 1997; Kaminsky and Schmukler, 2002; Pukthuanthong-Le et al., 2007; Afonso et al., 2012)[23], but their explanatory power changes over time (Kiff

[22] A more direct manner to alter the lenders beliefs is a change in the relative proportion of dependable countries. For instance, a negative aggregate shock may diminish the fraction of dependable countries, which could be captured by a smaller parameter p. However, p may be related to the business cycle, which, in turn, may also influence austerity. As a consequence, proxies for p might not be well suited to test the empirical implications of the model whereas ratings informativeness is less likely to be endogenous.

[23] In an event study of 49 countries in 1995, Cantor and Packer (1996) find that rating announcements

et al., 2012; De Santis, 2012; Bussière and Ristiniemi, 2012). In the model, this is captured by different values for π[24].

The parameter π modifies the proportion of A and B types in each sub-market. The proportion of A types, conditional on a rating r, is:

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

If $\pi = 1$, the CRA provides perfect information about the type of country, and the solution is the full information allocation. If, instead $\pi = 0.5$, the CRA does not add any information to the prior and we are in the baseline model with asymmetric information from the previous section. For $\pi \in (0.5, 1)$, beliefs about the composition of types in the two sub-markets are such that $\hat{p}(\pi, p, \bar{r}) > p > \hat{p}(\pi, p, \underline{r})$.

The informativeness of the ratings influences the amount of austerity, as I show in the following proposition. Notice that p can be interpreted as the fraction of A countries in an economy with a continuum of countries and recall, from proposition 3.3, that $\bar{p}$ is the threshold fraction where the equilibrium shifts from pooling to separating. The remainder of this paper focuses on the case where $p < \bar{p}$, that is, the case where type A countries would have an incentive to separate from type B countries in absence of rating.

Proposition 4.1. *For $p < \bar{p}$, the fraction of countries that adopt austerity measures decreases as a function of the informativeness level of the rating π.*

Proof. See appendix H. □

In the appendix, we show that there is a threshold π^* such that for $\pi < \pi^*$ both sub-markets are in the separating region and, hence, the fraction of countries performing austerity

have an effect on sovereign yield spreads in a two-day window around the date of the announcement. Two separate event studies using an international sample also find that sovereign downgrades are associated with a negative impact on bond returns: Larrain et al. (1997) for the period 1987-1996 and Pukthuanthong-Le et al. (2007) for the period 1990-2000. Focusing on EU countries, Afonso et al. (2012) also find a significant response of government bond yield spreads to changes in ratings and outlooks. Similar findings are validated by Kaminsky and Schmukler (2002) looking at emerging markets.

[24] A number of papers examine the economic mechanisms underlying changes in the quality of the ratings. A 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); Josephson and Shapiro (2019); Opp et al. (2013) and Cole and Cooley (2014).

is p (the fraction of countries adopting austerity is constant in this range). For $\pi = \pi^*$, the fraction of countries adopting austerity has a downward jump since separating now only occurs in the low rating sub-market. For $\pi > \pi^*$, such fraction strictly decreases as the fraction of A countries in the low rating sub-market decreases with π[25].

First empirical measurement of π: across-ratings variation. The empirical study of the predictions reported in proposition 4.1 requires an observable proxy for π, the probability that the rating reveals the true type of a country. According to the model, π affects the observable relationship between ratings and the average price of debt q conditional on a given rating. Given the linearity of the prices in the probability of default, the average price conditional on a rating, $\mathbb{E}[q|r]$, takes exactly the same expression in the pooling and in the separating equilibriums, taking the following form:

$$\mathbb{E}[q^* \mid \bar{r}] = \beta' \left[\frac{p\pi \left(1 - F(D_2^*(A) + \underline{c}^A)\right)}{p\pi + (1-p)(1-\pi)} + \frac{(1-p)(1-\pi)\left(1 - F(D_2^*(B) + \underline{c}^B)\right)}{p\pi + (1-p)(1-\pi)} \right];$$

$$\mathbb{E}[q^* \mid \underline{\mathrm{r}}] = \beta' \left[\frac{p(1-\pi)\left(1 - F(D_2^*(A) + \underline{c}^A)\right)}{p(1-\pi) + (1-p)\pi} + \frac{(1-p)\pi\left(1 - F(D_2^*(B) + \underline{c}^B)\right)}{p(1-\pi) + (1-p)\pi} \right],$$

where, recall that in case of pooling $D_2^*(A) = D_2^*(B) = D_2^{FI}$ (see condition (3.4)); while, in a separating equilibrium $D_2^*(A) < D_2^*(B) = D_2^{FI}$ (where the first inequality in the latter expression is due to austerity). As long as ratings have informational content, i.e., $\pi > 0.5$, it is immediate to see that $\mathbb{E}[q^* \mid \bar{r}] > \mathbb{E}[q^* \mid \underline{\mathrm{r}}]$.

Proposition 4.2. *For a given prior $p < \bar{p}$, the difference between the expected prices conditional on rating $\mathbb{E}[q^* \mid \bar{r}] - \mathbb{E}[q^* \mid \underline{r}]$ increases in the information contained in the ratings π for all π, except at $\pi = \pi^*$.*

Proof. See appendix I. □

As I note above, the level of debt for type B countries never changes while the level of

[25]For completeness, I also study the case for $p > \bar{p}$. In this case, we have a threshold level π^* such that for $\pi < \pi^*$ in both sub-markets, we have pooling and, thus, there is no austerity. For $\pi = \pi^*$ type A countries in the low rated sub-market now perform austerity. For $\pi > \pi^*$ austerity decreases strictly as the fraction of A countries receiving low rating decreases. To sum up, in this case, although the fraction of countries adopting austerity is almost always locally decreasing in π, it is in general non-monotone.

debt for type A countries is only affected by the nature of the equilibrium (separating or pooling) and not by the fraction of high types within an equilibrium outcome. Hence, the result is obtained from straightforward computations on the posteriors: as π increases, the difference between the fraction of type A countries in the high rating and that in the low rating sub-market increases, and this maps directly into the average price differences. The only exception may occur for the value of π such that the equilibrium in the high rating sub-market switches from separating to pooling. This might create a local non-monotonicity that, in the empirical analysis, I implicitly assume it is empirically dominated by the overall increasing tendency.

My first proxy for the informativeness of the ratings targets the slope of the relation between sovereign yields and ratings[26]. If the relationship between rating r and average price can be approximated linearly, we have:

$$\mathbb{E}[q|r] = \delta r. \tag{4.2}$$

The previous result implies that the higher the informativeness content of the ratings the higher δ should be[27]. I compute the cross-country correlation between sovereign *yields* and ratings for each year from 1980 to 2014. This gives me the time series $\{\hat{\rho}_t\}_t$, and $\hat{\rho}_t$ is our proxy for δ at time t[28]. Hence, we expect that a period with low informativeness of the ratings is associated with a low $\hat{\rho}_t$.

Note that the variable $\hat{\rho}_t$ is a measure of the correlation of the average price across markets, where each market is characterized by a rating that effectively segments the market into different sub-markets. Since the signalling game is played within a rating category, the nature of the equilibrium (pooling or separating) is a within-market concept. In addition, the average price in a market does not depend on the nature of the equilibrium being played

[26]This is in line with a stream of empirical studies that - at least since Cantor and Packer (1996) - measure informativeness as co-movements between ratings and the price of debt as we do in this section.

[27]We will see in section 5.3 that we should expect π to affect the volatility of price conditional on the rating as well. This will be the basis of our second proxy for π.

[28]The model is a simplified one and, in the empirical exercise, I consider that there might be an orthogonal measurement error generating additional volatility in the yields. In the case of noisy prices, we would have $q = \delta r + \epsilon$, where ϵ is a random variable with mean 0 and variance σ_ϵ. For a given $\sigma_\epsilon \neq 0$, the correlation comoves positively with δ.

(see the two equations on page 20).

5 Empirical evidence

5.1 Description of the dataset

The dataset contains observations at annual frequency for 31 OECD countries over 35 years (1980-2014)[29]. The economic variables, obtained from the World Economic Outlook (IMF), are: *Debt over GDP*, *Squared debt over GDP*, *Gross domestic product*, *Current account*, *Growth*, *Net lending/ borrowing, Primary surplus/ deficit, Cyclically adjusted primary balance (CAPB),* and *Government expenditure*[30]. Positive values of the fiscal variables, except for expenditure, mean that austerity is increasing, whereas negative values indicate fiscal profligacy. The dataset has been merged with the long-term government bonds yield to maturity from the IMF's International Financial Statistics and hand-collected historical data on sovereign ratings by the three biggest rating agencies (Moody's, Fitch, and Standard & Poor's). The rating categories (e.g., AAA) are transformed into a numerical variable[31] by taking end-of-month rating yearly averages. The final *Rating* variable is the mean of the three ratings (if available). Finally, I include other economic variables as controls of the macroeconomic cyle: *VIX index* and *S&P 500 index*. Summary statistics of the main relevant variables included in the dataset are found in table 1.

5.2 Empirical strategy

In what follows I test the main implication of the model summarized in corollary 4.1. *Ceteris paribus*, the lower the informativeness of the ratings, the more countries should perform

[29]The countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, and United States. For a complete list of countries and the range of years covered see appendix K.

[30]The definitions and calculation methods can be found in appendix L.

[31]I assign a number on a scale ranging from 0 (default) to 52 (maximum grade) to each rating. I also take into account the modulation of the rating captured by announcements in outlook changes or rating watch. The conversion table of the rating scale into the numerical variable is in appendix M.

Table 1: Summary statistics of the main variables

	Mean	Standard deviation	Minimum value	Maximum value
Debt	64.04	37.06	6.07	233.53
Net lending	-2.28	4.70	-30.86	18.79
Primary surplus	-0.14	3.92	-28.23	16.12
CAPB	-2.72	3.34	-19.10	5.85
Expenditure	44.56	7.93	19.67	67.87
GDP	0.03	0.16	0.00	1.61
Current account	0.30	5.61	-28.38	16.48
Growth	0.02	0.02	-0.09	0.10
Inflation	2.65	2.17	-1.71	14.35
Sovereign yields	5.49	3.10	0.33	23.27
Rating grade	46.61	8.28	2.64	52.00

Note: Mean value, standard deviation, minimum value, and maximum value of the following variables in the dataset: debt over GDP, net lending/ borrowing as a percentage of GDP, primary surplus/deficit as a percentage of GDP, cyclically adjusted primary balance (CAPB) as a percentage of GDP, government expenditure, GDP, current account, growth, inflation, the VIX index, the S&P 500 index, long term annual sovereign yields, and sovereign ratings. I consider a sample of 31 countries between 1980 and 2011. Source: IMF, IFS, Bloomberg, Moody's, S&P's and Fitch.

austerity. Additionally, we show in section 4 that we can linearly approximate the informativeness of the ratings with $\hat{\rho}$, the cross-sectional correlation between sovereign yields and sovereign ratings at each period of time. The following equation tests the co-movements between the fiscal fiscal stance and $\hat{\rho}$:

$$Y_{i,t} = \alpha + \gamma\hat{\rho}_t + \beta X_{i,t} + u_{i,t}, \tag{5.1}$$

where austerity $Y_{i,t}$ is measured by the cyclically adjusted primary balance (CAPB) of country i at time t. $\hat{\rho}_t$ is computed using the Spearman correlation to preserve the rank order of the ratings without assuming that any two consecutive rating grades are equally spaced. Results using the Pearson correlation are very similar. In figure 3, I report the values of $\hat{\rho}_t$ by year, represented by the solid line. The dotted lines are the confidence intervals at the 95% level. $\hat{\rho}_t$ has 35 observations, mean -0.61, and standard deviation 0.15. Higher rating grades are typically associated with lower sovereign yields. For my sample, the variable is negative throughout the period (although not statistically different from zero for the first

years of the 1980s). Over the years the tendency is toward a better alignment between ratings and yields (lower mean value) and tighter confidence intervals. This trend in improved informativeness of the ratings is specially marked until the mid-1990s. In his historical review of the credit rating agencies business model, White (2010) states that these decades were a very influential period of the rating agencies, citing the New York Times columnist Thomas L. Friedman in 1996: 'There are two superpowers in the world today in my opinion. There's the United States, and there's Moody's Bond Rating Service.... And believe me, it's not clear sometimes who's more powerful.' From 1997 to 1999, the Asian crisis put the reputation of the CRAs to the test: they were accused of being too sluggish and exacerbating the crisis (Ferri et al., 1999). Then, two other well-known episodes involving too optimistic ratings on companies that soon after went bankrupt inflicted momentary damage to the public opinion about the CRAs: the Enron scandal in 2001 and the bankruptcy of Lehman Brothers in 2008. The onset of all these episodes is marked with a vertical line in figure 3 and it is associated with a more or less prolonged spell of lower correlation between ratings and sovereign yields. The annual cross-correlation between sovereign ratings and yields is a measure of rating informativeness across rating categories and, thus, a time series variable.

In equation (5.1), $X_{i,t}$ represents a vector of control variables. It includes a number of economic variables that the literature on fiscal sustainability finds to be significant in explaining the fiscal stance (Gali and Perotti, 2003; Favero and Monacelli, 2005; Baldacci et al., 2013; Polito and Wickens, 2014) and which might be important for the determination of the CAPB in the data. The model compares austerity performed by different types of country, which are perceived by the lenders to be *ex-ante* identical. In reality, we need to control for the observable variables that may allow for differentiating countries from each other. Debt is one-period bonds in the model so there is no need to keep track of the stock of debt. In reality, of course, the amount of debt outstanding affect fiscal sustainability and the choice of CAPB. To explore non-linearities, I also include the squared term of debt. As established by the literature (Reinhart and Rogof, 2014), debt may limit fiscal choices more as the stock of debt grows larger. Similarly, the GDP may influence the fiscal space available to a country, as well as inflation and the current account. I control for these characteristics of the country, with one period lag, in my specification. I also include another set of controls

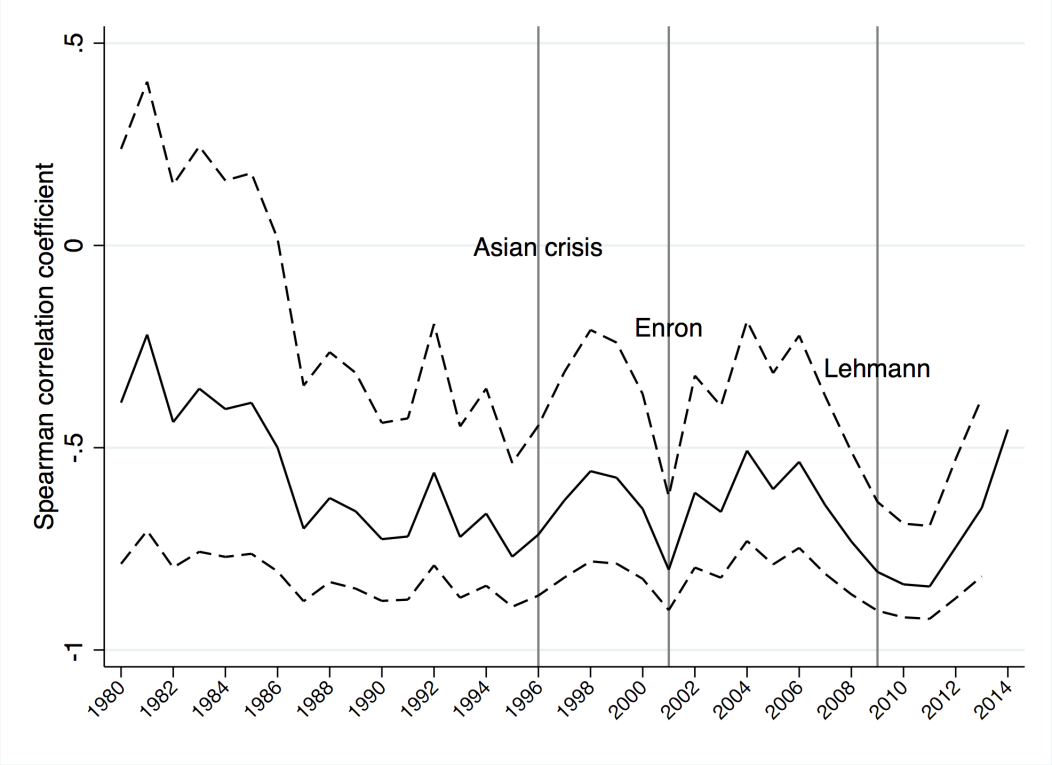

Figure 3: Cross-country correlation between long-term sovereign yields and sovereign ratings for all countries with at least one rating from Moody's, S&P, or Fitch at each year between 1980 and 2014. Dotted lines are confidence intervals.

aimed at capturing the business cycle. Whether the economy is in a recession or an expansion likely has an impact on fiscal decisions, either because resources may become scarce in the future or because credit may be tight. Changes in the cycle are absent in the model but I account for them in the empirical specification with the following variables: country growth, the VIX index, and the S&P 500 index. I explored the inclusion of other variables (such as the primary deficit, the GDP per capita, investment, and other squared terms of the variables for non-linear effects), but they are insignificant throughout the several specifications[32].

The coefficient of interest in equation (5.1) is γ. In estimating γ, I consider that the error term may be correlated with $\hat{\rho}_t$ due to the presence of omitted variables. For example, turbulence is a common element of many debt crises or recessions, where uncertainty about yields automatically increases and debt issuance might be compromised for reasons that have nothing to do with changes in the incentives to signal. To address the endogeneity issues

[32]Results are available upon request.

Table 2: Summary statistics of the main variables

	Obs.	Mean	Standard deviation	Min. value	Max. value
Negative news CRA	899	12.79	16.89	0.00	60.00
Excess returns MCO	496	0.14	0.28	-0.53	0.68

Note: Mean value, standard deviation, minimum value, and maximum value of the following variables included in the dataset: count of the pieces of news containing the words 'rating agencies, reputation, accuracy & criticism', 'rating agencies, credibility & mistake or error or blame' and 'rating agencies, reputation & regulation' (Negative news CRA) between 1986 and 2014 and the difference between Moody's annual stock returns and the S&P500 returns (Excess returns MCO) between 1999 and 2014. Source: LexisNexis and Bloomberg.

coming from omitted variables, I use an instrumental variables approach. I instrument the variable $\hat{\rho}_t$ with two instruments. Table 2 summarises these variables characteristics.

The first instrument measures negative press coverage received by the rating agencies. I collected the number of news articles in major distribution newspapers (in English) since 1986 that contain a negative view of the rating agencies using the LexisNexis database. Key search words for the first variable include 'rating agencies', 'accuracy', 'criticism', 'reputation', 'credibility', 'error, mistake or blame' and 'regulation'. A crisis could draw attention of the media and subject the rating agencies to a closer scrutiny. The fact that the CRA practices are examined more closely may trigger scepticism about the ratings but the market may also become more aware of them. In table 3, I report the first stage results of the IV estimation and find that news regarding the CRA are less frequent when informativeness is lower.

The second instrument is a financial variable measuring Moody's annual stock performance with respect to an index of the overall performance of the stock exchange[33]. The variable *Excess returns* is calculated as the return on Moody's annual stock prices minus the return on the S&P500 index. Overperformance of Moody's stock with respect to the market is associated with high informativeness of the agencies in table 3. Recall that $\hat{\rho}_t$ is a negative correlation. The negative coefficient in the second row indicates that the market is able to assess the ability of the agency to assign informative ratings and the higher the informativeness (lower ρ), the higher the excess returns.

The validity of the proposed instruments hinges on the assumption that the residual

[33]Moody's is the only agency among the big three that is quoted in the stock exchange.

Table 3: First stage results of the instrumental variables regression.

	(1) Corr. ratings-yields	(2) Corr. ratings-yields	(3) Corr. ratings-yields	(4) Corr. ratings-yields
Negative news CRA	-0.0031***	-0.0036***	-0.0031***	-0.0026***
	(0.0002)	(0.0002)	(0.0002)	(0.0005)
Excess returns MCO	-0.0487***	-0.0632***	-0.0727***	-0.1715***
	(0.0152)	(0.0161)	(0.0133)	(0.0227)
Other controls	Yes	Yes	Yes	Yes
Country FEs	No	Yes	Yes	Yes
Observations	470	465	465	465
Shea's partial R2	0.24	0.27	0.31	0.31
F-statistic	242.44	186.33	185.96	185.96

Note: The dependent variable is the correlation between sovereign yields and sovereign ratings. Instruments are: the variable *Negative news CRA* and the variable *Excess returns MCO*. Other control variables not shown here are the debt percentage over GDP, the square of debt, GDP, growth, the current account as percentage of GDP, inflation, the CAPB as percentage of GDP (all lagged one period), and the VIX and S&P 500 indices. The specification includes country fixed effects. Definitions of the variables can be found in appendix L. Note: Standard errors in parentheses. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

variation in the number of negative news articles (after controlling for the VIX index and an index for the performance of the stock market) is unlikely to be correlated with omitted macroeconomic variables. The same should hold for Moody's excess returns.

The first column in table 4 reports the results of the OLS estimation of equation (5.1). The other columns report the IV coefficients. Coefficients in the first row are positive and significant. Recall that higher numbers of ρ indicate lower informativeness and higher numbers of the CAPB indicate fiscal tightening. The Hansen test for overidentifying restrictions cannot be rejected; thus, confirming the choice of the set of instruments. I find that an increase from -1 to 0 in the correlation between sovereign yields and ratings (a one-point lower informativeness of the ratings) is associated with an almost 2.5 percentage point increase in the CAPB over GDP (a higher surplus or lower deficit) in the specification with all controls. A one-point change in a correlation is extreme. To give a better sense of the magnitude, a change of one standard deviation in the explanatory variable would be able to explain approximately 0.4 percentage points difference in austerity. For example, during the Enron

scandal[34], the estimated shrinkage of the deficit associated with the decrease in ρ_t between the year of the scandal (2001) and 2002 is between 0.5 and 1.3 percentage points. For a mean value of the CAPB over GDP of -2.6, this is a sizeable improvement in the public accounts, even with more conservative coefficients. Lastly, the last column takes into account that my measure of the informativeness (the cross-sectional correlation of sovereign yields and sovereign ratings) is an estimated regressor and, as such, it is measured with error. Ignoring this in the estimation of the fiscal stance may yield standard errors that are too small and provide statistically significant coefficients too often. Using a bootstrap estimation with 500 repetitions to correct the computation of the standard errors, the coefficient γ remains significant. The coefficient changes depending on the set of controls but it always remains strongly significant and the sign is consistent with the predictions of the model.

5.3 Measuring rating informativeness within a rating category

In this section, I present the empirical results based on a different proxy for the informativeness of the ratings. In the model, a type A country signals when the gains in the price of debt compared to the pooling price of debt are high enough. Although the model gives a simplistic (deterministic) relationship between ratings and prices, given the country type, in reality there is additional variation in the price of debt across countries within the same rating grade. The approach based on equation (4.2) disregards such variation. The empirical strategy of this section is based on the presumption that the difference between the price of debt faced by a country and the average price on the rating category to which the country belongs, $\varepsilon := q - \mathbb{E}[q|r]$, might incorporate information that the investors have about the country in addition to that provided by the CRA (and the fundamentals observed by the econometrician).

To make the discussion more precise while keeping tractability, let's move from the binary rating and two types model to a model with a continuum of values. Assume that the 'fair' price θ for the bond for a given country is normally distributed with zero mean and unitary variance. Assume that the CRA receives an informative (but noisy) signal about θ, which is

[34]Enron corporation was a major electricity company that was graded investment rate by Moody's, S&P, and Fitch days before it declared bankruptcy.

Table 4: The effect of ratings informativeness on the cyclically adjusted primary balance using $\hat{\rho}t$ as a measure of informativeness

	OLS	IV			
	(1)	(2)	(3)	(4)	(5)
	CAPB	CAPB	CAPB	CAPB	CAPB
Correlation ratings-yields	0.9735*	6.8953***	3.0004***	2.4799*	2.4799*
	(0.5489)	(1.7849)	(1.1267)	(1.2826)	(1.4318)
L.CAPB	0.7814***		0.7233***	0.7101***	0.7101***
	(0.0400)		(0.0572)	(0.0614)	(0.0638)
L.Debt	0.0262***	-0.0414***	0.0222*	0.0251*	0.0251*
	(0.0094)	(0.0113)	(0.0131)	(0.0129)	(0.0151)
L.Squared debt	-0.0033	0.0089	0.0011	0.0002	0.0002
	(0.0048)	(0.0065)	(0.0064)	(0.0067)	(0.0079)
L.GDP	-1.6707***	0.9028	-1.3052	-1.5420*	-1.5420
	(0.5808)	(0.5671)	(0.9074)	(0.8098)	(1.2067)
L.Current account	0.0624***	0.1686***	0.0646**	0.0607**	0.0607**
	(0.0227)	(0.0303)	(0.0286)	(0.0284)	(0.0308)
L.Inflation	-0.0327	0.0185	-0.0460	-0.0115	-0.0115
	(0.0241)	(0.0599)	(0.0512)	(0.0477)	(0.0549)
L.Growth	7.2258**	12.6899*		5.4063	5.4063
	(3.3647)	(6.5482)		(3.8596)	(4.8873)
VIX	-0.0317***			-0.0390**	-0.0390*
	(0.0103)			(0.0179)	(0.0207)
SP500	0.0010			-0.0086*	-0.0086
	(0.0035)			(0.0049)	(0.0073)
Country FEs	Yes	No	Yes	Yes	Yes
Observations	649	470	465	465	465
R-squared	0.83	0.30	0.81	0.82	0.82
F-statistic	82.97	17.23	52.46	56.83	
Hansen J		3.64	1.58	0.36	0.36
Standard errors	Robust	Robust	Robust	Robust	Bootstrap

Note: The dependent variable is the cyclically adjusted primary balance. Higher numbers indicate fiscal tightening. The measure of ratings informativeness is the cross-section correlation between sovereign yields and sovereign ratings at each period t instrumented by the variables *Negative news CRA* and *Excess returns MCO*. Other control variables are the debt percentage over GDP, the square of debt, GDP, growth, the current account as percentage of GDP, inflation, the CAPB as percentage of GDP (all lagged one period), and the VIX and S&P 500 indices. Where indicated, the specification includes country fixed effects. Definitions of the variables can be found in appendix L. Note: Robust standard errors in parentheses. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

reported truthfully by the rating r. In addition, suppose the market receives an independent noisy signal s about θ:

$$\begin{aligned} r_i &= \theta + \xi_i; \\ s_i &= \theta + \nu_i, \end{aligned}$$

with ξ_i and ν_i normally distributed with zero mean and inverse of the variance $\alpha_\xi = \frac{1}{\sigma_\xi^2}$ and $\alpha_\nu = \frac{1}{\sigma_\nu^2}$, respectively. Suppose now the price of the sovereign debt is proportional to the expected value of θ *conditional* on both the rating and the market signal. Due to the normality and linearity assumptions, Bayes' rule delivers a particularly simple expression for the price,

$$q_i = \delta r_i + \underbrace{\phi s_i}_{\varepsilon_i},$$

where $\delta = \frac{\alpha_\xi}{1+\alpha_\xi+\alpha_\nu}$ and $\phi = \frac{\alpha_\nu}{1+\alpha_\xi+\alpha_\nu}$ (e.g., see Chapter 2 in (Velkamp, 2011)). Hence, the model interprets the volatility of the price, given a rating, as generated by the error $\varepsilon_i = \phi s_i$. For a fixed precision of the market signal α_ν, the more precise the rating is - that is, the higher α_ξ - the lower ϕ is. Since $\sigma_\varepsilon^2 = \phi^2(1 + \sigma_\nu^2)$, the more the information provided by the rating signal, the lower σ_ε^2 is[35].

Proxy for σ_ε. Conditional on a rating category r, I can compute the standard deviation of the residuals ε_i as the standard deviation of the price of debt $\hat{\sigma}_{r,t}$ for each date t. The rating categories are defined as follows: 'prime' refers to the AAA rating, 'subprime' consists of the ratings AA- and higher excluding AAA, 'investment' refers to rating categories higher than BBB- but lower than AA-, and 'non-investment' contains the rating categories lower than BBB-.

The empirical implication I am expecting to find is that the higher the standard deviation of sovereign yields within a rating category, the more countries should perform austerity all other things equal. Hence, I modify the specification of the equation of the fiscal stance (5.1)

[35]Notice that this richer framework keeps the monotonicity of δ in the informativeness of the CRA signal (see equation (4.2)): *ceteris paribus*, a larger value of σ_ξ^2 is associated with a lower value of α_ξ.

to the following:

$$Y_{i,t} = \alpha + \gamma \hat{\sigma}_{r,t} + \beta X_{i,t} + \epsilon_{i,t}, \tag{5.2}$$

where $Y_{i,t}$ is the CAPB, $\hat{\sigma}_{r,t}$ is the standard deviation of sovereign yields at time t for rating category r and $X_{i,t}$ are the same control variables discussed in the previous section.

The variable $\hat{\sigma}_{r,t}$ is a measure of rating informativeness *within a rating category* and, thus, exploits the variation at the time and the rating category level. In figure 4, I report the values of $\hat{\sigma}_{r,t}$ by year for each of the broad rating categories r described above. Notice that the pattern differs across categories and that, for the sample of OECD countries, non-investment ratings are not a numerous category.

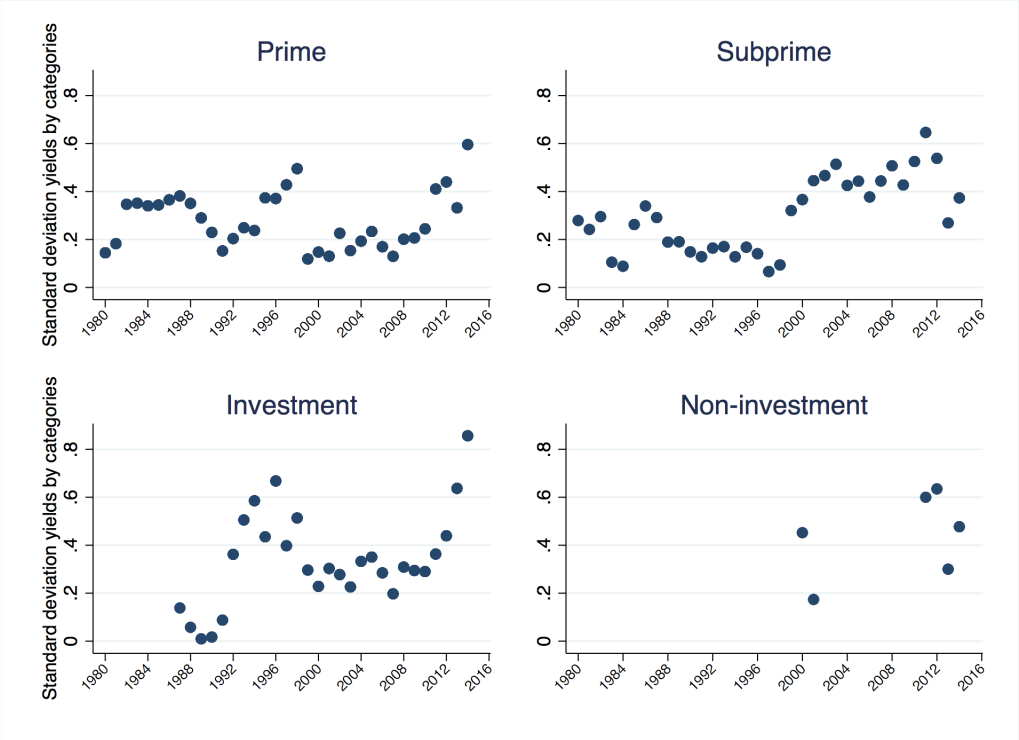

Figure 4: Annual standard deviations of long-term sovereign yields across countries for the following broad rating categories: prime (AAA ratings), subprime (from AA+ to AA- ratings), investment (from A+ to BBB- ratings), and non-investment (BB+ and lower ratings).

The estimated coefficient of $\hat{\sigma}_{r,t}$ in equation (5.2) is positive, as can be seen in table 5. More dispersed sovereign yields in a given year, relative to other rating categories, are associated with a tightening of the cyclically adjusted primary balance. An increase in the

Table 5: The effect of ratings informativeness on the cyclically adjusted primary balance using $\hat{\sigma}_{r,t}$ as a measure of informativeness

	(1) CAPB	(2) CAPB	(3) CAPB	(4) CAPB
St.dev. yields by rating	1.3311***	1.3403***	1.0875**	1.0875**
	(0.4502)	(0.3835)	(0.4703)	(0.5279)
L.CAPB	0.8703***	0.7794***	0.7648***	0.7648***
	(0.0303)	(0.0355)	(0.0389)	(0.0438)
L.Debt	0.0088*	0.0251***	0.0144	0.0144
	(0.0050)	(0.0091)	(0.0088)	(0.0090)
L.Squared debt	-0.0036	-0.0025	0.0013	0.0013
	(0.0030)	(0.0049)	(0.0046)	(0.0056)
L.GDP	-0.1902	-1.3287**	-0.5597	-0.5597
	(0.2669)	(0.5402)	(0.6508)	(0.6615)
L.Current account	0.0505***	0.0757***	0.0539***	0.0539***
	(0.0151)	(0.0235)	(0.0191)	(0.0200)
L.Inflation	0.0039	0.0149	0.0143	0.0143
	(0.0204)	(0.0216)	(0.0185)	(0.0293)
L.Growth	3.7740	8.2813**	0.9826	0.9826
	(3.2606)	(3.3223)	(4.6299)	(6.5160)
Country FEs	No	Yes	Yes	Yes
Year FEs	No	No	Yes	Yes
Observations	671	671	671	671
R-squared	0.81	0.83	0.87	0.87
F-statistic	159.92	88.91	64.06	
Standard errors	Robust	Robust	Robust	Bootstrap

Note: The dependent variable is the cyclically adjusted primary balance. Higher numbers indicate fiscal tightening. The measure of ratings informativeness is the standard deviation of the sovereign yields at each period t for each broad rating category (prime, subprime, investment, non-investment). Other control variables are the debt percentage over GDP, the square of debt, GDP, growth, the current account as percentage of GDP, inflation, the CAPB as percentage of GDP (all lagged one period), and the VIX and S&P indices. Where indicated, the specification includes country and year fixed effects. Definitions of the variables can be found in appendix L. Note: Robust standard errors in parentheses. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

dispersion of sovereign yields over time, within a rating category, is also associated with heightened fiscal austerity.

5.4 Extensive versus intensive margin

In my model, an increase in austerity is driven by the extensive margin, that is, a larger number of countries choose to signal creditworthiness. However, the higher the number of signalling countries, the larger the average amount of austerity in the overall sample of countries[36]. In the previous sections, I look at an intensive measure of austerity, the cyclically adjusted primary balance. In this section, I focus on a proxy for the extensive margin of austerity. The variable is constructed based on the collection of episodes of fiscal consolidations identified by Devries et al. (2011). The data covers 17 countries from 1978 to 2000, for which they examine 'policymakers' intentions and actions ... as described in contemporaneous policy documents'[37].

I estimate a probit regression of the following equation:

$$Y_{i,t} = \alpha + \gamma\hat{\rho}_t + \beta X_{i,t} + \kappa_i + \tau_t + u_{i,t}, \tag{5.3}$$

where $Y_{i,t}$ is a dummy variable that takes the value 1 if the country fiscally consolidates in that year and 0 if it does not; $\hat{\rho}_t$ is the correlation variable described in section 5.2; and $X_{i,t}$ are control variables (*CAPB over GDP, Debt over GDP, Squared debt over GDP, GDP, Growth, Current account over GDP, Inflation*, lagged one period, and the *VIX* and *S&P 500 indices*). The specification includes country and year fixed effects. Table 6 presents the results: lower informativeness, measured by an increase in $\hat{\rho}_t$, is associated with a higher probability of entering a period of fiscal consolidation.

[36]Signalling implies choosing a reduced amount of debt equal to D_2^{-B}. If type A countries reduce debt and type B countries stay put, the total amount of debt and, thus, the average amount of debt will be higher.

[37]Countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, United Kingdom, and United States. The list is a subset of the sample used in the previous sections.

Table 6: The effect of ratings informativeness on the extensive margin of austerity

	(1) Austerity episode	(2) Austerity episode	(3) Austerity episode	(4) Austerity episode
Correlation ratings-yields	1.6378*	12.4941**	8.7999**	13.5285**
	(0.9445)	(5.5238)	(4.2923)	(6.1181)
L.CAPB	-0.2632***	-0.2460***		-0.2420***
	(0.0506)	(0.0567)		(0.0728)
L.Debt	0.0200	-0.0255	0.0293*	0.0155
	(0.0222)	(0.0158)	(0.0175)	(0.0315)
L.Squared debt	0.0041	0.0171**	0.0014	-0.0004
	(0.0123)	(0.0083)	(0.0083)	(0.0166)
L.GDP	-28.9493	-2.5752*	-7.6956	42.2723
	(32.7671)	(1.5166)	(5.8366)	(46.1831)
L.Current account	0.0170	-0.0399	-0.2028***	-0.0215
	(0.0521)	(0.0396)	(0.0397)	(0.0697)
L.Inflation	-0.0298	-0.1311	-0.0776	-0.0956
	(0.0617)	(0.1069)	(0.0700)	(0.1216)
L.Growth	4.4346	-10.0693	-12.7259**	-7.1909
	(6.2569)	(8.6037)	(6.2859)	(9.6401)
Country FEs	Yes	No	Yes	Yes
Year FEs	No	Yes	Yes	Yes
Observations	287	289	381	272
Chi-squared	65.72	71.20	104.21	81.06
Log likelihood	-136.88	-122.62	-160.26	-108.40

Note: The dependent variable is a dummy variable from Devries et al. (2011) that takes the value 1 if the country fiscally consolidates in that year and 0 if it does not. The measure of ratings informativeness is the cross-section correlation between sovereign yields and sovereign ratings at each period t. Other control variables are the debt percentage over GDP, the square of debt, GDP, growth, the current account as percentage of GDP, inflation, the CAPB as percentage of GDP (all lagged one period), and the VIX and S&P 500 indices. Where indicated, the specification includes country and year fixed effects. Definitions of the variables can be found in appendix L. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5.5 Other robustness checks

The choice of the sample of countries is dictated by the desire to find a homogeneous set of countries, that could be considered similar from an *ex-ante* perspective, once the fundamentals of the country have been taken into account. Countries with stable governments, solid institutions, and a clean record of sovereign defaults, which have been consistently borrowing in the markets in the past. The OECD countries provide a good and sufficiently numerous sample[38]. In appendix O, I check whether the results found above for the OECD countries hold beyond this particular group of countries. I define the following geographical groups[39]: European Union countries, European peripherals countries, emerging market economies, and all countries; the latter comprises 58 developed and developing countries covered by the WEO statistics. I repeat the IV estimation of equation (5.1) for each of these groups between 1980 and 2011 and find my measure of ratings informativeness to be positively associated to austerity in all groups. In the emerging markets group, though, the coefficient becomes statistically insignificant[40].

As mentioned in the introduction, there is no clear consensus about the definition of austerity. In this paper, the definition I propose requires measuring the government's discretionary fiscal decisions[41]. For most of this paper, I use the CAPB as a proxy for austerity. This is the most commonly used measure of discretionary fiscal policy. As a robustness check, in appendix P, I present the results of estimating the equation of the fiscal stance (5.1) between 1980 and 2014 using three other fiscal variables commonly used to measure austerity: the net borrowing or lending as percentage of GDP (column 1), the primary surplus or deficit as percentage of GDP (column 2), and the amount of government expenditure over GDP (column 3). The results all go in the same direction as the previous sections: ρ_t co-moves positively with austerity, represented by larger surpluses and lower expenditures. The es-

[38]Investors, such as investment funds and pension funds, typically consider allocations into the sovereign bond market of OECD countries in general as relatively safe assets and dedicate part of their capital to invest in this market segment without committing to invest in any one given country.

[39]The composition of the groups is explained in appendix N.

[40]If we think that the other groups contain relatively more creditworthy countries with respect to emerging market economies, these results are consistent with the theory that creditworthy types are those undertaking austerity measures.

[41]A 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 13).

timated effect of one standard deviation change in the correlation between sovereign yields and sovereign ratings is a reduction of 1.4 percentage points in net borrowing over GDP, a 1.6 higher primary surplus over GDP, and a 1.3 lower expenditure over GDP.

Part of the explanation for the empirical findings above could be that a change in a country's price of debt may force the country to issue less debt. After controlling for the country's own sovereign yields in logs in the fiscal stance, as I do in the last column of the table in appendix P, I still find a positive effect in austerity of changes in ratings informativeness.

Finally, I also extend the sample for the OECD countries including more recent years. The mechanism is weaker from 2012 onwards, the size of the effect becomes smaller and it is still positive but statistically insignificant if we extend the sample to include the period between 2014 and 2019. This might be the consequence of the heavy market intervention of the European Central Bank (ECB) on the sovereign market from 2012 onwards. Following Mario Draghi's famous 'whatever it takes' speech in July indeed, the ECB launched a package of non-standard monetary policy measures from 2014. They included quantitative easing through an asset purchase programme (APP), which targeted in large part sovereign bonds and extended beyond 2019. The mechanism in my model works through the effect that signalling has on the sovereign yields. By acting as a lender of last resort for many European countries, the ECB might have severed the ties between fiscal austerity and sovereign yields. This reduced the reliance of sovereigns on the debt market and may mitigate the effect that I describe.

6 Conclusion

The main result of the paper is that signalling creditworthiness may be a novel motive that induces an austere fiscal behaviour. Creditworthy countries may find it worthwhile to tighten their fiscal stance in order to separate themselves from less reliable countries, depending on the price spreads between signalling and not doing so. Since austerity is costly, the incentives to distinguish from less performing countries need to be high enough. This is the case when the credit rating agencies provide less informative ratings.

I bring this implication of the model to the data. I find robust evidence that less infor-

mative ratings are associated with 'abnormally' high deficits, compared to those one would expect taking into account fundamental variables. I interpret this as evidence of the existence of a signalling channel in fiscal policy.

These findings are relevant for better understanding the forces behind public policy interventions. In that light, the cyclical waves of austerity that countries engage in recurrently could not only be a run for fiscal virtue but also a run for credibility. The evidence brought here may become ever more important in the coming years, as it is projected that sovereign debt will achieve new heights (OECD, 2020) and that debt price movements will have a large impact that countries might seek to mitigate.

References

Acharya, V. and Rajan, R. Sovereign debt, government myopia, and the financial sector. *Review of Financial Studies*, 26, 11 2011.

Afonso, A. Fiscal sustainability: the unpleasant European case. *FinanzArchiv: Public Finance Analysis*, 61(1):19–44, 2005.

Afonso, A., Furceri, D., and Gomes, P. Sovereign credit ratings and financial markets linkages: Application to european data. *Journal of International Money and Finance*, 31 (3):606–638, 2012.

Alesina, A. and Ardagna, S. Tales of fiscal adjustment. *Economic Policy*, 13(27):488–545, 1998.

Ardagna, S. Financial markets' behavior around episodes of large changes in the fiscal stance. *European Economic Review*, 53(1):37–55, 2009.

Ardagna, S., Caselli, F., and Lane, T. Fiscal discipline and the cost of public debt service: Some estimates for OECD countries. *The B.E. Journal of Macroeconomics*, 7(1):1935–1690, 2008.

Baldacci, E., Gupta, S., and Mulas-Granados, C. How effective is fiscal policy response in financial crises? In Claessens, S., Kose, M. A., Laeven, L., and Valencia, F., editors, *Financial Crises: Causes, Consequences, and Policy Responses*, pages 431–457. IMF Publication, 2013.

Bar-Isaac, H. and Shapiro, J. Ratings quality over the business cycle. *Journal of Financial Economics*, 108(1):62–78, 2013.

Blanchard, O., Chouraqui, J., R.P., H., and Sartor, N. The sustainability of fiscal policy: New answers to an old question. *OECD Economic Studies*, 15, 1990.

Bussière, M. and Ristiniemi, A. Credit ratings and debt crises. *Banque de France Working Paper*, 396, 09 2012.

Cantor, R. and Packer, F. Determinants and impact of sovereign credit ratings. *Economic Policy Review*, 2(2):37–53, 1996.

Catao, L., Fostel, A., and Ranciere, R. Fiscal discoveries and yield decouplings. *IMF Economic Review*, 65(4):704–44, 2017.

Cho, I.-K. and Kreps, D. M. Signaling games and stable equilibria. *Quarterly Journal of Economics*, 102(2):179–221, 1987.

Cole, H. and Cooley, T. Rating agencies. *NBER Working Paper*, 19972, 2014.

Cole, H., Dow, J., and English, W. Default, settlement, and signalling: Lending resumption in a reputational model of sovereign debt. *International Economic Review*, 36(2):365–385, 1995.

Corsetti, G. and Roubini, N. Fiscal deficits, public debt, and government solvency: Evidence from OECD countries. *Journal of the Japanese and International Economies*, 5(4):354 – 380, 1991.

De Santis, R. The Euro area sovereign debt crisis: safe haven, credit rating agencies and the spread of the fever from Greece, Ireland and Portugal. *European Central Bank Working Paper*, 1419, 2012.

Dellas, H. and Niepelt, D. Austerity. *The Economic Journal*, Forthcoming 2020.

D'Erasmo, P. Government reputation and debt repayment in emerging economies. 2008 Meeting Papers 1006, Society for Economic Dynamics, 2008.

Devries, P., Guajardo, J., Leigh, D., and Pescatori, A. A new action-based dataset of fiscal consolidation. *IMF Working Paper*, 11/128, June 2011.

Drudi, F. and Prati, A. Signaling fiscal regime sustainability. *European Economic Review*, 44(2):1897–1930, 2000.

Favero, C. and Monacelli, T. Fiscal policy rules and regime (in)stability: Evidence from the u.s. *IGIER Università Bocconi Working Paper Series*, 282, January 2005.

Ferri, G., Liu, L., and Stiglitz, J. The pro-cyclical role of rating agencies: Evidence from the East Asian crisis. *Economic Notes*, 28(3):335–355, 1999.

Gali, J. and Perotti, R. Fiscal policy and monetary integration in Europe. *Economic Policy*, 18(37):533–572, 2003.

Holden, S., Natvik, G., and Vigier, A. An equilibrium model of credit rating agencies. *Norges Bank Working Paper*, 23, 2012.

Josephson, J. and Shapiro, J. Credit ratings and structured finance. *Journal of Financial Intermediation*, April 2019.

Kaminsky, G. and Schmukler, S. Emerging market instability: Do sovereign ratings affect country risk and stock returns? *World Bank Economic Review*, 16(2):171–195, 2002.

Kiff, J., Nowak, S., and Schumacher, L. Are rating agencies powerful? An investigation into the impact and accuracy of sovereign ratings. *IMF Working Paper*, 12/23, 2012.

Larrain, G., Reisen, H., and von Maltzan, J. Emerging market risk and sovereign credit ratings. *OECD Development Centre Technical Papers*, 124, 1997.

Mailath, G. J., Okuno-Fujiwara, M., and Postlewaite, A. Belief based refinements in signaling games. *Journal of Economic Theory*, 60(2):241–276, 1993.

Manso, G. Feedback effects of credit ratings. *Journal of Financial Economics*, 109(2): 535–548, 2013.

Mathis, J., McAndrews, J., and Rochet, J. Rating the raters: Are reputation concerns powerful enough to discipline rating agencies? *Journal of Monetary Economics*, 56(5): 657–674, 2009.

OECD. *OECD Sovereign Borrowing Outlook 2020*. OECD Publishing, 2020. URL `https://www.oecd-ilibrary.org/content/publication/dc0b6ada-en`.

Opp, C., Opp, M., and Harris, M. Rating agencies in the face of regulation. *Journal of Financial Economics*, 108(1):46–61, 2013.

Polito, V. and Wickens, M. A model-based indicator of the fiscal stance. *European Economic Review*, 56(3):526–551, 2012.

Polito, V. and Wickens, M. Modelling the U.S. sovereign credit rating. *Journal of Banking and Finance*, 46:202–218, 2014.

Pukthuanthong-Le, K., Elayan, F., and Rose, L. Equity and debt market responses to sovereign credit ratings announcement. *Global Finance Journal*, 18(1):47–83, 2007.

Reinhart, C. M. and Rogof, K. S. This time is different: A panoramic view of eight centuries of financial crises. *Annals of Economics and Finance, Society for AEF*, 15(2):1065–1188, November 2014.

Sandleris, G. Sovereign defaults: Information, investment and credit. *Journal of International Economics*, 76(2):267–275, 2008.

Skreta, V. and Veldkamp, L. Ratings shopping and asset complexity: A theory of ratings inflation. *Journal of Monetary Economics*, 56(5):678–695, 2009.

Sobel, J. Signaling games. *Complex Social and Behavioral Systems: Game Theory and Agent-Based Models*, pages 251–268, 2020.

Spence, M. Job market signaling. *The Quarterly Journal of Economics*, 87(3):355–374, 1973.

Velkamp, L. L. *Information Choice in Macroeconomic and Finance*. Princeton University Press, 2011.

White, L. J. The credit rating agencies. *Journal of Economic Perspectives*, 24(2):211–226, 2010.

APPENDIX

A The single crossing property

The *single crossing condition* of indifference curves is defined as a ranking of the slopes of the indifference curves $U^i(D_2, q)$ such that $MRS^A(D_2, q) > MRS^B(D_2, q)$ for all D_2, q in the relevant range, where $MRS^i(D_2, q) := -\frac{\frac{\partial U^i(D_2,q)}{\partial D_2}}{\frac{\partial U^i(D_2,q)}{\partial q}}$. Let us show that the indifference curves of country type A are flatter than those of country type B. First, let us define the relevant range of D_2. Let $\underline{D}_2^i$ be the threshold debt level that satisfies constraint (2.3) for $t = 1$ for each type:

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

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

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

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 $MRS^i(D_2, q)$ for each type. Total differentiation of equation (2.5) gives:

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

and, simplifying,

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

Therefore, $MRS^i(D_2, q) = -\frac{q - \beta\left(1 - F(D_2 + \underline{c}^i)\right)}{D_2}$ and $MRS^A(D_2, q) < MRS^B(D_2, q)$ if $MRS^i(D_2, q) < 0$, which is the case for all $D_2 \in [\underline{D}_2^B, 0)$ given assumption (A5). □

B Full information optimal allocation

Let us show that the optimal debt level under full information D_2^{FI} is a local maximum. Differentiating the FOC (3.2) with respect to D_2 and rearranging gives:

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

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

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

therefore,

$$D_2 < \frac{\beta' - \beta}{\beta' h} + \frac{1}{h}. \tag{B.2}$$

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. □

C Separating equilibrium

We show that the allocation $\left[\left(D_2^{-B}, q^*(D_2^{-B})\right), \left(D_2^{FI}, q^*(D_2^{FI})\right)\right]$, along with beliefs $\mu^*\left(D_2^{-B}\right) = 1$, and $\mu^*\left(D_2\right) = 0$ for $D_2 \neq D_2^{-B}$, constitutes a separating equilibrium outcome. Recall that D_2^{-B} is the debt level that satisfies type B's incentive compatibility constraint (3.5) with equality:

$$U^B(D_2^{-B}, q^*(D_2^{-B})) = U^B(D_2^{FI}, q^*(D_2^{FI})). \tag{C.1}$$

Let us define $\mathbf{q}_i(\cdot, U)$ as the function that gives the price of debt necessary to keep type i's utility constant at U for each debt level D_2. $\mathbf{q}_i(\cdot)$ is continuous and one-to-one. If $\bar{U} = U^B(D_2^{FI}, q^B(D_2^{FI}))$ 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 $q^B(D_2^{FI})$ by definition. On the other hand, we know that $q^B(D_2) < q^A(D_2)\ \forall D_2$. Therefore,

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

Hence, $\mathbf{q}_B(\cdot, \bar{U})$ lies below $q^A(\cdot)$ at $D_2 = D_2^{FI}$. We now argue that the schedule $\mathbf{q}_B(\cdot, \bar{U})$ must intersect the schedule $q^A(\cdot)$ for some value D_2 below D_2^{FI}. Recall, from appendix A, that $\underline{D}_2^B$ represents the minimum level of debt for country B. If D_2 is below such level the country cannot consume its minimum $\underline{c}_B$. Hence, it is easy to see that either the two schedules cross to the right of $\underline{D}_2^B$, otherwise country A can always take $D_2 < \underline{D}_2^B$ and the market understand that country B will never be able to take such low level of debt. In what follows, I assume the crossing point occurs to the right of $\underline{D}_2^B$.

Let $D_2^{A,B}$ be the debt level most preferred by type A under the price schedule $q^B(D_2)$. It remains to be proven that type A prefers choosing D_2^{-B} and having the price of debt $q^*(D_2^{-B}) = q^A(D_2^{-B})$ to choosing $D_2^{A,B}$ and having the price $q^*(D_2^{A,B}) = q^B(D_2^{A,B})$. First, note that the full information allocation is optimal for type B, hence, it is its highest isoutility curve under the $q^B(D_2)$ schedule. It follows that the price schedule $q^B(D_2)$ must lie below B's isoutility curve going through the full information allocation for all $D_2 \neq D_2^{FI}$. To satisfy the tangency condition of $D_2^{A,B}$ for type A, the allocation $(D_2^{A,B}, q^B(D_2^{A,B}))$ must be below

the isoutility curve of B going through $(D_2^{FI}, q^B(D_2^{FI}))$. Given that the isoutility curves of A in (D_2, q) are steeper than those of B for any D_2, the two 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 $(D_2^{A,B}, q^B(D_2^{A,B}))$ is on a higher isoutility curve of A than $(D_2^{-B}, q^A(D_2^{-B}))$. Otherwise, it would be preferred by B as well, which contradicts (C.1). □

D Pooling equilibrium at D_2^{FI}

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

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 Proof of proposition 3.3

F.1 Selection of the separating equilibrium e^*

For e^* to be the unique equilibrium, it must be true 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 inconsistent with e^*. Note that this can only happen:

- To the right of D_2^{-B} if $\forall D_2 \in [\underline{D}_2^B, D_2^{-B}] \quad q(D_2) > q^A(D_2)$, 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 $\mu = p$ and $q^P(D_2)$ needs to be above A's isoutility curve going through $\left(D_2^{-B}, q^A(D_2^{-B})\right)$.

Thus, $q^P(D_2) < \mathbf{q}(D_2, \bar{U}^A)$, where $\bar{U}^A = U^A\left(D_2^{-B}, q^A(D_2^{-B})\right)$, is the condition for e^* to survive.[42] The condition holds for a sufficiently low p:

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

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'. However, 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^*. □

F.2 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 types that choose D_2' in e^* need to be positive for both A and B. Hence,

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

Condition $U^B(e') > U^B(e^*)$, i.e., $U^B(D_2^{FI}, q^*(D_2^{FI})) > U^B(D_2^{FI}, q^B(D_2^{FI}))$, is clearly true. For its A counterpart, we have to find conditions for $U^A(D_2^{FI}, q^*(D_2^{FI})) \geq U^A((D_2^{-B}, q^A(D_2^{-B}))$, it suffices to choose a p that is close enough to 1. To see it, note that due to the linearity of U^A in q and the linearity of q to the default probabilities, we have:

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

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

and that the first term:

$$U^A\left(D_2^{FI}, q^A(D_2^{FI})\right) > U^A\left(D_2^{-B}, q^A(D_2^{-B})\right),$$

because it is the full information solution. Thus, using $p = 1 - \epsilon$, with ε sufficiently small, we have the desired result since $U^A\left(D_2^{FI}, q^B(D_2^{FI})\right)$ is bounded. □

G Intuitive criterion and undefeated equilibrium refinement

One of the best well-known refinements of the PBE is the intuitive criterion (IC) developed by Cho and Kreps (1987). Let e^* and e' be two equilibria of the game and $\{(D_2^*(i), q^*; \mu^*(\cdot))\}$ and $\{(D_2'(i), q'; \mu'(\cdot))\}_{i\in\{A,B\}}$ its respective outcomes, as depicted in figure 5. If a deviation from an equilibrium allocation D_2' to an alternative allocation D_2'' is dominated for one type but not for another, this deviation should not be attributed to the type for which the deviation is dominated. Any $D_2 \in [D_2''', D_2'']$ would be preferred only for type A and not for B because the single crossing property creates a space between the indifference curves of A and B. Hence, beliefs in that interval must be such that $\mu = 1$ and, thus, they cannot sustain the candidate pooling equilibrium e'. For the same reason, no pooling equilibrium can dominate the separating equilibrium e^*.

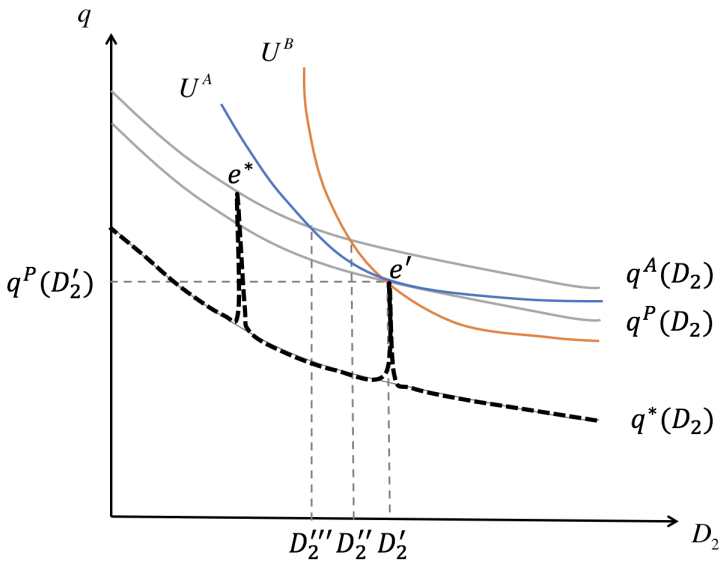

Figure 5: Off-equilibrium beliefs restrictions.

The IC 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 undefeated equilibrium (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 (for example, e^*). Beliefs at $D_2 \in [D_2''', D_2'']$ remain unrestricted,

unlike in the IC, because they are not part of the equilibrium strategies of an alternative equilibrium. The UE restricts off-equilibrium beliefs 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'.

An interesting feature of the IC is that it eliminates multiplicity of equilibria in this kind of signalling games with two players and single crossing preferences. The separating equilibrium remains the unique equilibrium of the game. The high type always engages in excessive austerity (compared to the full-information benchmark) in order to distinguish itself from the low type. The fact that this sharp result does not depend on the distribution of types is less appealing. The efficient separating equilibrium for a sequence of games in which the probability of the low type converges to zero does not converge to the separating equilibrium of the game in which the probability of the lowest type is zero (Sobel, 2020). This problem is solved when applying the UE refinement. Note that with the UE, pooling can survive and this happens when it is preferred by all types. Thus, the (efficient) pooling outcome will be selected when the probability of the low type goes to zero.

H Proof of proposition 4.1

The statement uses the following lemma:

Lemma H.1 (Comparative statics)**.** *Assume $p < \bar{p} \leq 1$.*
(a) (high rating) There exists a level of informativeness π^* such that for $\pi \geq \pi^*$ all equilibria in the high rating sub-market are pooling and for $\pi < \pi^*$ the unique equilibrium in the high rating sub-market is separating.
(b) (low rating) The least cost separating equilibrium is the unique equilibrium emerging in the low rating sub-market for all $\pi \in (0.5, 1)$.
(c) For a fixed p, the fraction of type A countries in the low rating submarket is decreasing with π.

Proof. (of the lemma) (a) Note that from (4.1), $\hat{p}(\pi, p, \bar{r})$ is increasing and continuous in π. Let π^* such that $\hat{p}(\pi^*, p, \bar{r}) = \bar{p}$. Note that this exists by continuity since for $\pi^* = 1$ we have $\hat{p}(1, p, \bar{r}) = 1$. The result follows from the monotonicity of $\hat{p}(\pi, p, \bar{r})$ in π.
(b) The result is immediate since for all $\pi \in (0.5, 1)$ we have $\hat{p}(\pi, p, \underline{r}) < p < \bar{p}$.
(c) It is straightforward from the expression for $\hat{p}(\pi, p, \underline{r})$ in (4.1). □

To complete the proof note that for $\pi < \pi^*$ both sub-markets are in the separating region and, hence, the fraction of countries performing austerity is p (G is constant). For $\pi = \pi^*$ the function has a downwards jump since now separation only occurs in the low rating sub-market. For $\pi > \pi^*$ G strictly decreases as the fraction of A countries in the low rating sub-market decreases with π.

I Proof of proposition 4.2

Recall the expressions for prices.

$$\mathbb{E}[q^* \mid \bar{r}] = \beta' \left[\frac{p\pi \left(1 - F(D_2^*(A) + \underline{c}^A)\right)}{p\pi + (1-p)(1-\pi)} + \frac{(1-p)(1-\pi)\left(1 - F(D_2^*(B) + \underline{c}^B)\right)}{p\pi + (1-p)(1-\pi)} \right];$$
$$\mathbb{E}[q^* \mid \underline{\mathrm{r}}] = \beta' \left[\frac{p(1-\pi)\left(1 - F(D_2^*(A) + \underline{c}^A)\right)}{p(1-\pi) + (1-p)\pi} + \frac{(1-p)\pi\left(1 - F(D_2^*(B) + \underline{c}^B)\right)}{p(1-\pi) + (1-p)\pi} \right],$$

As long as $D_2^*(A)$ and $D_2^*(B)$ are constant, it is a straightforward computation to see that

$$\frac{\partial}{\partial \pi} \left[\mathbb{E}[q^* \mid \bar{r}] - \mathbb{E}[q^* \mid \underline{\mathrm{r}}] \right] > 0.$$

From proposition 4.1, we know that for low π the economy has a separating equilibrium in both sub-markets while for large π it has a separating equilibrium only in the low rating sub-market. We also know that in all equilibria, the level of debt for country B remains the same regardless of the fraction of good types (and, hence, of π). The level of debt for type A countries $D_2^*(A)$ is constant within each segment and only changes when the equilibrium switches from separating to pooling. This switch happens for $\pi = \pi^*$, but it is otherwise constant in π. This completes the proof.

J Multiple-period model

Let us show that the multiple-period problem with iid shocks to the type is the same as the repetition of the two-period model. We will construct our model backwards, starting from the two-period version of the model. Recall the two-period sovereign problem. When D_2 is chosen, the borrower knows its type $\underline{c}_2^i$. By analogy, we will keep this important timing assumption. With the aim of writing the general multi-period problem, I write the two-period problem emphasising the relevant states and eliminating the time subscript. Future choices are indicated with prime. Moreover, I write the generalised version with an arbitrary initial level of debt D and endowment ω, allowing the possibility of default. Let

$$u(D, \omega, \underline{c}) := \max\{\underline{c}, \omega - D\}$$

be the flow value in each period considering the default choice and assuming that the choice of default occurs before issuing the new debt.

$$\max_{D', c} \quad c + \beta \int_{\underline{\omega}}^{\infty} u(D', \omega', \underline{c}') f(\omega') d\omega' \tag{J.1}$$

subject to

$$c = \begin{cases} \omega - D + q(D')D' & \text{if } \omega > D + \underline{c}, \\ \underline{c} + q(D')D' & \text{otherwise;} \end{cases}$$

The borrower takes as given the price schedule and the belief schedule that generates it. For all D' and $\mu(D')$ consistent with lender optimality and competition in the lending market, we have: $q(D') = \beta' \left[\mu(D')(\,1 - F(D' + \underline{c}^A)\,) + (1 - \mu(D'))(\,1 - F(D' + \underline{c}^B\,))\right]$. In the baseline version of the model in the main text, we assume fixed types and no default in the first period.

Before moving to three or more periods, note that, thanks to the linearity of preferences, the previous problem can be rewritten as follows:

$$\max_{D'} \quad u(D, \omega, \underline{c}) + q(D')D' + \beta \int_{\underline{\omega}}^{\infty} u(D', \omega', \underline{c}')f(\omega')d\omega' \tag{J.2}$$

$$= u(D, \omega, \underline{c}) + W_1(\underline{c}', \mu), \tag{J.3}$$

where

$$W_1(\underline{c}', \mu) := \max_{D'} \quad q(D')D' + \beta \int_{\underline{\omega}}^{\infty} u(D', \omega', \underline{c}')f(\omega')d\omega'.$$

This formulation emphasises an important stationary property of our model with linear preferences: the decision of future debt is only a function of the type the borrower knows at the moment of repayment. In particular, it does not depend on the initial outstanding debt or the previous type of the borrower.

The simple default condition arises from the assumption that there is no dynamic punishment for default. We now move to three periods. We assume that types c_t^i are drawn independently across time, with support $\{A, B\}$ and probability p and $1 - p$, respectively. We can consider the previous two-period model as the last two periods of a three-period model.

Assuming that the lender beliefs schedule and, hence, the price schedule q, is time constant, we can define

$$V_2(D, \omega, \underline{c}, \mu) := u(D, \omega, \underline{c}) + pW_1(\underline{c}^A, \mu) + (1 - p)W_1(\underline{c}^B, \mu) \tag{J.4}$$

Hence, we can define the function W_2 recursively as follows:

$$W_2(\underline{c}, \mu) := \max_{D} \quad q(D)D + \beta \int_{\underline{\omega}}^{\infty} V_2(D, \omega, \underline{c}, \mu)f(\omega)d\omega.$$

Given that we derive the recursive formulation of the three period problem, the extension to an arbitrary number of periods is immediate. The Bellman equation is as follows. For any level of debt D, endowment ω and initial type $\underline{c}^i$ we have

$$\begin{aligned} V_t(D, \omega, \underline{c}, \mu) &= u(D, \omega, \underline{c}) + pW_{t-1}(\underline{c}^A, \mu) + (1 - p)W_{t-1}(\underline{c}^B, \mu), \\ \text{where for all } \underline{c} \in \{c^A, c^B\}: & \\ W_{t-1}(\underline{c}, \mu) &= \max_{D} \quad q(D)D + \beta \int_{\underline{\omega}}^{\infty} V_{t-1}(D, \omega, \underline{c}, \mu)f(\omega)d\omega. \end{aligned}$$

In other terms, if we exclude the fact that the number of remaining periods decreases, each period can be seen as any other period with different initial conditions. The default

decision will always be determined by the difference $\omega - D$, justifying the stationarity of the price schedule q. In our linear setup, the initial conditions do not affect the shape of the indifference curve (as they only shift them in a parallel fashion). Both the full information optimal debt level, $D^{FI} = \frac{\beta' - \beta}{\beta' h}$, and the condition for the separating equilibrium debt level, D^{-B}: $U^B(D^{-B}, q^A(D^{-B})) = U^B(D^{FI}, q^B(D^{FI}))$, remain the same. The single crossing condition property is also maintained, hence, the solution to the problem between any two periods.

K The ratings geography and time span

Country	**Moody's**	**Fitch**	**S&P**	**Country**	**Moody's**	**Fitch**	**S&P**
Australia	1980	1996	1980	Korea	1987	1996	1989
Austria	1980	1995	1980	Luxembourg	1990	1995	1995
Belgium	1980	1995	1989	Mexico	1991	1996	1993
Canada	1980	1995	1980	Netherlands	1986	1995	1989
Czech Republic	1993	1996	1994	New Zealand	1980	2000	1980
Denmark	1980	1995	1981	Norway	1980	1995	1980
Estonia	1998	1998	1998	Poland	1995	1996	1995
Finland	1980	1995	1980	Portugal	1987	1995	1989
France	1980	1995	1980	Slovak Republic	1995	1997	1994
Germany	1986	1995	1984	Slovenia	1996	1997	1996
Greece	1991	1996	1989	Spain	1988	1995	1989
Hungary	1990	1996	1992	Sweden	1980	1995	1980
Iceland	1989	2000	1989	Switzerland	1982	1995	1989
Ireland	1988	1995	1989	United Kingdom	1980	1995	1980
Italy	1987	1995	1989	United States	1980	1995	1980
Japan	1982	1995	1980				

L Definition of the dataset economic 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, 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*, % potential GDP): The structural budget balance refers to the general government cyclically adjusted balance adjusted for non-structural 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 with fiscal data based on a fiscal calendar (e.g., July to June), this series would be the country's GDP over the same period. For countries with fiscal data 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 calculation applying the formula $\frac{GDP_t - GDP_{t-1}}{GDP_t}$ to the GDP series corresponding to fiscal year (current prices).

Current account balance (*CA*, %GDP): Current account is all transactions other than those in financial and capital items. The major classifications are goods and services, income, and current transfers.

Inflation, average consumer prices (*Inflation*, percent change): Annual percentages of average consumer prices are year-on-year changes.

M Rating scale conversion

S&P		Moody's		Fitch		Numerical variable
Categories	Modulation	Categories	Modulation	Categories	Modulation	
AAA	-	Aaa	-	AAA	-	52
	Negative		Negative		Negative	51
	Positive		Positive		Positive	50
AA+	-	Aa1	-	AA+	-	49
	Negative		Negative		Negative	48
	Positive		Positive		Positive	47
AA	-	Aa2	-	AA	-	46
	Negative		Negative		Negative	45
	Positive		Positive		Positive	44
AA-	-	Aa3	-	AA-	-	43
	Negative		Negative		Negative	42
	Positive		Positive		Positive	41
A+	-	A1	-	A+	-	40
	Negative		Negative		Negative	39
	Positive		Positive		Positive	38
A	-	A2	-	A	-	37
	Negative		Negative		Negative	36
	Positive		Positive		Positive	35
A-	-	A3	-	A-	-	34
	Negative		Negative		Negative	33
	Positive		Positive		Positive	32
BBB+	-	Baa1	-	BBB+	-	31
	Negative		Negative		Negative	30
	Positive		Positive		Positive	29
BBB	-	Baa2	-	BBB	-	28
	Negative		Negative		Negative	27
	Positive		Positive		Positive	26
BBB-	-	Baa3	-	BBB-	-	25
	Negative		Negative		Negative	24
	Positive		Positive		Positive	23
BB+	-	Ba1	-	BB+	-	22
	Negative		Negative		Negative	21
	Positive		Positive		Positive	20
BB	-	Ba2	-	BB	-	19
	Negative		Negative		Negative	18
	Positive		Positive		Positive	17
BB-	-	Ba3	-	BB-	-	16
	Negative		Negative		Negative	15
	Positive		Positive		Positive	14
B+	-	B1	-	B+	-	13
	Negative		Negative		Negative	12
	Positive		Positive		Positive	11
B	-	B2	-	B	-	10
	Negative		Negative		Negative	9
	Positive		Positive		Positive	8
B-	-	B3	-	B-	-	7
	Negative		Negative		Negative	6
CCC+	-		-	CCC+	-	5
CCC	-	Caa1	-	CCC	-	4
CCC-	-		-	CCC-	-	3
CC	-	Ca	-	CC	-	2
C	-	C	-	C	-	1
SD/D	-	WR	-	SD/D	-	0

N Definition of geographical groups

All countries are Australia, Austria, Belgium, Botswana, Bulgaria, Canada, Cyprus, Czech Republic, Denmark, Estonia, Fiji, Finland, France, Germany, Ghana, Greece, Guatemala, Honduras, Hungary, Iceland, India, Ireland, Italy, Jamaica, Japan, South Korea, Latvia, Lithuania, Luxembourg, Malawi, Malta, Mexico, Morocco, the Netherlands, New Zealand, Norway, Pakistan, Papua New Guinea, the Philippines, Poland, Portugal, Romania, Russia, Seychelles, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad and Tobago, Uganda, the United Kingdom, the United States, and Venezuela.

European Union countries are Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

European peripheral countries are Cyprus, Greece, Ireland, Italy, Portugal, and Spain.

Emerging market economies are Czech Republic, Hungary, India, Mexico, Morocco, Pakistan, the Philippines, Poland, Russia, South Africa, and Thailand.

O The effect of ratings informativeness on the cyclically adjusted primary balance by geographical area

	All countries	EU	Peripherals	EM
	(1)	(2)	(3)	(4)
	CAPB	CAPB	CAPB	CAPB
Correlation ratings-yields	3.5360***	4.2553**	11.6874*	0.0402
	(1.3426)	(1.6551)	(7.0540)	(4.1850)
L.CAPB	0.7134***	0.7111***	0.8150***	0.5048***
	(0.0695)	(0.0751)	(0.1282)	(0.1286)
L.Debt	0.0530***	0.0430	-0.0207	-0.5434***
	(0.0163)	(0.0291)	(0.0666)	(0.1771)
L.Squared debt	-0.0123*	0.0077	0.0652	0.6124***
	(0.0073)	(0.0210)	(0.0422)	(0.2261)
L.GDP	-1.2214	1028.7818*	4811.1123	3189.5136***
	(2.1025)	(611.9560)	(6841.0541)	(976.6050)
L.Current account	0.0691**	0.1483***	0.3602***	-0.3610**
	(0.0301)	(0.0436)	(0.1391)	(0.1466)
L.Inflation	-0.1016**	-0.1003*	-0.2242	-0.0709
	(0.0509)	(0.0568)	(0.2795)	(0.1084)
L.Growth	8.0954***	5.9420*	-9.7001	-12.8942**
	(2.9919)	(3.4406)	(11.5022)	(6.2751)
VIX	-0.0318*	-0.0106	0.0650	-0.2021***
	(0.0178)	(0.0232)	(0.0731)	(0.0404)
SP500	-0.0064	-0.0062	0.0081	-0.0301***
	(0.0046)	(0.0059)	(0.0145)	(0.0094)
Country FEs	Yes	Yes	Yes	Yes
Observations	364	240	61	36
R-squared	0.86	0.86	0.84	0.72
F-statistic	49.97	33.45	11.86	5.24
Hansen statistic	1.84	3.35	0.31	0.38

Note: The dependent variable is the cyclically adjusted primary balance. Higher numbers indicate fiscal tightening. The measure of ratings informativeness is the cross-section correlation between sovereign yields and sovereign ratings at each period t instrumented by the variables *Negative news CRA* and *Excess returns MCO*. Other control variables are the debt percentage over GDP, the square of debt, GDP, growth, the current account as percentage of GDP, inflation, the CAPB as percentage of GDP (all lagged one period), and the VIX and S&P 500 indices. Where indicated, the specification includes country fixed effects. Definitions of the variables can be found in appendix L. Note: Robust standard errors in parentheses. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

P Alternative measures of fiscal austerity

	(1) Net lending	(2) Primary surplus	(3) Expenditure	(4) CAPB
Correlation ratings-yields	7.4977****	8.4171****	-6.9144****	1.7157*
	(1.8242)	(2.2275)	(1.5156)	(1.1361)
L.CAPB				0.6946****
				(0.0594)
L.Net lending	0.5334****			
	(0.0741)			
L.Primary surplus		0.5479****		
		(0.0776)		
L.Expenditure			0.5936****	
			(0.0879)	
L.Debt	0.0015	0.0275**	-0.0037	0.0302***
	(0.0159)	(0.0153)	(0.0147)	(0.0127)
L.Squared debt	0.0043	-0.0032	0.0027	-0.0002
	(0.0063)	(0.0062)	(0.0058)	(0.0067)
L.GDP	-1.9369**	-5.6515****	0.2330	-1.6010***
	(1.0550)	(1.7372)	(0.9587)	(0.6321)
L.Current account	0.1115****	0.0999***	-0.0824***	0.0714***
	(0.0399)	(0.0399)	(0.0334)	(0.0300)
L.Inflation	-0.0729	-0.0579	-0.0420	-0.1052***
	(0.0716)	(0.0847)	(0.0732)	(0.0536)
L.Growth	18.4707****	17.9482***	-16.6949****	7.4108***
	(6.3803)	(7.0278)	(6.3350)	(3.4477)
VIX				
SP500	-0.0242****	-0.0215****	0.0242****	
	(0.0060)	(0.0062)	(0.0058)	
Log yields				0.4486**
				(0.2390)
Country FEs	Yes	Yes	Yes	Yes
Observations	496	463	496	454
R-squared	0.81	0.75	0.95	0.80
F-statistic	44.85	33.35	410.83	59.60
Hansen statistic	2.89	2.30	0.95	1.60

Note: The dependent variable is the net borrowing or lending in column (1), the primary surplus in column (2), the government expenditure in column (3), and the cyclically adjusted primary balance in column (4), all as a percentage of GDP. Higher numbers indicate fiscal tightening (except for expenditure). The measure of ratings informativeness is the cross-section correlation between sovereign yields and sovereign ratings at each period t instrumented by the variables *Negative news CRA* and *Excess returns MCO*. Other control variables are the debt percentage over GDP, the square of debt, GDP, growth, the current account as percentage of GDP, inflation, the CAPB as percentage of GDP (all lagged one period), the VIX and S&P 500 indices, and the log of the ten-years sovereign yields. Where indicated, the specification includes country fixed effects. Definitions of the variables can be found in appendix L. Note: Robust standard errors in parentheses. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.