Essays in Sovereign Debt and Sovereign Credit Ratings

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Essays in Sovereign Debt and Sovereign Credit Ratings

Thesis submitted for assessment with a view to obtaining the degree of
Doctor of Economics of the European University Institute

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Abstract

This thesis consists of two chapters regarding the transmission of information in the sovereign debt market. The first one looks into the signaling role of the choice of debt by the sovereign and the second one focuses on a class of intermediaries in the market of sovereign debt, the credit rating agencies, and examine the information consequences of their solicited and unsolicited ratings.

In the first chapter I build a model where creditworthy countries may use fiscal austerity to communicate their ability to repay sovereign debt and show that the signaling channel is active only for high levels of asymmetric information. The model generates a negative association between the amount of public information, provided by the rating agencies, and fiscal tightness. Informed by the model predictions, I perform an empirical investigation based on a panel of 58 OECD and emerging market economies since 1980 and find evidence of this signaling channel.

The second chapter aims at contributing to the debate on whether unsolicited ratings are strategically motivated. I present evidence from the sovereign debt market that strategic motivation is not necessarily behind the patterns that we see in the data and propose a model of credit ratings and ancillary services that abstracts from strategic considerations. In my model, borrowers with different unobservable characteristics select themselves into different solicitation groups. In equilibrium, the model can generate either a negative or a positive selection on unsolicited ratings, depending on the share of unsolicited ratings in a given market. The economic mechanism analyzed in this chapter implies a "natural" degree of market selection which is not associated to strategic motivation.

Acknowledgments

I want to thank my supervisor Piero Gottardi for his continued support during my PhD. He has been an incredible mentor and an example of rigor and perseverance. I also want to thank Árpád Ábrahám for his endless enthusiasm and complete availability. Without them, this thesis would not have been possible. I am also indebted to Thomas Cooley who helped me a lot at different stages of my thesis. Finally, a special thanks to the administrative staff at the Economics Department, whose efficiency and willingness to help are beyond question.

I have been incredibly lucky to have shared these years with a fantastic group of researchers, who made this experience much more enjoyable: Claudia Cerrone, Andrew Gimber, Abian Garcia, Stefan Lamp, Sarah Auster, Antoine Camous, Vincent Maurin. . . not to forget some wonderful Italians - Chiara, Chiara, Antonella, Giovanni, Andrea and Massi - who made me feel at home here.

I am grateful to my friends in Barcelona for their understanding and patience during the job market. Life has changed a lot in these years but they were always there for me.

I dedicate this thesis to the most important people in my life, my family: my parents, my brother, Nicola and Lluc.

Berlin, August 2016

Contents

Chapter 1

The Signaling Role of Fiscal Austerity

1.1   Introduction

Austerity is at the forefront of the public policy debate following the European sovereign debt crisis. It refers to a combination of measures that reduce a country's deficit, hence, the debt burden. Accordingly, most of the discussion about austerity measures revolved around the issue of debt sustainability (ECB, 2012; StLouisFED, 2012). The starting point of the present work is the observation that austerity may serve different purposes and need not be undertaken only under an unsustainable budget. A number of countries engaging in sizeable austerity after 2010 were indeed thought to be in the safe European "core." For instance, Germany announced plans to reduce its budget deficit by 80 billion euros by 2014. The UK embarked on the biggest cuts in state spending since World War II, and the Netherlands went through several austerity packages despite a low ratio of debt to GDP.[1]

Furthermore key policymakers believed that such measures may serve to reassure the markets about the country's creditworthiness and help maintain access to international lending. In the words of German Chancellor Angela Merkel, "austerity measures are adopted in order to send a very important signal,"[2] or, as the British Chancellor of the Exchequer George Osborne put it, "we have to convince the world that we can pay our way in the world."[3]

In this paper, I investigate the role of fiscal austerity as a way to communicate a sovereign's ability to honor its debt obligations. Signaling is a channel through which austerity may affect a country that has been overlooked in the past. As I argue below, understanding the informationational motivation for undertaking fiscal tightening measures may improve our understanding of the sovereign bond market and lead to new normative

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

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

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

prescriptions.

I propose a model where countries differ in their ability to repay their sovereign debt. Since this quality is unobservable, lenders cannot differentiate between different types of countries, hence the motivation for signaling creditworthiness. A country's type may reflect the political preferences of citizens with respect to the trade-off between public spending and debt repayment. For example, in Portugal, attempts to cut public wages and reform the pension system faced harsh social protests and had to be abandoned[4] whereas similar measures were successfully implemented in countries such as Italy and Spain. Broadly speaking, a type can be associated to anything that implies a different level of total fiscal revenues for the peak of the Laffer curve.

The economic mechanism I develop is similar to Spence's signaling model of education, where more able individuals also have a lower cost of getting educated and hence schooling is used to convey information about ability.[5] Since a creditworthy country has higher probability of repaying its debt it also has a higher expected future benefit in reducing debt. At the same time - for any given price of debt - the present cost of a debt reduction is the same across countries. The model, hence, enjoys a single-crossing property and admits a separating equilibrium featuring austerity for signaling purposes. In the separating equilibrium, the more creditworthy country chooses to markedly reduce its debt so that to differentiate itself from less able countries and enjoy a lower risk premium on sovereign debt. The model also admits pooling equilibria where all countries receive the same price for unit of debt.

Instead of employing the more common 'intuitive criterion' of Cho and Kreps (1987), to reduce the set of equilibria I employ the 'undefeated equilibrium' refinement proposed by Mailath et al. (1993). The proposed refinement always selects the equilibria with the highest welfare and it delivers the following interesting prediction, which I use in my empirical analysis. In my model, the amount of public information available in the market uniquely determines whether the prevailing equilibrium is separating or pooling. I model different levels of public information by introducing a a credit rating agency that provides public signals about country types. When the rating agency generates a weak signal, in the unique equilibrium, the creditworthy countries find it profitable to undertake fiscal consolidation for signaling purposes. In contrast, when the public signal provided by the agency is very informative only pooling equilibria exist.

In the empirical section, I consider a panel of 58 countries since the 1980s and study how the amount of public information provided by rating agencies is associated to changes in the

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[4] "Portugal court rules public sector pay cut unconstitutional," BBC News, 6 July 2012.

[5] More precisely, my model differs from Spence's baseline framework in that the choice of debt also has a direct effect to the ability to repay.

structural deficit and other measures of a country's fiscal austerity. I use two alternatives proxies as indicators of the amount of public information about a country creditworthiness. The cross-sectional correlation between the sovereign yields and the sovereign ratings issued by the rating agency is an aggregate measure of the informativeness of the rating in a given period. This first empirical exercise is based on the assumption that the overall informativeness of the ratings affects an individual country incentives to signal but, being a cross-country measure, it is not likely to be affected by the fiscal policy of a single country. I find that a decrease in the cross-sectional correlation between sovereign yields and ratings is associated to an abnormally high level of fiscal tightness, that is not explained by changes in the fundamentals of the country.

The second indicator of the amount of information I use is a dummy variable capturing large sovereign yield movements in a given rating category. In my model, an episode of signaling is characterised by an increase in the yield differentials across country types. A country that separates itself from the other ones in the same rating category enjoys a lower cost of debt. I look at each rating category (for example, triple B sovereigns) and count the episodes of drastic yield changes within a period of no change in the rating. I take this as a measure of how likely it is that this category is in a separating equilibrium. Then I check how the structural deficit changes in the other countries belonging to that category. Those countries have not been subject to a yield nor a rating change, therefore reducing reverse causality issues. The model predict that those countries should exert higher fiscal pressure compared to the countries belonging to other rating categories where such drastic yield changes have not occurred. In line with the theoretical predictions I find that a higher number of drastic yields changes at constant rating is associated with higher fiscal consolidation in the countries within the category with the exclusion of the ones experiencing the yield change or a rating change. There is time variation within each category allowing me to have both time and country fixed effects.

The coefficient is significantly different from zero after controlling for other variables that are usually used in the literature estimating fiscal rules (Gali and Perotti, 2003; Favero and Monacelli, 2005; Baldacci et al., 2013) such as total debt over GDP, the amount of GDP and GDP per capita and growth. Further robustness checks evaluate alternative hypotheses and favor the signaling channel as the most compelling explanation of the evidence.

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), or - more recently - in order to achieve more office-oriented or short-sighted goals (e.g., Persson and Tabellini (1999)). This paper studies an alternative channel through which the presence of information asymmetries might also lead to fiscal policies that deviate from the

first best.

A few other works consider incomplete information in a model of sovereign debt (Cole et al., 1995; Sandleris, 2008; Drudi and Prati, 2000; Fostel et al., 2013; D'Erasmo, 2008). None of them has addressed the problem at hand: the signaling role of fiscal policy.

Sandleris (2008) and Dellas and Niepelt (2014) use the absence of a default as a signalling device. Differently from them, I use fiscal consolidation as a signal. In another section of their paper, Dellas and Niepelt (2014) have a model where signaling is done through real (over)investment; hence the signaling activity is compatible both with a reduction and an increase in debt. In my model, the signaling activity is always associated with a fiscal consolidation.

There is a large body of literature that estimates fiscal rules (Gali and Perotti, 2003; Favero and Monacelli, 2005; Baldacci et al., 2013) and study the main variables behind fiscal policy changes. This paper contributes to this literature by introducing the signaling motivation to fiscal policy changes. Other papers have studied exclusively the change of informativeness of the credit ratings (Partnoy, 2006; Kiff et al., 2012; Bussiere and Ristiniemi, 2012; De Santis, 2012). None of them links those changes in informativeness to austerity measures.

The paper is organized as follows. In the next section I present the model and in Section 1.3 I characterize the equilibrium set. Sovereign credit ratings are introduced in Section 1.4.1, while Section 1.4.2 extends the model to multiple periods. Section 1.5 is devoted to the empirical analysis. Section 2.4 concludes.

1.2 Model

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

Lenders' problem. Lenders are risk-neutral. They lend the amount qD_2 in period 1 to the sovereign, where q is the price of debt in period 1. If there is no default, they receive D_2 in

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[6]In the model, sovereign debt is equivalent to external debt. Domestic debt does not play any role in this model because the government has enough instruments to allocate consumption intertemporally for its citizens.

period 2. In case of default, there is no partial repayment. The lender profit function is:

$$\Pi = -qD_2 + \beta'D_2[1 - \lambda(D_2, \mu)], \tag{1.2.1}$$

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

$$q(D_2, \mu) = \beta'[1 - \lambda(D_2, \mu)]. \tag{1.2.2}$$

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

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

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

$$c_t \leq \omega_t - T_t, \quad \text{for } t = 1, 2; \tag{1.2.3}$$

$$T_1 \geq D_1 - q(D_2, \mu)D_2 \quad \text{and} \quad T_2 \geq D_2. \tag{1.2.4}$$

$$c_t \geq \underline{c}^i \quad \text{for } t = 1, 2. \tag{1.2.5}$$

Constraint (1.2.3) is the budget constraint of the respective citizens. Constraints (1.2.4) represent the government budget constraint in $t = 1, 2$. The initial level of debt D_1 is exogenous and $D_3 = 0$ since in the last period debt cannot be rolled over. It is easy to see that both (1.2.3) and (1.2.4) will be satisfied with equality. Hence, once the choice of D_2 is taken, taxes and consumption in $t = 1$ are fully pinned down under repayment. Constraint (1.2.5) introduces heterogeneity in the ability to pay across countries. It states that the sovereign government must guarantee to its citizens a consumption level of $\underline{c}^i$ every period. Differences in the guaranteed level of consumption are the only source of *ex-ante* heterogeneity across countries.

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

I assume

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

Constraint (1.2.5), together with the budget constraint (1.2.3), imposes a cap on the ability to tax. Since $\underline{c}^B$ is higher than $\underline{c}^A$, country B is less able to repay the outstanding debt than country A for the same level of income. Stated differently, *ceteris paribus*, country B is less creditworthy.

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

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

I assume away strategic default. Since $\omega_2 \in [\underline{\omega}, \infty)$, in the first period, a country will never default. Default will occur in period 2 for $\omega_2 \leq D_2 + \underline{c}^i$. If the second period endowment realization does not suffice to cover both the commitments versus foreign lenders and the domestic commitments on citizens' required consumption, the country defaults on its debt. Otherwise the country complies with its commitment. The probability of default for country $i = A, B$, with debt level D_2 is hence $F(D_2 + \underline{c}^i)$.

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

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

This condition rules out the uninteresting case in which the two types have zero probability of default.[8] By assumption (A1), $F(D_2+\underline{c}^A) \leq F(D_2+\underline{c}^B) \, \forall \, D_2$ and, by (A3), the inequality is strict. For any given debt level, a type A country is less prone to default. This predisposition to default is driven by unobservable fundamentals of the country - $\underline{c}_i$ - but the type that actually defaults depends on the equilibrium choices and, ultimately, the endowment realization.

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

$$\beta' > \beta \cdot \frac{1 - F(D_2 + \underline{c}^A)}{1 - F(D_2 + \underline{c}^B)} = \beta \cdot e^{h(\underline{c}^B - \underline{c}^A)}. \tag{A4}$$

Thanks to the exponential assumption, we can state this condition as a function of exogenous

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

parameters. Since $e^{h(\underline{c}^B - \underline{c}^A)} > 1$, it implies that the discount factor abroad β' is higher than the domestic discount factor β by a wedge that is high enough to compensate for the difference in risk premia across types. External lenders are willing to finance a type B sovereign at a rate that is attractive domestically for both types. This makes a sovereign country *willing to increase period 1 consumption and finance it by issuing new debt.*[9] What remains to be determined is how much new debt the country wants to issue, once it internalizes that issuing debt changes the relative price of debt versus repayment. And this choice can be made contingent on the type.

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

$$U^i(q, D_2) := \omega_1 - D_1 + qD_2 \tag{1.2.6}$$
$$+ \beta \left[F(D_2 + \underline{c}^i)\underline{c}^i + \left(1 - F(D_2 + \underline{c}^i)\right) \left(\mathbb{E}[\omega_2 | \omega_2 \geq D_2 + \underline{c}^i] - D_2\right) \right].$$

The first line of the right-hand side represents the citizens' consumption in the first period: the endowment ω_1 plus the net borrowing of the period. The second line represents the expectation of consumption in period 2 discounted by β: with probability $F(D_2 + \underline{c}^i)$, the country defaults and consumption is $\underline{c}^i$, and with the complementary probability, consumption is the result of the endowment, noticing that ω_2 can only be a realization compatible with repayment, minus the debt outstanding. Expression (1.2.6) can be used to define the indifference curves in the space of two key variables (D_2, q). Those indifference curves are represented in figure 1.1 for the two types of countries.

As explained below, for all D_2, the slope of type B's indifference curves in (D_2, q) is steeper than that of type A. A decrease from D_2 to D_2', as depicted in figure 1.1, needs to be compensated with an increase from q to q_A' for type A and from q to q_B' for type B. This implies that any two curves of A and B can cross at most once in the space (D_2, q). The reason behind it is that default occurs when a country cannot afford repayment and, as this depends only on solvency, B can do it more often.[10] Hence, a type B country benefits more from debt because it anticipates that it has to pay back less. A formal proof of the *single-crossing* property can be found in Appendix 1.7.1.

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

[10]Note that the penalty for default is higher for type A, $\underline{c}^A - \omega_2 - D_2 < \underline{c}^B - \omega_2 - D_2 \,\forall D_2$. However, the single crossing property does not require heterogeneous penalty across types. The penalty could be made equal, provided it is not high enough to prevent any default, and type B would still default in more states than A because default is not strategic.
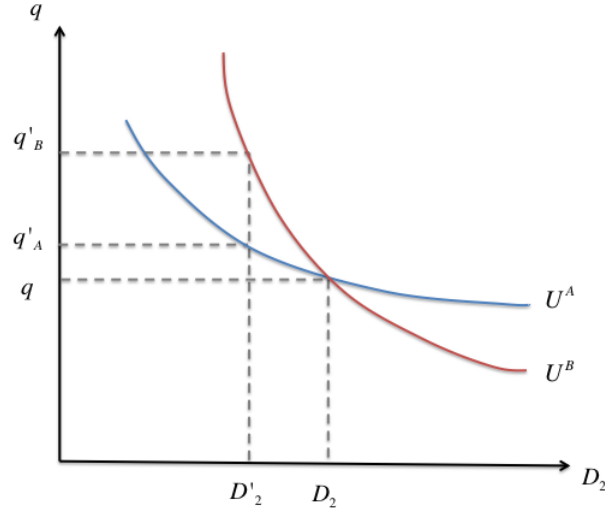
Figure 1.1: *Single crossing property* of the preferences.

1.3 Equilibrium analysis

1.3.1 Full information

As a benchmark, let us describe the equilibrium of the model when the type of the country is observable. The full information equilibrium allocation is a price and a debt level for each type. In this case, the lenders know type i's probability of default for each level of debt and charge the actuarially fair price $q^i(D_2) = \beta' \left[1 - F(D_2 + \underline{c}^i)\right]$. The sovereign faces the price schedule $q^i(D_2)$ and maximises the discounted expected utility (equation (1.2.6)):

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

(1.3.1)

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

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

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

(1.3.2)

The first term in (1.3.2) represents the change in cost that every inframarginal unit of debt experiences when an additional unit is issued. The second term is the gain from bringing consumption to the present at the current price $q^i(D_2)$. Finally, the third term represents the cost of the repayment promise: each unit of debt will be repaid in the next period only if there is no default, which happens with probability $1 - F(D_2 + \underline{c}^i)$.

8

Substituting the price schedule $q^i(D_2)$ in the FOC, after some transformations, we obtain:[11]

$$D_2^i = \frac{\beta' - \beta}{\beta'} \left[\frac{F'(D_2^i + \underline{c}^i)}{1 - F(D_2^i + \underline{c}^i)} \right]^{-1}. \tag{1.3.3}$$

And, recalling that h is the hazard rate of the endowment exponential distribution $f(\cdot)$, equation (1.3.3) simplifies to:

$$D_2^A = D_2^B = \frac{\beta' - \beta}{\beta' h}. \tag{1.3.4}$$

The expression (1.3.4) is the optimal level of debt under full information. Call the full information equilibrium debt level D_2^{FI}. D_2^{FI} is positive because of assumption (A4). It means that the country issues a positive amount of debt in order to take advantage of the favourable lending conditions. Despite D_2^{FI} is the same for both types, in equilibrium, different types face a different price. Price is lower for type B because this type defaults more than the other, so its debt carries a higher risk premium:

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

1.3.2 Incomplete information

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

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

Definition 1.3.1. *A symmetric PBE in pure strategies is a set of strategies for the sovereign and the lenders,*

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

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[11]See Appendix 1.7.2 for the proof.

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

- *For $i = A, B$, $D_2^*(i)$ maximises expected utility U^i given the lenders' strategy $q^*(\cdot)$.*

- *$q^*(\cdot)$ is consistent with zero expected profits: $q^*(D_2, \mu^*) = \beta'[1 - \lambda(D_2, \mu^*)] \; \forall D_2, \mu$.*

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

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

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

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

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

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

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

$$U^B\left(D_2^*(B), q^*(B)\right) \geq U^B\left(D_2^*(A), q^*(A)\right). \tag{1.3.5}$$

Proposition 1.3.1. *There exists a separating equilibrium outcome $\left(D_2^*(A), q^*(A)\right), \left(D_2^*(B), q^*(B)\right)$, where $D^*(B) = D_2^{FI}$, $q^*(B) = \beta'\left[1 - F(D_2^*(B) + \underline{c}^B)\right]$, $D^*(A) = D_2^{-B}$ is the level that satisfies (1.3.5) with equality and $q^*(A) = \beta'\left[1 - F(D_2^*(A) + \underline{c}^A)\right]$. This is supported by the equilibrium beliefs $\mu^*(D_2^*(A)) = 1$ and $\mu^*(D_2) = 0$ for $D_2 \neq D_2^*(A)$.*

Proof. Appendix 1.7.3. □

The allocation $(D_2^{-B}, q(D_2^{-B}, 1))$, represented in figure 1.2, is preferred by A to any other allocation under the price represented by the dotted bold line. At the same time, B is indifferent between that allocation and $(D_2^{FI}, q(D_2^{FI}, 0))$ by definition.[12] The intuition is

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[12]Its incentive compatibility constraint (1.3.5) is satisfied with equality.
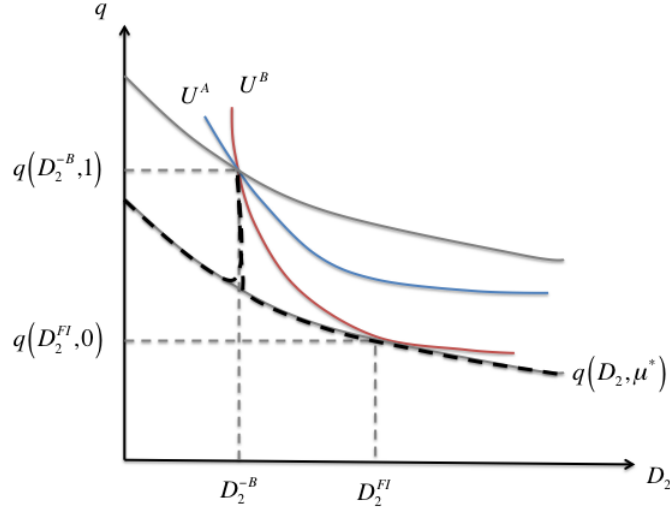
Figure 1.2: Separating equilibrium e^*.

that A's isoutility curves in the space (D_2, q) are flatter than B's. Type A is willing to accept a larger debt reduction for a given change in the price of debt. It, therefore, finds attractive allocations that are not attractive to B.

Type A chooses $(D_2^{-B}, q(D_2^{-B}, 1))$ while B chooses its full information allocation D_2^{FI}. No type has an incentive to deviate unilaterally. But choosing a different allocation than D_2^{FI} is costly for A as well. The larger the deviation, the higher the cost for A. Since D_2^{-B} is the threshold debt level that allows separation of the types, the equilibrium e^* described in proposition 1.3.1 is the least cost separating equilibrium.

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

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

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

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best guess is the prior p. For example:

Proposition 1.3.2. *A pooling equilibrium at the full information allocation is supported by the belief system $\mu^*(D_2^{FI}) = p$ and $\mu^*(D_2) = 0$ for $D_2 \neq D_2^{FI}$. The price of debt in a pooling equilibrium equals*

$$q^*(D_2^{FI}, p) = \beta' \left(p \left[1 - F(D_2^{FI} + \underline{c}^A) \right] + (1 - p) \left[1 - F(D_2^{FI} + \underline{c}^B) \right] \right). \tag{1.3.6}$$

Proof. Appendix 1.7.4. □

See figure 1.3, where the price schedule is again represented by the dotted bold line. The off-equilibrium threat that a country will be penalised in its risk premium if it deviates from D_2^{FI} might allow a pooling equilibrium to be sustained at the candidate D_2^{FI}. Any type of sovereign prefers to choose D_2^{FI} and be offered the pooling price under these beliefs. Beliefs are admissible because in equilibrium the pooling price satisfies Bayes' rule and off-equilibrium they are free to be any $\mu \in [0, 1]$.[14]

Figure 1.3: A pooling equilibrium at D_2^{FI}.

1.3.3 Refinements

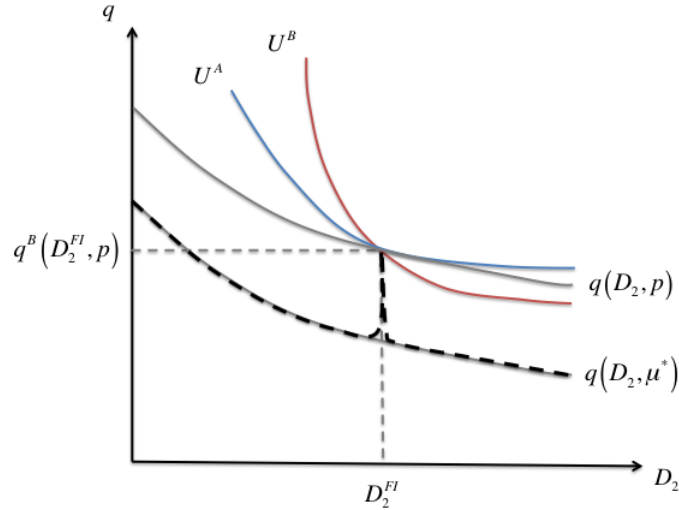A signaling game, like the one presented here, typically admits a multiplicity of equilibria. This is because a large set of off-equilibrium beliefs is consistent with the equilibrium defi-

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

nition, making it easier to sustain a given equilibrium. In my model, proposition 1.3.1 and proposition 1.3.2 are examples of different equilibria that may coexist. To reduce the set of equilibria, I use a refinement of the PBE introduced by Mailath et al. (1993): the undefeated equilibrium (UE).

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

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

Proposition 1.3.3. *Applying the UE refinement to the game, equilibria of the separating and the pooling class cannot coexist. For a sufficiently small p there is a unique separating equilibrium where type A chooses D_2^{-B}, otherwise there are pooling equilibria with $D_2 > D_2^{-B}$.*

As stated in the proposition, for $p < \bar{p}$, the unique equilibrium of the problem is e^*, where $\bar{p}$ is the threshold level of the prior that makes type A indifferent between the signaling allocation $\left(D_2^{-B}, q(D_2^{-B}, 1)\right)$ and pooling with type B at $(D_2^*, q(D_2^*, \bar{p}))$. The line of proof goes as follows: first, notice that the least costly separating equilibrium e^* defeats any other separating equilibrium. All separating equilibria reveal the type of the sovereign but e^* does it with the smallest deviation from the full information allocation for type A. Hence, type A is strictly better off at e^*. This means that off-equilibrium beliefs at D_2^{-B} must be $\mu = 1$ for any other separating equilibrium but those beliefs do not sustain an equilibrium at $D_2 \neq D_2^{-B}$ because such an equilibrium would be defeated by e^*. Furthermore, e^* defeats any pooling equilibrium if type A is better off signaling (that is, for $p < \bar{p}$). When choosing D_2^{-B} gives type A a higher utility, this cannot be ignored off equilibrium in any pooling equilibrium and thus it is inconsistent if A does not realize it would be better off deviating to D_2^{-B}. The

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[15]See appendix 1.7.5 for a formal definition of the UE refinement.

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

pooling equilibrium is, therefore, defeated. In this case, e^* is the unique equilibrium of the model. A formal proof is presented in appendix 1.7.6.

If $p \geq \bar{p}$ then both types are better off pooling, thus e^* is defeated by a pooling equilibrium. The proof is presented in appendix 1.7.7. The UE refinement allows pooling equilibria to survive.[17] Pooling e' survives if there is no other pooling equilibrium in which both types are better off. Hence, undefeated pooling can be sustained at any allocation in the range $[D_2^{*A}, D_2^{*B}]$, where D_2^{*A} is the allocation preferred by type A under schedule $q(\cdot, p)$ and D_2^{*B} is the one preferred by type B. Pooling equilibria in allocations outside that range are defeated by other pooling equilibria within that range because they are strictly preferred by both types. Within this range moving closer to one type's preferred allocation means moving further from the other; hence, types cannot both be made better off.

Restating the result of proposition 1.3.3, a separating equilibrium will exist depending on the beliefs about the creditworthiness of a country. A small p reflects a prior that the country is most likely of type B, thus providing large incentives for a type A to signal and separate itself from the uninformed pool. As p becomes larger, *ex-ante* beliefs of the lenders about creditworthiness are more optimistic, and both types are satisfied foregoing austerity because the potential price benefits of signaling would not be large. Once both types prefer to pool, the least preferred separating equilibrium is defeated and only pooling equilibria exist.

1.4   Public information and multiple-periods

1.4.1   Credit rating

In the model, signaling depends on the belief distribution over types: if lenders believe the sovereign's creditworthiness is most likely high, a country does not gain much from

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

implementing costly austerity to improve the market's perception. Thus, it is useful to explore how changes in the lender's views on creditworthiness affect austerity.

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

Once ratings are assigned, the debt market is segmented into different markets conditional on the rating. A low rating perfectly reveals a B type and the country rated $\underline{r}$ is removed from the complementary market $\bar{r}$. Hence, the rating ameliorates the asymmetry of information but does not eliminate it completely. The residual asymmetry of information depends on ρ.[18] The empirical literature on credit ratings finds robust evidence that the ratings add information on average, measuring the impact that either ratings or new announcements have on the market (Cantor and Packer, 1996; Lee et al., 2010; Pukthuanthong-Le et al., 2007). In addition, some papers note that this impact changes over time (Kiff et al., 2012; De Santis, 2012) and that the explanatory power of the ratings diminishes in times of crisis (Bussiere and Ristiniemi, 2012).

I concentrate my analysis on the $\bar{r}$ category for the remainder of this paper.[19] Recall from proposition (1.3.3) that the existence of an equilibrium with 'signaling austerity' depends on the proportion of types p. The parameter ρ, by modifying the proportion of types in each segmented market, affects the determination of the equilibrium. The posterior $\hat{p}(\rho)$ is:

$$\hat{p}(\rho, r) = \begin{cases} \frac{p}{1 - \rho(1-p)} & \text{if} \quad r = \bar{r} \\ 0 & \text{if} \quad r = \underline{r}. \end{cases} \tag{1.4.1}$$

If ρ is set to 1, the CRA provides perfect information about the type of country and the solution is the full information one. If, instead, $\rho = 0$, we are in the baseline model with

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[18]ρ can take on different values, $\in (0, 1)$, for a number of reasons that are not explicitly modelled here: for example, a conflict of interest due to the issuer-pays model of rating fees would be represented as a decrease in ρ, as we go from an investors-pay to an issuer-pays model. Similarly, either 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.

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

asymmetry of information from the previous section. For values between 0 and 1, the degree of informativeness affects to a lesser or greater extent the beliefs about the composition of types in the rating category $\bar{r}$ and, thus, the equilibrium debt price of pooling in that category, which equals:

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

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

Let e^* be the least cost separating equilibrium defined in proposition 1.3.1 and $\bar{p}$ be the threshold level of the prior that makes type A indifferent between signaling and pooling as described in the previous section.

Proposition 1.4.1. *If the prior p is such that $p < \bar{p}$, there exists a level of informativeness ρ^* of the rating so that for all $\rho \geq \rho^*$ all equilibria are pooling and for $\rho < \rho^*$ the unique equilibrium is e^*.*

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

$$U^A \left(D_2^{-B}, q(D_2^{-B}, 1) \right) > U^A \left(D_2^*(p), q(D_2^*(p), p) \right)$$
$$= U^A \left(D_2^*(\hat{p}), q(D_2^*(\hat{p}), \hat{p}) \right) \text{ if } \rho=0. \tag{1.4.2}$$

The last line exploits the fact that the two problems without ratings and with ratings that add no information are the same. The left-hand side of (1.4.2) is independent of ρ, while the right-hand side is increasing in ρ because $\frac{\partial \hat{p}}{\partial \rho} \mid_{\bar{r}} > 0$. 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 to e^*. $\square$

Thus,

Corollary 1.4.1. *A deterioration of ratings informativeness from $\rho \geq \rho^*$ to $\rho < \rho^*$ makes 'signaling austerity' appear.*

A worse posterior $\hat{p}(\rho)$ about the sovereign's ability means that more type B countries are perceived to be in the $\bar{r}$ category and the pooling price is lower for every level of debt. Price schedule $q(D_2, \hat{p})$ shifts downwards as in the transition from figure 1.4a to figure 1.4b.

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(a) Equilibrium with $\rho \geq \rho^*$. (b) Equilibrium with $\rho < \rho^*$.
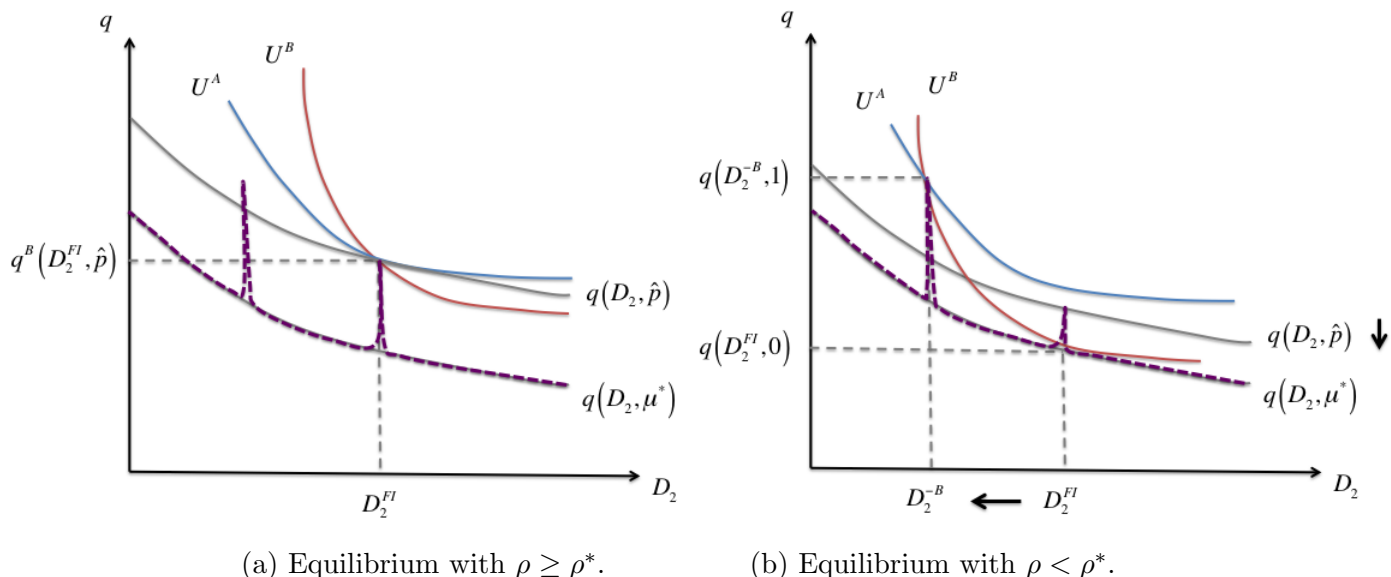
Figure 1.4: A change in ρ induces a shift from a pooling (left panel) to a separating (right panel) equilibrium.

If a pooling equilibrium exists, it will be on the new schedule. But, when $\rho < \rho^*$, any of the allocations on this schedule is worse off for A than the separating allocation, defeating pooling equilibria. To sum up, a worse perception of the $\bar{r}$-rated category makes it less attractive for A to pool with the others, because the pooling price is low, and revealing the type compensates the cost of austerity.

Think about a situation where the informativeness of the ratings was presumably high, like before the 2008 financial crisis. Ratings are believed to be very informative and the markets take them at face value and react strongly to them. The prediction of the model is that all types of sovereigns would likely find it advantageous to pool at a high debt level. They do not have an incentive to signal through costly austerity in order to overcome the little residual asymmetry of information. However, if the informativeness of the ratings plummets, for instance when the reputation of the rating agencies came into question after the collapse of Lehman Brothers, the equilibrium may shift to a separating equilibrium. In this new scenario, corollary 1.4.1 tells us to expect 'signaling austerity' as countries benefit from standing out as creditworthy. The effects of signaling will show in the price of debt, which becomes more responsive to the fiscal magnitudes than before. In that way, you can rationalize the surge in austerity in the European core countries in the aftermath of the crisis and the increase in the Euro area sovereign spreads. In the next section, I simulate the model for a number of periods and compare it with the time series data.

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

In this section, I extend the model to multiple periods. There are two cases in which this extension can be done without excessive complications: the case with constant types over time and the case with iid shocks to the type. With constant types, once there is a separating equilibrium, the type is fully revealed. From then onward, each country chooses its optimal amount of debt under perfect information. Signaling, hence, takes place at most once.

With independent shocks to the type, the problem changes in the following way: at the end of period t a new type is drawn, $\underline{c}^i_{t+1}$. Then, the income realization ω_t is obtained and the country may default. After a default, there is immediate re-entry in the debt market and the country can borrow again D_{t+1}.

The solution to any two consecutive periods t and $t+1$ is the same as that of the previous two-period game.[20] The reason is that the current realization of the type carries no information about the type in the future and, thanks to the linear preferences and the absence of a dynamic punishment for default, the optimal level of debt is independent from the past stock of debt.

I simulate this economy during $T = 28$ to compare it with the last 28 years of data. The parameters of the model are the following: the lender's discount factor is normalized to be $\beta' = 1$; the sovereign's discount factor is $\beta = 0.6$, lower than the lender's to satisfy assumption (A4); the minimum consumption in a type A country is normalized to $\underline{c}_A = 0$; while in a type B country it is higher at $\underline{c}_B = 1$. The lower bound of the support of the income distribution is $\underline{\omega} = 1$, which satisfies assumption (A2) with equality. The coefficient of the exponential distribution of income h is set to 1, so the mean income is also 1. $D_1 - \omega_1$ is set to 0 without loss of generality. Finally, the probability of being type A is set to be 30%.

I assume that the probability that the CRA detects a type B country, ρ, is a parameter that becomes known at the beginning of each period. I find the equilibrium of the model for every value of ρ in a grid between $[0, 1]$ and calculate the correlation between debt prices and sovereign ratings as a function of ρ. I choose the value of ρ_t that minimizes the difference between the simulated correlation and the correlation in the data each period.

Figure 1.5b depicts austerity in the data in the bars, measured as the sum of the primary balance of the government budgets over GDP weighted by the number of countries in each period.[21] The solid line plots the cross-section correlation between sovereign yields and sovereign ratings for the same sample of countries between 1985 and 2012. The two variables have a negative co-movement: a high correlation between sovereign ratings and yields

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[20]See appendix 1.7.8 for a proof.
[21]The sample is described in section 1.5.1 and can be found in appendix 1.7.9.
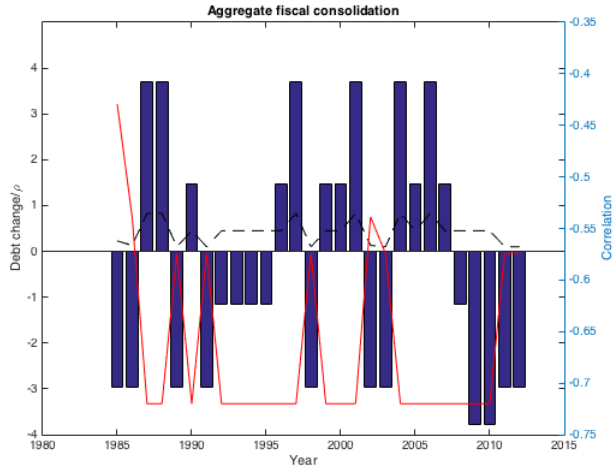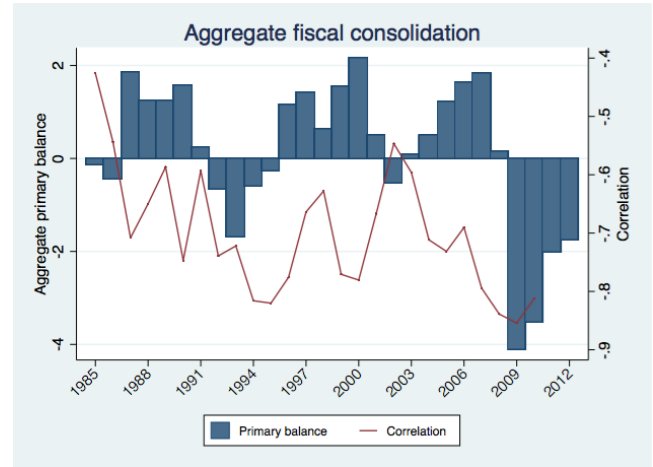
(a) Simulated data. (b) Actual data.

Figure 1.5: Negative co-movement between correlation and austerity.

happens with little or no austerity while a low correlation is associated with bar spikes in austerity. Figure 1.5a plots the choice of ρ_t (dotted line), the cross-sectional correlation (solid line) and the aggregate debt change implied by the model (bars). I am able to replicate the negative co-movement that we see in the data.

Let us now focus on the evolution of sovereign yields over time. Figure 1.6 depicts the same bars as before for the aggregate debt change, together with the simulated sovereign bond yields of each country type. A period of separating equilibrium, characterized by austerity, corresponds to the troughs in the bars. At those times, the sovereign yields of the two country types diverge and a positive spread appears between sovereigns in the same rating category. The prediction associated with a pooling equilibrium is the opposite: the debt bars spike and the spread disappears.

The two empirical regularities that emerge in this simple multiple-period model - the negative co-movement between the sovereign yields-ratings correlation and austerity and the changes in yields dispersion with austerity - are used in the empirical analysis in the next section.

1.5 Empirical analysis

In this section I go beyond the aggregate data from the previous section and examine individual countries over three decades in a panel regression analysis. A given country's choice of fiscal policy is determined by a number of different variables that the literature has identified (Gali and Perotti, 2003; Favero and Monacelli, 2005; Baldacci et al., 2013). For instance,
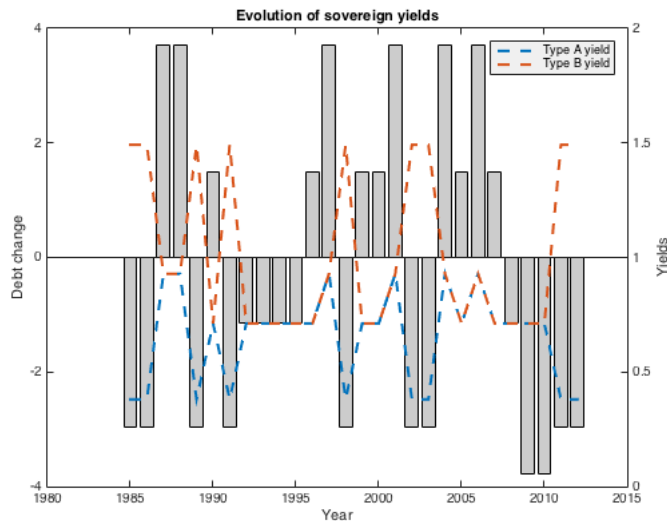
Figure 1.6: Simulated sovereign yields.

the stock of debt matters for debt sustainability and might affect how much austerity a country engages in. In order to distinguish between how much austerity results from signaling motives, I look at the evolution of austerity that is associated with changes in the incentives to signal, conditional on fundamentals.

Incentives to signal are measured in two ways. The first measure I use is the cross-section correlation between sovereign yields and sovereign ratings in a given period. This variable proxies the market assessment of the ratings' information. According to Corollary 1.4.1, the less information there is (low ρ) the more likely is a surge in austerity. This, controlling for other determinants of the fiscal stance. I now explain how the ratings' information is related to the correlation variable in my model. Recall that $Prob(\underline{r}|B) = \rho$ and $Prob(\underline{r}|A) = 0$ and, in the setup with two ratings, it represents the information that the rating conveys to the market. Since Cantor and Packer (1996), a large body of literature investigates the market impact of credit ratings by regressing the sovereign yields, spreads and other measures of the market value on the sovereign ratings.[22] Following the literature, I estimate the equation:

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

using cross-sectional variation. Hence, $\hat{\rho}_t = corr_t(Sovereign\ Yield_t, \text{Rating}_t)$ is an estimate of the changes in public information that the sovereign ratings convey over time. Each year, the correlation reflects the extent to which the sovereign yields charged by the lenders to all sovereigns are explained by the order in which they are placed in the rating scale. A larger

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[22]Possibly controlling for an array of covariates.

correlation is presumed to mean a high ρ while a lower one implies a low ρ. This is what I also find in the simulation of the multiple-period economy in section 1.4.2 (see figure 1.5a).

An alternative way to identify austerity is to measure if market spreads are dispersing within a given rating category. As shown in figure 1.6, increased dispersion in yields inside a category is indicative of low informativeness of the ratings and should prompt austerity in the separating equilibrium for that group of countries vis-à-vis the other groups. I look for extreme events in the yields of a sovereign within the yields distribution by rating category in the data: the variable *Yield Event*$_{i,k,t}$ represents the events in country i belonging to the rating category k in year t and takes value 1 if a large change happened and 0 if not. Rating categories are defined more coarsely than the rating grades in order to obtain a larger number of countries in each category.[23] I define a yield event as extreme when the difference in demeaned log yields between two consecutive years is larger than two standard deviations of the log yields distribution in that year for that rating category.[24] Demeaning allows me to remove the time trend in the time series of yields. I use log yields because the interpretation of differences in log yields as percentage changes is useful and more realistic. In appendix 1.7.10, I present the list of countries experiencing such events. Finally, I aggregate the number of events by rating category at every point in time, excluding those affecting country j itself:

$$Yield\ Shocks_{j,k,t} = \sum_{i \in k, i \neq j} Yield\ Events_{i,k,t}. \tag{1.5.1}$$

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

$$Austerity_{it} = \alpha + \beta\hat{\rho}_{it} + \lambda X_{it} + \xi_{it} \tag{1.5.2}$$

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

Austerity is also proxied by two different variables, depending on the specification, as summarized in table 1.1. The first is an indicator variable measuring whether a given country was under a consolidation program. This is determined according to the narrative approach

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[23]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+.

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

by Devries et al. (2011) and the sample goes from 1978 to 2009 for 17 countries. The second proxy for austerity is a continuous variable for the cyclically adjusted primary balance (CAPB). It is defined as 'general government balance adjusted for nonstructural elements beyond the economic cycle' and data covers 58 countries from 1980 to 2011 and is taken from the WEO database.

Table 1.1 recaps the main empirical specifications of equation (1.5.2) for different measures of austerity (consolidation dummy/ CAPB) and the market assessment of the ratings' information (correlation between yields and ratings/ yield shocks). In the table I also report the expected sign of the coefficient according to the implications of the model in section 1.4.2.

Table 1.1: Main empirical specifications and expected sign.

		Independent variable: MARKET ASSESSMENT RATINGS' INFORMATION	
		Correlation	*Yield Shocks*
Dependent variable: AUSTERITY	*Consolidation dummy*	negative	positive
	Cyclically adjusted primary balance	negative	positive

1.5.1 Dataset and description of the variables

The dataset contains observations at annual frequency for 58 countries over 32 years (1980–2011). Countries covered principally include OECD countries, as well as a selection of emerging market economies. For a complete list of countries and the range of years covered see appendix 1.7.9. The economic variables included in the dataset are obtained from the World Economic Outlook (IMF) 2013; the definitions and calculation methods are found in appendix 1.7.11. These include the following fiscal variables: *Net lending/ borrowing, Primary surplus/ deficit, CAPB,* and *Government expenditure.* Positive values of these variables - except expenditure - mean that the government is saving and negative values indicate that it is borrowing. Hence, increased fiscal austerity is represented by a positive change in savings/ deficit or a negative change in expenditure.

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

were transformed into a numerical variable. I assigned each rating and modulation of the rating (outlook/ rating watch) a number on a scale ranging from 0 (default) to 52 (maximum grade). The final *Rating* variable was obtained taking an annual average of the three ratings (if available). Since each sampled country received an initial sovereign rating at different points in time, the resulting panel is unbalanced.[25]

1.5.2 Evidence on 'signaling austerity'

Results using the Correlation as the independent variable

The results presented below correspond to the first column of the specifications in table 1.1: ρ_t is proxied with the correlation variable throughout this section.

First, I use the consolidation episodes as a measure of austerity and I estimate equation (1.5.2) by probit:

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

where $Consolidation_{i,t}$ is a dummy variable from Devries et al. (2011), that takes the value 1 if the country fiscally consolidates in that year and 0 if it does not; $Corr_t$ is the correlation[26] variable estimating ρ_t; and $X_{i,t-1}$ are one-period-lagged control variables (*Net lending over GDP, Squared primary surplus, Debt over GDP, Squared debt over GDP, Log fiscal GDP, Log GDP per capita* and *Growth*). The specification includes country and year fixed effects.

The coefficient $\hat{\beta}_c = -13.5$ in table 1.2 is statistically different from zero. A lower correlation variable has a positive effect on the probability that the country is fiscally consolidating, as expected.

I also estimate equation (1.5.2), letting primary deficit be the measure of austerity, using OLS:

$$CAPB_{i,t} = \alpha + \beta_d Corr_t + \lambda X_{i,t-1} + \kappa_i + \epsilon_{i,t}. \tag{1.5.3}$$

The link from $Corr_t$ to $CAPB_{i,t}$ is hardly endogenous because the correlation is an aggregate measure. One country's austerity, $CAPB_{i,t}$, might affect its yields, which enter the calculation of the correlation. But this variable is a measure of the relation between all yields and all ratings in the sample, hence reverse causality from a given country's austerity

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

[26]Correlations are calculated using the Spearman method to preserve the order of the ratings without imposing a linear scale. Results from calculations using the Person correlation are also are available upon request.

<table>
<tr><td colspan="2" align="center">Table 1.2: Panel probit</td></tr>
</table>

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

Standard errors in parentheses

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

Table 1.3: OLS with robust standard errors

	CAPB
Correlation	-1.809**
	(0.805)
CAPB$_{t-1}$	0.758***
	(0.0461)
Primary surplus$^2_{t-1}$	0.000165
	(0.00152)
Debt$_{t-1}$	0.0575***
	(0.0136)
Debt$^2_{t-1}$	-0.000190***
	(0.0000569)
Log GDP$_{t-1}$	-1.055
	(0.919)
Log GDPpc$_{t-1}$	1.267
	(2.155)
Growth$_{t-1}$	1.992
	(3.557)
Country FE	Yes
Time FE	No
N	607
R-square	0.821
F	51.84

Standard errors in parentheses

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

$CAPB_{i,t}$ to the global $Corr_t$ is unlikely. As can be seen in table 1.3, the estimated coefficient $\hat{\beta}_d$ is negative and significant. The effect of a 1 point decrease in the correlation implies a 1.8 percentage points increase in cyclically adjusted primary surplus over GDP. Since the correlation is normalized to lie in the interval $[0, 1]$, this increase in austerity is difficult to interpret; hence, I use one standard deviation in the distribution of the $Corr_t$ variable as a benchmark. Such a change would be responsible for a quarter percentage point change in the structural deficit.

Robustness

I performed a series of robustness checks in order to assess whether results are consistent through changes in some measures and specifications. First, I discuss the choice about the measures of austerity. As mentioned in the introduction, there is no clear consensus about the definition of austerity but the one I propose in this paper[27] requires measuring the discretionary fiscal decisions made by the government . I opted for the narrative approach, in which Devries et al. (2011) identify episodes of fiscal consolidations through "policymakers' intentions and actions as described in contemporaneous policy documents." Their focus is on fiscal actions motivated primarily by deficit reduction as a response to past economic conditions. Hence this measure, by construction, is particularly well-suited for the analysis of discretionary fiscal policy. I also show an alternative proxy for austerity, based on a statistical measure, such as the CAPB. This is the most commonly used aggregate of discretionary fiscal policy. One might wonder, though, whether other fiscal variables are also in line with the results. I present three in table 1.4. Results are consistent with those in the previous section. The $Corr$ variable co-moves negatively with austerity, represented by larger surpluses and lower expenditures. Coefficients are larger than that of $CAPB$: a change in $Corr$ of one standard deviation is associated with up to 0.48pp in austerity.

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

$$Y_{i,t} = \alpha + \beta Corr_t^J + \gamma X_{i,t-1} + \kappa_i + \epsilon_{i,t} \ \forall i \notin J. \tag{1.5.4}$$

by OLS. In (1.5.4) the fiscal position $Y_{i,t}$ cannot affect $Corr_t^J$ as a consequence of the computation method because the correlation is calculated for a different subsample. Table 1.5 shows that the effect found in the previous regressions still holds.

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[27]A lower debt choice than that of the full information solution due to the signaling motive (see the definition of *'austerity for signaling purposes'* on page 11).

Table 1.4: OLS with robust standard errors

	Net lending	Primary surplus	Expenditure
Correlation	-3.562***	-2.913***	3.260***
	(0.883)	(0.839)	(0.786)
Net lending$_{t-1}$	0.740***		
	(0.0503)		
Primary surplus$_{t-1}$		0.723***	
		(0.0485)	
Expenditure$_{t-1}$			0.757***
			(0.0409)
Primary surplus$^2_{t-1}$	0.00717	0.00653	-0.00580
	(0.00474)	(0.00452)	(0.00560)
Debt$_{t-1}$	0.0893***	0.112***	-0.0649***
	(0.0158)	(0.0161)	(0.0155)
Debt$^2_{t-1}$	-0.000358***	-0.000448***	0.000267***
	(0.0000742)	(0.0000775)	(0.0000704)
Log GDP$_{t-1}$	-0.929	-1.818**	0.328
	(0.784)	(0.826)	(0.777)
Log GDPpc$_{t-1}$	1.825	2.712	-0.696
	(2.150)	(2.155)	(2.199)
Growth$_{t-1}$	13.55***	12.28***	-10.59***
	(4.189)	(4.095)	(4.002)
Country FE	Yes	Yes	Yes
N	741	740	741
r2	0.764	0.730	0.960
F	38.72	32.82	862.2

Standard errors in parentheses

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

Table 1.5: OLS with robust standard errors

	Consolidation	Net lending	Primary surplus	CAPB	Expenditure
Correlation^J	-1.745**	-2.566**	-3.492***	-1.547*	1.628*
	(0.827)	(1.041)	(1.007)	(0.874)	(0.937)
Net lending$_{t-1}$		0.672***			
		(0.0693)			
Primary surplus$_{t-1}$			0.572***		
			(0.0908)		
CAPB$_{t-1}$				0.729***	
				(0.0791)	
Expenditure$_{t-1}$					0.797***
					(0.0478)
Primary surplus$^2_{t-1}$		0.000522	-0.000698	-0.00694	0.00208
		(0.00556)	(0.00501)	(0.00775)	(0.00610)
Debt$_{t-1}$	0.0541**	0.0505*	0.0713***	0.0446**	-0.0352
	(0.0215)	(0.0286)	(0.0266)	(0.0185)	(0.0238)
Debt$^2_{t-1}$	-0.000102	-0.000147	-0.000268*	-0.000122	0.0000570
	(0.0000956)	(0.000156)	(0.000149)	(0.0000827)	(0.000126)
Log GDP$_{t-1}$	1.460	0.316	-0.222	-0.660	-1.673**
	(1.019)	(0.960)	(0.979)	(1.184)	(0.838)
Log GDPpc$_{t-1}$	-6.899**	-1.976	-0.510	0.0944	5.574**
	(2.781)	(2.812)	(2.816)	(2.883)	(2.457)
Growth$_{t-1}$	-2.230	2.894	3.120	1.181	0.0566
	(5.927)	(5.141)	(5.269)	(5.891)	(4.130)
Country FE	Yes	Yes	Yes	Yes	Yes
N	217	465	464	286	465
r2		0.632	0.664	0.802	0.961
F		30.60	29.08	49.22	1123.1

Standard errors in parentheses

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

Next, I instrument $Corr_t$ in (1.5.3) with two instruments: the annual stock prices of the company Moody's and the number of negative news about the CRAs. Moody's is one of the big rating agencies and it is quoted in the stock exchange since 1998 (ticker: MCO). I retrieved information on its stock prices (yearly averages) from Bloomberg. I also collected the number of news counts in major distribution newspapers (in English) that contain a negative view of the rating agencies from the LexisNexis database.[28]

The first underlying assumption is that Moody's stock price reflects the ability of the agency to assign informative ratings. The second assumption is that the opinion of experts and the media on the rating agencies' ability is informative. The relevance of these variables to explain the $Corr_t$ can further be assessed by looking at the results of the first stage instrumental variables regression in the table in appendix 1.7.12. On the other hand, neither Moody's stock price nor the critical opinions about the rating agencies should directly affect any given country's willingness to implement austerity; it should only affect this willingness indirectly through the effect they have on the correlation via the signaling channel. In table 1.6 results are confirmed for several austerity measures and the magnitude of the effect is larger than in the previous estimations.

Further, I also exploit the time-series dimension of the data by substituting $Corr_t$ with its one period lag. Since the correlation at $t-1$ is predetermined when looking at it from the current period, it cannot be affected by the austerity that takes place at period t. $X_{i,t-1}$ contains the lagged dependent variables (*Net lending, Primary surplus, CAPB, Expenditure*), *Debt over GDP, Squared debt over GDP, Log fiscal GDP, Log GDP per capita* and *Growth*. In order to deal with possible error autocorrelation, regression (1.5.3) has been estimated using the Arellano-Bond GMM estimator.[29] The $Corr_{t-1}$ is instrumented with further lags of the same variable. As reported in table 1.7, there is no autocorrelation left in the residuals. I also apply the correction for small samples. Results in table 1.7 confirm the previous ones and are significant. Robust estimators are used to correct for heteroskedasticity.

Results using the Yield Shocks as the independent variable

Here I present the results of the estimation corresponding to the specifications in the second column of table 1.1. The independent variable in this section is the *Yield Shocks*. The

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[28]Search 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.

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

Table 1.6: IV regression results

	Net lending	Primary surplus	CAPB	Expenditure
Correlation$_{t-1}$	-18.49***	-18.04***	-4.092*	14.44***
	(3.377)	(3.790)	(2.418)	(2.928)
Net lending$_{t-1}$	0.504***			
	(0.0387)			
Primary surplus$_{t-1}$		0.534***		
		(0.0393)		
CAPB$_{t-1}$			0.630***	
			(0.0382)	
Expenditure$_{t-1}$				0.542***
				(0.0385)
Debt$_{t-1}$	0.0674***	0.110***	0.0515***	-0.0514***
	(0.0194)	(0.0208)	(0.0137)	(0.0170)
Debt$^2_{t-1}$	-0.0000956	-0.000231**	-0.0000983	0.0000908
	(0.0000927)	(0.0000957)	(0.0000624)	(0.0000806)
Log GDP$_{t-1}$	-0.799	-2.040***	-1.800***	0.0419
	(0.728)	(0.747)	(0.495)	(0.632)
Log GDPpc$_{t-1}$	5.418***	7.459***	1.602	-0.421
	(1.768)	(2.227)	(1.377)	(1.522)
Growth$_{t-1}$	4.943	1.958	2.564	-3.265
	(3.914)	(4.471)	(2.899)	(3.396)
Country FE	Yes	Yes	Yes	Yes
N	611	541	513	611
R-square	0.726	0.722	0.807	0.955
F	27.98	25.93	40.55	212.9

Standard errors in parentheses

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

Table 1.7: GMM with robust standard errors

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

Standard errors in parentheses

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

following specification:

$$Y_{j,k,t} = \alpha + \gamma_d\,Yield\ Shocks_{j,k,t-1} + \lambda X_{j,t-1} + \kappa_j + \tau_t + u_{j,t}, \qquad (1.5.5)$$

estimates how the number of extreme yield events in a rating category affects the fiscal position of the countries in that rating category in the next period.

Table 1.8: Panel probit

	Consolidation dummy
Yield shocks	0.389*
	(0.211)
Net lending$_{t-1}$	-0.306***
	(0.0527)
Primary surplus$^2_{t-1}$	-0.0112
	(0.00907)
Debt$_{t-1}$	0.0152
	(0.0208)
Debt$^2_{t-1}$	0.0000294
	(0.000102)
Log GDP$_{t-1}$	2.066
	(1.262)
Log GDPpc$_{t-1}$	-7.147**
	(3.216)
Growth$_{t-1}$	11.91**
	(6.070)
Country FE	Yes
N	335
Chi-square	83.58
Loglikelihood	-130.8

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note that the definition of *Yield Shocks* in equation (1.5.1) does not include country j's own yields events; it contains only information about other countries in the same rating category. Moreover, in order to be more careful, the independent variable is lagged one period. Finally, I also exclude from the estimation those countries experiencing a yield event

Table 1.9: OLS with robust standard errors

	Net lending	Primary surplus	CAPB	Expenditure
Yield shocks$_{t-1}$	0.533***	0.601***	0.294**	-0.247**
	(0.154)	(0.166)	(0.116)	(0.118)
Net lending$_{t-1}$	0.684***			
	(0.0416)			
Primary surplus$_{t-1}$		0.738***		
		(0.0412)		
CAPB$_{t-1}$			0.725***	
			(0.0521)	
Expenditure$_{t-1}$				0.762***
				(0.0299)
Debt$_{t-1}$	-0.00823	0.0000688	-0.00352	0.0120**
	(0.00580)	(0.00586)	(0.00532)	(0.00552)
Log GDP$_{t-1}$	-1.467**	-1.981***	-2.267**	1.089*
	(0.682)	(0.727)	(0.963)	(0.640)
Log GDPpc$_{t-1}$	0.714	2.430	3.098*	1.329
	(1.466)	(1.640)	(1.823)	(1.361)
Growth$_{t-1}$	5.198	0.501	5.121	-4.315
	(3.792)	(4.170)	(6.206)	(3.534)
Rating$_{t-1}$	-0.0837**	-0.0776*	-0.0684*	0.0418
	(0.0372)	(0.0431)	(0.0380)	(0.0341)
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	885	772	653	885
r2	0.838	0.831	0.870	0.978
F	45.85	40.75	99.59	783.4

Standard errors in parentheses

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

or a rating change between $t-1$ and t. The objective is that the yield shocks are exogenous to the countries' fiscal position $Y_{j,k,t}$ and the effect on austerity comes from the change in information alone. $X_{j,t}$ includes the usual controls and the lagged ratings.[30]

The regression results for this specification are presented in tables 1.8 (independent variable: consolidation dummy) and 1.9 (independent variables: net lending, primary surplus, CAPB, expenditure). Note that when more countries in your rating category are subject to a yield event, it means a larger number in the variable $Yield\ Shocks_{i,k,t}$. Hence, an increase in the explanatory variable is associated with more austerity (an increase in the probability of a fiscal consolidation, $\hat{\gamma}_c > 0$, or higher values in the primary surplus, $\hat{\gamma}_d > 0$) as expected. This approach confirms the results from previous sections. Experiencing a yield shock in your rating category increases the austerity over GDP on the order of one half percentage points of net borrowing or primary deficit and about one quarter of CAPB. For example, the primary deficit over GDP would go from 3.5% to 3%.

1.5.3 Alternative explanations

There could be alternative theories explaining the empirical results. I list a selection and discuss them in this section.

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

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

$$Y_{i,t} = \alpha + \beta Corr_t + \gamma X_{i,t-1} + \kappa_i + \epsilon_{i,t}, \tag{1.5.6}$$

where in reality $\epsilon_{i,t} = Z_t + u_{i,t}$ and $Corr(X_{i,t-1}, Z_t) \neq 0$. Then, $Corr(X_{i,t-1}, \epsilon_{i,t}) \neq 0$ and estimation by OLS would produce biased coefficients. Concerns about omitted variables, e.g. global uncertainty, are addressed by including country and time fixed effects in the last specification (1.5.5). The effect of changes in information on austerity remains after the omitted variables are controlled for.

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

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[30]In order to control for any other domestic reason that affects the fiscal stance.

yield events operating at the level of the rating category and we would be unsure whether we were capturing the correct effect. For example, think about precautionary savings by countries within a rating category triggered by uncertainty clustered at the category level. Note, though, that the precautionary motive should be homogenous in all countries within a given category. But austerity by category shows high dispersion. This indicates that austerity is not implemented 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 signaling motive.

The results obtained here could also be attributed to contagion. A shock to a country is transmitted to others, even if they are not directly hit. By the nature of contagion, it cannot be captured by controlling for the fundamentals of the country as I did before. In order to detect contagion among countries, the literature usually relies on price co-movements, thus implying that contagion should matter-of-factly show in the price of debt. Controlling for the country's own lagged log yields and the lagged rating in specification (1.5.5), as I do in appendix 1.7.13, I still find an effect of changes in the ratings information content.

One issue that remains is that we cannot predict what each type does because types are not observable (neither in theory nor in the data). But we can work around that in the following ways: one is to use regional sub-samples. I repeat the same regression (1.5.2) on the sample split by regions (OECD countries, European Union countries, peripheral European countries 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 peripheral countries and it is not significant for emerging markets (see appendix 1.7.14 for further details). According to the model, this would be expected if there were a higher proportion of type B countries in these two groups relative to the OECD and EU groups.

Another way is to use a two-stage strategy. In a first stage, I find the proximity to being a 'good type' based on past observable information, where 'good' is defined tautologically as those countries overshooting austerity from that predicted by the fitted regression (1.5.5). In the second stage I can use the predicted proximity to good type/ austerian to explain the CAPB. It turns out that the more the observable variables predict a country to behave as a 'good' type in a certain year, the higher its out of sample austerity really is (coefficient: 1.201, standard deviation: 0.177).[31]

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

1.6 Conclusion and policy discussion

In this paper I show that a sovereign may use fiscal policy as a signal to communicate its ability to repay public debt. In the empirical analysis I find that sovereigns adopt a more austere fiscal policy when the credit ratings are less informative about a country creditworthiness. This result is robust to different empirical strategies, specifications and measures of austerity. The evidence favors the signaling channel over other alternative explanations.

The findings in this paper are relevant for policymakers wishing to implement austerity programs in order to reduce the risk of a sovereign default. For instance, during the recent debt crisis several European countries adopted a common debt ceiling.[32] In my model this policy is equivalent to setting an exogenous debt limit that is the same for any country type. The introduction of a debt limit may make the optimal choice of debt unfeasible if it is stringent enough. Hence, it triggers a change in the equilibrium that prevails. If the undefeated equilibrium is separating, both countries are worse off because they cannot choose their constrained optimal debt level and the incentive compatibility constraint of the less able country is harder to satisfy. If the undefeated equilibrium is pooling, instead, both types are still worse off, otherwise they could have chosen to pool at that debt level in the unrestricted set-up. In some cases, as in the example in appendix 1.7.15, the overall riskiness of debt increases. A 'one-size-fits-all' austerity program, such as the Fiscal Compact, may backfire when countries are trying to signal with austerity.[33]

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[32]The Fiscal Compact introduced the rule of fiscal budget balance in its Article 3 of Title II.

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

1.7 Appendix

1.7.1 The single crossing property

The *single crossing condition* of indifference curves is defined as a ranking of the slopes of the indifference curves $U^i(D_2, q)$ such that $\Delta^A(D_2, q) < \Delta^B(D_2, q)$ for all D_2, q in the relevant range, where $\Delta^i(D_2, q) := -\frac{\frac{\partial U^i(D_2,q)}{\partial D_2}}{\frac{\partial U^i(D_2,q)}{\partial q}}$. Let us show that the indifference curves of country type A are flatter than those of country type B. First, let us define the relevant range of D_2. Let $\underline{D}_2^i$ be the threshold level of debt that satisfies constraint (1.2.5) for $t = 1$ for each type:

$$\underline{D}_2^i = \frac{\underline{c}^i - \omega_1 + D_1}{\beta' \left[1 - F(\underline{D}_2^i + \underline{c}^i)\right]}. \tag{1.7.1}$$

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

$$\underline{D}_2^i = \frac{\underline{c}^i - \omega_1 + D_1}{\beta'} e^{h(\underline{c}^i - \omega)} e^{h \underline{D}_2^i}. \tag{1.7.2}$$

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

Next, let us compute $\Delta^i(D_2, q)$ for each type. Total differentiation of equation (1.2.6) 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, $\Delta^i(D_2, q) = -\frac{q - \beta\left(1 - F(D_2 + \underline{c}^i)\right)}{D_2}$ and $\Delta^A(D_2, q) < \Delta^B(D_2, q)$ if $\Delta^i(D_2, q) < 0$, which is the case for all $D_2 \in [\underline{D}_2^B, 0)$ given assumption (A4). $\qquad \square$

1.7.2 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 (1.3.2) with respect to D_2 and rearranging gives:

$$F'' \left(D_2 + \underline{c}^i \right) \left[-\beta' D_2 - \beta' \frac{F' \left(D_2 + \underline{c}^i \right)}{F'' \left(D_2 + \underline{c}^i \right)} + (\beta' - \beta) h^{-1} \right]. \tag{1.7.3}$$

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 (1.7.3) 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,

$$D_2 < \frac{\beta' - \beta}{\beta' h} + \frac{1}{h}. \tag{1.7.4}$$

The derivative of the FOC is negative when (1.7.4) holds. Since $D_2^{FI} = \frac{\beta' - \beta}{\beta' h}$ and $h > 0$, the expression (1.7.3) is negative at D_2^{FI} and D_2^{FI} is a local maximum. $\qquad \square$

1.7.3 Separating equilibrium

We show that the allocation $\left[\left(D_2^{-B}, q(D_2^{-B}, 1) \right), \left(D_2^{FI}, q(D_2^{FI}, 0) \right) \right]$, along with beliefs $\mu^* \left(D_2^{-B} \right) = 1$, and $\mu^* \left(D_2 \right) = 0$ for $D_2 \neq D_2^{-B}$, constitutes a separating equilibrium outcome. Recall that D_2^{-B} is the debt level that satisfies type B's incentive compatibility constraint (1.3.5) with equality:

$$U^B(D_2^{-B}, q(D_2^{-B}, 1)) = U^B(D_2^{FI}, q(D_2^{FI}, 0)). \tag{1.7.5}$$

Let $D_2^{A,B}$ be the debt level most preferred by type A under the price schedule $q(D_2, 0)$.

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

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

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

to the left of D_2^{FI}:

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

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

It remains to be proven 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, note that the full information allocation is optimal for type B, hence, it is its highest isoutility curve under the $q(D_2, 0)$ schedule. It follows that the price schedule $q(D_2, 0)$ must lie below B's isoutility curve going through the full information allocation for all $D_2 \neq D_2^{FI}$. So, in order to satisfy the tangency condition of $D_2^{A,B}$ for type A, the allocation $(D_2^{A,B}, q(D_2^{A,B}, 0))$ must be below the isoutility curve of B going through $(D_2^{FI}, q(D_2^{FI}, 0))$. And, given that the isoutility curves of A in (D_2, q) are steeper than those of B for any D_2, the two can only cross to the right of $D_2^{A,B}$. Since they cannot cross to the left of $D_2^{A,B}$ it is impossible that $(D_2^{A,B}, q(D_2^{A,B}, 0))$ is on a higher isoutility curve of A than $(D_2^{-B}, q(D_2^{-B}, 1))$. Otherwise, it would be preferred by B as well and that is a contradiction to (1.7.5). $\qquad\square$

1.7.4 Pooling equilibrium at D_2^{FI}

In order to show that there can be a pooling equilibrium at the full information debt level, note that B's utility level pooling at $(D_2^{FI}, q^*(D_2^{FI}, p))$ must be higher than the full information allocation $(D_2^{FI}, q^*(D_2^{FI}, 0))$ because the debt level is the same but the price is better. Since $\mu^*(D_2) = 0$ for any $D_2 \neq D_2^{FI}$, type B's optimal choice of $D_2^*(B)$ is D_2^{FI}. At the same time, A's utility at $(D_2^{FI}, q^*(D_2^{FI}, p))$ also needs to be higher than at its preferred allocation under the $q(D_2, 0)$ schedule, $(D_2^{A,B}, q(D_2^{A,B}, 0))$. By contradiction, for $(D_2^{A,B}, q(D_2^{A,B}, 0))$ to be preferred, U^A going through it must cross $q(\cdot, p)$ at some point between $D_2^{A,B}$ and D_2^{FI}. At $D_2^{A,B}$, $q(D_2^{A,B}, p) > q(D_2^{A,B}, 0)$ and, as $D_2 \to \infty$, 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 1.7.2. Hence, they cannot cross to the right of $D_2^{A,B}$, and D_2^{FI} is type A's optimal choice. To sum up, D_2^{FI} is the optimal choice of both A and B given the system of beliefs and, therefore, by Bayes' rule, $\mu = p$ at D_2^{FI}. $\qquad\square$

1.7.5 Definition of the Undefeated Equilibrium refinement

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

1. D_2' is a non-equilibrium outcome in e^*.

2. $\Theta = \{\{A\}, \{B\}, \{A, B\}, \{\emptyset\}\}$ is the set of types that choose strategy D_2' in e'.

3. Denoting $U^i(e)$ the utility of type i under equilibrium e:

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

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

4. The off-equilibrium beliefs after observing D_2' in e^*, $\mu^*(D_2')$, are positive for the type(s) with a strict inequality and zero for the type(s) not belonging to Θ,

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

1.7.6 Selection of the separating equilibrium e^*

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

a) e^* is defeated if there is an equilibrium e' whose μ' at D_2' is not consistent with e^*. Note that this can only happen:

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

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

Thus, $q(D_2, p) < \mathbf{q}(D_2, \bar{U}^A)$, where $\bar{U}^A = U^A \left(D_2^{-B}, q(D_2^{-B}, 1)\right)$, is the condition for e^* to survive.[34] The condition holds for a sufficiently low p:

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

For example, for $\beta' = 1$, $\beta = 0.6$, $\underline{c}_A = 0$, $\underline{c}_B = 1$, $h = 1$ and $D_1 - \omega_1 = 0$, any $p < 1$ would work.

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

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

1.7.7 Selection of the pooling equilibria

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

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

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

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

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

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

□

1.7.8 Multiple-period model

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

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

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

$$\max_{D', c} \quad c + \beta \int_{\underline{\omega}}^{\infty} u(D', \omega', \underline{c}') f(\omega') d\omega' \tag{1.7.6}$$

subject to

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

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

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

$$\max_{D'} \quad u(D, \omega, \underline{c}) + q(D', \mu(D'))D' + \beta \int_{\underline{\omega}}^{\infty} u(D', \omega', \underline{c}') f(\omega') d\omega' \tag{1.7.7}$$

$$= u(D, \omega, \underline{c}) + W_1(\underline{c}', \mu), \tag{1.7.8}$$

where

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

This formulation emphasizes an important stationary property of our model with linear

preferences: the decision of future debt is only function of the type the borrower knows at the moment of re-payment. In particular, it does not depend on the initial outstanding debt or the previous type of the borrower. The simple default condition arises from the assumption that there is no dynamic punishment for default. We now move to three periods. We assume that types c_t^i are drawn independently across time, with support $\{A, B\}$ and probability p and $1 - p$, respectively. We can consider the previous two-period model as the last two periods of a three-period model. Assuming the lender beliefs schedule - and hence the price schedule q - is time constant, we can define

$$V_2(D, \omega, \underline{c}, \mu) := u(D, \omega, \underline{c}) + pW_1(\underline{c}^A, \mu) + (1 - p)W_1(\underline{c}^B, \mu) \qquad (1.7.9)$$

We can hence define the function W_2 recursively as follows:

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

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

$$V_t(D, \omega, \underline{c}, \mu) = u(D, \omega, \underline{c}) + pW_{t-1}(\underline{c}^A, \mu) + (1 - p)W_{t-1}(\underline{c}^B, \mu),$$

where for all $\underline{c} \in \{c^A, c^B\}$:

$$W_{t-1}(\underline{c}, \mu) = \max_D \quad q(D, \mu(D))D + \beta \int_{\underline{\omega}}^{\infty} V_{t-1}(D, \omega, \underline{c}, \mu)f(\omega)d\omega.$$

In other terms, if we exclude the fact that the number of remaining periods decreases, each period can be seen as any other one with different initial conditions. The default decision will be always determinate by the difference $\omega - D$, justifying the stationarity of the price schedule q. In our linear set-up, the initial conditions do not affect the shape of the indifference curve (as they only shift them in a parallel fashion). Both the full information optimal debt level, $D^{FI} = \frac{\beta' - \beta}{\beta' h}$, and the condition for the separating equilibrium debt level, D^{-B}: $U^B(D^{-B}, q(D^{-B}, 1)) = U^B(D^{FI}, q(D^{FI}, 0))$ remain the same. The single crossing condition property is also maintained, hence, the solution to the problem between any two periods.

1.7.9 The ratings geography and time span

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

1.7.10   Yield Events

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

1.7.11   Dataset: definition of variables

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

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

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

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

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

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

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

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

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

1.7.12 First stage IV regressions

Table 1.10: OLS with robust standard errors

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

Standard errors in parentheses

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

1.7.13 Robustness check for contagion

Table 1.11: OLS with robust standard errors

	Net lending	Primary surplus	CAPB	Expenditure
Yield Shocks$_{t-1}$	0.459***	0.468***	0.249**	-0.265**
	(0.157)	(0.166)	(0.122)	(0.128)
Net lending$_{t-1}$	0.724***			
	(0.0426)			
Primary surplus$_{t-1}$		0.753***		
		(0.0410)		
CAPB$_{t-1}$			0.720***	
			(0.0554)	
Expenditure$_{t-1}$				0.770***
				(0.0344)
Debt$_{t-1}$	0.0198	0.0510***	0.00951	0.00266
	(0.0123)	(0.0133)	(0.0107)	(0.0123)
Debt$_{t-1}^2$	-0.000161***	-0.000249***	-0.0000845*	0.0000686
	(0.0000470)	(0.0000498)	(0.0000488)	(0.0000477)
Log GDP$_{t-1}$	-1.784**	-2.430***	-2.424**	1.177
	(0.816)	(0.812)	(1.150)	(0.794)
Log GDPpc$_{t-1}$	1.881	4.002**	2.876	0.858
	(1.635)	(1.894)	(2.042)	(1.585)
Growth$_{t-1}$	5.182	2.142	8.253	-5.805
	(3.936)	(4.450)	(6.371)	(3.930)
Rating$_{t-1}$	-0.116**	-0.0976*	-0.0594	0.0781*
	(0.0473)	(0.0550)	(0.0479)	(0.0431)
Log yields$_{t-1}$	0.00670	0.617	0.827	0.441
	(0.455)	(0.535)	(0.583)	(0.407)
Country	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	748	658	598	748
R-square	0.849	0.845	0.846	0.979
F	41.58	43.36	.	661.5

Standard errors in parentheses

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

1.7.14 Regression by country groups

Table 1.12: OLS with robust standard errors

Effect of a 1 unit change in $Corr_t$ in:	(1) OECD	(2) EU	(3) PERIPHERALS	(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
R-square	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
R-square	0.752	0.712	0.733	0.731
F	39.80	32.87	13.86	44.28
Potential structural balance	-0.0107*	-0.0105	-0.0574**	-0.0220
	(0.00645)	(0.00856)	(0.0243)	(0.0182)
N	535	397	93	96
R-square	0.848	0.852	0.857	0.853
F	59.24	43.61	22.59	70.95
Government spending	0.0246***	0.0278**	0.0425	0.0246
	(0.00906)	(0.0122)	(0.0282)	(0.0310)
N	535	397	93	96
R-square	0.942	0.928	0.840	0.975
F	399.3	249.0	62.09	302.8

Standard errors in parentheses

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

1.7.15   Introduction of a common debt limit

In this section I analyze the effect of setting an exogenous common debt limit. This policy only has an effect when the debt ceiling $\bar{D}_2$ is lower than type B's full information allocation D_2^{FI}, as in figure 1.7. Suppose the equilibrium is the separating one e^*. Once the debt ceiling is introduced, type B is not allowed to choose its optimal debt level because it would violate the fiscal rule. In a separating equilibrium under the new debt ceiling rule, type B chooses the highest amount of debt possible, $\bar{D}_2$, as depicted in figure 1.8. But this gives type B a lower utility, thereby forcing type A to choose an even lower amount of debt than D_2^{-B}. Type A needs to implement more austerity in order to avoid imitation from B because the outside option for B has become worse. Both types are worse off, even though the riskiness of debt improves because the sovereigns have a lower default probability.

Nevertheless, the introduction of a debt limit might let the separating equilibrium be defeated. For instance, the pooling equilibrium at $\bar{D}_2$ in figure 1.9 makes both types better off, thus defeating the separating equilibrium. Compared with the initial equilibrium e^* in figure 1.7, 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 1.7 represented by the dotted lines. Moreover, type B's default premium decreases but A's increases, as the arrows on the vertical axis show, thus the overall probability of default may increase or decrease. All countries can be made worse off by the introduction of a debt ceiling, which also fails to improve the riskiness of debt.
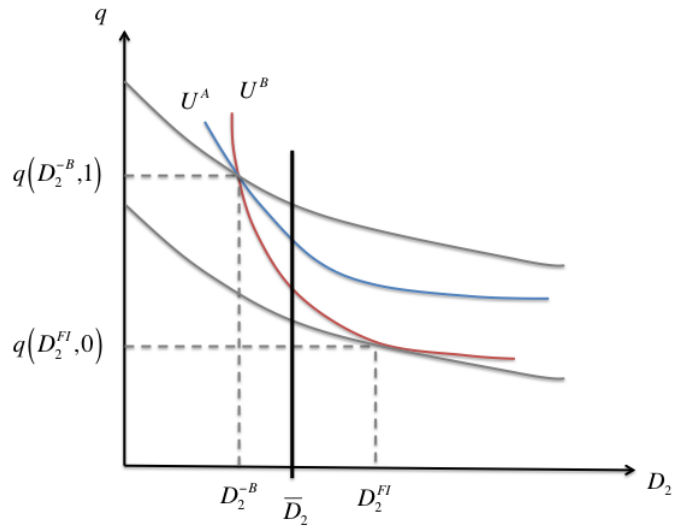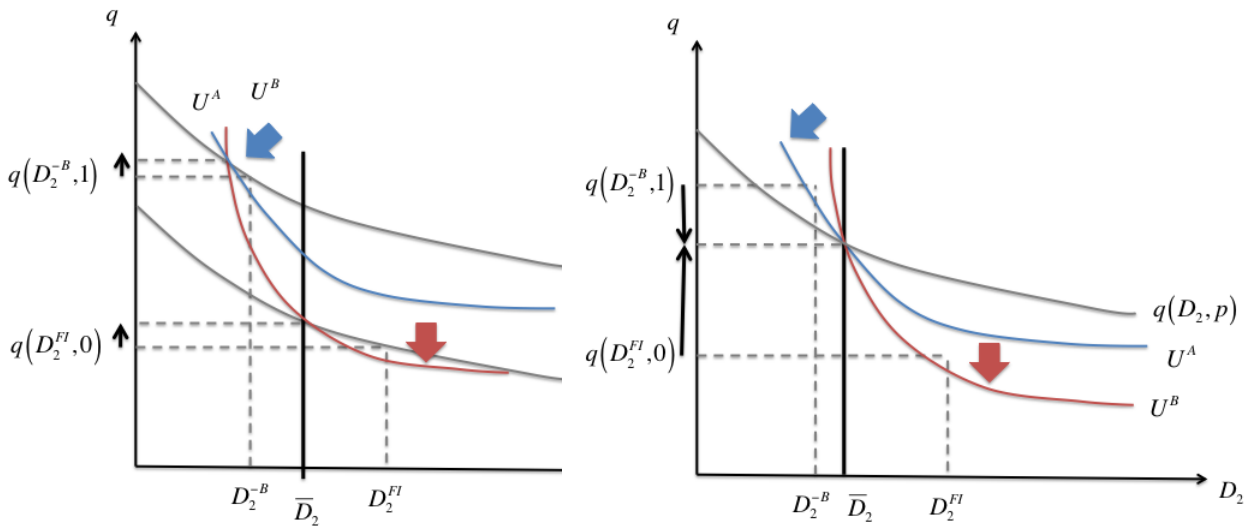
Figure 1.7: A common debt ceiling at $\bar{D}_2$.

Figure 1.8: Separating equilibrium with a common debt ceiling.

Figure 1.9: Pooling equilibrium with a common debt ceiling.

Chapter 2

Unsolicited Sovereign Ratings and Market Selection

2.1 Introduction

Unsolicited ratings are opinions about the creditworthiness of the borrower that are not initiated nor paid for by the issuer. Standard and Poor's (S&P) has been issuing unsolicited ratings since 1996. Moody's and Fitch - the other two biggest rating agencies - have been doing it as well.[1] Since the majority of the rating agencies (CRAs) receive compensation from the issuer, one could wonder why the rating agencies would want to issue a rating for which they do not receive fees.

Fulghieri et al. (2014) propose a strategic motivation for unsolicited ratings. They argue that unsolicited ratings can be used as threat to pressure issuers towards solicitation. This model implies that unsolicited ratings have to be lower on average than solicited ones and this fact is consistent with the empirical literature.[2]

Further evidence on the difference between solicited and unsolicited ratings is brought by Bannier et al. (2010). They compare the *ex-post* default probabilities of similar non-U.S. borrowers with solicited and unsolicited S&P ratings between January 1996 and December 2006 and find that, conditional on a rating, default probabilities are different across the two groups. The unsolicited rating group has lower default rates, which might be an indication that rating agencies choose to rate those borrowers more strictly compared to solicited ones.

Understanding whether lower unsolicited ratings are motivated by strategic considera-

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[1]At least since 2000 and 2001, respectively, Moody's and Fitch have recognised issuing unsolicited ratings (Behr and Guettler, 2008) but they were possibly doing it before that.

[2]Evidence that unsolicited ratings are associated with lower grades is broad in the empirical literature (Poon and Firth, 2005; Poon and Chan, 2010; Van Roy, 2013).

tions of the rating agencies is important for policy. For example, the rating agency Moody's had been subjected to an antitrust investigation in 1996 by America's Justice Department, which suspected that the agency's practice of issuing unsolicited ratings on companies might be "a way to force them to pay up for the full service" (The Economist, 2001).

In this paper, I argue that lower average unsolicited rating grades and a lower probability of default in unsolicited ratings vis-à-vis the same solicited ratings do not necessarily imply the strategic use of lower ratings by the rating agencies. Different types of firms might select themselves into soliciting or not soliciting ratings depending on their characteristics. For example, more solvent firms may reasonably expect higher grades on average and thus have more incentives to solicit a rating. Unsolicited ratings are, therefore, more likely to be assigned to lower quality firms.

An argument against the strategic motivation of the CRA for giving unsolicited ratings is the fact that, in the sovereign market, unsolicited ratings have higher grades - not lower - than solicited ones. Figure 2.1 reports the histograms of Moody's unsolicited and solicited sovereign grades between 2010 and 2015. The distribution of unsolicited ratings has more weight to higher grades compared to that of solicited ratings. The unconditional mean of
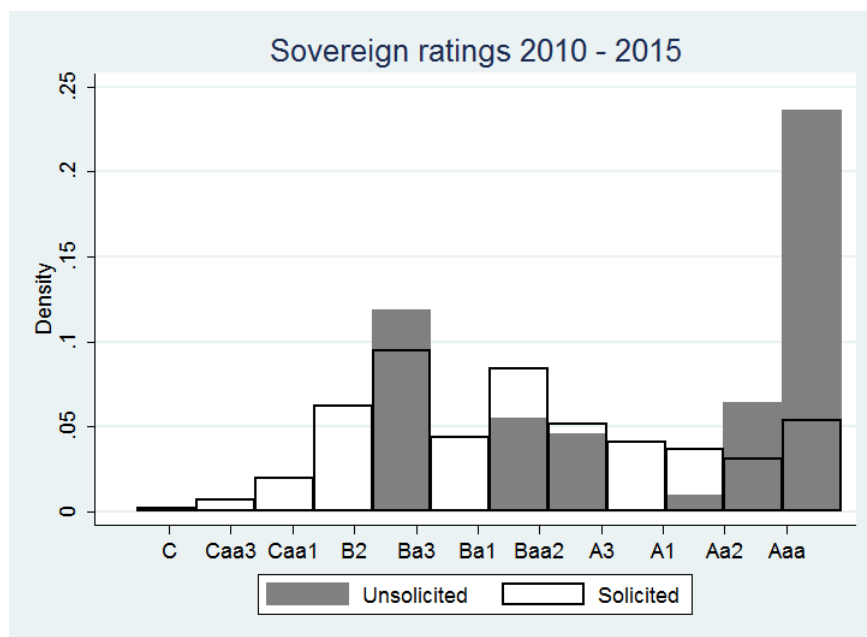
Figure 2.1: Histogram of solicited versus unsolicited rating grades. Source: Moody's, 2010 -2015.

solicited sovereign ratings is a Baa2 grade while that of unsolicited ratings is on average an A2 grade.[3] A Wilcoxon-Mann-Whitney test of the difference in means is significantly different

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[3]Moody's rating scale is, in decreasing order of credit quality: Aaa, Aa, A, Baa, Ba, B, Caa, Ca, C. Moody's adds numerical modifiers 1, 2, and 3 to each rating grade from Aa through Caa.

Figure 2.2: Moody's revenues by line of business from 2000 to 2007.

from zero as can be seen in table 2.1. The median values are also statistically different. More generally, equality of the distribution functions is rejected at the 99% confidence using a two-sample Kolmogorov-Smirnov test (K-S statistic: 0.4348).
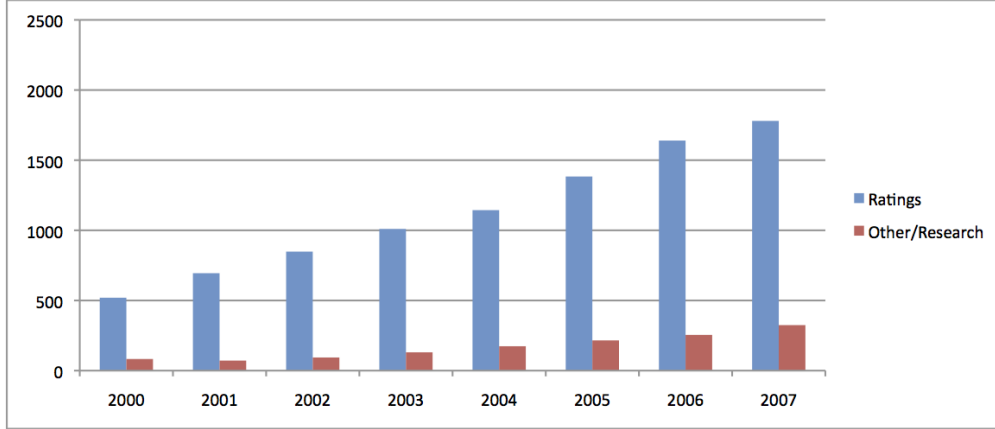
Table 2.1: Differences between sovereign mean and median grades for solicited and unsolicited ratings. Source: Moody's, 2010 -2015.

	difference in value	t-statistic	p-value
Mean	−3.89	−5.31	0.0000
Median	−8	20.46	0.0000

The fact that unsolicited sovereign ratings are higher on average calls for a model of market self-selection that is able to produce not only a downward bias but also an upward one, like the one I present here.

Credit rating agencies provide as well "ancillary services", a business that has been growing since the late 90s. Ancillary services "comprise market forecasts, estimates of economic trends, pricing analysis and other general data analysis as well as related distribution services" (ESMA, 2013). Since 2000 the share of revenues from the rating business went from a maximum of 90% (in 2002) to 70% (in 2015) versus an increasing share of ancillary services that reaches up to 30% (see figures 2.2 and 2.3). An example of ancillary service consists in providing the borrower with a forecast of the rating. Moody's Rating Assessment Service was launched in 2000 and charges a company 75.000 euros to know what its credit rating would be if it solicited one (The Economist, 2001). Feedback is provided only to the issuer and assessments are confidential until the issuer decides to announce them publicly. S&P also offers a similar service: the Ratings Evaluation System.

Literature. Fulghieri et al. (2014) introduce the first model of strategic motivation for unsolicited ratings. They see unsolicited ratings as an off-equilibrium threat, which is credible
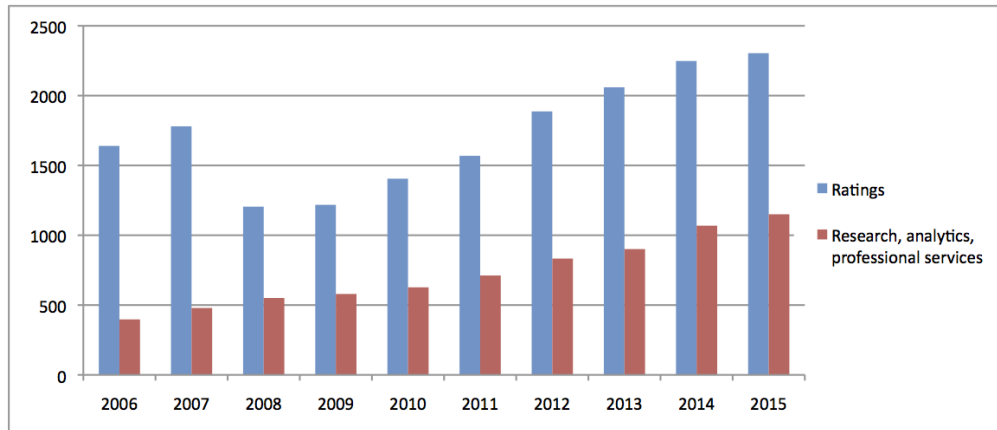
Figure 2.3: Moody's revenues by line of business from 2006 to 2015.

because it shows that the CRA fights the temptation to issue inflated ratings. Byoun (2014) presents a model of ratings where the existence of unsolicited ratings in equilibrium is not strategically motivated, it is granted by the assumption that the CRA has to produce a rating for each firm. In my model, rating agencies are interested in issuing unsolicited ratings because it improves visibility, allowing the CRA to charge higher fees on solicited ratings.

There is ample empirical evidence regarding the properties of unsolicited ratings (Poon and Firth, 2005; Poon and Chan, 2010; Van Roy, 2013; Bannier et al., 2010; Gan, 2004). None of them studies *sovereign* unsolicited ratings. As we will see below, descriptive statistics evidence indicate that, contrary to what has been found in other markets, unsolicited sovereign ratings have higher grades and are associated with lower bond yields compared to solicited ones. This contrasts with what has been found in the previous literature for banks, corporations and insurance companies (Behr and Guettler, 2008; Byoun, 2014; Klusak et al., 2015).

This paper sheds light on the relationship between different services provided by the rating agency. To the best of my knowledge, this is the first paper that considers the ratings and the ancillary services jointly. The business of ancillary services has received attention from the regulators, who advocated more transparency in order to avoid conflicts of interest.[4] Here I focus on their effect in the selection that arises in the market.

The paper is organized as follows. In the following section I present some stylised facts about the sovereign unsolicited ratings. In section 2.3, I set up a model of borrowing under incomplete information where the credit rating agencies may issue ratings, solicited as well as unsolicited, and provide ancillary services. I solve for the equilibrium, characterise

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[4]Regulation (EC) No 1060/2009 on credit rating agencies, amended by Regulation (EU) No 462/2013 of the European Parliament and of the Council of 21 May 2013.

the equilibrium outcomes and present the relationship to the empirical facts. Section 2.4 concludes.

2.2 Stylized facts about sovereign ratings

2.2.1 Unsolicited sovereign ratings are more frequent than in other markets

Unsolicited ratings are not issued homogeneously across market segments nor across regions. In 2000, the proportion of unsolicited ratings with respect to the total number of outstanding ratings varied between 6% and 27% in industrial countries, depending on rating agency and region (Bannier et al., 2010). In the US, unsolicited ratings are rare. In the European Union they are more numerous, especially in the segment of sovereign and public finance. Table 2.2 reports the number of ratings issued by each rating agency by solicitation status and for each market segment. In 2012, 12.24% of the sovereign and public finance ratings by the three biggest rating agencies in the EU was unsolicited, while only 4.95% of the corporate ratings, 3.33% of the financial and insurance institutions and 0% of the structured finance ratings (ESMA, 2013). The agencies Moody's and S&P gave in 2012 more unsolicited

		Fitch	Moody's	S&P
Corporate	Solicited	518	760	951
		82.48%	*99.48%*	*99.79%*
	Unsolicited	110	4	2
		17.52%	*0.52%*	*0.21%*
Financials and Insurance	Solicited	597	542	1006
		97.07%	*99.82%*	*94.82%*
	Unsolicited	18	1	55
		2.93%	*0.18%*	*5.18%*
Sovereign and Public Finance	Solicited	296	232	189
		83.38%	*93.93%*	*87.91%*
	Unsolicited	59	15	26
		16.62%	*6.07%*	*12.09%*
Structured Finance	Solicited	4861	4438	4705
		100.00%	*100.00%*	*100.00%*
	Unsolicited	0	0	0
		0.00%	*0.00%*	*0.00%*

Table 2.2: Ratings by solicitation status for different market segments in the EU in 2012. Source: ESMA.

rating to sovereigns than to other categories and Fitch to both sovereigns and corporates.

The majority of the other smaller rating agencies specialize in issuing only solicited or only unsolicited ratings (ESMA, 2013).

For the agency Moody's, the fraction of sovereigns that receive an unsolicited rating are distributed by grade as follows: 10.9% are high grades (investment grade) and 4.15% are low grades (below investment grade) as can be read from table 2.3.

Table 2.3: Fraction of sovereigns that receive an unsolicited rating by rating grade (Moody's, 2010-2015).

	Unsolicited	Observations
Grade Baa3 or above	10.9%	412
Grade below Baa3	4.15%	313

2.2.2 Unsolicited sovereign ratings are higher than solicited ones

In a sample of all the sovereign ratings issued by Moody's between 2010 and 2015,[5] I translated the rating grades into a numerical scale that goes from 1 (grade C) to 21 (grade AAA). If we control for some observable characteristics of the sovereigns (current account, debt over GDP, primary deficit, GDP per capita, inflation, direct investment and a set of regional and year dummies), having an unsolicited rating improves the rating grade by almost one and a half points with respect to a similar country that has paid for its rating. From a rating of Baa2, this would imply an upgrade to A3. The specification is similar to that of Gan (2004) and Van Roy (2013):

$$Rating_{i,t} = X_{i,t}\beta + \delta Solicitation_{i,t} + \epsilon_{i,t} \qquad (2.2.1)$$

but including time (year) as well as region (country) variation, where *Solicitation* is a dummy variable for the solicitation status that takes value 0 if the rating is solicited and 1 if it is unsolicited. Table 2.4 presents the estimated coefficient $\hat{\delta}$, which is positive and significant at the 1% level.

The first column does not include fixed effects. The estimated positive effect of receiving on unsolicited rating becomes larger and more significant once you include year fixed effects (column 2), country fixed effects (column 3) or both (column 4). The average rating grade is higher for unsolicited sovereign ratings.

Is this effect homogeneous along the rating scale? Table 5 reports three quantile regressions. The first column refers to the effect of solicitation on the rating grade for the first

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[5]The sample is obtained from reading the internal documents published by Moody's ("Unsolicited Ratings List") from its earliest release in September, 6 2010 to the latest in December 30, 2015.

Table 2.4: OLS with robust standard errors

| | (1) | (2) | (3) | (4) |
	Rating grade	Rating grade	Rating grade	Rating grade
Solicitation dummy	0.939*	1.489***	0.984**	1.469***
	(0.498)	(0.512)	(0.489)	(0.506)
Current account	0.135***	0.128***	0.134***	0.128***
	(0.0140)	(0.0140)	(0.0139)	(0.0139)
Debt	-0.0177***	-0.0214***	-0.0172***	-0.0207***
	(0.00427)	(0.00437)	(0.00425)	(0.00434)
Primary deficit	-0.211***	-0.196***	-0.209***	-0.194***
	(0.0320)	(0.0294)	(0.0322)	(0.0296)
GDP per capita	0.000152***	0.000143***	0.000151***	0.000143***
	(0.00000924)	(0.00000955)	(0.00000920)	(0.00000956)
Inflation	-0.151***	-0.145***	-0.156***	-0.150***
	(0.0201)	(0.0195)	(0.0221)	(0.0216)
Direct investment	0.136***	0.121***	0.135***	0.119***
	(0.0199)	(0.0215)	(0.0197)	(0.0214)
Region FE	no	yes	no	yes
Time FE	no	no	yes	yes
N	669	669	669	669
R-square	0.676	0.690	0.682	0.695
F	126.0	418.5	72.17	198.9

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

quartile (0.25) and its effect is the least significant and the smallest. The higher the rating grades (columns 2 and 3), the more sizeable the positive effect of unsolicited ratings.

Let us see which countries are likely to receive unsolicited ratings. The unconditional probability for an individual country of obtaining an unsolicited rating is 7.49% in my sample. It is more likely, though, for countries with a higher rating grade, more outstanding public debt over GDP and a higher GDP per capita. Controlling for other factors, being in the region of Europe or East Asia makes it less likely that a suitable candidate receives an unsolicited rating. This might be due to the fact that there are more countries in those regions that could potentially be candidates.

Table 2.5: Quantile regressions

	(1) Rating grade	(2) Rating grade	(3) Rating grade
Solicitation dummy	0.775*	1.371***	1.536***
	(0.409)	(0.461)	(0.451)
Current account	0.109***	0.142***	0.120***
	(0.0134)	(0.0161)	(0.0157)
Debt	-0.0177***	-0.0241***	-0.0225***
	(0.00331)	(0.00370)	(0.00415)
Primary deficit	-0.138***	-0.165***	-0.179***
	(0.0271)	(0.0302)	(0.0245)
GDP per capita	0.000127***	0.000175***	0.000196***
	(0.00000808)	(0.00000725)	(0.00000620)
Inflation	-0.202***	-0.134***	-0.134***
	(0.0139)	(0.0181)	(0.0216)
Direct investment	0.107***	0.155***	0.156***
	(0.0212)	(0.0208)	(0.0215)
Region FE	yes	yes	yes
Time FE	yes	yes	yes
N	669	669	669
Quantile	0.25	0.50	0.75
Residual degree freedom	651	651	651

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In order to see whether Moody's changed its criteria for rating countries unsolicitedly over time, I predicted the estimated probability that a country of certain characteristics receives an unsolicited rating for each year between 2010 and 2015.[6] As expected, countries rated unsolicitedly had a higher predicted probability of receiving an unsolicited rating. But other countries with solicited ratings were just as likely or more to receive an unsolicited rating, for example Austria, Belgium, Norway, Botswana, South Africa and Ghana. You can find the complete list of the sovereign unsolicited ratings in the first column in appendix 2.5.2. In the second column there is the list of sovereigns with a predicted probability of receiving

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[6]See appendix 2.5.1.

an unsolicited rating higher than the average predicted probability of the sovereigns in the first column. First, in 2010 and 2011, the profile were top quality sovereign borrowers in Europe. Later on, as the competition across CRAs got increasingly intense and Africa started issuing international debt more frequently, some relatively stable economies in that continent became natural candidates for unsolicited ratings as well.

2.2.3   Unsolicited sovereign ratings have lower associated debt yields

I merged the sample of Moody's unsolicited ratings between November 2010 and December 2015 with the long-term sovereign yields at the end of the month for the same period. I also have data on the outlook (negative, neutral or positive) at the end of the month. I use the following specification:

$$Sovereign\,Yields_{i,t} = X_{i,t}\beta + \lambda Solicitation_{i,t} + u_{i,t} \qquad (2.2.2)$$

and report the results in table 2.6. In a linear regression of the yields on the solicitation dummy variable (and additional controls), I find that the unsolicited status of a rating grade represents an average decrease of 3.8 percentage points in the sovereign yields compared to the solicited status. Unsolicited ratings are associated with an improvement in the price of debt higher than that of a one point higher rating grade (0.75) or a better outlook (0.22)[7] Thus, the market charges a lower risk premium to bonds from issuers with high unsolicited rating grades than to bonds from issuers with the same solicited grades. For example, a triple A unsolicited borrower pays on average 1.67, whereas a triple A solicited one pays an average yield of 2.43.

How good are the ratings at explaining the sovereign yields? The correlation between sovereign yields and sovereign ratings is -0.69, both for solicited as well as for unsolicited ratings. Year by year the correlation can be found in figure 2.4 and it is shown to be not significantly different for the groups of solicited and unsolicited ratings. Hence, there is no evidence that the rating agencies perform better at predicting the sovereign yields in any particular category.

2.3   Model

A crucial component of the model will be market selection. I hence need to introduce borrowers' heterogeneity. For simplicity I assume there are only two types of borrowers, one

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[7]The outlook becomes insignificant in my last specification once all controls have been introduced.

Table 2.6: OLS with robust standard errors

	(1) Sovereign yields	(2) Sovereign yields	(3) Sovereign yields
Solicitation dummy	-3.023***	-3.023***	-3.823***
	(0.127)	(0.125)	(0.126)
Rating	-0.314***	-0.379***	-0.745***
	(0.0626)	(0.0623)	(0.198)
Positive outlook	no	-2.600***	-0.223
		(0.398)	(0.195)
Negative outlook	no	1.187***	0.277
		(0.338)	(0.256)
Country FE	yes	yes	yes
Month FE	yes	yes	yes
Country-Year FE	no	no	yes
N	1837	1837	1837
R-square	0.768	0.771	0.923
F	138.8	145.6	717.1

Standard errors in parentheses

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

with a higher probability to default than the other. The probability to default is ex-ante not observable. But the CRA can obtain information about it at a cost. This cost can be interpreted as the analyst wage to study the data and produce a rating. The CRA incurs this cost every time they have to come up with a rating, regardless of whether they are compensated for it or not.

Unsolicited ratings are a way to increase the visibility of a rating agency. According to Byoun and Shin (2012),"unsolicited ratings are also considered a means of raising a rating agency's profile in particular countries: that is, rating agencies provide unsolicited ratings to investors in an attempt to gain a competitive advantage over those who do not assign unsolicited rating". As an agency becomes known it will be more likely approached by some client to request its services. Clearly, borrowers who are unaware of the existence of a particular rating agency are not going to ask for a solicited rating there. Even if a rating agency is known already, producing more ratings or more recent ratings may be a way to let the market know about your technology and advertise your accuracy. A more standard rating is easier for the lenders to interpret and more attractive when trying to attract funds.
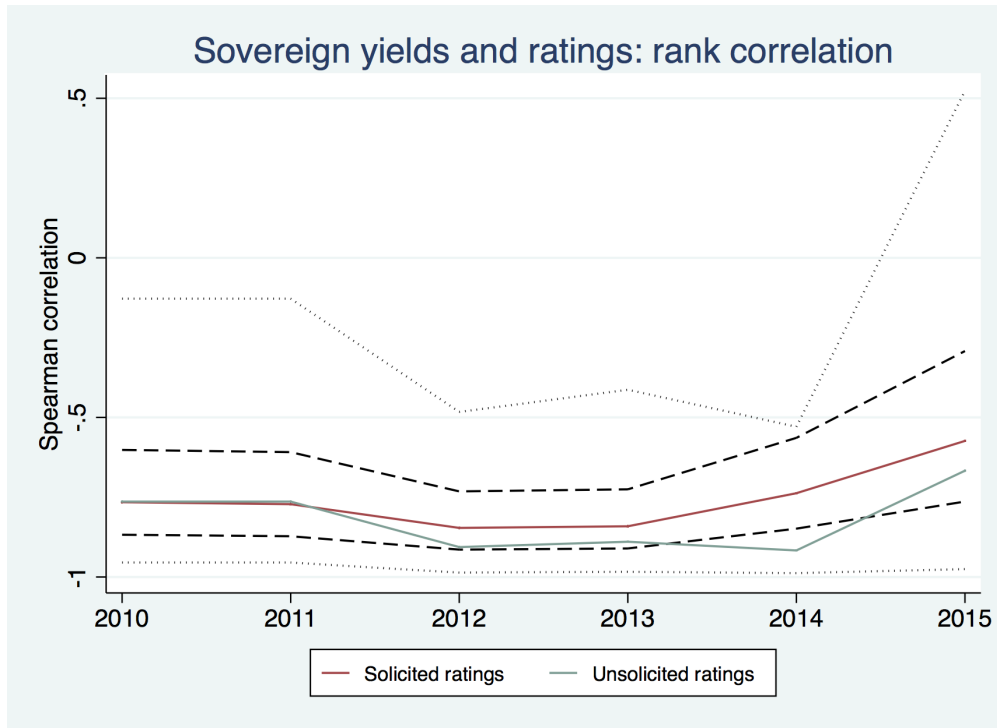
Figure 2.4: Confidence intervals for the correlation between sovereign yields and ratings by Moody's from 2010 to 2015 separated by solicitation status.

For instance, the company FCE Bank plc replies to an ESMA call for evidence on the "Competition, choice and conflicts of interest in the credit rating industry" that "in order to protect and provide confidence to our investors, we tend to select the market accepted CRAs." (ESMA, 2015).

In the previous section we saw evidence that 1) in the sovereign market unsolicited ratings are more numerous, 2) unsolicited sovereign ratings have higher grades than solicited sovereign ratings and 3) unsolicited ratings are associated with lower debt yields, that is, sovereigns with unsolicited ratings pay less for issuing debt than others with the same grade but solicited ratings. Current theories about the existence of unsolicited ratings cannot account for these facts. Unsolicited ratings are generally modelled as a punishment in the form of downward biased ratings, which contradicts evidence 2 and 3. Or they can be an option that only some borrowers face: those not confident enough to ask for a rating previously. I present an economic mechanism that may account for these facts by changing two assumptions: the first one is the timing, the CRA chooses whether to assign an unsolicited rating before the borrower decides if it solicits one. The second assumption is about the beliefs in the case of unsolicited ratings: I assume the borrowers do not expect the CRA to give them a bad rating if the CRA knows this information is untrue.

My model gives rise to two possible equilibria as a function of some parameters: one

where unsolicited ratings are associated with lower grades and another one where they are associated with higher grades. In what follows, the determinants of each of these equilibria will become clear.

2.3.1 Basic economic environment

Borrowers can be of two types $i \in \{A, B\}$ with shares θ and $1 - \theta$. Each borrower of type i gets indebted for a fixed amount D. The future gross return is $\tilde{R} = R$ with probability λ_i and $\tilde{R} = r$ with probability $1 - \lambda_i$, where $R > D > r > 0$. Since the borrower has limited liability, type i's probability of default is $1 - \lambda_i$, where $1 \geq \lambda_A > \lambda_B > 0$.

Lenders do not know the borrower's type. They are risk neutral with discount factor β. Lenders compete on debt prices à la Bertrand, making zero expected profits. They charge a price q for lending D, taking into account the expected probability of default, which will be specified later. For a pair (q, D), the borrower's expected payoff equals $qD + \mathbb{E}_i\{\tilde{R}\} - \lambda_i D$, where $\mathbb{E}_i\{\tilde{R}\} := \lambda_i R + (1 - \lambda_i)r$.

In the economy, there exists a credit rating agency (CRA) which has access to costly private information about the borrower's type. By paying a cost c, the CRA receives the random signal $\sigma = \{H, L\}$: if the country is of type A, the CRA receives the H signal with probability 1 while, if the country is of type B, the H signal is received with probability $p < 1$. The rating grade consists of a truthful report on the signal received and is denoted by $g \in \{H, L\}$.

A borrower can choose to solicit a rating to the agency before issuing debt. The benefit of doing so is that a rating can give information to the market and improve the debt price q that the lenders are willing to offer. The rating agency charges a fee ϕ for issuing solicited ratings.

The CRA can also issue unsolicited ratings. Unsolicited ratings are free of charge. As we will see, the CRA benefits from unsolicited ratings because they affect the fee that can be charged for a rating. I assume that when a CRA issues more ratings (either solicited or unsolicited), it has a higher visibility and/ or improves its bargaining power with respect to the borrower. Therefore, unsolicited ratings allow the agency to charge higher fees for solicited ratings. I assume the following functional form: $\phi(D, \gamma) = \alpha_1 + \alpha_2 \gamma D$. For $\alpha_1, \alpha_2 > 0$ fees are increasing in the amount of debt issued and in the fraction of unsolicited ratings assigned.

The CRA also provides ancillary services for a fee χ. Ancillary services give the borrower the opportunity to learn about the CRA's private signal and to veto the revelation of that

Figure 2.5: Ancillary services assesment.
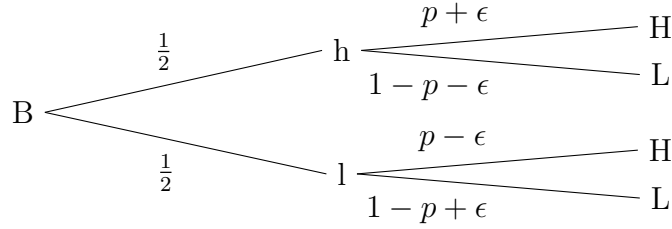
information.[8] The rating assesment $m = \{h, l\}$ is an imperfect forecast of the rating signal g and it is summarized in figure 2.5. An assesment $m = h$ is received with probability $\frac{1}{2}$ and $m = l$ with probability $\frac{1}{2}$. Conditional on receiving a positive assesment, type B receives a rating grade H with probability $p + \epsilon$, and L with the complementary probability $1 - p - \epsilon$, whereas conditional on a negative assesment a rating grade H is given with probability $p - \epsilon$ and L with probability $1 - p + \epsilon$. There is no uncertainty about type A rating, it receives H with probability 1. Assume $\epsilon > 0$ and $\epsilon < 1 - p$. These probabilities can be seen as posteriors and the technology of information acquisition is the same in both cases.

Additionally, in the ancillary services contract, the agency commits not to issue an unsolicited rating if the borrower does not solicit one.

Assume that a fraction ξ of borrowers do not enter the game; they access the market issuing unrated debt. This assumption guarantees that the $g = L$ rating, which is fully revealing of a B type, is perceived to be worse than no rating $g = 0$. Having a low rating or being downgraded is known to have an effect in the price of debt. It is reasonable that borrowers expect the market to judge them more harshly if they have been given a bad rating than if they have none. In the absence of bad news they could expect the lenders to have some uncertainty about their credit standing, which is even more likely to happen in the case where more types could be mistaken for one another. As unrated countries are a pool of different borrowers that do not access the rating services, being unrated could be perceived to be better than having a low rating.[9]

The timing is the following:

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[8]Ancillary services can play several roles: for instance, reducing the uncertainty about the outcome of the rating process for the borrowers or improving the transmission of information between the borrower and the rating agency. On top of that, confidentiality is an essential element of some of these services that are recently provided by the CRAs.

[9]As a matter of fact, there is a small but growing number of borrowers which decide to issue debt in the international debt market without a rating. They have accounted for about 10 per cent of the European corporate bond market in recent years and usually they could be classified as investment, or near-investment grade (Bolger and Wigglesworth, 2014).

1. In stage $t = 0$, the borrower decides whether to buy ancillary services at cost χ. Denote this decision by $a \in \{0, 1\}$.

2. If the borrower is a client of ancillary services, in stage $t = 1$, it receives a non-binding assessment about the rating grade, which can be $m = h$ or $m = l$. In stage $t = 2$, borrowers choose whether to solicit and pay the fee $\phi(D, \gamma)$ for a rating: $s = \{0, 1\}$. Denote as $g = 0$ the case in which the borrower remains unrated.

3. If the borrower is not a client of ancillary services, in stage $t = 1$, the rating agency may issue an unsolicited rating. $\gamma \in [0, 1]$ represents the fraction of unsolicited ratings issued. After deciding to issue an unsolicited rating, the signal $\sigma = \{H, L\}$ is received. In stage $t = 2$, borrowers that did not receive an unsolicited rating have the option to solicit one, $s = \{0, 1\}$. Note that a borrower cannot have both a solicited and unsolicited rating.

The lenders observe the choices of the borrower and those of the rating agency, except for the existence of ancillary services, which is kept confidential between the borrower and the CRA. To sum up, the borrower can have a rating, $g = H$ or $g = L$, or none, $g = 0$. Ratings can be either solicited or unsolicited but not both of them.

2.3.2   CRA problem

The CRA takes two actions: in $t = 1$ it decides the fraction γ of unsolicited rating to non-clients of ancillary services[10] and, in $t = 2$, it issues a solicited rating if it has been asked for one. The truth-telling assumption implies that the grade report will be either the signal the CRA received or none. Denote the rating grade report $g(a, u, s, \sigma)$, where the first element corresponds to the choice of ancillary services, the second represents the existence of an unsolicited rating, the third of a solicited one and the last element is the signal about the creditworthiness of the borrower available to the CRA. Depending on those elements, the rule for assigning a rating grade is the following:

$$g^*(1, 0, 1, \sigma) = \sigma, \ g^*(1, 0, 0, \sigma) = 0, \tag{2.3.1}$$

$$g^*(0, 0, 1, \sigma) = \sigma, \ g^*(0, 1, 0, \sigma) = \sigma \tag{2.3.2}$$

$$\text{and } g^*(0, 0, 0, \sigma) = 0. \tag{2.3.3}$$

When the borrower is a client of ancillary services, $a = 1$, it may request a rating or not, in which case it won't receive an unsolicited one. If the borrower is not a client, $a = 0$, it may

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[10]Recall that clients of ancillary services do not receive unsolicited ratings.

request a rating and, if not, it may receive on unsolicited one or it may also be unrated.

In $t = 1$ the CRA problem is the following:

$$\max_{\gamma} -\gamma c + [(1 - \gamma)f^*(\gamma)(\phi(D, \gamma) - c)], \qquad (2.3.4)$$

where $f^*(\gamma)$ is the fraction of borrowers that solicit a rating in equilibrium. The CRA chooses the proportion of unsolicited ratings taking into account that each rating has a cost c today and it also has an effect in the next stage: on the one hand, it crowds out solicited ratings, as a borrower cannot have both a solicited and unsolicited rating, hence only $1 - \gamma$ borrowers are susceptible to solicit a rating afterwards; on the other hand, it increases the fees that can be charged for those solicited ratings. Therefore, γ^* is, as well, the probability that a non-client of ancillary services gets an unsolicited rating.

2.3.3 Lenders' problem

Lenders lend the amount qD to the borrower and receive D at the end of the game if there is no default. In case of default, there is no partial repayment. The lender profit function is:

$$\Pi = -qD + \beta [\mu \lambda_A D + (1 - \mu) \lambda_B D], \qquad (2.3.5)$$

where $\mu = \mu(s, g)$ are the lenders' beliefs that the borrower is of type A. Beliefs depend on what the lender observes about the borrowers creditworthiness: the solicitation statute and the rating grade. As a result of imposing the zero-profit condition, the price function satisfies:

$$q(\mu) = \beta[\mu \lambda_A + (1 - \mu) \lambda_B]. \qquad (2.3.6)$$

The value $\mu(0, 0)$ represents the lenders' beliefs when they see no rating for some borrower, $\mu(0, H)$ and $\mu(0, L)$ the lenders see an unsolicited rating of H or L, respectively.

2.3.4 Borrower's problem

The borrower faces two problems: whether to buy ancillary services at $t = 0$ and whether to solicit a rating at $t = 2$. The borrower's payoff, depending on its rating, is the following:

- If the borrower buys ancillary services and it also solicits a rating: $q(\mu)D + \lambda_i(R - D) + (1 - \lambda_i)r - \phi(D, \gamma) - \chi$, where the first term is the amount of borrowing at price $q(\mu) = q(1, g)$, the second and third terms are the net revenues weighted by the

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repayment probabilities and the last two terms are the fee for solicitation and ancillary services, respectively.

- If the borrower solicits a rating but does not buy ancillary services, it saves on the amount of ancillary fees: $q(1, g)D + \lambda_i(R - D) + (1 - \lambda_i)r - \phi(D, \gamma)$.

- A borrower that does not buy ancillary services may receive an unsolicited rating with an associated payoff of $q(0, g)D + \lambda_i(R - D) + (1 - \lambda_i)r$, where the price of debt is $q(0, g)$ and the borrower does not incur in any fees.

- Finally, if the borrower is unrated the payoff equals $q(0, 0)D + \lambda_i(R - D) + (1 - \lambda_i)r$ if it did not buy ancillary services or $q(0, 0)D + \lambda_i(R - D) + (1 - \lambda_i)r - \chi$ if it did.

2.3.5 Equilibrium

I solve using the Perfect Bayesian Equilibrium.

Definition 2.3.1. *Given the CRA rule of $g^*(a, u, s, \sigma)$, a symmetric equilibrium is a γ^*, a strategy for the borrower:*

$$\{a^*, s^*\} : \{A, B\} \to \{0, 1\} \times \{0, 1\}, \tag{2.3.7}$$

where $a^*(i)$ is the choice of ancillary services and $s^* (i, a(i))$ is the rating solicitation, a strategy for the lender about the debt price $q^*(s, g) : \{0, 1\} \times \{H, L, 0\} \to \mathbb{R}_+$ and a system of beliefs $\mu^*(s, g) : \{0, 1\} \times \{H, L, 0\} \to [0, 1]$ about the borrower being type A, such that:

- *γ^* maximises the CRA profit function (2.3.4) and $f^*(\gamma)$ is consistent with the borrower's strategy.*

- *The strategy profile is sequentially rational given the beliefs and γ^*.*

- *The beliefs are consistent with Bayes' rule whenever possible.*

2.3.6 Model without ancillary services

Let us first solve the model without ancillary services as a benchmark. The game starts at $t = 1$. All the other modeling assumptions stay the same.

Proposition 2.3.1. *A rule of $g^*(u, s, \sigma)$: $g^*(0, 1, \sigma) = \sigma$, $g^*(1, 0, \sigma) = \sigma$ and $g^*(0, 0, \sigma) = 0$, the strategies $s^*(A) = 1, s^*(B) = 0$, $q^*(\mu) = \mu\lambda_A + (1 - \mu)\lambda_B$ and $\gamma^* = \frac{(1-\theta)c+\theta\alpha_1}{-2\theta\alpha_2 D} + \frac{1}{2}$*

constitute an equilibrium of the model without ancillary services given the following beliefs $\mu(s,g)$: $\mu(s,L) = 0 \, \forall \, s, \mu(1,H) = 1$,

$$\mu(0,H) = \begin{cases} 1 & w. \; prob. \; \frac{\theta}{\theta+(1-\theta)p} \\ 0 & w. \; prob. \; \frac{(1-\theta)p}{\theta+(1-\theta)p} \end{cases}$$

and

$$\mu(0,0) = \begin{cases} 1 & w. \; prob. \; \frac{\theta\xi}{\theta\xi+(1-\theta)(1+\gamma(\xi-1))} \\ 0 & w. \; prob. \; \frac{(1-\theta)(1+\gamma(\xi-1))}{\theta\xi+(1-\theta)(1+\gamma(\xi-1))}. \end{cases}$$

The CRA assigns a proportion γ^* of unsolicited ratings to both type A and type B borrowers in order to maximise its profit function (2.3.4) in $t=1$:

$$\max_{\gamma} -\gamma c + (1-\gamma)\theta \left[\phi(D,\gamma) - c \right].$$

Substituting the functional form of $\phi(D,\gamma)$ and solving the maximization problem, we obtain the first order condition:

$$-c - \theta(\alpha_1 + \alpha_2\gamma D) + \theta(1-\gamma)\alpha_2 D + \theta c = 0.$$

Rearranging we find an expression for the optimal fraction of unsolicited ratings that the CRA issues:

$$\gamma^* = \frac{(1-\theta)c + \theta\alpha_1}{-2\theta\alpha_2 D} + \frac{1}{2}. \tag{2.3.8}$$

Since $\gamma'(D) > 0$ if $\alpha_1 > c$, γ^* is increasing in the amount of debt.

For condition $\underline{\underline{\phi}} > \phi > \bar{\bar{\phi}}$[11] type A prefers to solicit a rating rather than remaining unrated, if they are not given an unsolicited one, while type B does not. Conditions state that ϕ in equilibrium has to stay within some upper and lower bounds: the bounds depend on $D, \gamma^*, \theta, \lambda_A$ and λ_B. A fee too high would discourage even the best borrowers to ask for a rating.

Type A can have either a solicited or unsolicited H rating and a fraction ξ is unrated by assumption. If type A were allowed to solicit a rating after an unsolicited one they may choose to do so. The reason is the price of debt is better for solicited ratings for the same H grade. We simplify away from this possibility but this behaviour is something we might observe. Type B can have an H unsolicited rating, L unsolicited rating or no rating. There

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[11]See Appendix 2.5.3 for a proof.

are no grade L solicited ratings. Thus, unsolicited ratings have lower grades on average.

Type A knows that it is more likely to receive an H rating, so it has an incentive to pay the fee for a solicited rating. Type B, on the contrary, has a lower probability p to receive an H rating and a high probability to receive an L rating, which bears a higher risk premium than an absence of rating. The fact that higher quality borrowers are more inclined to get rated is a well-known result in the literature (Lizzeri, 1999; Mathis et al., 2009; Fulghieri et al., 2014).

2.3.7 Introducing ancillary services

Proposition 2.3.2. *For $g^*(a, u, s, \sigma)$ given by equations (2.3.1)-(2.3.3), the strategies $a^*(A) = 0, a^*(B) = 1, s^*(A, 0) = 1, s^*(B, 0) = 0, s^*(A, 1) = 1$, $s^*(B, 1) = 1$ if $m = h$ and 0 if $m = l$, $q^*(\mu) = \mu\lambda_A + (1 - \mu)\lambda_B$ and γ^* that solves problem (2.3.4) constitute an equilibrium of the model given the following beliefs: $\mu(0, H) = 1, \mu(0, L) = 0, \mu(1, L) = 0$,*

$$\mu(1, H) = \begin{cases} 1 & w.\ prob.\ \frac{2\theta(1-\gamma)}{2\theta(1-\gamma)+(1-\theta)(p+\epsilon)} \\ 0 & w.\ prob.\ \frac{(1-\theta)(p+\epsilon)}{2\theta(1-\gamma)+(1-\theta)(p+\epsilon)} \end{cases}$$

and

$$\mu(0, 0) = \begin{cases} 1 & w.\ prob.\ \frac{2\theta\xi}{2\theta\xi+(1-\theta)(\xi+1)} \\ 0 & w.\ prob.\ \frac{(1-\theta)(\xi+1)}{2\theta\xi+(1-\theta)(\xi+1)} \end{cases}$$

if $\gamma > \bar{\gamma}$.

The CRA assigns a proportion γ^* of unsolicited H ratings to type A borrowers. Type B borrowers enter a contract of ancillary services and avoid receiving unsolicited ratings. They can either have a solicited H or L rating, after having observed the assessment $m = h$, or no rating, after having observed the assessment $m = l$. A fraction ξ of borrowers is unrated by assumption. Type A borrowers who are neither unrated nor received an unsolicited rating, solicit and receive an H rating. There are no grade L unsolicited ratings, as the type B borrowers that would be subject to receiving one prefer to pay for ancillary services and veto that possibility. Hence, unsolicited ratings have higher grades on average. There are two thresholds values $\bar{\phi}$ and $\underline{\phi}$[12] such that: for $\phi > \underline{\phi}$ and $\phi < \bar{\phi}$, $s^*(A, a) = 1\ \forall a$ and $s^*(B, 0) = 0$, $s^*(B, 1) = 1$ if $m = h$ and 0 if $m = l$.

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[12]The thresholds depend on the parameters of the model and a formal derivation can be found in appendix 2.5.4.

Type A prefers to solicit a rating whenever $\phi < \bar{\phi}$, whether they are clients of ancillary services or not. Their incentives to solicit are high, because the probability of getting a high rating is large, as long as the price of ratings is sufficiently low. Type B, on the contrary, prefers not to solicit a rating unless they are given a strong signal, a positive assessment, that the rating will be high. That is, if the fees are high enough with respect to the probability p of being given an H rating.

The CRA problem (2.3.4) can be rewritten in the following way:

$$\max_{\gamma} -\gamma c + (1 - \gamma)\theta \left[\phi(D, \gamma) - c\right] + \frac{1}{2}(1 - \theta) \left[\phi(D, \gamma) - c\right]. \tag{2.3.9}$$

Plugging in the functional form of $\phi(D, \gamma)$ and solving for γ:

$$\gamma^* = \frac{(1 - \theta)c + \theta\alpha_1}{-2\theta\alpha_2 D} + \frac{1}{2}\left(\frac{1}{2} + \frac{1}{2\theta}\right), \tag{2.3.10}$$

where the first two terms coincide with the expression for the optimal fraction of unsolicited ratings in the model without ancillary services and the term in parenthesis, which is > 1 for $0 > \theta > 1$, represents the additional incentive to issue unsolicited ratings due to the gains coming from the clients of ancillary services.

For $a^*(B) = 1$,

Proposition 2.3.3. *Provided γ is high enough, type B prefers to buy ancillary services for a fee χ and obtain a rating H with probability p and no rating $g = 0$ with probability $1 - p$ than risk getting an unsolicited H rating with probability γp and L with probability $\gamma(1 - p)$.*

The existence of this equilibrium depends on the value of γ:

$$\gamma > \bar{\gamma} := \frac{\beta G(\theta, \xi, \lambda_A, \lambda_B) + \frac{\alpha_1}{2} + \chi}{2\beta G(\theta, \xi, \lambda_A, \lambda_B) - \alpha_2 D}. \tag{2.3.11}$$

where $G(\theta, \xi, \lambda_A, \lambda_B) = \frac{2\theta\xi\lambda_A + (1-\theta)(\xi+1)\lambda_B}{2\theta\xi + (1-\theta)(\xi+1)}$. Note that $a^*(A) = 0$ is always true[13]. If type A does not ask for ancillary services it might get an unsolicited H rating or a solicited H rating. With ancillary services the outcome is always a solicited H rating but at the extra cost of having to pay the fee χ.

In this set-up, unsolicited H ratings are assigned only to A types, therefore they are fully revealing of the high quality type. This confirms equilibrium beliefs in proposition 2.3.2. Off-equilibrium beliefs $\mu(0, L)$ are set equal to 0.

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[13]For $a^*(A) = 0$: $\gamma q(0, H)D + (1 - \gamma)\left[q(1, H)D - \phi(\gamma, D)\right] > \frac{1}{2}q(1, H)D + \frac{1}{2}q(1, H)D - \phi(\gamma, D) - \chi$. Since $q(0, H) > q(1, H)$, the statement is always true.

Since unsolicited H ratings are assigned only to A types but solicited H ratings can be assigned to A and B types, we expect to see a market premium in the price of debt of high unsolicited ratings with respect to solicited.

Note that γ is a choice of the rating agency that is described by the expression (2.3.10). When γ is low, type B does not choose ancillary services and the equilibrium outcome is similar to the one described in the solution to the model without ancillary services.

Proposition 2.3.4. *For $g^*(a, u, s, \sigma)$ given by equations (2.3.1)-(2.3.3), the strategies $a^*(A) = 0, a^*(B) = 0, s^*(A, 0) = 1, s^*(B, 0) = 0, s^*(A, 1) = 1, s^*(B, 1) = 1$ if $m = h$ and 0 if $m = l$, $q^*(\mu) = \mu\lambda_A + (1 - \mu)\lambda_B$ and γ^* that solves problem (2.3.4) constitute an equilibrium of the model given the following beliefs: $\mu(s, g)$: $\mu(s, L) = 0 \, \forall \, s, \mu(1, H) = 1$,*

$$\mu(0, H) = \begin{cases} 1 & w.\ prob.\ \frac{\theta}{\theta + (1-\theta)p} \\ 0 & w.\ prob.\ \frac{(1-\theta)p}{\theta + (1-\theta)p} \end{cases}$$

and

$$\mu(0, 0) = \begin{cases} 1 & w.\ prob.\ \frac{\theta\xi}{\theta\xi + (1-\theta)(1+\gamma(\xi-1))} \\ 0 & w.\ prob.\ \frac{(1-\theta)(1+\gamma(\xi-1))}{\theta\xi + (1-\theta)(1+\gamma(\xi-1))} \end{cases}$$

if $\gamma \leq \bar{\gamma}$.

Thus, all grade H solicited ratings are assigned to type A borrowers whereas grade H unsolicited ratings can be given to type A or B with different probabilities. Grade L unsolicited ratings are assigned to type B borrowers. Finally, unrated borrowers can be either type A or B. This confirms equilibrium beliefs in proposition 2.3.4. Off-equilibrium beliefs $\mu(1, L)$ are free to be $[0, 1]$, in this case, they are equal to 0.

2.3.8   Comparative statics

Some parameters affect the determination of the equilibrium.

- The amount of debt issued by a given borrower category or in a given market segment (D). D affects the fraction of borrowers susceptible to receive an unsolicited rating: since $\gamma'(D) > 0$, the higher the amount of debt in a given market or whenever the borrowers issue more debt, the more incentives the CRA has to assign unsolicited ratings. This is because the benefits from increased fees in the future - due to the high debt - more than compensate for the costs of issuing unsolicitedly. The CRA has

incentives to increase their revenues when those are the largest, as it is the case when there is a lot of debt to intermediate.

Suppose there are two equilibrium probabilities of issuing an unsolicited rating, γ_1^* and γ_2^*, where $\gamma_1^* < \bar{\gamma} < \gamma_2^*$. Recall that $\bar{\gamma}$ is the threshold of γ that makes type B want to buy ancillary services as defined in equation (2.3.11). An increase from γ_1^* to γ_2^* makes type B willing to buy ancillary services in order to avoid a more likely unsolicited rating. Therefore, the equilibrium changes from one without equilibrium ancillary services and lower grades unsolicited ratings to one with equilibrium ancillary services and higher grades unsolicited ratings.

- The ex-ante market perception about the creditworthiness of a borrower (θ). θ affects the conditions on the maximum and minimum levels of ϕ that allow to sustain a given equilibrium. A higher θ provides more incentives for B to ask for ancillary services but also more incentives for A to solicit a rating since both $q(0,0)$ and $q(1,H)$ increase but $q(0,H)$ does not change. Hence, it favours the equilibrium with ancillary services. On the contrary, a lower θ favours the equilibrium without ancillary services because the worsening of the unrated pool makes it less attractive to be a part of it.

- The parameters governing the fixed part (α_1) and the variable part (α_2) of the CRA's rating fees.
$\gamma'(\alpha_2) > 0$, hence, an increase in α_2 makes γ higher and it is more likely that there is an equilibrium with ancillary services. α_2 captures the steepness in which unsolicited ratings allow you to charge more fees per unit of debt. Hence, it works very similarly to an increase in γ:

$$\phi(\alpha_1, \alpha_2, D, \gamma) = \alpha_1 + \alpha_2 \gamma D. \qquad (2.3.12)$$

α_2 can be interpreted as the bargaining power or the market share of the CRA. If they are in a better position to extract more fees per unit of debt in one market; it is reasonable that they want to take advantage of that by increasing their presence and maximising revenues.

α_1 is the fixed part of the CRA compensation, irrespective of debt and market position. You can think of it as the minimum amount they require to rate a borrower no matter what the circumstances. It might not compensate the CRA to issue a rating if they are paid below a certain compensation. Condition (2.3.8) tells us that α_1 has to be higher than the cost of issuing a rating for $\gamma'(D) > 0$. I.e. the fixed part of the rating fees has to compensate for the fixed costs of issuing a rating.
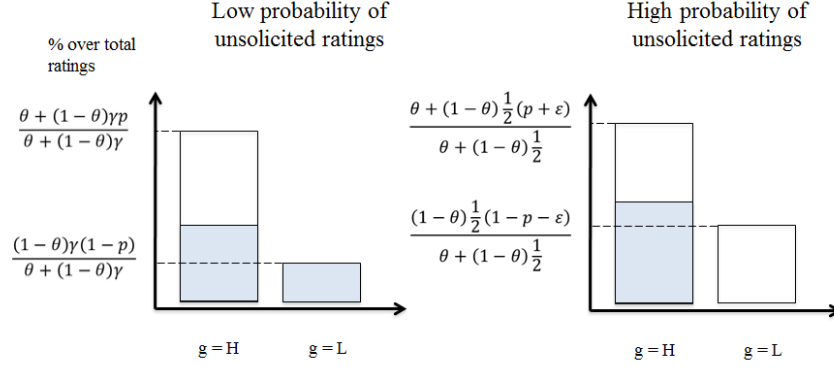
Figure 2.6: Percentage of solicited and unsolicited ratings.

2.3.9 Relationship with the data

Higher average debt and high α_2 give incentives to the CRA to assign more unsolicited ratings. In the equilibrium with ancillary services, the proportion of unsolicited ratings, γ^*, is higher, hence, the percentage of type A borrowers that get an unsolicited rating is higher. Moreover, the percentage of unsolicited ratings over total ratings, $\frac{\theta\gamma}{\theta+(1-\theta\frac{1}{2})}$ is higher than in the equilibrium with unsolicited ratings, $\frac{\gamma}{\theta+(1-\theta)\gamma}$, as long as there is not a large number of type B firms: $\gamma < \frac{\theta(1-\theta)}{2(1-\theta-\theta^2)}$. We have seen that unsolicited ratings are frequent among sovereign ratings and they are mostly high rating grades (stylised facts 2.1 and 2.2).

The equilibrium with a higher probability of unsolicited ratings features higher unsolicited rating grades thanks to the opt out option provided by ancillary services (see figure 2.6). In the equilibrium without ancillary services (low probability of unsolicited ratings γ^*), unsolicited ratings are $g = H$ and $g = L$ (shaded areas) while in the equilibrium with ancillary services (with high probability of unsolicited ratings γ^*) they are $g = H$. Hence, in the latter equilibrium unsolicited ratings are higher on average than solicited ones. But this is not necessarily true for the other equilibrium. This explains $\delta > 0$ in the regression of sovereign rating grades on solicitation status (table 2.4).[14]

Conditional on the rating, unsolicited ratings are associated with higher or lower yields depending on the equilibrium. In the equilibrium with ancillary services, $q(0, H) - q(1, H) > 0$ and $q(0, L) - q(1, L) = 0$, hence, unsolicited ratings are associated with lower yields whereas in the equilibrium without, $q(0, H) - q(1, H) < 0$ and $q(0, L) - q(1, L) = 0$, they are associated with higher yields. High unsolicited ratings are associated with a higher $q(0, H)$ because they reveal a type A perfectly (type B chooses to buy ancillary services). This result is in line with $\delta < 0$ in the regression of sovereign yields on solicitation status (table 2.6).

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[14]This effect would disappear if we could control perfectly for the type, which we assume we cannot do here since it is private information.

2.4 Conclusion

To what extent rating agencies strategically downgrade their unsolicited ratings? The answer to this question is relevant for policy because it matters to determine if the rating agencies may have misbehaved. In this paper I propose a model that assumes away strategic motivations for unsolicited ratings by assuming true-telling on the part of the CRA. The degree of market selection in equilibrium depends on the market size and other market characteristics. The model is, hence, able to explain both the downward bias in unsolicited ratings for certain categories of borrowers (banks, insurance, corporates) as well as the upward bias for sovereign borrowers.

The equilibrium with positive selection on unsolicited ratings is generated thanks to the possibility to enter a private contract with the CRA with a confidentiality clause (e.g. ancillary services). This also allows us to explore in which circumstances the value of opacity for some borrowers can be marketed by the CRAs. When the rating agencies cater to both the borrowers that have incentives to be transparent as well as those that prefer opacity, they still provide the market with valuable information but the amount of information might be biased towards a particular group of borrowers.

An extended version of the model presented in this paper, properly calibrated, could be able to deliver a useful benchmark for the downward natural bias as a function of the characteristics of the market under study. Identifying the "natural size" of the market selection bias would help to detect the presence of strategic motivation and, hence, inform policy intervention.

2.5 Appendix

2.5.1 Probit models for years 2010 - 2015

Probit models for the probability of having an unsolicited rating given the rating grade, the level of debt over GDP, GDPpc and regional fixed effects for each year between 2010 and 2015.

Table 2.7: Probit model

	2010	2011	2012	2013	2014	2015
			Unsolicited rating			
Rating grade	0.430	0.397*	0.185**	0.162**	0.174**	0.146*
	(0.287)	(0.204)	(0.0809)	(0.0759)	(0.0815)	(0.0768)
Debt	0.0411*	0.0491**	0.0312**	0.0267**	0.0270**	0.0212**
	(0.0226)	(0.0241)	(0.0139)	(0.0118)	(0.0117)	(0.00931)
GDPpc	0.0000414	0.0000453*	0.0000116	0.00000924	0.0000112	0.00000978
	(0.0000258)	(0.0000267)	(0.0000186)	(0.0000166)	(0.0000177)	(0.0000154)
Geographic dummies	yes	yes	yes	yes	yes	yes
N	93	95	99	104	107	120
r2_p	0.593	0.634	0.481	0.445	0.430	0.357
chi2	32.37	34.82	29.04	31.26	30.48	26.28

Standard errors in parentheses

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

2.5.2 List of sovereigns rated unsolicitedly and comparable sovereigns

	Unsolicited		Solicited	
	France	Aaa	Austria	Aaa
	Germany	Aaa	Belgium	Aa1
	Italy	Aa2	Norway	Aaa
	Luxembourg	Aaa		
2010	Mauritius	Baa2		
	Netherlands	Aaa		
	Switzerland	Aaa		
	United Kingdom	Aaa		
	France	Aaa	Austria	Aaa
	Germany	Aaa	Belgium	Aa1
	Italy	Aa3		
	Luxembourg	Aaa		
2011	Mauritius	Baa2		
	Netherlands	Aaa		
	Switzerland	Aaa		
	United Kingdom	Aaa		
	France	Aaa	Austria	Aaa
	Germany	Aaa	Belgium	Aa3
	Italy	Baa1	Botswana	A2
	Kenya	B1	South Africa	A3
2012	Mauritius	Baa1		
	Netherlands	Aaa		
	Switzerland	Aaa		
	United Kingdom	Aaa		
	Zambia	B1		
	France	Aa1	Austria	Aaa
	Germany	Aaa	Belgium	Aa3
	Italy	Baa2	Botswana	A2
	Kenya	B1	Ghana	B1
	Mauritius	Baa1	South Africa	Baa1
2013	Mozambique	B1		
	Netherlands	Aaa		
	Switzerland	Aaa		
	Uganda	B1		
	United Kingdom	Aa1		
	Zambia	B1		
	France	Aa1	Austria	Aaa
	Germany	Aaa	Belgium	Aa3
	Italy	Baa2	Botswana	A2
	Kenya	B1	Ghana	B2
	Mauritius	Baa1	South Africa	Baa1
2014	Mozambique	B1		
	Netherlands	Aaa		
	Switzerland	Aaa		
	Uganda	B1		
	United Kingdom	Aa1		
	Zambia	B1		
	Bahrain	Baa3	Austria	Aaa
	France	Aa1	Belgium	Aa3
	Germany	Aaa	Botswana	A2
2015	Italy	Baa2	South Africa	Baa2
	Kenya	B1		
	Mauritius	Baa1		
	Netherlands	Aaa		
	Switzerland	Aaa		
	Uganda	B1		
	United Kingdom	Aa1		
	Zambia	B1		

2.5.3 Equilibrium conditions in the model without ancillary services

According to the beliefs, the lenders' price function is the following:

$$
q(s, \sigma) = \begin{cases}
q(0,0) = \beta \left[\frac{\theta\xi\lambda_A + (1-\theta)(1+\gamma^*(\xi-1))\lambda_B}{\theta\xi + (1-\theta)(1+\gamma^*(\xi-1))} \right] \\
q(0,H) = \beta \left[\frac{\theta\lambda_A + (1-\theta)p\lambda_B}{\theta + (1-\theta)p} \right] \\
q(0,L) = \beta\lambda_B \\
q(1,H) = \beta\lambda_A \\
q(1,L) = \beta\lambda_B.
\end{cases}
\tag{2.5.1}
$$

The condition for $s^*(A) = 1$ is $q(1,H)D + \lambda_A(R-D) + (1-\lambda_A)r - \phi(D,\gamma) > q(0,0)D + \lambda_A(R-D) + (1-\lambda_A)r$, that is, the payoff for soliciting and obtaining a rating H with probability 1 for a fee $\phi(D,\gamma)$ is higher than the payoff of remaining without a rating. Substituting the expressions for $q(\cdot)$ from (2.5.1), we obtain:

$$
\phi(D,\gamma^*) < \beta \left[\left(1 - \frac{\theta\xi}{\theta\xi + (1-\theta)(1+\gamma^*(\xi-1))} \right) \lambda_A - \frac{(1-\theta)(1+\gamma^*(\xi-1))}{\theta\xi + (1-\theta)(1+\gamma^*(\xi-1))} \lambda_B \right] D.
$$

On the other hand, for $s^*(B) = 0$, paying the fee to solicit a rating, which is H with a probability p and L with a probability $1-p$, is not worth for type B: $q(0,0)D + \lambda_B(R-D) + (1-\lambda_B)r > p\left[q(1,H)D + \lambda_B(R-D) + (1-\lambda_B)r\right] + (1-p)\left[q(1,L)D + \lambda_B(R-D) + (1-\lambda_B)r\right] - \phi(D,\gamma)$. Substituting and rearranging, we obtain the following condition:

$$
\phi(D,\gamma^*) > \beta \left[\left(p - \frac{\theta\xi}{\theta\xi + (1-\theta)(1+\gamma^*(\xi-1))} \right) \lambda_A + \left((1-p) - \frac{(1-\theta)(1+\gamma^*(\xi-1))}{\theta\xi + (1-\theta)(1+\gamma^*(\xi-1))} \right) \lambda_B \right] D
$$

The two conditions verify the proposed equilibrium choices $s^*(A) = 1$ and $s^*(B) = 0$. This confirms the beliefs in equilibrium and off-equilibrium beliefs $\mu(1,L)$ are free to be set arbitrarily.

2.5.4 Equilibrium conditions in the model with ancillary services

According to the beliefs, the lenders' price function is the following:

$$q(s,g) = \begin{cases} q(0,0) = \beta \left[\frac{2\theta\xi\lambda_A + (1-\theta)(\xi+1)\lambda_B}{2\theta\xi + (1-\theta)(\xi+1)} \right] \\ q(0,H) = \beta\lambda_A \\ q(0,L) = \beta\lambda_B \\ q(1,H) = \beta \left[\frac{2\theta(1-\xi)(1-\gamma)\lambda_A + (1-\theta)(1-\xi)(p+\epsilon)\lambda_B}{(1-\xi)[2\theta(1-\gamma)+(1-\theta)(p+\epsilon)]} \right] \\ q(1,L) = \beta\lambda_B. \end{cases}$$

(2.5.2)

The condition for $s^*(A,0) = 1$, under such beliefs, is the following: $q(1,H)D + \lambda_A(R - D) + (1 - \lambda_A)r - \phi(D,\gamma) > q(0,0)D + \lambda_A(R - D) + (1 - \lambda_A)r$. Substituting the expressions for $q(\cdot)$ from (2.5.2), we obtain:

$$\phi(D,\gamma^*) < \beta \left[\frac{2\theta(1 - \xi)(1 - \gamma^*)\lambda_A + (1 - \theta)(1 - \xi)(p + \epsilon)\lambda_B}{(1 - \xi)\left[2\theta(1 - \gamma^*) + (1 - \theta)(p + \epsilon)\right]} - \frac{2\theta\xi\lambda_A + (1 - \theta)(\xi + 1)\lambda_B}{2\theta\xi + (1 - \theta)(\xi + 1)} \right] D.$$

(2.5.3)

The condition above is the same to guarantee $s^*(A,1) = 1$, no matter whether the assessment is $m = h$ or $m = l$. Moreover, the condition for $s^*(B,1) = 1$ if $m = h$ is: $(p + \epsilon)q(1,H)D + (1 - p - \epsilon)q(1,L)D + \lambda_A(R - D) + (1 - \lambda_A)r - \phi(D,\gamma) > q(0,0)D + \lambda_A(R - D) + (1 - \lambda_A)r$. Thus,

$$\phi(D,\gamma^*) < \beta \left[(p + \epsilon)\frac{2\theta(1 - \xi)(1 - \gamma^*)\lambda_A + (1 - \theta)(1 - \xi)(p + \epsilon)\lambda_B}{(1 - \xi)\left[2\theta(1 - \gamma^*) + (1 - \theta)(p + \epsilon)\right]} + (1 - p - \epsilon)\lambda_B - \right.$$

(2.5.4)

$$\left. -\frac{2\theta\xi\lambda_A + (1 - \theta)(\xi + 1)\lambda_B}{2\theta\xi + (1 - \theta)(\xi + 1)} \right] D := \bar{\phi}.$$

Since $\lambda_B < \lambda_A$, condition (2.5.4) is more restrictive than condition (2.5.3). If type B wants to solicit a rating after an assessment $m = h$, then type A wants to solicit a rating as well.

On the other hand, for $s^*(B,0) = 0$, paying the fee to solicit a rating, which is H with a probability p and L with a probability $1-p$, is not worth for type B: $q(0,0)D + \lambda_B(R - D) + (1 - \lambda_B)r > p\left[q(1,H)D + \lambda_B(R - D) + (1 - \lambda_B)r\right] + (1-p)\left[q(1,L)D + \lambda_B(R - D) + (1 - \lambda_B)r\right] -$

$\phi(D, \gamma)$. Substituting and rearranging, we obtain the following condition:

$$\phi(D, \gamma^*) > \beta \left[p \frac{2\theta(1-\xi)(1-\gamma^*)\lambda_A + (1-\theta)(1-\xi)(p+\epsilon)\lambda_B}{(1-\xi)\left[2\theta(1-\gamma^*) + (1-\theta)(p+\epsilon)\right]} + (1-p)\lambda_B - \right. \quad (2.5.5)$$

$$\left. - \frac{2\theta\xi\lambda_A + (1-\theta)(\xi+1)\lambda_B}{2\theta\xi + (1-\theta)(\xi+1)} \right] D.$$

And, if they receive a negative assessment $m = l$, type B prefers again not to solicit a rating $s^*(B, 1) = 0$: $q(0,0)D + \lambda_B(R-D) + (1-\lambda_B)r > (p-\epsilon)\left[q(1,H)D + \lambda_B(R-D) + (1-\lambda_B)r\right] + (1-p+\epsilon)\left[q(1,L)D + \lambda_B(R-D) + (1-\lambda_B)r\right] - \phi(D, \gamma)$. Thus,

$$\phi(D, \gamma^*) > \beta \left[(p-\epsilon)\frac{2\theta(1-\xi)(1-\gamma^*)\lambda_A + (1-\theta)(1-\xi)(p+\epsilon)\lambda_B}{(1-\xi)\left[2\theta(1-\gamma^*) + (1-\theta)(p+\epsilon)\right]} + (1-p+\epsilon)\lambda_B - \right.$$

$$(2.5.6)$$

$$\left. - \frac{2\theta\xi\lambda_A + (1-\theta)(\xi+1)\lambda_B}{2\theta\xi + (1-\theta)(\xi+1)} \right] D := \underline{\phi}.$$

Since $\epsilon > 0$, if $\theta(D, \gamma^*)$ satisfies condition (2.5.5) it also satisfies (2.5.6) .

Conditions (2.5.4) and (2.5.5) verify the proposed equilibrium choices. These choices confirm the equilibrium beliefs.

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