Signalling Fiscal Austerity

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Abstract

Austerity measures may play a signalling role when sovereigns have private information about their ability to repay their debts. Reducing debt is less costly for more creditworthy countries, so by implementing a sufficient degree of austerity they can avoid imitation by less creditworthy ones. In a separating equilibrium, more creditworthy countries suffer from an 'excessive' debt reduction, but benefit by being able to sell their debt at a higher price. The incentive to signal creditworthiness through austerity increases when sovereign credit ratings are less informative. Using a panel of 58 countries from 1980 to 2011, I find that, consistent with the model, increased fiscal austerity is associated with episodes in which ratings are less informative.

JEL Classification: D82; F34; E62; G24.

Keywords: asymmetric information; sovereign risk; fiscal austerity; credit ratings.

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1 Introduction

Fiscal austerity refers to any measure aimed at tightening the government budget. Consolidation can come in the form of a decrease in the expenditure side or an increase in the revenue side of the budget. It is also linked to debt, since any current expenditure that is not paid for today can only be postponed to the future through an increase in debt. In this sense, a reduction in the amount of debt can also be seen as fiscal austerity.

In Europe austerity has been a salient issue in the policy debate in the aftermath of the financial crisis of 2007–08. The bailout of part of the banking system by the government in certain countries and, in some cases, an initial fiscal stimulus plan at the onset of the crisis raised questions about debt sustainability and forced some countries to tighten their budgets. For instance, the indebtedness of the Italian government, whose debt to GDP ratio exceeds one hundred percent, prompted a series of austerity packages amounting to 30 billion euros implemented during the Monti administration (2011–2013). The puzzling fact is that austerity was not only confined to highly indebted countries or financially distressed economies. Germany's bond yields were lower than ever before, yet the government announced plans to reduce the budget deficit by 80 billion euros before 2014. The UK also embarked on the biggest cuts in state spending since World War II.[1] Even the Netherlands, whose ratio of debt to GDP is one of the lowest in Europe, went through several austerity packages.

Naturally austerity measures have consequences for the population: when more resources are devoted to debt repayment, citizens' consumption is lower. The reason given by policymakers for implementing such measures was the need to reassure the markets about the country's creditworthiness in order to maintain access to international lending. In the words of Angela Merkel, the German Chancellor, *'austerity measures are adopted in order to send a very important signal'*; or, as the British Chancellor of the Exchequer George Osborne put it: *'we have to convince the world that we can pay our way in the world.'*

[1] 'EU austerity drive country by country', BBC News, 21 May 2012. `http://www.bbc.com/news/10162176`.

Heterogeneity in the ability to repay depends on many factors, and some of these may be unobservable. If a country's citizens are more resilient to a decrease in consumption, this puts a looser constraint on the government's taxation. Therefore, such a country is less prone to default on its outstanding debt. This capacity is unlikely to be known by outside market participants. For instance, cuts in public wages and a pension system reform were met with social protest in Portugal and were never implemented. Similar measures have been introduced elsewhere in Europe though, as in Italy or Spain. Different levels of tax evasion across countries also imply that sovereigns have a different capacity to extract taxes from citizens. The potential for tax evasion is unknown, and even historical evasion is difficult to observe. But this maps into different probabilities of default across countries, which affect the sovereign's borrowing terms. Thus, a sovereign with a higher ability to repay might have incentives to use any instrument at its disposal to communicate this ability to the market.

In this paper I build a signalling model in which sovereigns with different abilities to repay debt use fiscal policy as a signal about their creditworthiness. The more able country might reduce its debt below the optimal level in order to communicate its private information to lenders. This type is more willing to tighten because it faces a lower cost of debt reduction. Default is good for the country if debt is high or its endowment is low, but the more able type finds itself having to repay more often, which means it does not gain as much advantage from each unit of debt as the less able type. Hence, the more able type can choose austerity to avoid imitation by the less able one. Austerity improves lenders' beliefs about the country, thereby improving the price of debt.

Introducing a credit rating agency that provides superior information affects the incentives to signal. If a good rating improves the lenders' prior about the country's ability, the more able type has less to gain from revealing its type. This might reverse the previous result: the more able type prefers to pool with the other type rather than to use austerity as a signal. More informative ratings favour the emergence of pooling and less informative ratings that of signalling. In the latter case, characterised by the emergence of signalling austerity, the correlation between sovereign ratings and yields is lower and the yields distribution within rating categories is more dispersed. I test for these empirical relations in the data and find evidence that greater fiscal austerity is associated with a lower correlation between ratings and yields. Moreover, in the presence of extreme yield events, where there is a relatively large change in the yields of a sovereign, I find that the other countries in that rating category increase their austerity as well. Additionally, I present different robustness checks that control for other possible explanations for the surge in austerity that are not accounted for in the model, and show that the result persists.

Literature review. The conduct of fiscal policy has traditionally been envisioned as a way to distribute resources optimally across periods in order to maximise social welfare (Barro, 1979). But fiscal policy has been shown not to be countercyclical as predicted by the theory, thus prompting further research in order to explain this fact. Political economists have theorised that the government might have a different objective function than the rest of society, in particular, it might be office-motivated and short-sighted with respect to its citizens (Persson and Tabellini, 1999). There might also be financial frictions constraining countries to deviate from first best policies, particularly in emerging market economies (Cuadra et al., 2010). I claim that the existence of a problem of asymmetry of information can also be a compelling reason to deviate from the first best fiscal policy. Signalling models have proven useful to describe some stylised features of sovereign debt prices (Drudi and Prati, 2000), the decoupling of yields (Fostel et al., 2013) and the absence of more generalised defaults (Sandleris, 2008). The cited papers focus on the optimal choice of debt, which happens to release information to the market as a result. My contribution is to study the mechanism by which a country strategically manages the release of information and, therefore, lenders' beliefs. I focus on the signalling trade-off. In my model the sovereign truly internalises the costs and the benefits of its debt choice, through the effect it has on lenders' perceptions of its creditworthiness. I also provide empirical evidence of the signalling channel. Baldacci et al. (2013), Favero and Monacelli (2005), **?** among others have estimated fiscal policy rules. I examine the relation between the stance of fiscal policy and the correlation between yields and ratings. This correlation might evolve over time for several reasons. Public perceptions about the informativeness of ratings have changed over time (Partnoy, 2006, Kiff et al., 2010, Bussiere and Ristiniemi, 2012, De Santis, 2012). The literature has suggested several plausible reasons: conflicts of interest due to the change from an investors-pay business model to an issuer-pays model (Bar-Isaac and Shapiro, 2013, Holden et al., 2012, Manso, 2013, Mathis et al., 2009, White, 2010), increasingly more complicated products over time (Skreta and Veldkamp, 2009, Josepson and Shapiro, 2014) or the unintended consequences of regulation (Opp et al., 2013, Cole and Cooley, 2014).

The paper is organised as follows. In the next section I present the model, and in section 3 I characterise the equilibrium set. In section 4, I analyse the effects of introducing sovereign credit ratings. Section 5 is devoted to the empirical analysis. Section 6 concludes.

2 Model

Environment. Consider a two-period model of sovereign debt with a sovereign borrower and foreign lenders, who are imperfectly informed about the type of the sovereign. The sovereign can be of two types, indexed by $i \in \{A, B\}$ with probability p and $1-p$ respectively, depending on its ability to repay its debt. In the model, differences in the ability to repay come from differences in the ability to levy taxes on the citizens' income. Country A might be more capable of, or more efficient at, raising taxes than country B. Country A is, therefore, able to mobilise more of the economy's resources in order to pay back the outstanding debt.

The model is based on the heterogenous ability to tax and the fact that such heterogeneity is not completely observable ex-ante. Taxation capacity depends on many factors, among others the country's income, the stock of debt and the level of government spending. My claim is that there exists at least one other factor, that goes beyond the economic fundamentals, and that is inherently unobservable: the citizens' attitude towards the measures that allow debt repayment.

An example of this can be found in the aftermath of the European debt crisis in 2008–2010. A number of countries reacted to the turbulence in the market by implementing fiscal consolidation and other rationalisation measures – something that was generally acclaimed as necessary by the international lenders. But these measures were not equally welcomed domestically: public wages cuts and a pension system reform, that passed in Spain, were rejected by the citizens of Portugal with massive protests and demonstrations, ultimately forcing the government to withdraw them.[2] This shows that similar measures may be politically acceptable or not in different countries and such idiosyncrasy is likely to be better known within the country than abroad.

Lenders' problem. Foreign lenders are assumed to be risk-neutral.[3] They lend qD_t to the sovereign, where q is the price of debt, and get repaid D_t in the next period if there is no default. Otherwise, default is complete: there is no partial repayment. Thus, the lenders profit function is:

$$\Pi = -qD_t + \beta' \left[\mu \left(1 - \lambda(D_t, 1)\right) + (1 - \mu) \left(1 - \lambda(D_t, 0)\right)\right] D_t, \tag{2.1}$$

where β' is the lenders' discount factor. The term in brackets in (2.1) represents the expectation of debt repayment, which equals the probability that the country is of each type times the probability that each of these types repay. $\lambda(D_t, \mu)$ is the probability of default, which depends on the amount of debt and the common lenders' belief that the country is type A, μ. Perfect competition drives profits to zero and, as a result, the price is a function of the

[2]'Portugal court rules public sector pay cut unconstitutional', BBC News, 6th July 2012. `http://www.bbc.com/news/world-europe-18732184`

[3]Sovereign debt in the model is equivalent to external debt. The model could be extended to include domestic debt but the effect of domestic debt on the citizens could be completely off-set by the presence of lump-sum transfers. Hence, the inclusion of domestic debt does not change the results.

amount of debt and μ:

$$q(D_t, \mu) = \beta' \left[\mu \left(1 - \lambda(D_t, 1)\right) + (1-\mu)\left(1 - \lambda(D_t, 0)\right)\right]. \tag{2.2}$$

Sovereign's problem. The problem solved by the sovereign is to maximise the citizens' utility with risk-neutral preferences, $c_1 + \beta\mathbb{E}[c_2]$, where β is the discount factor of the country. Citizens have an endowment in period 1, ω_1, and in period 2, ω_2, as their only income. ω_2 is drawn from an exponential distribution $f(\omega_2)$ with support $[\underline{\omega}, \infty)$ and hazard rate h.[4] The sovereign chooses the debt level D_t and taxes T_t on the citizens' income in order to allocate consumption optimally across periods. There is no other role for the government: it does not provide public goods, nor does it have to finance wasteful government spending. If the country repays, a sovereign i is subject to the following constraints:

$$c_t \leq \omega_t - T_t \tag{2.3}$$

$$T_t \geq D_t - q(D_{t+1}, \mu)D_{t+1} \tag{2.4}$$

$$c_t \geq \underline{c}^i \quad t = 1, 2. \tag{2.5}$$

Constraint (2.3) is the budget constraint; it states that the citizens' consumption is at most the endowment net of taxes. Constraint (2.4) represents the government budget. D_1 is given and common to both types and $D_3 = 0$ because debt cannot be rolled over in the last period. Finally, the ability to tax is capped by constraint (2.5), which guarantees a minimum $\underline{c}^i$ to the citizens that cannot be taxed away in order to repay the debt. Differences in $\underline{c}^i$ are the source of heterogeneity.

Assumption 1 *Assume*

$$\underline{c}^A < \underline{c}^B \tag{C1}$$

[4]The exponential function is chosen for simplicity to be able to obtain closed form solutions, thanks to the constant hazard rate.

$$\underline{c}^B \leq \underline{\omega}. \tag{C2}$$

Default depends on the ability to pay. Accordingly, a country will not default if it can raise enough debt to satisfy its budget. Since $\omega_2 \in [\underline{\omega}, \infty)$, a sovereign has always a positive probability to repay any D_2. Therefore, it is able to get indebted in order to avoid default in period 1. As a consequence, default can only occur in period 2. A country defaults in period 2 if:

$$\omega_2 \leq D_2 + \underline{c}^i, \tag{2.6}$$

the current endowment of the economy is not enough to cover the external commitments and the domestic ones. This happens with probability $F(D_2 + \underline{c}^i)$, where $F(\cdot)$ is the endowment cumulative function. Given assumption (C1), $F(D_2 + \underline{c}^A) \leq F(D_2 + \underline{c}^B)$ and type A defaults (weakly) less for any given debt level. In order to let the types be strictly different in their ability to repay at every debt level, I introduce the following assumption:

Assumption 2 *Assume:*

$$\underline{c}^B > \frac{\omega_1 - D_1 + \beta' \underline{\omega}}{1 + \beta'}, \tag{C3}$$

which guarantees that type B is never risk-free.[5] Now, $F(D_2 + \underline{c}^A) < F(D_2 + \underline{c}^B)$.

In case of default, there is no need to raise taxes to pay the debt, $T_2 = 0$. The citizens' consumption is assumed to be $\underline{c}^i$ and the remaining income ω_2 fully confiscated and destroyed. Nevertheless, due to assumption (C2), consumption $\underline{c}^i$ is budget feasible. Some kind of penalty is usual in models of sovereign default with finite periods in order to induce repayment. In this model, the choice of penalty implies that the condition for the country to be willing to repay, i.e. consumption after repayment to be higher than consumption after

[5]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 infeasible in the first period: $\underline{c}^B > \omega_1 - D_1 + \beta'(\underline{\omega} - \underline{c}^B)$, or reformulated, $\underline{c}^B \geq \frac{\omega_1 - D_1 + \beta' \underline{\omega}}{1+\beta'}$. Assumptions (C3) and (C2) are compatible as long as $\underline{\omega} \geq \omega_1 - D_1$.

default,

$$\omega_2 - D_2 > \underline{c}^i, \tag{2.7}$$

is the same as the ability to pay in condition (2.6). This feature avoids dealing with inconvenient implications if a country is unwilling to repay but it is forced to. Further,

Assumption 3 *Assume*

$$\beta' > \beta \cdot e^{h(\underline{c}^B - \underline{c}^A)}, \tag{C4}$$

where $e^{h(\underline{c}^B - \underline{c}^A)} = \frac{F(D_2+\underline{c}^A)}{F(D_2+\underline{c}^B)}$ is the wedge between the default premia of the two types. The assumption says that, if the sovereign were a price taker, debt is a 'good' because the discount factor abroad β' is higher than the domestic discount factor β (by a wedge that is high enough to compensate for the differential risk premium). External lenders are willing to finance a type B sovereign at a rate that is attractive domestically for both type A and B. This makes a sovereign *prefer to increase period 1 consumption and finance this increase by issuing new debt.*[6] It remains to be determined how much of this cheap credit a country wants to use optimally, once it internalises that issuing debt changes the relative price of debt versus repayment. And this affects different types differently.

Combining all the previous ingredients, the discounted expected utility of sovereign i is:

$$\begin{aligned} U^i(q, D_2; \omega_1 - D_1) &:= \omega_1 - D_1 + qD_2 + \\ &+ \beta \left[F(D_2 + \underline{c}^i)\underline{c}^i + \left(1 - F(D_2 + \underline{c}^i)\right) \left[\mathbb{E}(\omega_2 | \omega_2 \geq D_2 + \underline{c}^i) - D_2 \right] \right]. \end{aligned} \tag{2.8}$$

The first line of the right-hand side is the citizens' consumption in the first period: the endowment ω_1 minus/plus the net lending/borrowing of the period. The second line is the expectation of consumption in period 2 discounted by β: with probability $F(D_2 +$

[6] Other papers achieve the same results with different assumptions: for example, assuming the government needs to finance an investment project that pays in the future (Sandleris, 2008) or that office-motivated politicians like debt (Acharya and Rajan, 2011).

$\underline{c}^i$), 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 (2.8) implicitly defines the indifference curves of the sovereign in the space of two key variables (q, D_2). Those indifference curves are represented in figure 1. The blue line depicts all the combinations of q and D_2 that give the same level of utility to type A and the red line to type B. Appendix B shows that, for all D_2, the slope of type B's indifference

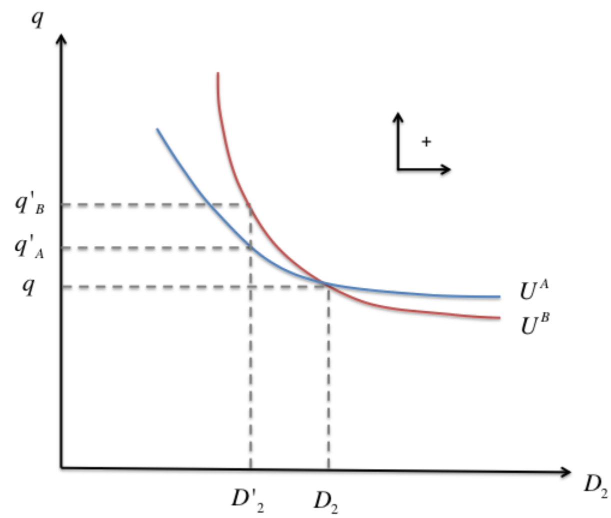


Figure 1: *Single crossing property*: the indifference curves of the two type cross at most once in the space (q, D_2).

curves is larger than that of type A. This implies that any two indifference curves of A and B can cross at most once in the space (q, D_2). As a consequence, for a given change in debt, type B needs to be compensated more in terms of q than type A in order to remain indifferent. A decrease from D_2 to D_2', as depicted in figure 1, needs to be compensated with an increase from q to q_A' for type A and from q to q_B', a bigger compensation, for type B. The reason behind this *single-crossing* property of the preferences is that type B defaults in more states than A and, when it does, its consumption is higher. Default is good news when a country cannot afford repayment and, as this depends only on ability to repay, B can do it more often.[7] Hence, it benefits more from debt because it has to pay back less.

3 Equilibrium analysis

3.1 Full information

As a benchmark, let us first find the equilibrium of the model when the type of the sovereign is observable. The full information equilibrium allocation is a price and a debt level, q^i and $D_2^{FI}(i)\,\forall i \in \{A, B\}$, for each type. In this case, the lenders know type i's probability of default, conditional on the debt level, and charge an actuarially fair price $q^i(D_2) = \beta' \left[1 - F(D_2 + \underline{c}^i)\right]$. The sovereign internalises this when it maximises the discounted expected utility (2.8):

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

Notice that the sovereign is not a price taker in (3.1). The term $q^i(D_2)$ recognises the effect of the choice of debt on the price. Thus, the first order condition (FOC) with respect to D_2 is:

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

In the previous expression the terms in brackets cancel out because the change in default generated by the marginal unit of D_2 gives a utility post default of $\underline{c}^i + D_2$, the minimum consumption plus the foregone repayment, but a loss equal to the realisation of ω_2 right

[7] This result holds independently from the fact that the default penalty is higher for type A. The penalty could be made equal, provided it is not high enough to actually prevent default, and type B would still default in more states than A because default is not strategic.

below the default point, which is exactly $D_2 + \underline{c}^i$. Three terms are left in the FOC:

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

The first term represents the change in price that every infra marginal unit of debt experiences when an additional unit is issued. The second term is the gain from bringing consumption to the present at the current price $q^i(D_2)$. Finally, the third term is the cost of the repayment promise: a unit of debt needs to be paid in the future but only if the sovereign does not default, which happens with probability $1 - F(D_2 + \underline{c}^i)$.

Substituting the expression of the price schedule $q^i(D_2)$ in equation (3.2), after some transformations, we obtain:

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

Proposition 3.1. *Denoting by h the hazard rate of the endowment exponential distribution $f(\cdot)$, the full information equilibrium debt for country type A is the same as for type B and equals $D_2^{FI} = \frac{\beta'-\beta}{\beta' h}$.*

Proof. Notice that the expression in brackets in (3.3) is the hazard rate of $F(\cdot)$. With constant hazard rate h, the right hand side of (3.3) is a constant and there is only one D_2 that satisfies the FOC. □

Condition (3.3) is a necessary condition for optimality and D_2^{FI} is the unique point that satisfies it. In appendix A I show that D_2^{FI} is a local maximum. Uniqueness implies that it is also a global maximum. D_2^{FI} is equal for both types due to the functional form of $F(\cdot)$. But this allows us to obtain a unique closed form solution of the problem. Moreover, D_2^{FI} is positive because assumption (C4) makes $\beta' - \beta > 0$. It means that the country issues a positive amount of debt in order to take advantage of the favourable lending conditions. However, in equilibrium, in spite of issuing the same amount of debt different types face a different price, lower for type B because this type defaults more than the other:

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

3.2 Imperfect information

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

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

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

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

- *A sovereign i chooses $D_2^*(i)$ that maximises its $U^i(D_2, q)$ given the lenders' strategy q^*.*
- *q^* let lenders break even in expectation given the system of beliefs $\mu^*(D_2)$ and the sovereign strategy $D_2^*(i)$.*
- *The system of beliefs $\mu^*(D_2)$ must be consistent with Bayes' rule and the equilibrium strategies whenever possible. That gives an equilibrium beliefs function:*

$$\forall D_2 \ \mu^*(D_2) = \frac{p\mathbb{1}_{\{D_2^*(A)=D_2\}}}{p\mathbb{1}_{\{D_2^*(A)=D_2\}} + (1-p)\mathbb{1}_{\{D_2^*(B)=D_2\}}} \text{ if the denominator is} \neq 0,$$

where $\mathbb{1}$ *is an indicator function that takes value 1 if the condition in parentheses holds and zero otherwise.*

- *If the denominator is zero, beliefs must be consistent with probabilities derived from some distribution over the strategy profiles. This implies that* $\forall D_2\ \mu^*(D_2) \in [0,1]$ *and* $q^*(\cdot)$ *is bounded between* $\beta' \left[1 - F(\underline{c}^A + D_2)\right]$ *and* $\beta' \left[1 - F(\underline{c}^B + D_2)\right]$.

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

Recall that D_2^{FI} is the optimal debt for type B when the types are known. But, if types are not observable, B would like to pass off as type A because that would be beneficial in terms of the price of debt. In order to achieve that, it is willing to choose a different D_2. This is true up to the point where deviating is too costly, even if it is guaranteed to be granted the same debt price as type A. This threshold level is the point where B's indifference curve passing through the full information allocation crosses the debt price schedule for $\mu = 1$, as shown in figure 2. Denote by D_2^{-B} the debt level that leaves B indifferent between deviating

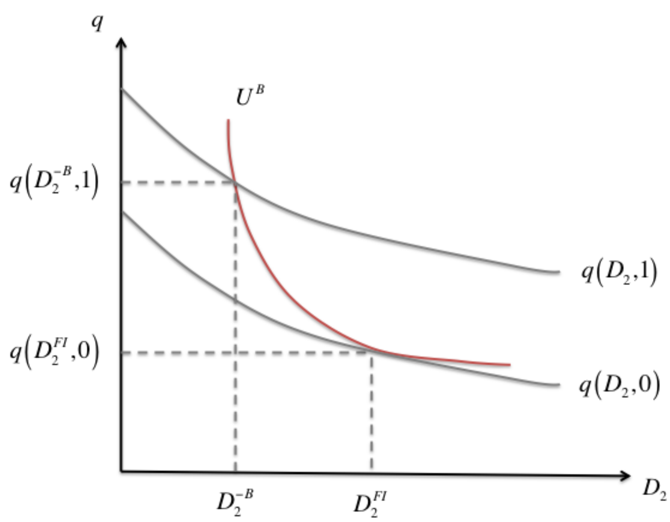


Figure 2: Sovereign B's indifference curves at the full information allocation.

or not. Hence, we have that:

$$U^B\left(D_2^{-B}, q(D_2^{-B},1)\right) = U^B\left(D_2^{FI}, q(D_2^{FI},0)\right)$$

and, for $D_2 > D_2^{-B}$, the left-hand side is strictly larger, thus, type B would like to choose it if it could pass off as A. On the contrary, for $D_2 < D_2^{-B}$, B would not want to imitate A no matter what the price consequences were. In any separating equilibrium type A will have to choose one of the debt levels $[0, D_2^{-B}]$ that discourages B from imitating and type B will consequently be happy not to deviate from its full information allocation.

Proposition 3.2. *There exists a separating equilibrium* e^* *at the allocation* $(D_2^*(A), q^*(A)), (D_2^*(B), q^*(B))$, *where* $D^*(A) = D_2^{-B}$, $D^*(B) = D_2^{FI}$ *and*

$$q^*(A) = \beta'\left[1 - F(D_2^*(A) + \underline{c}^A)\right] \tag{3.4}$$

$$q^*(B) = \beta'\left[1 - F(D_2^*(B) + \underline{c}^B)\right], \tag{3.5}$$

supported by the equilibrium beliefs $\mu^*(D_2^*(A)) = 1$ *and* $\mu^*(D_2) = 0$ *for any other* D_2.

Proof. Appendix C. □

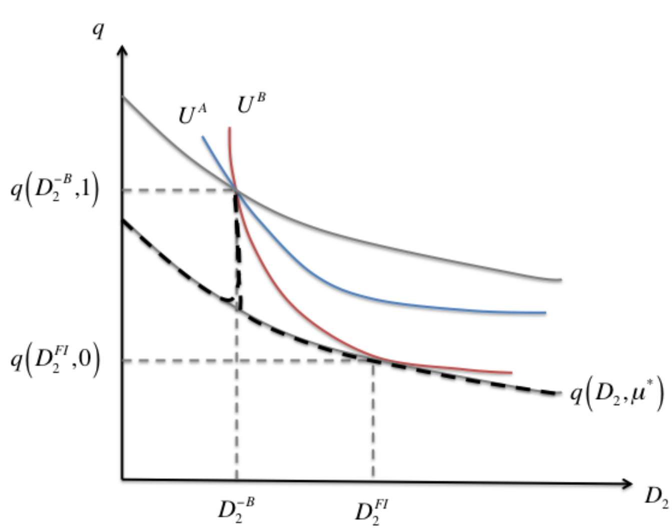


Figure 3: Separating equilibrium e^*.

The allocation $(D_2^{-B}, q(D_2^{-B}, 1))$, plotted in figure 3, is preferred by A to any other allocation under the system of beliefs represented by the dotted bold line. At the same time, B is indifferent by definition. This is because A's indifference curves are flatter than B's, hence, A is more willing to trade debt for price improvements and finds allocations attractive that would not be attractive for B. Therefore, A chooses $(D_2^{-B}, q(D_2^{-B}, 1))$ while B remains at its full information allocation. But for A deviating from D_2^{FI} is costly as well. The further away D_2 is from D_2^{FI}, the higher the cost for A in order to signal. Since D_2^{-B} is the threshold debt level that allows separation of types, the equilibrium described in proposition 3.2 is the least cost separating equilibrium e^*. e^* involves a debt reduction by type A with respect to the full information equilibrium, $D_2^{-B} < D_2^{FI}$. This is what I refer to as 'signalling austerity'. Country A's deviation from its optimal allocation has to be interpreted as a self-inflicted cost in order to avoid being confounded with type B. This improves its debt price schedule, lowering the risk premium associated with each D_2. Recall (2.2) and take into account how $\mu(D_2)$ changes in equilibrium as a function of D_2:

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

The signalling channel is an indirect effect that operates through $\mu(D_2)$. But being perceived as an A type entails choosing a lower debt level, as has just been explained, thus it also has an additional effect on the risk premium coming directly from a lower 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 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. Hence, the signalling channel is essential for fiscal policy to tilt towards austerity.

Pooling equilibria. A pooling equilibrium exists when type A does not find it advantageous to reduce the amount of debt in order to obtain the benefits from revealing its type.

Higher debt is preferred to a price improvement and type A accepts being confounded with type B. As a result, the lenders cannot distinguish the types from their debt choices and their best guess is the prior p.

A pooling equilibrium consists of an equilibrium debt level D_2^* and a price of debt $q^*(D_2^*, p)$, equal for both types. For example:

Proposition 3.3. *A pooling equilibrium can be sustained at the full information allocation with $\mu^*(D_2^{FI}) = p$ and $\mu^*(D_2) = 0$ for any other D_2. The price of debt is equal to*

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

Proof. Appendix D. □

See figure 4, where beliefs are again represented by the dotted bold line. The off-equilibrium threat that a country will be penalised in its risk premium if it deviates from D_2^* might allow a pooling equilibrium to be sustained at a candidate D_2^*. As a consequence, any type of sovereign prefers to choose D_2^* and be offered the pooling price. Beliefs are admissible because in equilibrium the pooling price satisfies Bayes' rule and off-equilibrium the beliefs, $\mu = 0$ in this case, are free to be any $\mu \in [0, 1]$. As happened with the separating equilibria, a different system of beliefs may support other pooling equilibria.

3.3 Equilibrium refinement

A signalling model typically admits a multiplicity of equilibria. This is so because a large set of beliefs can be invoked, making it easier to sustain a given equilibrium by selecting the beliefs that give the candidate equilibrium the best chance. To reduce the set of equilibria I use the undefeated equilibrium (UE) refinement introduced by Mailath et al. (1993).

Unlike dominance-based refinements,[8] the UE refinement concentrates on the efficiency properties of the equilibrium. It regards any off-equilibrium strategy as an attempt by some

[8]Notably the intuitive criterion by Cho and Kreps (1987) and divinity by Banks and Sobel (1987).

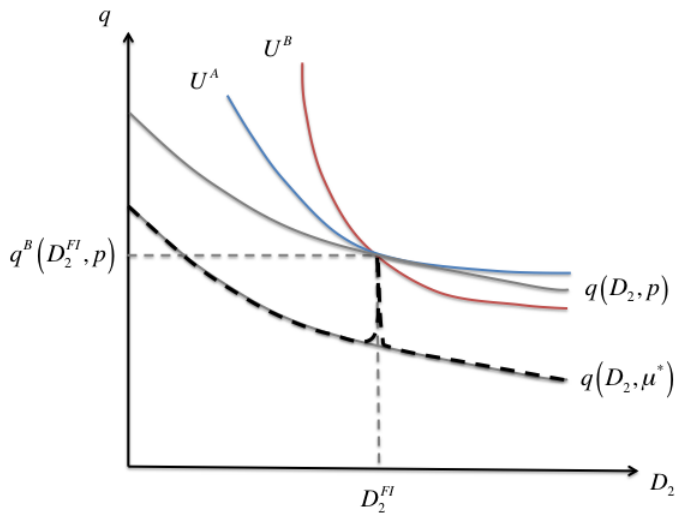


Figure 4: An example of a pooling equilibrium.

(or all) types to coordinate on another equilibrium. Thus it restricts the off-equilibrium beliefs to be consistent with those of the equilibrium where such a strategy would be played, if those types are (weakly) better off. The lenders, when they see a D_2 that is not part of the equilibrium, are only allowed to believe that the country is of the type(s) that would choose this D_2 in another equilibrium and would be better off doing that. If this consistency requirement restricts off-equilibrium beliefs in such a way that they do not sustain the current equilibrium, this equilibrium is *defeated* and does not survive the refinement.[9] An equilibrium is said to be *undefeated* if it is not defeated by any other. Notice that the refinement introduces the requirement that the types choosing the off-equilibrium strategy be weakly better off in the new equilibrium. In the case of pooling, since types choose the same D_2, both have to be weakly better off in order to defeat another equilibrium. Thus, the UE privileges the equilibria that are efficient in a Pareto sense.

Proposition 3.4. *Applying the UE refinement, separating and pooling equilibria do not coexist.*

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

The equilibria that survive the UE refinement are either a unique separating equilibrium or a multiplicity of pooling equilibria. First, notice that the least costly separating equilibrium e^* defeats any other separating equilibrium. All separating equilibria reveal the type of the sovereign but e^* does it with the smallest deviation from the full information allocation for type A. Hence, type A is strictly better off at e^*. This means that off-equilibrium beliefs at D_2^{-B} must be $\mu = 1$ for any other separating equilibrium but those beliefs do not sustain an equilibrium $D_2 \neq D_2^{-B}$ because such an equilibrium would be defeated by e^*.

Furthermore, e^* defeats any pooling equilibrium if type A is better off signalling. When choosing D_2^{-B} gives type A a higher utility, this cannot be ignored off equilibrium in any pooling equilibrium and thus it is not consistent that A does not believe it will be better off deviating to D_2^{-B}. The pooling equilibrium is therefore defeated. A formal proof can be found in appendix G. In this case, e^* is the unique equilibrium of the model.

But with the UE refinement e^* can also be defeated by a pooling equilibrium e' if both types are better off at e'.[10] The proof is in appendix H. e' is undefeated if there is no other pooling equilibrium in which both types are better off. Hence, any allocation in the range $[D_2^{*A}, D_2^{*B}]$,[11] where D_2^{*A} is the allocation preferred by type A under schedule $q(\cdot, p)$ and D_2^{*B} is the one preferred by type B,[12] can be undefeated. If this is the case, the equilibria are of

[10] Notice that with the 'intuitive criterion' (Cho and Kreps, 1987) the separating equilibrium can never be eliminated by a pooling equilibrium. On the contrary, the separating equilibrium always eliminates all pooling equilibria and it remains the unique equilibrium in this kind of signalling game with two players with single crossing preferences. The intuitive criterion says that if a deviation from a candidate equilibrium is dominated for one type but not for another, this deviation should not be attributed to the type for which the deviation is dominated. Hence, no pooling equilibrium can dominate the separating equilibrium e^* because the single crossing property creates a space between the indifference curves such that any D_2 to the left of the pooling allocation would be preferred only for type A and not for B. At every such D_2 beliefs must be such that $\mu = 1$ and those off-equilibrium beliefs cannot sustain the candidate pooling equilibrium. The intuitive criterion fixes an equilibrium (e.g. e') and then restricts the off-equilibrium beliefs that are inconsistent with the dominated choices for each agent based on that equilibrium e'. Similarly, the UE fixes an equilibrium e' but the off-equilibrium beliefs at D_2 are restricted looking at another equilibrium where this allocation D_2 is an equilibrium allocation. Restrictions are established based on consistency with the type(s) that would choose D_2 in the new equilibrium, only if the type(s) are better off than at the fixed equilibrium e'. So the allocations that dominate the pooling allocation in the intuitive criterion do not exist in the UE because they are not equilibrium strategies of an alternative equilibrium. As a consequence, pooling can survive.

[11] Pooling equilibria in allocations outside that range are defeated by other pooling equilibria within that range because they are strictly preferred by both types. Within this range moving closer to one type's preferred allocation means moving further from the other; hence, types cannot be both made better off.

[12] In appendix F I derive the expressions for D_2^{*A} and D_2^{*B}.

the pooling kind.

4 The role of the credit rating agencies

In this model the sovereign uses fiscal policy to signal. The question might arise whether this result would still persist in the presence of an alternative signalling mechanism. Sovereign credit ratings are well-known public signals about a country's creditworthiness. They provide a public qualification of the country's debt at no cost. I examine if the addition of credit ratings to the model still leaves room for the emergence of 'signalling austerity'.

I introduce a credit rating agency (CRA) that is a public signal with imperfect information. The CRA has the ability to identify a type B country with probability ρ and assign a rating $\underline{r}$ to it: $\text{Prob}(\underline{r} \mid B) = \rho$. Otherwise the rating is $\bar{r}$. Thus, ρ represents the CRA's informativeness.[13] This simplifying assumption models the CRA as a wake-up call or an alarm sign. A rating $\bar{r}$ can be interpreted as *business as usual* since the CRA has no information to the contrary and a rating $\underline{r}$ means that the CRA knows that a country is less able to repay. I restrict the analysis to one type of error – $\bar{r}$ when $i = B$ – and concentrate on the informativeness in the $\bar{r}$ category.[14]

Technically, the CRA in this model modifies the common prior p. The posterior is:

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

If $\rho = 1$ the CRA provides perfect information about the type of country and the solution

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

[14] This could be extended to having two types of error – $\bar{r}$ when $i = B$ and also $\underline{r}$ when $i = A$ – and the two categories would have imperfect information. The main prediction would not be affected as long as the rank order of creditworthiness in the rating categories is not reversed, i.e., as long as $\bar{r}$ contains more A types than $\underline{r}$.

is the full information one. If, instead, $\rho = 0$ we are in the baseline model with asymmetry of information. Therefore, the CRA can only ameliorate the *ex-ante* information problem of the lenders.

The debt market becomes segmented into different markets conditional on the rating $\{\underline{r}, \bar{r}\}$. In the rating category $\bar{r}$, the pooling equilibrium price of debt is:

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

where the perception about a country depends on the prior and the ratings capacity to improve this prior with new information.

For a value of $p < \bar{p}$, the unique equilibrium of the problem without the CRA is e^*. $\bar{p}$ is the threshold level of the prior that makes type A indifferent between the signalling allocation $\left(D_2^{-B}, q(D_2^{-B}, 1)\right)$ and pooling with type B at $(D_2^*, \bar{p})$.[15]

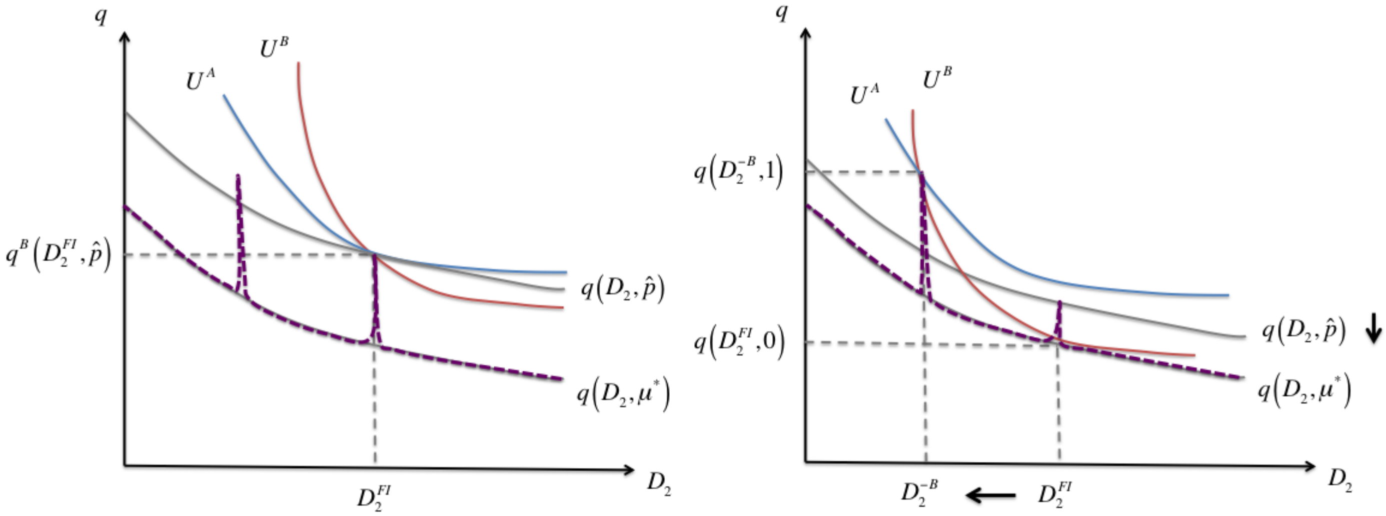
Proposition 4.1. *If the prior $p < \bar{p}$, there exists a level of informativeness ρ^* of the rating $\bar{r}$ such that for $\rho \geq \rho^*$ the equilibrium is a pooling one and for $\rho < \rho^*$ the equilibrium is e^*.*

Proof. Since the equilibrium is e^* for p, it follows that

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

The left-hand side is independent of ρ while the right-hand side is increasing in ρ because $\frac{\partial \tilde{p}}{\partial \rho} |_{\bar{r}} > 0$. And for $\rho = 1 - \epsilon$, with ϵ very small, the right-hand side tends to $U^A \left(D_2^{FI}, q^A(D_2^{FI})\right)$ and the inequality is reversed. Hence, there must exist a threshold ρ^* where the equilibrium shifts from a pooling one for $\rho \geq \rho^*$ to e^* for $\rho < \rho^*$. □

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



(a) Equilibrium with $\rho \geq \rho^*$. (b) Equilibrium with $\rho < \rho^*$.

Figure 5: Shift from a pooling (left panel) to a separating (right panel) equilibrium.

Corollary 4.1. *A deterioration of rating $\bar{r}$ informativeness from $\rho \geq \rho^*$ to $\rho < \rho^*$ makes 'signalling austerity' appear.*

A worse prior about the sovereign's ability means that more type B countries are perceived to be in the $\bar{r}$ category and the pooling price is lower for every level of debt. Type A would have to pool at some point along this new schedule in figure 5. But, when $\rho < \rho^*$, none of these points is preferred by A to the separating allocation. A worse perception of the $\bar{r}$-rated country makes it less attractive for A to pool with the other type, because the pooling price is too low, and it pays off to do austerity in order to reveal its type.

5 Empirical analysis

5.1 Dataset and empirical strategy

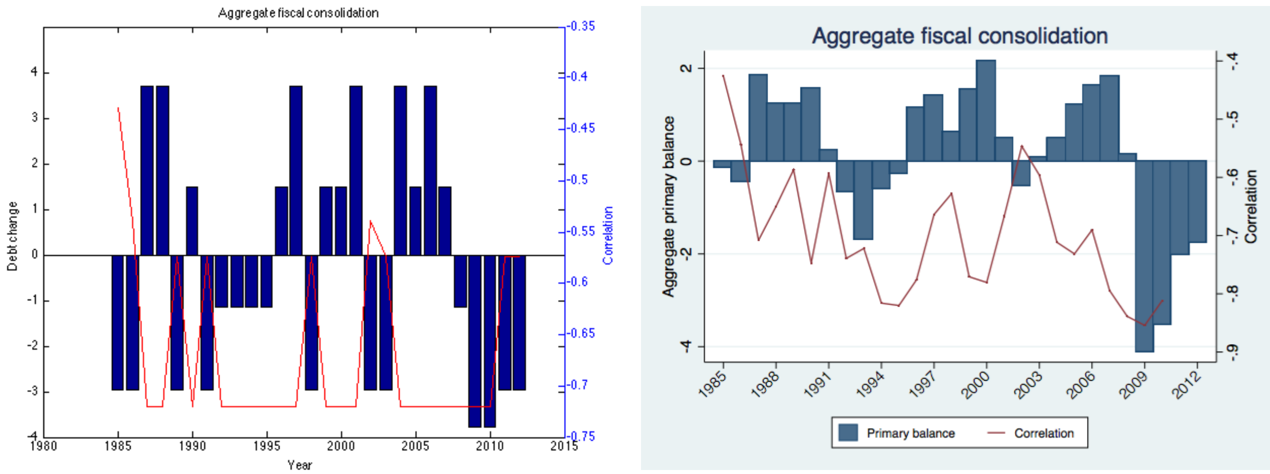
In what follows I present empirical evidence in favour of the signalling channel. Recall the main result from the the previous section: a low informativeness of the ratings, below a certain threshold ρ^*, implies more fiscal austerity in order to signal. The objective of the empirical analysis is to use the variation of ratings informativeness in the data and relate it to changes in fiscal austerity. I expect to find a higher (lower) ratings informativeness to be associated with less (more) austerity by the sovereign.

The two key variables of the analysis, informativeness and austerity, are difficult to define. I use the following variables to measure fiscal austerity: government net lending/borrowing, primary budget, potential structural budget and government expenditure as a percentage of GDP. The convention is that positive values of these variables, except for expenditure, mean that the government is saving and negative values that it is borrowing. Hence, higher values represent more fiscal austerity. Government expenditure works the opposite way: lower values represent more austerity.

The dataset contains observations at annual frequency for 58 countries during 32 years (1980–2011). Countries covered are mainly OECD and some emerging market economies. For a complete list of countries and the range of years covered see appendix I. The variables included in the dataset have been obtained from the World Economic Outlook (IMF) 2013 and their definitions and calculation method can be found in appendix J. The dataset has been merged with the average yield to maturity in percentage points of long-term government bonds collected by the IMF in its International Financial Statistics.

In addition, an average annual rating is computed for each sovereign using the historical information on sovereign ratings obtained from the three biggest rating agencies: Moody's, Fitch and Standard & Poor's. The rating grades have been transformed into an ordinal variable with each rating and modulation of the rating (outlook/rating watch) represented by a unit change in a scale going from 0 (default) to 52 (AAA for S&P and Fitch or Aaa for Moody's). Ratings have been observed at the end of each month and an annual average constructed. The final *global rating* is obtained from the weighted sum of the ratings assigned by each agency to the country. Given that different countries started being rated by an agency at different points in time,[16] the panel is unbalanced. Still, there is no reason to believe that the initial observations for the non-rated countries are not randomly missing.

[16]Moody's started rating sovereigns in June 1958, S&P in January 1975 and Fitch only in August 1994.



(a) Simulated data. (b) Actual data.

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

Informativeness below ρ^* translates into a low correlation between ratings and yields.[17] Sovereign ratings are a measure of the country's creditworthiness, that is, an evaluation of the sovereign's default probability. Comparing the default probability forecasted by the ratings and the true default probability is impeded because we rarely observe sovereign defaults. However, we do observe a different form of market evaluation of the country's creditworthiness, that is more volatile than ratings, in the sovereign yields. The market assesses the informativeness of the ratings over time and the correlation can be used as an indirect evaluation of the ratings' informativeness by the market.

Simulating the model, I find the outcome of an economy that starts off every period. Figure 6a shows a possible path for the correlation and the aggregate austerity. Notice that a low correlation between sovereign yields and ratings is associated with more austerity. This is the pattern, compatible with the model presented above, that I also find in the data. Figure 6b plots the negative co-movement between the correlation variable and a measure of aggregate austerity: the primary balance of the government budget over GDP summed up for all countries with weights correcting for the number of countries in the sample each year.

[17]Sovereign yields are calculated as the inverse of the price of debt.

In order to test for this prediction I use the following econometric specification:

$$Y_{i,t} = \alpha + \beta Corr_t + \gamma X_{i,t-1} + \kappa_i + \epsilon_{i,t}, \tag{5.1}$$

where $Y_{i,t}$ is one of the several fiscal variables that proxy for austerity, $Corr_t$ is the Spearman rank correlation between the sovereign yields and the *global ratings* and $X_{i,t-1}$ are one-period-lagged control variables. A negative β coefficient is suggestive evidence of signalling austerity. In the next section I adjust the specification to make the correlation more exogenous.

The empirical strategy until here has relied on the simultaneity of the shift between equilibria. In reality, it is possible that this change does not take place for all countries at the same time but is sequential instead. If a country is being subject to more attention by the market at a certain point for any reason, for example it is about to issue new debt, its debt price might be seen by others as an anticipation of the markets assessment about its rating. In the logic of the model, we would expect to see other countries with the same rating interpret this as an indication of the equilibrium in place and choose their own austerity accordingly. I therefore calculate how many *large* price changes happen to a country in a given year and how this number affects the fiscal position one year ahead of the other countries in the same rating category. *Large* price changes should mean that the market anticipates a separating equilibrium, since the price distribution is more dispersed. The regression I estimate is the following:

$$Y_{j,k,t} = \alpha + \beta \text{Price Shocks}_{i,k,t-1} + \gamma X_{j,t-1} + \kappa_j + \delta_t + u_{j,t}, \tag{5.2}$$

$\forall j \neq i$ in the same k. β here captures the effect that an additional extreme price event in a given rating category has on the other countries that belong to it, all other things equal.

5.2 Evidence on 'signalling austerity'

In the first empirical strategy I estimate equation (5.1) by OLS:

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

where $Y_{i,t}$ is one of the several fiscal variables that proxy for austerity, $Corr_t$ is the rank correlation variable and $X_{i,t-1}$ are one-period-lagged control variables (the fiscal variables explained above, debt over GDP, squared debt over GDP, log fiscal GDP, log GDP per capita and growth). The specification includes country fixed effects.

As can be seen in table 1, the estimated value of β is significant and has the expected sign. A decrease in the correlation is associated with the following: an increase in net lending, as well as in the primary budget balance and in potential structural balance, and a decrease in government spending. The effects are small (a 1% decrease in the correlation implies a 0.03 percentage point reduction of net borrowing over GDP) but statistically significant, as reported in table 1.

As a robustness check, in appendix K I repeat the same regression (5.1) on the sample split by regions (OECD countries, European Union countries, peripheral European countries named 'PIIGS' and emerging market economies). The effect of a decrease in the correlation is qualitatively the same, however, it becomes less significant for the group of PIIGS and it is not significant for emerging markets. According to the model, this would be expected if there were a higher proportion of type B countries in these two groups relative to the OECD and EU groups.

The right-hand side of regression (5.1) is a time aggregate and the left-hand side is individual data, hence reverse causality from a given country's austerity $Y_{i,t}$ to $Corr_t$ is unlikely. Nevertheless, I replace $Corr_t$ in (5.1) by the rank correlation calculated over a random subsample constituted by half of the countries (J) in the sample and estimate the

Table 1: OLS regression results with robust standard errors

	Dependent Variable			
	Net lending	Primary budget	Structural budget	Expenditure
Correlation	-0.0337***	-0.0298***	-0.0169**	0.0327***
	(0.00890)	(0.00866)	(0.00716)	(0.00874)
Lag net borrowing	0.177	-0.693***	-0.286***	0.439***
	(0.141)	(0.139)	(0.105)	(0.113)
Lag primary deficit	0.281***	1.167***	0.214**	-0.152*
	(0.101)	(0.101)	(0.0839)	(0.0835)
Lag expenditure	-0.0307	-0.00929	-0.0493	0.807***
	(0.0559)	(0.0578)	(0.0496)	(0.0548)
Lag structural deficit	0.366***	0.301***	0.807***	-0.299***
	(0.0891)	(0.0883)	(0.0565)	(0.0855)
Lag debt	0.0539**	0.0571***	0.0386***	-0.0295
	(0.0217)	(0.0211)	(0.0135)	(0.0185)
Lag square debt	-0.000170*	-0.000191**	-0.000113**	0.000104
	(0.0000893)	(0.0000875)	(0.0000562)	(0.0000785)
Lag logGDP	-0.290	-0.689	0.0183	0.518
	(0.580)	(0.664)	(0.582)	(0.565)
Lag logGDPpc	2.524	3.016	-0.382	-2.839*
	(1.648)	(1.834)	(1.507)	(1.647)
Lag growth	10.03**	9.283**	1.465	-5.603
	(3.996)	(3.994)	(3.474)	(3.563)
Country FE	yes	yes	yes	yes
N	670	669	670	670
r2	0.813	0.745	0.847	0.962
F	49.11	37.51	61.51	612.0

Standard errors in parentheses

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

following regression for the other countries:

$$Y_{i,t} = \alpha + \beta Corr_t^J + \gamma X_{i,t-1} + \kappa_i + \epsilon_{i,t} \; \forall i \notin J. \tag{5.3}$$

by OLS. In (5.3) the fiscal position $Y_{i,t}$ cannot affect the correlation $Corr_t^J$ as a consequence of the computation method because they belong to different groups. Table 2 shows that the effect found in the previous regressions holds.

In table 3 I present the results of the following specification:

$$Y_{i,t} = \alpha + \beta Corr_{t-1} + \gamma X_{i,t-1} + \kappa_i + \epsilon_{i,t}, \tag{5.4}$$

where I have substituted $Corr_t$ by its one period lag. In order to deal with error autocorrelation, regression (5.4) has been estimated using the Arellano-Bond GMM estimator.[18] The $Corr_{t-1}$ is instrumented with further lags of the same variable. As reported in table 3, there is no autocorrelation left in the residuals. $X_{i,t-1}$ contains the lagged dependent variable, debt over GDP, squared debt over GDP, log fiscal GDP, log GDP per capita and growth. I also apply the correction for small samples. Results confirm the previous ones and are significant.

Next, I instrument $Corr_t$ with the annual stock prices of the company Moody's. Moody's is the only big rating agency that is quoted since 1998 in the stock exchange with the ticker MCO. Since the ratings are very similar across rating agencies (correlation coefficient of 98%) I assume that so is the perception about the informativeness of the agencies. See in figure 7 the evolution of Moody's stock prices plotted against the number of news items retrieved from major distribution newspapers (in English) that contain a negative view of the rating

[18]The idea is that the correlation at $t-1$ is predetermined when looking at it from the current period and, hence, it can not be affected by the austerity that takes place at period t. The Arellano-Bond estimator in differences uses first differentiation to eliminate the autocorrelated fixed component of the error term.

Table 2: OLS regression results with robust standard errors

	Dependent Variable			
	Net lending	Primary budget	Structural budget	Expenditure
Correlation^J	-0.0462***	-0.0451***	-0.0149*	0.0318***
	(0.0105)	(0.0106)	(0.00831)	(0.0100)
Lag net borrowing	0.253	-0.564***	-0.117	0.109
	(0.178)	(0.173)	(0.172)	(0.172)
Lag primary deficit	-0.0241	0.769***	0.133	0.165
	(0.136)	(0.134)	(0.131)	(0.131)
Lag expenditure	-0.0898	-0.00860	-0.0495	0.734***
	(0.0748)	(0.0758)	(0.0799)	(0.102)
Lag structural deficit	0.544***	0.567***	0.694***	-0.325**
	(0.104)	(0.0954)	(0.143)	(0.140)
Lag debt	0.0919***	0.0893***	0.0434**	-0.0501**
	(0.0247)	(0.0247)	(0.0191)	(0.0220)
Lag square debt	-0.000309***	-0.000324***	-0.000126*	0.000202**
	(0.0000943)	(0.0000936)	(0.0000752)	(0.0000861)
Lag logGDP	-2.405***	-3.806***	-0.853	1.833
	(0.672)	(0.760)	(1.235)	(1.137)
Lag logGDPpc	6.881***	9.682***	1.308	-4.754*
	(1.803)	(1.923)	(3.023)	(2.822)
Lag growth	9.130**	9.545**	1.321	-4.470
	(4.570)	(4.672)	(6.018)	(4.431)
Country FE	yes	yes	yes	yes
N	306	305	306	306
r2	0.783	0.781	0.804	0.970
F	55.26	48.51	51.03	679.9

Standard errors in parentheses

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

Table 3: Arellano Bond GMM regression results

	Dependent Variable			
	Net lending	Primary budget	Structural budget	Expenditure
Lag correlation	-0.0410***	-0.0377***	-0.0346***	0.0266***
	(0.00853)	(0.0103)	(0.00883)	(0.00721)
Lag net borrowing	0.421***			
	(0.0938)			
Lag primary deficit		0.334***		
		(0.0767)		
Lag structural deficit			0.653***	
			(0.0972)	
Lag expenditure				0.646***
				(0.102)
Lag debt	0.178*	0.338***	0.134	-0.144
	(0.104)	(0.114)	(0.0805)	(0.125)
Lag square debt	-0.000632	-0.00127*	-0.000372	0.000306
	(0.000579)	(0.000640)	(0.000569)	(0.000639)
Lag logGDP	0.0269	-4.672*	2.483	2.283
	(2.323)	(2.788)	(1.997)	(3.550)
Lag logGDPpc	1.202	13.58	-9.046	-5.635
	(7.505)	(8.456)	(6.014)	(11.86)
Lag growth	27.97***	31.37***	9.734**	-10.41
	(6.807)	(8.031)	(3.920)	(6.505)
N	1182	947	733	1184
hansen	58.28	50.63	35.10	58.78
ar2p	0.640	0.953	0.0235	0.699
F	21.67	13.53	34.51	24.99

Standard errors in parentheses

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

agencies.[19] Since the year 2007 the articles critical of the ratings agencies become more numerous and that coincides with a step decrease in the stock valuation of the company Moody's. In 2012, though, the increasing trend of bad news reverts and the stock recovers a large part of the previous decrease. The visibility of negative opinions about the rating agencies may have played a role in the evolution of Moody's stock price.

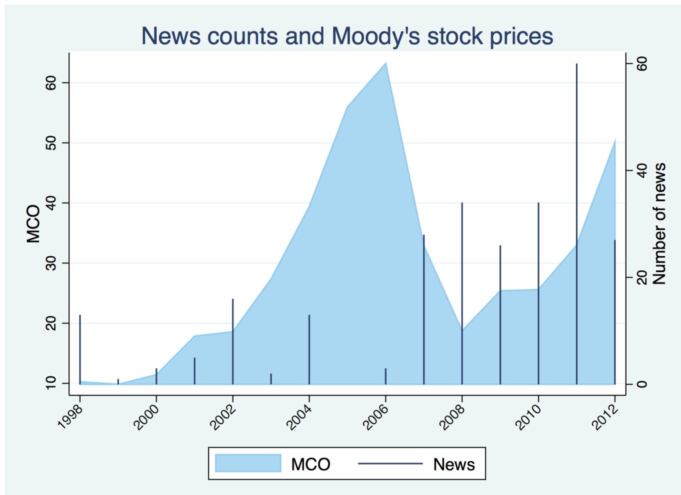


Figure 7: News counts on CRAs' reputation and the relation to Moody's stock price.

Thus, the assumption here is that Moody's stock price reflects the ability of the agency to assign informative ratings. The relevance of the price to explaining the $Corr_t$ can further be assessed by looking at the results of the first stage instrumental variables regression in table 4.

On the other hand, Moody's stock price should not directly affect any given country's willingness to do austerity; it should only affect this willingness indirectly through the effect of the stock price on the correlation that impacts austerity via the signalling channel. In table 5 results are confirmed for all proxies of austerity at the 99% significance level, though the magnitude of the effect is larger than in the previous estimations.

The previous results might be affected by omitted variable bias, e.g. global uncertainty.

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

Table 4: First stage instrumental variable regression results

	Dependent Variable			
	Lag correlation	Lag correlation	Lag correlation	Lag correlation
Lag MCO	-0.144***	-0.135***	-0.144***	-0.141***
	(0.0191)	(0.0208)	(0.0231)	(0.0188)
Lag net borrowing	-0.159*			
	(0.0964)			
Lag primary deficit		-0.123		
		(0.0990)		
Lag structural deficit			-0.111	
			(0.166)	
Lag expenditure				0.302***
				(0.0823)
Lag debt	0.0830*	0.141***	0.177***	0.0823**
	(0.0428)	(0.0485)	(0.0541)	(0.0415)
Lag square debt	0.0000364	-0.0000432	0.000136	-0.0000107
	(0.000217)	(0.000230)	(0.000271)	(0.000215)
Lag logGDP	13.74***	12.86***	12.25***	13.23***
	(1.299)	(1.542)	(1.801)	(1.292)
Lag logGDPpc	11.79***	16.25***	24.64***	11.35***
	(4.064)	(4.761)	(5.231)	(4.035)
Lag growth	-40.83***	-52.63***	-56.46***	-38.70***
	(8.166)	(9.377)	(10.72)	(7.888)
Country FE	yes	yes	yes	yes
N	855	698	555	857
r2	0.447	0.477	0.485	0.455
F	9.067	9.511	9.711	9.360

Standard errors in parentheses

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

Table 5: Instrumental variable regression results

	Dependent Variable			
	Net lending	Primary budget	Structural budget	Expenditure
Lag correlation	-0.323***	-0.358***	-0.152***	0.232***
	(0.0552)	(0.0687)	(0.0406)	(0.0479)
Lag primary deficit		0.475***		
		(0.0457)		
Lag structural deficit			0.606***	
			(0.0433)	
Lag expenditure				0.584***
				(0.0346)
Lag net borrowing	0.442***			
	(0.0427)			
Lag debt	0.0332*	0.0994***	0.0579***	-0.0314**
	(0.0181)	(0.0234)	(0.0153)	(0.0152)
Lag square debt	-0.0000663	-0.000242**	-0.0000480	0.000129*
	(0.0000909)	(0.000103)	(0.0000690)	(0.0000771)
Lag logGDP	2.983***	2.063*	-0.275	-1.887**
	(0.900)	(1.077)	(0.644)	(0.758)
Lag logGDPpc	2.114	5.907***	3.898***	0.193
	(1.694)	(2.215)	(1.494)	(1.436)
Lag growth	-4.587	-13.00**	-5.466	7.302**
	(4.372)	(6.087)	(3.813)	(3.649)
Country FE	yes	yes	yes	yes
N	855	698	555	857
r2	0.523	0.518	0.757	0.941
F	17.05	15.81	34.86	182.7

Standard errors in parentheses

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

Imagine that we were estimating this regression:

$$Y_{i,t} = \alpha + \beta Corr_t + \gamma X_{i,t-1} + \kappa_i + \epsilon_{i,t}, \tag{5.5}$$

where in reality $\epsilon_{i,t} = Z_t + u_{i,t}$ and $Corr(X_{i,t-1}, Z_t) \neq 0$. Global uncertainty Z_t might affect the $Corr_t$ because it makes the yields less predictable and, at the same time, it induces countries to do more austerity, for instance for precautionary motives. Then, $Corr(X_{i,t-1}, \epsilon_{i,t}) \neq 0$ and estimation by OLS would produce biased coefficients.

The second empirical strategy of equation (5.2) addresses the issue of omitted global factors. First I find in the dataset *large* price changes without a change in the rating: the variable Price $\text{Shock}_{i,k,t-1}$ captures a change to the price of country i that belongs to the rating category k in year $t-1$. Rating categories have been defined more coarsely than the rating grades in order to obtain a large number of countries in each category.[20] I categorise a price change as *large* when the change in demeaned log yields between two consecutive years is larger than two standard deviations of the log yields distribution in that year for that rating category.[21] I use log yields because first, the distribution of yield changes is smoother (otherwise the majority of data points is concentrated around the mean) and, second, the interpretation of differences in log yields as percentage changes is useful and more realistic: it has the consequence that the same difference in yield points represents a larger percentage change for lower yields than for higher ones. This feature seems particularly true for countries with good funding rates, where a change in yields may double the current rate, whereas for countries already paying higher yields the same change might represent a smaller effect. Demeaning allows me to get rid of the time trend in the time series of yields.

Then I calculate the number of *large* price changes in one year in one rating category and how it affects the fiscal position one year ahead of the other countries in the same rating

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

[21] This is robust to small changes in the threshold of standard deviations.

category that did not have a shock. The regression I estimate is the following:

$$Y_{j,k,t} = \alpha + \beta \text{Price Shocks}_{i,k,t-1} + \gamma X_{j,t-1} + \kappa_j + \delta_t + u_{j,t},$$

$\forall j \neq i$ in the same k. In (5.2) the omitted variable Z_t is now captured by the time dummy.

I excluded from the estimation countries that had a price change or a rating change so that in this specification the dependent variable is exogenous to the countries' fiscal position. The effect on austerity is assumed to come from the change in CRA informativeness. $X_{j,t}$ includes the usual controls and, additionally, the lagged log yield and the lagged rating. This is trying to control for any other domestic reason that affects the fiscal stance.

Regression (5.2) deals with omitted variable bias even if it has asymmetric effects on different rating categories because the category performing higher austerity changes every time (depending on the category that experienced the price change). The regression results for this specification are presented in table 6. Notice that experiencing one or more price changes means a larger number in the variable Price $\text{Shocks}_{i,k,t-1}$, hence, an increase in the explanatory variable should be associated with more austerity (a positive coefficient for net lending and budget balance variables and a negative one for government expenditure). Results are confirmed by this approach. The coefficients continue to be statistically significant although the significance has dropped for government spending. Being subject to a *large* price change in the rating category increases the austerity over GDP in the order of one-quarter to one-half of a percentage point depending on the measure we are looking at.[22]

In appendix L, I present the list of countries that experienced a *large* price change.

5.3 Alternative explanations

There could be alternative theories that explain the empirical results obtained in the previous section. I attempt to address them in this section.

[22]An example with the primary deficit would be going from 3.5% over GDP to 3%.

Table 6: OLS regression results with robust standard errors

	Dependent Variable			
	Net lending	Primary budget	Structural budget	Expenditure
Lag price shocks	0.478***	0.510***	0.241**	-0.225*
	(0.156)	(0.168)	(0.119)	(0.127)
Lag net borrowing	0.721***			
	(0.0426)			
Lag primary deficit		0.768***		
		(0.0417)		
Lag structural deficit			0.722***	
			(0.0563)	
Lag expenditure				0.774***
				(0.0317)
Lag debt	-0.00481	0.00633	-0.00344	0.0109*
	(0.00605)	(0.00622)	(0.00639)	(0.00572)
Lag logGDP	-2.521	-3.715	-6.441**	-0.318
	(2.792)	(3.072)	(3.026)	(2.439)
Lag logGDPpc	0.523	2.997	5.393*	3.760
	(2.915)	(3.390)	(2.877)	(2.546)
Lag growth	5.544	1.780	7.546	-4.933
	(4.223)	(4.687)	(6.468)	(3.884)
Log yields	0.215	0.766	0.972	0.0617
	(0.436)	(0.518)	(0.640)	(0.401)
Rating	-0.0807	-0.100	-0.101**	0.0355
	(0.0554)	(0.0643)	(0.0493)	(0.0478)
Country FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
N	725	637	577	725
r2	0.845	0.833	0.846	0.978
F	46.97	39.81	88.45	748.7

Standard errors in parentheses

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

First, in order to rule out that austerity is due to criteria of budget sustainability, I have controlled in all the regressions above for a set of individual characteristics that the literature has identified as important. Concerns about omitted global variables, that affect all the countries at the same time, are addressed by including country and time fixed effects in the last specification. The effect of changes in informativeness on austerity remains after the global variables are controlled for.

But there could also be omitted variables that affect only some countries and not others. Particularly problematic is the case when an omitted variable affects the countries in some particular category only. In this case the effects could be confounded with the effects of the *large* price changes operating at the level of the rating category and we would be unsure whether we were capturing the correct effect. For example, think about precautionary savings by countries within a rating category triggered by uncertainty clustered at the category level. Notice, though, that the 'savings glut' should be homogenous in all countries affected by the precautionary motive. But austerity by category shows high dispersion. This indicates that austerity is not performed by every country, as would be consistent with the precautionary motive, but only by some countries that belong in the category affected by a price change, as consistent with the signalling motive.

Finally, the result could also be attributed to contagion. A shock to a country transmits to others, even though they are not directly affected by it. By the nature of contagion, it cannot be captured by controlling for the fundamentals of the country as I did before. In order to detect contagion from the risk of one country to another, the literature usually relies on price comovements, thus implying that contagion should indeed show in the price of debt. Including the own debt price in the last specification, as is shown in table 6, I still find an effect of changes in the informativeness of credit ratings.

6 Conclusion and policy discussion

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

The findings in this paper might be useful in informing policymakers about how to stabilise debt markets and avoid sovereign crises. A particular measure that has been proposed during the recent debt crisis in Europe has been the introduction of a common debt ceiling. For instance, the Fiscal Compact has introduced the rule of fiscal budget balance in its Article 3 of Title II.[23] In the model this policy is equivalent to setting an exogenous debt limit that is the same for any country type. This policy is relevant only when the debt ceiling $\bar{D}_2$ is lower than type B's full information allocation D_2^{FI} as in figure 8. Imagine a situation where the equilibrium is the separating one e^*. Once the debt ceiling is introduced, type B is not allowed to choose its optimal debt level because it would violate the rule. In a separating equilibrium in the new circumstances, type B chooses the highest amount of debt possible, $\bar{D}_2$, as depicted in figure 9. But this brings type B to a lower indifference curve, thereby forcing type A to choose an even lower amount of debt than D_2^{-B}. Type A needs to do more austerity in order to avoid imitation from B because the outside option for B has become worse. Both types are worse off, even though the price of debt improves because the sovereign has a lower default probability.

But, given that type A's utility has changed, the separating equilibrium in figure 9 might be defeated, applying the UE refinement, by a pooling one. In figure 10 the pooling

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

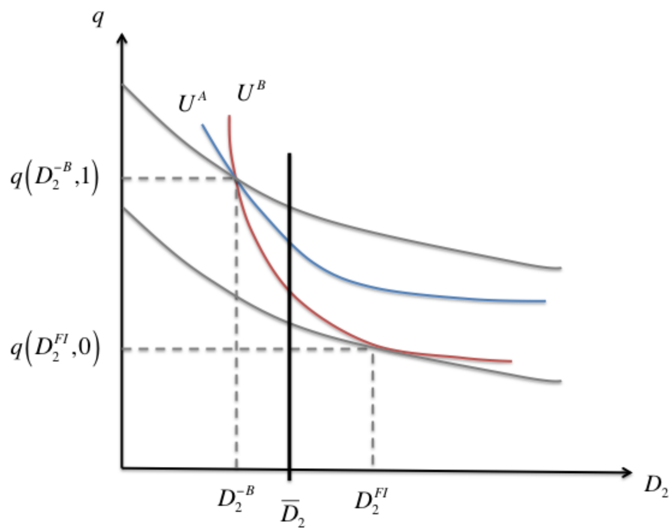


Figure 8: A common debt ceiling at $\bar{D}_2$.

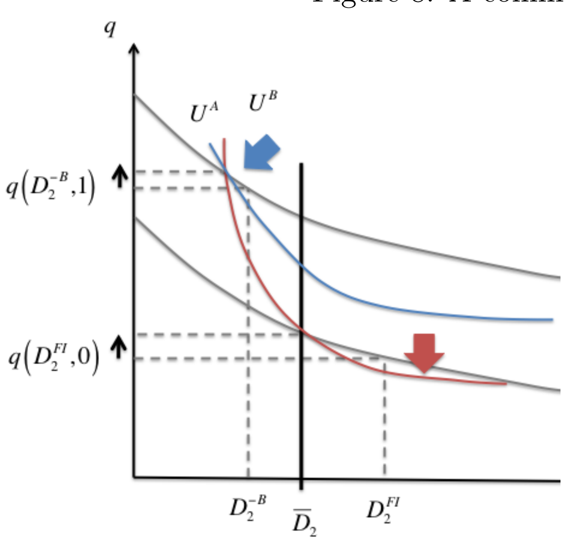


Figure 9: Separating equilibrium with a common debt ceiling.

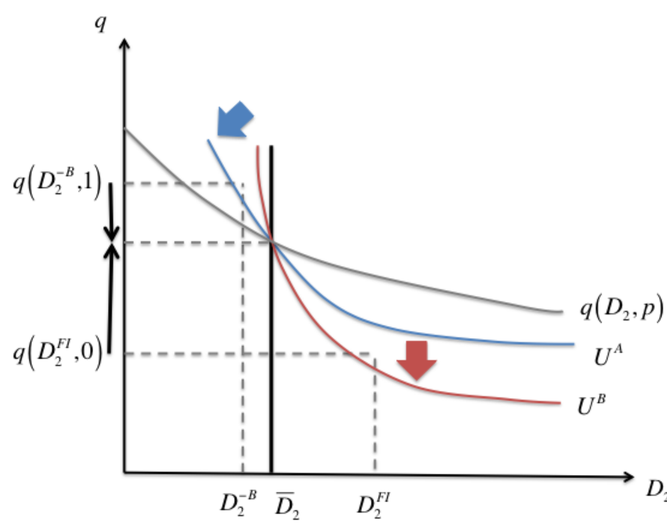


Figure 10: Pooling equilibrium with a common debt ceiling.

equilibrium at $\bar{D}_2$ makes both types better off, thus the separating equilibrium is defeated and any sovereign chooses $\bar{D}_2$. Compared with the initial equilibrium without the debt ceiling in figure 8, however, every country type loses. This can be seen by comparing the utility levels of type A and B with the equilibrium allocations from figure 8 represented by the dotted lines. Moreover, type B's default premium decreases but A's increases, as the black arrows on the vertical axis show, leaving open the possibility that the overall probability of default increases or decreases. It is, therefore, possible that the introduction of a debt ceiling makes all countries worse off and also fails to improve the situation of the creditors. A 'one-size-fits-all' austerity programme such as the Fiscal Compact may backfire when countries are trying to signal with austerity.[24]

In the midst of the current debate on austerity, the question about its optimal amount is in the forefront of the research and policy agenda. It is, therefore, important to understand all the different roles that austerity might play. In this paper I have stressed one of these roles, complementary to others shown in the literature, of fiscal austerity: the signalling role.

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

APPENDIX

A Full information optimal allocation

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

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

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 (A.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,

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

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

B The single crossing property

The definition of *single crossing* preferences is the following: $U^i(D_2,q;\omega_1-D_1)$ satisfies the *single crossing* condition if $U^B(D_2,q)\leq U^B(D_2',q')$ for $D_2'<D_2$ implies that $U^A(D_2,q)\leq U^A(D_2',q')$ (Sobel, 2009). Geometrically it is equivalent to a ranking of the slopes of the

indifference curves $\Delta^A > \Delta^B$, where

$$\Delta^i = -\frac{\frac{\partial U^i(D_2,q)}{\partial D_2}}{\frac{\partial U^i(D_2,q)}{\partial q}}. \tag{B.1}$$

Let us show that the slope of country type B's indifference curves is higher than that of A's for the relevant range of D_2. First, let us find the threshold level of debt that satisfies constraint (2.5) for $t = 1$ for each type:

$$\underline{D}_2^i = \frac{\underline{c}^i - \omega_1 + D_1}{\beta' \left[1 - F(\underline{D}_2^i + \underline{c}^i)\right]}. \tag{B.2}$$

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

$$\underline{D}_2^i = \frac{\underline{c}^i - \omega_1 + D_1}{\beta'} e^{h(\underline{c}^i - \underline{\omega})} e^{h\underline{D}_2^i}, \tag{B.3}$$

$e^{h\underline{D}_2^i}$ is bounded between 0 and 1 and, therefore, $\underline{D}_2^i > 0$. Moreover, since $\underline{c}^A < \underline{c}^B$, $\underline{D}_2^A < \underline{D}_2^B$. So the range of interest of D_2 is between $\underline{D}_2^B$ and ∞.

Next, let us compute Δ^i for each type. Total differentiation of (2.8) gives:

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

and, simplifying,

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

Therefore, $\Delta^i = -\frac{q - \beta\left(1 - F(D_2 + \underline{c}^i)\right)}{D_2}$ and $\Delta^A < \Delta^B$ if $\Delta^i < 0$, which is the case for all $D_2 \in [\underline{D}_2^B, 0)$ given assumption (C4).

C Separating equilibrium

Define first D_2^{-B} as the debt level where type B's indifference curve going through the full information allocation crosses price schedule $q(\cdot, 1)$,

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

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

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

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

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

$$q(\underline{D}_2^B, 1) = \beta' \left[1 - F(\underline{D}_2^B + \underline{c}^A)\right] > 0$$

and

$$\lim_{D_2 \to \underline{D}_2^B} \mathbf{q}_B(D_2, \bar{U}) = +\infty.$$

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

It remains to be proved that type A prefers choosing D_2^{-B} and having the price of debt $q(D_2^{-B}, 1)$ to choosing $D_2^{A,B}$ and having the price $q(D_2^{A,B}, 0)$. First, notice that at the full information allocation type B is at its maximum, hence, it is at its highest indifference curve under the $q(D_2, 0)$ schedule. If follows that the price schedule $q(D_2, 0)$ must lie below B's indifference curve going through the full information allocation. So, in order to satisfy the optimality of $D_2^{A,B}$ for type A, $(D_2^{A,B}, q(D_2^{A,B}, 0))$ must be below the indifference curve of B going through $(D_2^{FI}, q(D_2^{FI}, 0))$. And, given that the indifference curve of A is steeper than that of B for any D_2, the two curves can only cross to the right of $D_2^{A,B}$. Since they cannot cross to the left of $D_2^{A,B}$ it is impossible that $(D_2^{A,B}, q(D_2^{A,B}, 0))$ is on a higher indifference curve of A than $(D_2^{-B}, q(D_2^{-B}, 1))$.

D Pooling equilibrium at D_2^{FI}

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

E Definition of the Undefeated Equilibrium refinement

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

1. D_2' be a non-equilibrium outcome in e^*.
2. $\Theta = \{\{A\}, \{B\}, \{A, B\}, \{\emptyset\}\}$ be the set of types that choose strategy D_2' in e'.
3. Denote the utility of type i under equilibrium e: $U^i(e)$. Let $U^i(e') \geq U^i(e) \, \forall i \in \Theta$ with the inequality being strict for at least one $i \in \Theta$.
4. The off-equilibrium beliefs after observing D_2' in e^* be positive for the type(s) with a strict inequality and zero for the type(s) not belonging to Θ.

Then, if $\mu(D_2')$ do not support e^*, e^* is *defeated* by e'.

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

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

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

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

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

Plugging this equation into the FOC we obtain:

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

Hence,

$$D_2^{*i} = h^{-1} - \frac{\beta(1 - F(D_2^{*i} + \underline{c}^A))}{\beta' \left[pF'(D_2^{*i} + \underline{c}^A) + (1-p)F'(D_2^{*i} + \underline{c}^B)\right]}$$

and

$$D_2^{*A} < D_2^{FI} < D_2^{*B}.$$

G Selection of the separating equilibrium e^*

The separating equilibrium e^* must be undefeated. e^* is defeated if there is an equilibrium e' whose μ' at D_2' is not consistent with e^*. Notice that this can only happen:

- To the right of D_2^{-B} if $\forall D_2 \in [\underline{\mathrm{D}}_2^B, D_2^{-B}] \quad q(D_2, \mu) > q(D_2, 1)$, which is impossible according to the definition of PBE.

- To the left of D_2^{-B} any possible equilibria are of the pooling type. Hence, equilibrium beliefs are $q(D_2, \mu) = q(D_2, p)$ and $q(D_2, p)$ needs to be above the indifference curve of A going through $\left(D_2^{-B}, q(D_2^{-B}, 1)\right)$.

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

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

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'. Thus, off-equilibrium beliefs in e' must be $\mu'(D_2) \neq 1 \, \forall D_2 \neq D_2'$ in order to be able to sustain e'. But, since $\Theta = \{A\}$ at D_2^{-B}, $\mu'(D_2^{-B}) = 1$ and any e' is defeated by e^*.

H Selection of the pooling equilibria

A pooling equilibrium e' defeats the least cost separating equilibrium e^* if $U^A(e') \geq U^A(e^*)$ and $U^B(e') > U^B(e^*)$. D_2' is not an equilibrium strategy for A in e^* but both types choose D_2' in e', hence $\Theta = \{A, B\}$. Off-equilibrium beliefs about the type(s) that choose D_2' in e^* cannot be zero for type B and need to be positive for both A and B. Hence,

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

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

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

and

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

because it is the full information solution, and

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

as has been shown in Section 3.2. Thus, using $p = 1 - \epsilon$,

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

I Dataset: the ratings geography and time span

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

J Dataset: definition of variables

General government gross debt (Debt, percent of GDP): Gross debt consists of all liabilities that require payment or payments of interest and/or principal by the debtor to the creditor at a date or dates in the future. This includes debt liabilities in the form of SDRs, currency and deposits, debt securities, loans, insurance, pensions and standardised guarantee schemes, and other accounts payable. Thus, all liabilities in the GFSM 2001 system are debt, except for equity and investment fund shares and financial derivatives and employee stock options. Debt can be valued at current market, nominal, or face values (World Economic Outlook 2013, WEO13).

General government net lending/borrowing (Netbor, percent of GDP): Net lending (+)/borrowing (-) is calculated as revenue minus total expenditure. This is a core GFS balance that measures the extent to which general government is either putting financial resources at the disposal of other sectors in the economy and nonresidents (net lending), or utilising the financial resources generated by other sectors and nonresidents (net borrowing). This balance may be viewed as an indicator of the financial impact of general government activity on the rest of the economy and nonresidents. Note: Net lending (+)/borrowing (-) is also equal to net acquisition of financial assets minus net incurrence of liabilities (WEO13).

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

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

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

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

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

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

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

K Regression by country groups

Table 7: OLS with robust standard errors

	(1) OECD	(2) EU	(3) PIIGS	(4) EM
Net lending/borrowing	-0.0284***	-0.0350***	-0.0770**	-0.0249
	(0.00885)	(0.0112)	(0.0333)	(0.0233)
N	535	397	93	96
r2	0.823	0.765	0.741	0.761
F	45.38	33.02	14.59	45.21
Primary balance	-0.0258***	-0.0315***	-0.0722**	-0.0272
	(0.00863)	(0.0107)	(0.0319)	(0.0222)
N	534	396	92	96
r2	0.752	0.712	0.733	0.731
F	39.80	32.87	13.86	44.28
Potential structural balance	-0.0107*	-0.0105	-0.0574**	-0.0220
	(0.00645)	(0.00856)	(0.0243)	(0.0182)
N	535	397	93	96
r2	0.848	0.852	0.857	0.853
F	59.24	43.61	22.59	70.95
Government spending	0.0246***	0.0278**	0.0425	0.0246
	(0.00906)	(0.0122)	(0.0282)	(0.0310)
N	535	397	93	96
r2	0.942	0.928	0.840	0.975
F	399.3	249.0	62.09	302.8

Standard errors in parentheses

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

L Large price changes

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

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