Endogenous Credit Ratings*

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Abstract

Creditors of a borrower who needs to roll over its debt face a coordination problem. Even with good fundamentals, fear that liquidity problems become solvency problems may trigger preemptive action, undermining the ability to refinance and leading to default. Financial prices and credit ratings combine to influence lending decisions, thus affecting the creditworthiness of borrowers. I show that: (a) lenders overreact to changes in prices and credit ratings; (b) credit ratings are inaccurate during crises; (c) regulation relying on credit ratings should be redesigned to suspend their use in crises; (d) in the case of sovereign debt, an international financial institution helps prevent liquidity runs and reduce the negative effects of ratings; (e) transparency in financial markets makes credit ratings more volatile.

Keywords: Credit ratings, coordination risk, debt crises, nonlinearities.

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1 Introduction

I have often wondered what drives credit ratings. They are supposed to be independent opinion on the relative creditworthiness of an obligor. But the meaning of *independent opinion* is less than obvious in terms of the criteria and the methodology used in the construction of credit ratings. Credit rating agencies (CRAs) react to unfolding and impending events in financial markets. First, financial prices convey information that is valuable to determine the underlying quality of debt. Second, if downgrades contribute to lenders's unwillingness to roll over debt claims, then the lowering of a credit score by a CRA may induce default because of the inability to sell new debt. Rating agencies thus face the problem of setting independent credit ratings when much of the relevant information is endogenous to financial markets and their actions affect the credit quality of issuers. These two features call into question the independence of external ratings.

Many claim that CRAs are as much following investor opinion as leading it. Following investor opinion is pertinent because perceptions about credit quality influence lending decisions, thereby affecting the creditworthiness of borrowers that must roll over their debts. During times of crisis, individuals look frequently over their shoulders to learn about the actions and the opinions of others. Undoubtedly, CRAs monitor financial prices and economic indicators as these convey information about what market participants are doing and thinking.

But credit ratings themselves are closely watched by people making important economic decisions. If creditors rely on ratings to roll over their loans, credit ratings themselves affect the credit quality of borrowers. Besides, the big rating agencies have high public visibility and everybody knows that everybody else watches credit ratings. Credit ratings become reference points giving them a powerful coordination effect because they signal *and* influence what others are doing and thinking. In the case of sovereign debt, it is plausible that the lowering of a credit score by a CRA feeds a vicious circle and leads to self-fulfilling debt crises. Much, then, depends on the interaction between market participants and CRAs. Yet, little effort has been done to understand the channels of contagion linking credit ratings to credit quality.

What is missing from the literature is an understanding of the way credit ratings are formed in a *market-based financial system*. This paper provides a theoretical model of credit ratings and their vulnerabilities. In the model, information is largely endogenous and the credit rating is formed using private information known by the CRA and public information available in financial markets. This study draws on the theoretical model of defaultable debt by Morris and Shin (2004) and on the analysis of financial markets as endogenous sources of public information by Angeletos and Werning (2006). Consistent with these contributions, public information embodied in prices and credit ratings provides a reference point towards which the investors' beliefs gravitate.[1] When issuing credit ratings, CRAs take into account the effects of ratings and prices on the creditworthiness of issuers.

There are two major areas in which the model contributes to the current debate on the reform of the credit rating system: the design of standards, laws and regulations that rely on credit ratings, and the effectiveness of external finance in the context of sovereign debt crises. As regards the first area, the Financial Stability Board, which coordinates the G20's financial policies, has asked regulators and standard-setting bodies to reduce reliance on credit ratings in bank capital requirements and other forms of prudential oversight regulation, rules on investment-fund holdings, security regulations and rules, central bank operations and collateral eligibility standards. The Dodd-Frank Act on financial reform takes a firm approach regarding the use of credit ratings requiring their removal or replacement by appropriate alternatives. The European Union decided to bring CRAs into the regulatory net and the European Securities and Markets Authority will directly supervise them. Under one of the most contentious proposals being discussed, this institution would be able to ban sovereign credit ratings in "exceptional situations".

The model in this paper provides the conditions under which proposals to reform regulations and standards are effective and reasonable. In what I define as *"crisis zone A"*, credit ratings are very sensitive to fundamentals and, near the default threshold, ratings turn out to be volatile and inaccurate. These features justify a flexible use of credit ratings in rules and regulations and, notably, support measures to suspend the use of credit ratings during episodes of financial instability. I also provide clues about the role of prices, and in particular on the role of credit default swap (CDS) prices, in the design of regulation and I conclude that prices suffer from the same drawbacks as credit ratings.

As regards the second area, the analysis lends support to the hypothesis presented by Morris and Shin (2006) and Corsetti, Guimarães and Roubini (2006) that even a small amount of

[1] In game theory jargon, credit ratings have the capacity to become *focal.*

liquidity provision by official institutions can work to prevent a destructive liquidity run via coordination of agent's expectations. In what I define as *"crisis zone B"*, sovereign credit ratings have the potential to precipitate the default of (illiquid but) solvent borrowers, and it is reasonable to suspend credit ratings of a country undergoing an international bailout programme.

In this paper, I introduce a financial market in a coordination game with imperfect information. Individuals trade assets using their private information. As in Grossman and Stiglitz (1976), the (noisy) rational expectations equilibrium price aggregates dispersed private information. This price is an endogenous public signal. Once I allow for this specification, a new framework of analysis opens up, in which default probabilities are not independent of credit ratings and financial prices. This framework allows a full assessment of the response of credit ratings and default thresholds to changes in the fundamentals, financial prices and information disclosed by the CRAs. The analysis is related to a fast growing literature on the design of credit rating institutions, to which I contribute in a number of dimensions.

First, I study a rational expectations competitive equilibrium. Credit ratings incorporate *new* information - known only by the CRA - about the fundamentals and public information available in financial prices. Market participants recognize how credit ratings are formed and extract the *new* and relevant information produced by the CRA.

Second, there is a critical threshold for the value of the fundamentals below which the borrower is unable to roll over its debt and defaults. Conventional accounts obtain the default threshold for sovereign debt using some natural debt limit. This limit comes from assuming the risk-free status of government debt and finding the maximum debt that could be repaid under an optimal fiscal policy. Yet, in the short run, default depends mainly on the ability of the sovereign to coordinate creditors into rolling over their claims. In my model, the default threshold depends on natural debt limits and on the willingness of investors to roll over their credit and, as a result, the default threshold is more stringent than in conventional models of sovereign debt because solvency and liquidity problems are not separable.

Third, there are crisis zones when public information signals that economic fundamentals are near the default threshold. In *"crisis zone A"*, a small deterioration in the fundamentals leads to a substantial reduction in debt roll over. The intuition is as follows. Imperfect information prevents investors from knowing the exact value taken by the fundamentals. When fundamentals are clearly above the default threshold, almost all investors agree on rolling over their credit; the opposite happens when fundamentals are clearly below the default threshold. When fundamentals are near the default threshold, many investors are uncertain about whether others will roll over their claims or not and they will pay close attention to the information received in order to guess what others will do. A small deterioration of the fundamentals entails (slightly) negative information which is sufficient to induce many investors to refuse to roll over their claims with fear that others will do the same. This contributes to "credit cliff" situations, whereby small changes in the fundamentals induce considerable changes in creditworthiness. Such "overreaction" need not be based on irrational behavior on the part of investors.

In *"crisis zone B"*, the default threshold is very sensitive to the information disclosed by CRAs. In this zone, investors are unsure about whether others will roll over their claims or not and they pay close attention to credit ratings so as to guess what others will do. A downgrade, however small, induces many investors to refuse to roll over their claims with fear that others will do the same, thereby affecting the ability of the borrower to refinance its debt.

Fourth, because agents want to coordinate their decisions they place too much weight on public information - financial prices and credit ratings. Public information serves largely as a focal point for the coordination of agent's expectations. With agents overreacting to public information, small changes in prices or credit ratings have a large impact on investment decisions. Significantly, the weight given to public information is larger near the default threshold and in *"crisis zone B"* thereby creating nonlinearities in the response of investors. The dilemma posed by the potential for overreaction to public information is well-known to government officials with high public visibility. Central bankers have developed specific communication skills, knowing how their public statements may disproportionately influence financial markets. Strikingly, no restrictions have been imposed so far on the communication strategies of CRAs, which have allowed them to unduly influence financial markets; CRAs insist their ratings are mere opinions, and as such should be protected by free speech.

Fifth, the degree of nonlinearities depends on the precision of public information. The weight given to public information increases with its precision, compelling agents to overreact to precise public information. Since the impact of variations in credit ratings depends on the information structure, then credit ratings (and regulation relying on credit ratings) should reflect the specific features of each market. European authorities have decided that CRAs should clearly differentiate between ratings for structured finance instruments and ratings for other financial obligations. Ideally, such differentiation should depend on the relative precision of public information and on the relative precision of credit ratings.

The impact of public information is larger with more precise public information, and so is the impact of any noise in the public signals. For example, small drops in prices may be interpreted as a deterioration in credit quality and can reduce the willingness to roll over credit, thereby precipitating default of illiquid borrowers and creating instability in financial markets. This issue is relevant from a practical perspective because it has implications regarding the recent regulatory trend towards more transparency in derivatives markets; I examine the sensitivity of outcomes to nonfundamental disturbances in prices and conclude that transparency is a double-edged instrument. Transparency may lead to more informative prices but it increases the sensitivity of debt default to nonfundamental shocks, bringing new challenges to the industry.

Sixth, I shed light into the claim, *regarding periods of financial crisis*, that CRAs are initially too slow to downgrade and subsequently downgrade faster and sharper than the worsening of the fundamentals would justify. I refocus the debate by showing that CRAs account for the coordination motive. This motive makes credit ratings very sensitive near the default threshold and in *"crisis zone A"* and multi-notch downgrades may occur in response to small shocks to fundamentals. Moreover, if CRAs make small mistakes (for example when they collect information) then a small error may lead to a sharp and disproportionate downgrade. I also show that short term debt hinders coordination among lenders, leaving borrowers vulnerable to financial crises.

I model the interaction between creditors and borrowers as a game with strategic complementarity and, like Manso (2011), I find feedback effects that amplify the impact of credit ratings. I analyze the role of CRAs using equilibrium selection in global games. Boot, Milbourn and Schmeits (2006) also see ratings as focal points, meaning that investors may rationally base their investment and pricing decisions on the rating, anticipating that sufficiently many will do the same. In doing so, credit ratings help fix the desired equilibrium in environments for which multiple equilibria would otherwise exist. Agencies may use the feedback effects and the endogeneity of rating information to influence markets to their benefit. For example, they may have and incentive to announce ratings that trigger market reactions that render their ratings even more precise ex post. Boot, Milbourn and Schmeits (2006) show that credit watch procedures condition issuers and may be used in this vein.

The objective of this paper is not to explain the strategic behavior of CRAs, but rather to understand how credit ratings influence investors when their decisions are strategic complements. CRAs merely function as a pass-through entity of new information instead of choosing the ratings to maximize their own benefits. In this sense, the setting differs from recent models focusing on how incentive problems of financial intermediaries may reduce the quality of the information disclosed to investors. In those models ratings are manipulated because reputational concerns are insufficient to discipline CRAs (Mathis, McAndrews and Rochet 2009), or are inflated by the issuers's ability to engage in "rating shopping" and possibly collude with rating agencies (Bolton, Freixas and Shapiro 2012). Also, Mählmann (2011) suggests that CRAs have an incentive to "rescue" borrowers in order to uphold their business relations with them. Skreta and Veldkamp (2009) show how the combination of an increase in asset complexity and issuers shop for ratings can produce ratings inflation. Opp, Opp and Harris (2012) and Bolton, Freixas and Shapiro (2012) analyze the distortion in ratings caused by regulatory requirements like rating-contingent regulation that favors highly rated securities, and barriers to entry. Finally, the issuance of ratings based on coarse information is seen by many not only as the source of pre-crisis mispricing of asset backed securities but also as the reason for the subsequent sequence of downgrades in the subprime crisis. The issuance of uninformative ratings is highlighted by Pagano and Volpin (2008) as a major inefficiency and suggests that there is a discrepancy between the private and the social benefits of transparency in debt issues.

According to those views, the reform of the credit rating industry should aim at guaranteeing more accurate information. This implies eliminating the conflicts of interest that CRAs face (Bolton, Freixas and Shapiro, 2007), reforming the issuer-pay model, minimizing the effects of barriers to entry in the industry and guaranteeing that reputational concerns do give incentives to reveal information (Mariano, 2008). The main drawback of models that predict biased ratings is that they often rely on some form of non-optimal behavior or assume that some investors have limited ability to process information, ruling out by construction the existence of any type of rational expectations equilibrium. Rational expectations imply that investors are not deceived in equilibrium by conflicts of interest, rating shopping, or other distortions in the issuer-pay model.

This paper specifically focus on sovereign ratings, given the most recent escalation in sovereign credit risk and the propensity for ratings to affect sovereign debt markets. Yet, the issues dealt with in the model are common to corporate and municipal credit ratings and this is why some of the examples presented belong to corporate issuers. I proceed by steps. The next Section presents the coordination problem when issuers must roll over their debts. It identifies the main drivers of the results by showing the nonlinear responses of credit ratings and default thresholds and how these responses depend on the precision of public information. The following Section incorporates a market for credit derivatives and examines the effects of nonfundamental volatility. Section 4 shows that a model with direct signals on the actions of investors is equivalent to a model with exogenous signals. Section 5 discusses the hardwiring of credit ratings into the regulatory framework, and Section 6 discusses welfare and policy related issues. Section 7 concludes.

2 The basic model with exogenous information

I assume that the sovereign government has an outstanding amount of one period debt equal to 1. The government can and is willing to repay an exogenous share θ of this debt while the remaining amount of debt $(1-\theta)$ needs to be rolled over. Government debt is held by a continuum of short term creditors indexed by i and uniformly distributed over the $[0,1]$ interval. Each short term creditor individually decides whether or not to roll over his unit of debt and define $a_i \in \{0,1\}$ as individual investment. Let $A = \int_0^1 a_i di$ denote the aggregate level of investment.

I introduce strategic complementarity by assuming that the individual return to investment depends on the aggregate level of investment. Accordingly, investors have utility

$$u\left(a_i, A, \theta, \psi\right) = \begin{cases} R & \text{when } a_i = 1 \text{ and } \psi + A + \theta \geq 1 \\ R - \Delta & \text{when } a_i = 1 \text{ and } \psi + A + \theta < 1 \\ 1 & \text{when } a_i = 0 \end{cases}$$

where R and Δ are constants with $0 < R - 1 < \Delta \leq R$. I give the following interpretation of the payoff function. Provided the mass of investors A is large enough, the government is able to fulfil its promise and repays R; otherwise, the country is forced to default on its debt and repays $R - \Delta$ (where Δ measures Loss Given Default, LGD). Alternative investment opportunities yield zero interest.

The random variable θ measures the ability of the sovereign to meet short-term obligations (the underlying fundamental) and $1-\theta$ gauges the need for roll-over. I interpret ψ as the amount of exogenous funding that the government can guarantee. Factors determining this parameter are:

- The proportion of debt in the hands of institutional investors who have a long term horizon and follow "buy and hold strategies".
- Exogenous shocks in preferences of investors which affect the demand for sovereign bonds.
- Financial assistance from international agencies - for instance, obtained through stabilization programmes by the International Monetary Fund (IMF) or the European Stability Mechanism (ESM)[2] -, interventions by the European Central Bank (ECB) and the purchase of government bonds by other countries - giving scope for international cooperation.

Parameter ψ captures the degree of strategic complementarity and measures the degree of vulnerability of the issuer; it is an indicator of how easy it is to coordinate investors. I confine my attention to the actions of short term creditors.

Information and transparency. The fundamental $\theta \in \mathbb{R}$ is not known at the time the investment decisions are made and short term creditors have heterogeneous beliefs about θ. The common prior about θ is uniformly distributed on the real line. A sufficient statistic z summarizes the public information such that $z = \theta + \sigma_z \varepsilon$, where ε is standard normal, independent of θ and common across agents. The private information of short term creditor i is summarized by a sufficient statistic $x_i = \theta + \sigma_x \xi_i$, where ξ_i is standard normal, independent of θ and independent and identically distributed across agents.

The information structure is parametrized by the standard deviations σ_x and σ_z or, equivalently, by $\alpha_x = \sigma_x^{-2}$ and $\alpha_z = \sigma_z^{-2}$, the precisions of private and public information. The information structure and the values of parameters α_x and α_z are common knowledge. The posterior belief of agent i about θ is normal with mean $E_i[\theta] = E[\theta|x_i, z] = \frac{\alpha_x}{\alpha_x+\alpha_z}x_i + \frac{\alpha_z}{\alpha_x+\alpha_z}z$ and variance $Var_i[\theta] = Var[\theta|x_i, z] = \frac{1}{\alpha_x+\alpha_z}$. Private information introduces heterogeneity in

[2]The ESM is a permanent rescue funding programme that will succeed the temporary European Financial Stability Facility and European Financial Stabilization Mechanism. The ESM is due to be launched in mid-2012.

market expectations about the fundamental and may be read as heterogeneity in the filtering and interpretation of available information.

2.1 Equilibrium

A short term creditor finds it optimal to invest $a_i = 1$ if $E_i[\psi + A + \theta] \geq 1$, and $a_i = 0$ otherwise. I restrict attention to equilibria in which short term creditors use "switching strategies", in which case for every z there exits a threshold $x^*(z)$ such that $a_i = 1$ if and only if $x_i \geq x^*(z)$. Aggregate investment is thus increasing in the economic fundamental θ.

The equilibrium can be described by the threshold for the economic fundamental, $\theta^*(z)$, below which there is default because an insufficient number of short term creditors chooses to roll over their debt. When $\theta \geq \theta^*(z)$ there is no default; let p_i be the probability that agent i attributes to $\theta \geq \theta^*(z)$. An agent finds it optimal to invest when the expected return from roll-over is larger than the payoff from the alternative, that is, when $p_i R + (1 - p_i)(R - \Delta) \geq 1$.

I restrict $\sigma_z^2 \sqrt{2\pi} > \sigma_x$. This suffices for the equilibrium to be unique and amounts to saying that public information cannot be too precise, otherwise there are multiple equilibria. Let Φ and ϕ denote, respectively, the standard normal cumulative distribution function and the standard normal density distribution function.

Proposition 1 *(Morris and Shin 2004) There exists a unique equilibrium and $\theta^*(z)$ is implicitly determined by $\theta^* = \Phi\left(\sigma_x\left[\sqrt{\alpha_x + \alpha_z}\Phi^{-1}\left(1 - \frac{R-1}{\Delta}\right) + \alpha_z(\theta^* - z)\right]\right) - \psi$. The default threshold θ^* is decreasing in the return R, increasing in the LGD Δ, decreasing in the statistic for public information z, and decreasing in exogenous funding ψ.*

Proof. Follows from Morris and Shin (2004). An agent invests if and only if $x \geq x^*$ where x^* solves $p_i R + (1 - p_i)(R - \Delta) = 1$ with $p_i = 1 - \Phi\left(\left(\theta^* - \left[\frac{\alpha_x}{\alpha_x + \alpha_z}x^* + \frac{\alpha_z}{\alpha_x + \alpha_z}z\right]\right)\sqrt{\alpha_x + \alpha_z}\right)$. The mass of investors equals $A = 1 - \Phi\left(\sqrt{\alpha_x}(x^*(z) - \theta)\right)$. The sovereign defaults if and only if $\theta < \theta^*$ where θ^* solves $\psi + A + \theta^* = 1$, or equivalently $\theta^* = \Phi\left(\sqrt{\alpha_x}(x^* - \theta^*)\right) - \psi$. Solving for θ^* yields $\theta^*(z)$. The condition for uniqueness guarantees (with a slight abuse of notation) $\frac{\partial\theta^*}{\partial R} < 0$, $\frac{\partial\theta^*}{\partial\Delta} > 0$, $\frac{\partial\theta^*}{\partial z} < 0$ and $\frac{\partial\theta^*}{\partial\psi} < -1$. ■

The previous results account for a number of stylized facts. First, a high promised return R attracts short term creditors and reduces the probability of default while a high LGD has the opposite effect. Second, favorable public information, measured by z, improves confidence regarding the capability of the sovereign to fulfil its obligations and favours debt roll-over. Since $z = \theta + \sigma_z \varepsilon$, a stronger fundamental facilitates access to credit, which is a desirable property for any model of defaultable debt. Third, exogenous and long term funding, measured by ψ, reduce the incidence of failure.

Efficiency. The efficient outcome is rolling over if and only if $R+\theta \geq 1$ because the return from sovereign debt is higher than its alternative. Since $A \leq 1$, the borrower defaults whenever $\psi + \theta < 0$. In this sense, the sovereign is insolvent when $\theta < -\psi$. If $\theta \in [-\psi, \theta^*)$ there will be default in equilibrium, which would not occur if all investors were able to coordinate on rolling over the debt. As long as $R - \psi \geq 1$, liquidation is inefficient but it is forced on the sovereign. I interpret the value of the threshold θ^* as a measure of inefficiency due to coordination failure.

2.2 Model with a credit rating agency

CRAs base their analysis on public information and on private information and confidential information which borrowers agree to share with them. I assume that there is one single representative rating agency which privately observes a signal $\rho = \theta + \sigma_\rho \varepsilon_\rho$, where ε_ρ is standard normal, independent of θ, ε, and ξ_i, and the standard deviation σ_ρ is common knowledge. Signal ρ represents *new* available information not previously accessible to investors; variable ε_ρ is associated with errors in the agency signal. These errors may be interpreted as mistakes resulting from the process of collecting information and have the potential to mislead investors. The rating agency publicly announces its signal and short term creditors update their common prior accordingly.[3] The new prior about θ is normal with mean $E[\theta|z,\rho] = \frac{\alpha_z}{\alpha_z+\alpha_\rho} z + \frac{\alpha_\rho}{\alpha_z+\alpha_\rho}\rho$ and precision $\alpha_z + \alpha_\rho$ with $\alpha_\rho = \sigma_\rho^{-2}$. I focus on the case in which there is a unique equilibrium, i.e. $\sigma_z^2 \sigma_\rho^2 \sqrt{2\pi} > \sigma_x \left(\sigma_z^2 + \sigma_\rho^2\right)$.

Proposition 2 *(Carlson and Hale 2005) There exists a unique equilibrium and $\theta^*(z,\rho)$ is implicitly determined by $\theta^* = \Phi\left(\sigma_x \left[\sqrt{\alpha_x + \alpha_z + \alpha_\rho}\Phi^{-1}\left(1 - \frac{R-1}{\Delta}\right) + (\alpha_z + \alpha_\rho)\left(\theta^* - \frac{\alpha_z}{\alpha_z+\alpha_\rho} z - \frac{\alpha_\rho}{\alpha_z+\alpha_\rho}\rho\right)\right]\right) - \psi$. The default threshold θ^* is decreasing in the signal ρ.*

Proof. Follows from Carlson and Hale (2005). The uniqueness condition guarantees $\frac{\partial \theta^*}{\partial \rho} = -\frac{\sigma_x \alpha_\rho \phi\left(\Phi^{-1}(\theta^*+\psi)\right)}{1-\sigma_x(\alpha_z+\alpha_\rho)\phi(\Phi^{-1}(\theta^*+\psi))} < 0$. ■

[3] I take an agnostic view regarding the incentives of CRAs to disclose information. If there were several agencies, the signal ρ would summarize the information disclosed by all agencies.

The default threshold decreases with favorable information disclosed by the CRA but short term creditors are unable to identify the source of favorable information - a strong fundamental or a mistake in the information being disclosed (a positive shock ε_ρ).

Credit ratings. I map the probability that the sovereign is able to repay its debt into rating grades.[4] The credit rating equals the probability that the actual value of the fundamental θ lies above the threshold θ^*, conditional on z and ρ - the information available to the CRA. The agency is not merely rendering and opinion on credit worthiness; it anticipates the chain of events which will unfold - and lead to a shift in θ^* - following the issue of the rating. Define $\widehat{\rho}$ as the rating of sovereign debt such that $\widehat{\rho}(z,\rho) = \Phi\left(\left(\frac{\alpha_z}{\alpha_z+\alpha_\rho}z + \frac{\alpha_\rho}{\alpha_z+\alpha_\rho}\rho - \theta^*\right)\sqrt{\alpha_z+\alpha_\rho}\right)$. Given the public signal z, variables $\widehat{\rho}$ and ρ have identical informational content in equilibrium so it is indifferent which is announced. Still, while z and ρ are exogenous variables, the rating is determined endogenously.

Rating actions. The response of credit ratings to shifts in the fundamental θ equals

$$\frac{\partial\widehat{\rho}}{\partial\theta} = \sqrt{\alpha_z+\alpha_\rho}\,\phi\left(\Phi^{-1}(\widehat{\rho})\right) + \frac{\phi\left(\Phi^{-1}(\widehat{\rho})\right)\phi\left(\Phi^{-1}(\theta^*+\psi)\right)\sigma_x}{\sqrt{\alpha_z+\alpha_\rho}\left[1-\phi\left(\Phi^{-1}(\theta^*+\psi)\right)\sigma_x(\alpha_z+\alpha_\rho)\right]} > 0 \tag{1}$$

where I use the result $\partial z/\partial\theta = \partial\rho/\partial\theta = 1$. The term $\sqrt{\alpha_z+\alpha_\rho}\,\phi\left(\Phi^{-1}(\widehat{\rho})\right)$ expresses the conventional intuition that favorable information reduces the probability of default. The term $\frac{\phi\left(\Phi^{-1}(\widehat{\rho})\right)\phi\left(\Phi^{-1}(\theta^*+\psi)\right)\sigma_x}{\sqrt{\alpha_z+\alpha_\rho}[1-\phi(\Phi^{-1}(\theta^*+\psi))\sigma_x(\alpha_z+\alpha_\rho)]}$ is the novel feature. It arises because auspicious information favours coordination thereby reducing the default threshold θ^*. Following Morris and Shin (2004), I call this term the *"coordination effect"*.

A fixed and stable base of investors (associated with a high ψ) facilitates debt roll-over and improves ratings (because $\partial\widehat{\rho}/\partial\psi = \partial\widehat{\rho}/\partial\theta$). This effect comes about as a result of a shift in the default threshold. To the extent that individual investor i has a choice between rolling over or withdrawing, we can regard investor i as being a short-term claim holder while ψ represents long term debt. The response of credit ratings suggests the hypothesis that issuers with a large proportion of short-term debt are more vulnerable to coordination problems and hence more fragile. This explains a significant review and change in sovereign risk methodologies

[4] Standard & Poor's measures default risk in terms of default probability whereas Moody's ratings measure expected loss. Fitch uses probability of default for its issuer ratings and expected loss for its ratings of individual security issues. CRAs insist that they do not target their ratings to specific credit risk metrics but only to ordinal rankings of credit risk. Despite this claim, ratings are often used as though they map into specific credit-risk metrics, including the Basel Accord standardized approach.

which happened after the Asian crisis - when CRAs were widely criticized for failing to see the accumulation of risks that affected sovereign balance sheets. Today, the big rating agencies state that they closely monitor countries with a high proportion of short-term external debt.[5]

Finally, parameter ψ can be used to address explicitly a number of issues. If we interpret ψ as exogenous shocks in investors's preferences, identical fundamentals may generate different ratings across borrowers. This parameter can also be used to explain the role played by contingent liabilities in the determination of credit ratings (with the materialization of large claims being represented by low values of ψ). This is potentially important given the role the extraordinary support to the banking sector played in the current financial crisis. No matter which interpretation we give, CRAs may adjust ratings without any changes in the fundamental θ; they will reduce the credit score of a country whenever they perceive that ψ is lower.

Nonlinearities and cliff effects. There is anecdotal evidence of rating failure. During the 1997 Asian crisis, CRAs were accused both of being initially too lenient with the East Asian sovereigns, and subsequently of downgrading more than the deterioration of fundamentals would warrant. Ferri, Liu and Stiglitz (1999) show that the drop in actual ratings was sharper than the predictions of a model of ratings based on economic fundamentals, suggesting that rating downgrades were larger than what economic fundamentals would justify. Similar anomalies have been documented by the IMF (1999) and Afonso, Gomes and Rother (2007); Mora (2006) suggests that ratings are sticky because they adjust only when there is a sufficiently large divergence of predicted ratings from assigned ratings. The CRAs in recent years have come under close scrutiny in the US, as regulators and lawmakers blamed them for feeding the mortgage bubble by awarding top grades to bonds backed by subprime mortgages, while in Europe the CRAs have been accused of being too slow initially to downgrade sovereigns and subsequently downgrading sovereign credits too aggressively (see, for example, European Commission 2010). Because credit ratings coordinate agent's expectations, the relation between ratings, fundamentals and default is not linear. Nonlinearities create zones in which ratings (i) have a big influence on default probabilities and financial markets and, (ii) are inaccurate.

The sensitivity of the default threshold to variations in the *new* information disclosed by the CRA ρ depends on the expected value of the fundamental conditional on public information,

[5] Yet, recent empirical work has tried to reverse-engineer sovereign ratings from fundamental inputs and overall results indicate that short term external debt does not appear to be a significant factor in determining the level of credit ratings.

that is $E[\theta|z,\rho]$. The value of the derivative $\frac{\partial\theta^*}{\partial\rho}$ is larger when $\Phi^{-1}(\theta^*+\psi)=0$, that is for $E[\theta|z,\rho]=\theta^*+\frac{\sqrt{\alpha_x+\alpha_z+\alpha_\rho}}{\alpha_z+\alpha_\rho}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)$. I call *"crisis zone B"* to the set of values of $E[\theta|z,\rho]$ that belong to the neighborhood of $\theta^*+\frac{\sqrt{\alpha_x+\alpha_z+\alpha_\rho}}{\alpha_z+\alpha_\rho}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)$. For the special case $R-1=\Delta/2$, *"crisis zone B"* corresponds to the neighborhood of θ^* which means that the response of the default threshold is maximum when public information reveals that the fundamental is near the default threshold. In this case, many investors are uncertain about whether others will roll over their claims or not and they pay close attention to public information in order to guess what others will do. A small downgrade is sufficient to induce many investors to refuse to roll over their claims with fear that others will do the same, thereby making the default threshold very sensitive to small adjustments in the credit rating. The response of the default threshold θ^* to public information z is also larger in *"crisis zone B"*.

Consider $R-1\leq\Delta/2$, that is, the LGD is large when compared with the net return, and let ϑ be the value of $E[\theta|z,\rho]$ that maximizes expression (1). If $\vartheta\in\left[\theta^*,\theta^*+\frac{\sqrt{\alpha_x+\alpha_z+\alpha_\rho}}{\alpha_z+\alpha_\rho}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)\right]$, I call *"crisis zone A"* to the set of values of $E[\theta|z,\rho]$ that belong to the neighborhood of ϑ.[6] In this zone, the response of credit ratings to shifts in the fundamental θ or exogenous funding ψ is larger. For the special case $R-1=\Delta/2$, $\vartheta=\theta^*$ which means that the credit rating is more sensitive when public information signals that the fundamental is near the default threshold. In this case, investors pay close attention to the information received so as to guess if others will roll over or not. A small deterioration of the fundamental entails (slightly) negative information which is sufficient to induce many investors to refuse to roll over their claims with fear that others will do the same. As a result, the likelihood of default increases significantly, making the rating sensitive to apparently innocuous shifts in the fundamental or in the funding ψ.

The strength of the *"coordination effect"* increases as the sovereign approaches default. Since the default threshold θ^* is determined by the public signals z and ρ, agents attribute more weight to public information (when compared with private information) when they perceive a higher likelihood of sovereign default.

For reasonable values of the parameters, *"crisis zone B"* lies above *"crisis zone A"* (because $\vartheta\leq\theta^*+\frac{\sqrt{\alpha_x+\alpha_z+\alpha_\rho}}{\alpha_z+\alpha_\rho}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)$, see Figure 1), meaning that a sovereign facing a slow

[6] If $R>1+\frac{\Delta}{2}$ the interval becomes $\left[\theta^*+\frac{\sqrt{\alpha_x+\alpha_z+\alpha_\rho}}{\alpha_z+\alpha_\rho}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right),\theta^*\right]$. When $\vartheta\notin\left[\theta^*,\theta^*+\frac{\sqrt{\alpha_x+\alpha_z+\alpha_\rho}}{\alpha_z+\alpha_\rho}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)\right]$, *"crisis zone A"* does not exist.

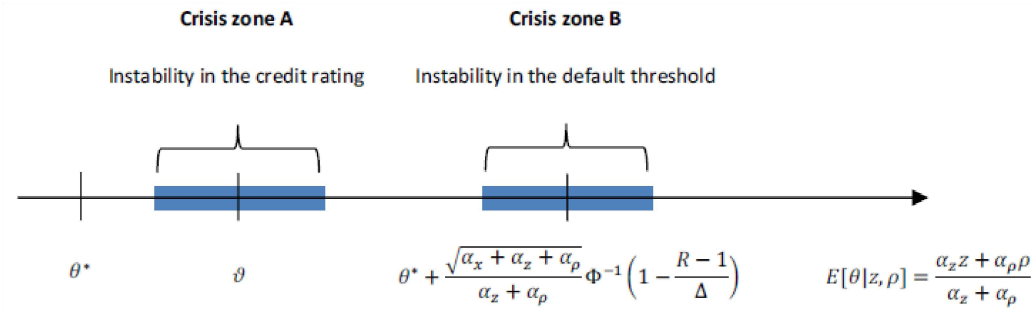

Figure 1: Crisis zones A and B when $R - 1 < \Delta/2$. When $R - 1 = \Delta/2$ the two zones coincide.

degradation of its balance sheet (for example, as a result of low economic growth) is likely to enter first *"crisis zone B"* before hitting *"crisis zone A"*. In this case, large adjustments in the credit rating (which are equivalent to changes in the default probability) occur after large changes in the default threshold.

The distance between the two crisis zones increases with the LGD Δ. This result calls for careful identification in models that predict credit ratings, because variation in default probabilities differs from variation in the default threshold. A number of reasons make identification difficult. As CRAs anticipate the feedback effects of ratings on credit quality, they may delay their decisions to downgrade debt. Additionally, CRAs may attach higher weights to their qualitative judgement in the crisis zones in an attempt to smooth credit ratings.[7] It has been suggested that efforts to smooth rating changes actually make them more prone to abrupt downgrades because smoothing practises merely delay what is likely to be inevitable. The model indicates that CRAs' attempts to avoid volatile ratings is more difficult in *"crisis zone A"* than in *"crisis zone B"*.

The model predicts that sharp downgrades should be less frequent for strong fundamentals. Indeed, transition matrices among rating grades confirm that over the long term, higher rating grades are more stable than the lower rating categories. Figure 2 summarizes the distribution of large downgrades among the several rating grades for corporate issuers rated by Standard

[7] Various tests of quantitative, model-driven ratings indicate that qualitative judgment done by CRAs is indeed an important rating driver. CRAs acknowledge that their assessment relies both on quantitative and on qualitative analysis and accounts for characteristics that are difficult to measure objectively. Although there are a number of studies analyzing how fundamentals determine ratings, it less clear how qualitative assessment influences the actions of CRAs.

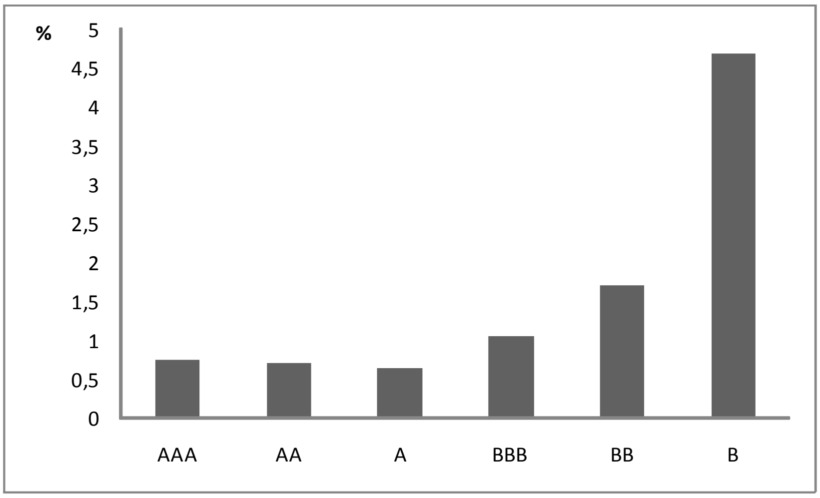

Figure 2: Proportion of corporate issuers with downgrades of at least two rating grades during the following year (Average for 1981-2010). Source: Standard & Poor's (2011).

& Poor's around the world in the past two decades, showing how low grades are less stable.[8] This is not conclusive evidence regarding the existence of feedback effects because one would also expect that uncertainty regarding the possibility of default increases as debtors approach the default threshold, thereby making lower grades less stable.

Studies relating credit ratings with historical default probabilities have shown that differences among the probabilities of default are minor among the highest ratings categories. Differences become significantly larger for the lowest rating categories. The reason for this non-proportional relation is because, for strong fundamentals, large shifts in the fundamental θ lead to small changes in the default probability (or, equivalently, in the credit rating).

These features justify preemptive action taken by sovereign governments before ratings become too volatile; government officials recognize how important it is to maintain a good rating in order to avoid the crisis zones. They also explain the fetish around the highest rating grades because, for the highest rating categories, small differences in ratings indicate large differences in fundamentals.[9]

[8] While downgrades are expected to some extent, a large number of them - in particular when they involve three or more notches at the same time or when the downgrading takes place within a short period after issuance or after another downgrade - are evidence of rating failure (see, for example, Bhatia 2002).

[9] Some say that governments and investors may well be attaching too much importance to the AAA grade because a downgrade from AAA to AA means only a slight increase in default risk. Yet, the Treasury Secretary, Tim Geithner, claimed that the US would "never" loose its AAA credit rating and a countless number of government officials have promised to defend the AAA rating.

I examine the role of the information structure for nonfundamental volatility, that is, volatility conditional on the fundamental θ. Specifically, I evaluate the sensitivity of the default threshold to ε_ρ, which I interpret as mistakes done by the CRA. I perform the analysis for values of the fundamental near the threshold θ^*. The regime is abandoned if and only if $\theta \leq \theta^*(z,\rho)$ where $z = \theta + \sigma_z \varepsilon$ and $\rho = \theta + \sigma_\rho \varepsilon_\rho$. Function $\theta^*(z,\rho)$ is continuously decreasing in both arguments and z and ρ are continuously increasing in θ. Hence, the sovereign defaults if and only if $\theta \leq \widehat{\theta}(\varepsilon, \varepsilon_\rho)$ where $\widehat{\theta}(\varepsilon, \varepsilon_\rho)$ is the unique solution to

$$\begin{aligned}\widehat{\theta} \;&=\; \Phi\left(\sigma_x\left[\sqrt{\alpha_x+\alpha_z+\alpha_\rho}\,\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)+\right.\right.\\&\left.\left.+\left(\alpha_z+\alpha_\rho\right)\left(\widehat{\theta}-\frac{\alpha_z}{\alpha_z+\alpha_\rho}\left(\widehat{\theta}+\sigma_z\varepsilon\right)-\frac{\alpha_\rho}{\alpha_z+\alpha_\rho}\left(\widehat{\theta}+\sigma_\rho\varepsilon_\rho\right)\right)\right]\right)-\psi.\end{aligned}$$

or, equivalently, $\widehat{\theta} = \Phi\left(\sigma_x\left[\sqrt{\alpha_x+\alpha_z+\alpha_\rho}\,\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)-\sqrt{\alpha_z}\varepsilon-\sqrt{\alpha_\rho}\varepsilon_\rho\right]\right)-\psi$. It follows that

$$\frac{\partial\widehat{\theta}}{\partial\varepsilon_\rho} = -\phi\left(\Phi^{-1}\left(\widehat{\theta}+\psi\right)\right)\frac{\sigma_x}{\sigma_\rho} < 0.$$

and function $\widehat{\theta}(\varepsilon, \varepsilon_\rho)$ satisfies the single crossing property with respect to ε_ρ. Figure 3 depicts the default threshold as a function of new information divulged by the CRA (measured by ε_ρ), with the dashed line corresponding to a higher precision α_ρ than the solid one.

The curvature of the relation becomes more pronounced when public information is more precise. Near the default threshold, the issuer is vulnerable to information released by the CRA because the probability of default is largely determined by the beliefs of market participants and short term creditors place too much weight on public information. Noisy (but on average accurate) private information about the fundamentals of the borrowers is not so valuable; investors assign a lower weight to their private information relative to credit ratings, which leads to the default threshold becoming excessively dependent on ratings. Investors tend to take CRAs' pronouncements too seriously and the situation is similar to the New York Times theatre critic who can shut down a Broadway show with an hostile review.

I analyze the relationship between the credit rating and the information released by the CRA (measured by ε_ρ), when the fundamental is near the default threshold θ^*. In this case, the credit rating may be written as $\widehat{\rho}(\varepsilon, \varepsilon_\rho) = \Phi\left(\sqrt{\frac{\alpha_z}{\alpha_z+\alpha_\rho}}\varepsilon + \sqrt{\frac{\alpha_\rho}{\alpha_z+\alpha_\rho}}\varepsilon_\rho\right)$. Figure 4 plots the credit rating as a function of ε_ρ, with the dashed line corresponding to a higher ratio $\frac{\alpha_\rho}{\alpha_z}$

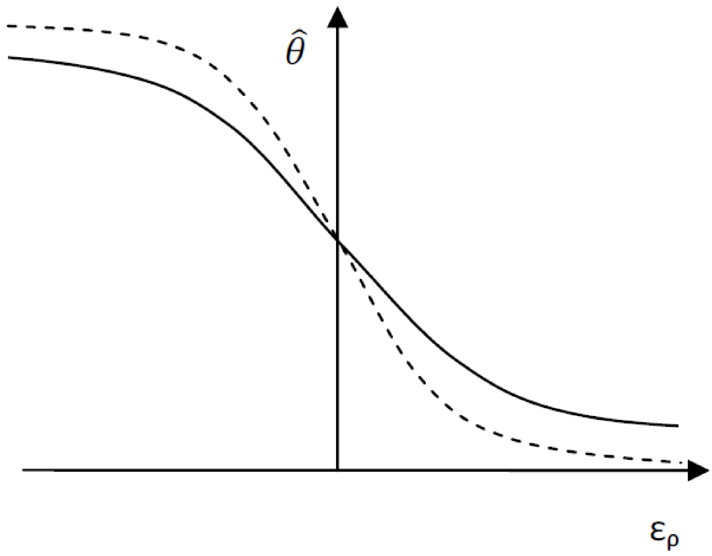

Figure 3: Default threshold as a function of ε_ρ. The dashed line corresponds to higher precision α_ρ.

than the solid one (again, I use the single-crossing property). The effect of variations in noise ε_ρ depends on the relative precision of the credit rating and, therefore, credit ratings should reflect the specific features of each market. During the subprime crisis, CRAs are generally seen to have performed well in the corporate bond market. It is in the structured finance segment that ratings performance has come under severe criticism. Indeed, the Issing Committee (2008) argues that the CRAs were wrong to carry over a well-established methodology from bond markets to more complex, structured finance instruments. Ratings of complex securities are very sensitive to the information disclosed by CRAs because there are few sources of information available. Creditworthiness rests on agencies' appraisals because investors overly rely on agencies' pronouncements to take decisions and, as a result, small mistakes in the information collected by CRAs may lead to very different ratings. For simple assets, agencies issue nearly identical forecasts but, for complex assets, ratings often reveal large assessment differences which create incentives to shop for the best rating. These features support the decision by European authorities that CRAs should discriminate between ratings for structured finance products and ratings for other financial obligations and back the decision to give the European markets regulator the power to approve rating methods.

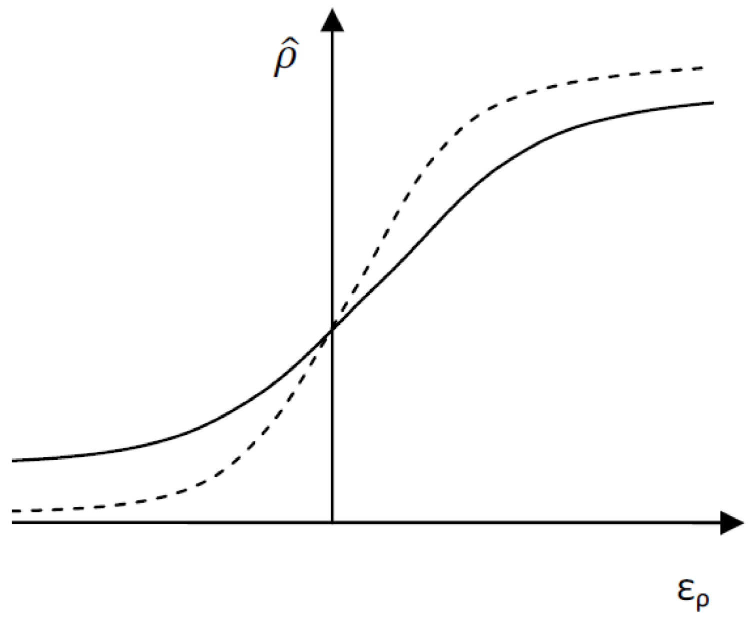

Figure 4: Credit rating as a function of ε_ρ. The dashed line corresponds to higher ratio $\frac{\alpha_\rho}{\alpha_z}$.

The effect of exogenous finance ψ on the default threshold is higher in *"crisis zone B"* and when the fundamental θ is near the default threshold, lending support to the hypothesis of "catalytic finance" by Morris and Shin (2006) and Corsetti, Guimarães and Roubini (2006). The idea behind "catalytic finance" is that the provision of official assistance to a country undergoing a financial crisis stimulates the private sector creditors into rolling over short term loans, thereby alleviating the funding crisis faced by the debtor country. Liquidity provision by an official institution like the IMF, the ESM or the ECB can work to prevent a destructive run by moving the default threshold θ^* downwards. To the extent that these institutions do not have infinite resources, the results make clear that "catalytic finance" is not effective when the fundamental is too weak: as more and more individuals receive bad private signals, the unwillingness to invest will cause a crisis regardless of whether there is an intervention or not. Hence, assistance to countries with conditioned access to liquidity should be limited to the crisis zones, where a small amount of liquidity can shore up the issuer and prevent its default. Additionally, the excess sensitivity of the default threshold θ^* suggests that the European markets regulator should be able to temporarily suspend the issuance of sovereign ratings for a country undergoing an international bailout programme.

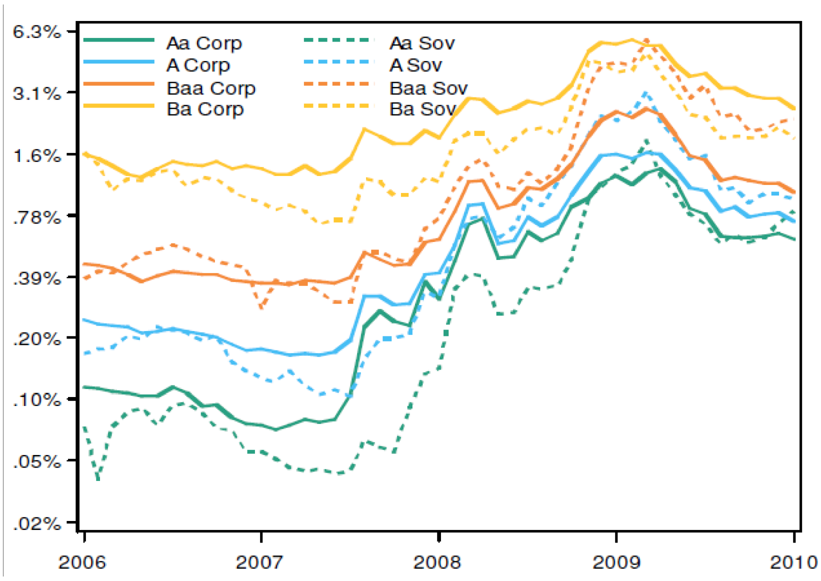

Figure 5: Median CDS spread by rating for sovereign and corporate debt. Source: Moody's Analytics (2010) formerly Moody's KMV.

3 Financial markets

The previous results presume that the precision of public information is independent of the precision of private information. This is unlikely to be the case when there are financial markets because prices aggregate private information. To investigate the role of prices, I introduce a financial market where agents trade a derivative security prior to playing the coordination game. Because the return on the derivative depends on the underlying fundamental, the equilibrium price will convey information that is valuable in the coordination game. Figure 5 compares median CDS spreads for corporations and for sovereign issuers by rating grades and shows that CDS spreads are lower for borrowers with higher rating.[10]

Setup. As before, the fundamental θ is drawn from an improper uniform distribution over the real line and each agent i receives the exogenous private signal $x_i = \theta + \sigma_x \xi_i$. For tractability reasons I separate the investment coordination game from the derivatives market. Agents can be seen as interacting in two separate stages.

The first stage happens in the derivatives market: agents trade a risky asset with return θ

[10] As of the credit crisis in 2007, CDS spreads have increased for all letter grades. This confirms that CRAs focus on the rank ordering of credit risk, instead of striving to maintain stable default rates for given rating groups.

at a price p. I adopt the CARA-normal framework introduced by Grossman and Stiglitz (1976). The utility of agent i is $v(w_i) = -e^{-\gamma w_i}$ for $\gamma > 0$, where $w_i = w_0 + (\theta - p) k_i$ is the final wealth, w_0 is the initial endowment, and k_i is investment in the asset. The supply of the asset is uncertain and not observed, given by $K^S(\varepsilon_s) = \sigma_s \varepsilon_s$, where $\sigma_s > 0$ and ε_s is standard normal, independent of θ and ξ_i. This formulation means that the derivative security exists in zero net supply plus some noise - parametrized by σ_s - which prevents a fully revealing equilibrium.

The second stage is essentially the same as the model with credit rating agency in the previous Section: short term creditors decide whether to invest or not; the sovereign government defaults if and only if $\psi + A + \theta < 1$ and the payoff from this stage is $u(a_i, A, \theta, \psi)$. The only difference is that short term creditors observe the price that cleared the financial market. The eventual default by the sovereign, the derivative's return and the payoffs from both stages are realized at the end of stage 2.

Individual derivative security demand is a function of x and p, the realizations of the private and public signals, and the corresponding aggregate is a function of θ and p. The individual investment decision on sovereign debt is a function of x, ρ and p and the corresponding aggregate is a function of θ, ρ and p.

Definition 1 *An equilibrium is a price function, $P(\theta, \varepsilon_s)$, individual strategies for investment in the derivative and in public debt, $k(x,p)$ and $a(x,\rho,p)$, and their corresponding aggregates, $K(\theta,p)$ and $A(\theta,\rho,p)$, such that:*

$$\begin{aligned} k(x,p) &\in \arg\max_{k \in R} E_i\left[v\left(w_0 + (\theta - p) k\right)\right] \\ K(\theta,p) &= E\left[k(x,p) \mid \theta, p\right] \\ K(\theta, P(\theta,\varepsilon_s)) &= K^S(\varepsilon_s) \end{aligned}$$

and

$$\begin{aligned} a(x,\rho,p) &\in \arg\max_{a \in \{0,1\}} E_i\left[u(a_i, A, \theta, \psi)\right] \\ A(\theta,\rho,p) &= E\left[a(x,p) \mid \theta, \rho, p\right] \end{aligned}$$

and the sovereign government defaults if and only if $\psi + A(\theta,\rho,p) + \theta < 1$.

The above conditions define a rational expectations competitive equilibrium for the first stage and a Bayesian equilibrium for stage 2. There is an important difference in the second stage with respect to the model in Section 2.2: the endogenous price p replaces the exogenous public signal z.

Equilibrium. In the first stage, I guess a linear price function. Observing the price realization then is equivalent to observing a normally distributed signal with some precision $\alpha_p = \sigma_p^{-2} \geq 0$. The posterior of θ conditional on x and p is normally distributed with mean $\frac{\alpha_x}{\alpha_x+\alpha_p}x + \frac{\alpha_p}{\alpha_x+\alpha_p}p$ and precision $\alpha_x + \alpha_p$. Individual asset demand is $k(x,p) = \frac{\alpha_x}{\gamma}(x-p)$ and aggregate demand is $K(\theta,p) = \frac{\alpha_x}{\gamma}(\theta-p)$. Market clearing implies $P(\theta,\varepsilon_s) = \theta - \gamma\sigma_s\sigma_x^2\varepsilon_s$ which verifies the initial guess with $\sigma_p = \gamma\sigma_s\sigma_x^2$. This result highlights the informative role of prices because the precision of public information improves with private information.

The second stage is equivalent to the benchmark model in the previous Section, with the price p playing the role of the public signal. Replace σ_z with σ_p and the uniqueness condition becomes $\gamma^2\sigma_s^2\sigma_x^3\sigma_\rho^2\sqrt{2\pi} > \gamma^2\sigma_s^2\sigma_x^4 + \sigma_\rho^2$.

Proposition 3 *(Angeletos and Werning 2006) There exists a unique equilibrium and $\theta^*(p,\rho)$ is implicitly determined by $\theta^* = \Phi\left(\sigma_x\left[\sqrt{\alpha_x+\alpha_p+\alpha_\rho}\,\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right) + (\alpha_p+\alpha_\rho)\left(\theta^* - \frac{\alpha_p}{\alpha_p+\alpha_\rho}p - \frac{\alpha_\rho}{\alpha_p+\alpha_\rho}\rho\right)\right]\right) - \psi$. The default threshold θ^* is decreasing in the price p.*

Proof. Follows from Angeletos and Werning (2006). The uniqueness condition guarantees $\frac{\partial\theta^*}{\partial p} < 0$. ■

The model behaves in a similar way to the model with CRA in Section 2.2, with prices replacing the public signal z; high prices signal a strong fundamental and favour debt roll-over. It follows that the model of financial markets without CRA is the limit case in which the precision of the information disclosed by the agency is null ($\alpha_\rho \to 0$) and the market price of the derivative is the only source of public information.

3.1 Nonfundamental volatility

I examine the role of the information structure for nonfundamental volatility. Specifically, I evaluate the sensitivity of the default threshold and credit ratings to shocks in prices (ε_s) and to shocks in the information disclosed by the CRA (ε_ρ). I interpret the former as noise in financial markets and the latter as mistakes done by the CRA. I obtain two sets of results.

First, the impact of the exogenous shocks ε_s and ε_ρ is larger near the default threshold and, second, less noise in public information increases volatility in credit ratings and instability in primary markets.

Credit ratings. The CRA incorporates the information embedded in the financial price into the credit rating, so that $\widehat{\rho}(p,\rho) = \Phi\left(\left(\frac{\alpha_p}{\alpha_p+\alpha_\rho}p + \frac{\alpha_\rho}{\alpha_p+\alpha_\rho}\rho - \theta^*\right)\sqrt{\alpha_p+\alpha_\rho}\right)$. It follows that

$$\frac{\partial\widehat{\rho}}{\partial\varepsilon_s} = -\phi\left(\Phi^{-1}\left(\widehat{\rho}\right)\right)\left(\sqrt{\frac{\alpha_p}{\alpha_p+\alpha_\rho}} + \frac{\sqrt{\alpha_p}\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\sqrt{\alpha_p+\alpha_\rho}}{1-\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\left(\alpha_p+\alpha_\rho\right)}\right) < 0.$$

A positive supply shock reduces the price of the derivative which the CRA interprets as a deterioration in credit quality. Noise in financial markets has two effects on the rating of sovereign debt. First, there is a direct effect because low prices signal low credit quality. Second, there is the *"coordination effect"* working through the default threshold. For completeness,

$$\frac{\partial\widehat{\rho}}{\partial\varepsilon_\rho} = \phi\left(\Phi^{-1}\left(\widehat{\rho}\right)\right)\left(\sqrt{\frac{\alpha_\rho}{\alpha_p+\alpha_\rho}} + \frac{\sqrt{\alpha_\rho}\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\sqrt{\alpha_p+\alpha_\rho}}{1-\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\left(\alpha_p+\alpha_\rho\right)}\right) > 0.$$

Impact on sovereign default. In order to obtain a better understanding of the effect of noise on the default threshold, I perform the analysis for θ near θ^*. The regime is abandoned if and only if $\theta \leq \theta^*(p,\rho)$ where $p = \theta - \sigma_p\varepsilon_s$ and $\rho = \theta + \sigma_\rho\varepsilon_\rho$. Function $\theta^*(p,\rho)$ is continuously decreasing in both arguments and p and ρ are continuously increasing in θ. Hence, the sovereign defaults if and only if $\theta \leq \widehat{\theta}(\varepsilon_s,\varepsilon_\rho)$ where $\widehat{\theta}(\varepsilon_s,\varepsilon_\rho)$ is the unique solution to $\widehat{\theta} = \Phi\left(\sigma_x\left[\sqrt{\alpha_x+\alpha_p+\alpha_\rho}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right) - \sqrt{\alpha_p}\varepsilon_s - \sqrt{\alpha_\rho}\varepsilon_\rho\right]\right) - \psi$. Function $\widehat{\theta}(\varepsilon_s,\varepsilon_\rho)$ satisfies the single crossing property with respect to the shocks because

$$\begin{aligned}\frac{\partial\widehat{\theta}}{\partial\varepsilon_\rho} &= -\phi\left(\Phi^{-1}\left(\widehat{\theta}+\psi\right)\right)\frac{\sigma_x}{\sigma_\rho} < 0,\\ \frac{\partial\widehat{\theta}}{\partial\varepsilon_s} &= \phi\left(\Phi^{-1}\left(\widehat{\theta}+\psi\right)\right)\frac{\sigma_x}{\sigma_p} = \phi\left(\Phi^{-1}\left(\widehat{\theta}+\psi\right)\right)\frac{1}{\gamma\sigma_s\sigma_x} > 0.\end{aligned}$$

The potential for real damage provoked by errors in credit ratings is immense near the default threshold. This is a consequence of the feedback effects of credit ratings and the pivotal role played by CRAs; the use of credit ratings is so pervasive that market participants cannot ignore them even if they do not consider them reliable. The same can be said about the noise in prices; these too may increase the coordination motive and bring instability to financial markets. A

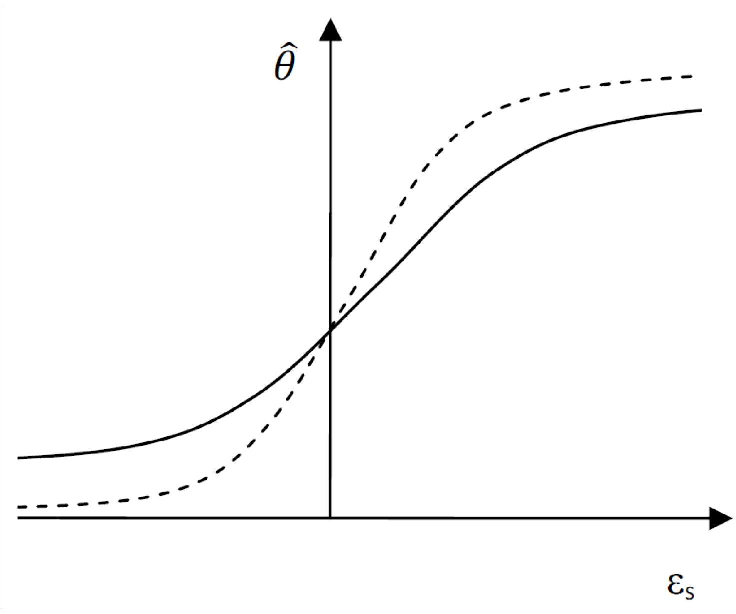

Figure 6: Default threshold $\widehat{\theta}$ as a function of ε_s. The dashed line corresponds to a lower σ_s.

reduction in the standard deviation σ_s or σ_ρ increases the sensitivity of the equilibrium outcomes to the exogenous shocks ε_s and ε_ρ, making primary markets more unstable. Figure 6 depicts function $\widehat{\theta}\,(\varepsilon_s, \varepsilon_\rho)$ with the dashed line corresponding to lower standard deviation σ_s than the solid one.

Near the default threshold, the sensitivity of credit ratings to noise in prices increases with the relative precision of the information contained in prices. This set of results calls for a reassessment of the current trend towards more transparency in derivatives markets as regulators move over-the-counter (OTC) contracts to exchanges (and clearing houses). By making prices more widely available to buyers of OTC derivatives, regulators will raise the coordination role of prices thereby creating new challenges for the industry.[11]

4 Following investor opinion

In this Section I examine situations where information originates within the coordination game itself: the CRA divulges a public signal about the aggregate level of investment in sovereign

[11] The result that more transparency in public information can be damaging for welfare contrasts with some of the results on the social value of public information (Svensson, 2006). The difference is due to the specification of the payoff function and because I focus on the crisis zones.

debt. Such feature seems relevant for thinking about CRAs because some authors argue that CRAs do not produce new information and follow investor opinion instead; somehow CRA are able to observe (or anticipate) what investors do. Still, credit ratings are unique because they serve as focal points for the coordination of agent's expectations.

The model is identical to the basic model of Section 2, except that the public signal z is replaced with $y = \Phi^{-1}(1-A) + \sigma_y \varepsilon_y$ where ε_y is normally distributed and independent of θ and ξ_i (see Dasgupta 2003, for details on this specification). The public signal y is disclosed by the CRA and agents condition their investment decisions on this indicator of aggregate behavior.

Definition 2 *An equilibrium consists of an endogenous signal* $y = Y(\theta, \varepsilon_y)$*, an individual investment strategy* $a(x, y)$ *and aggregate investment* $A(\theta, y)$*, which satisfy:*

$$\begin{aligned} a(x,y) &\in \arg\max_{a\in\{0,1\}} E_i\left[u\left(a_i, A(\theta,y), \theta, \psi\right)\right] \\ A(\theta,y) &= E\left[a(x,p)\,|\theta, y\right] \\ y &= \Phi^{-1}\left(1 - A(\theta,y)\right) + \sigma_y \varepsilon_y. \end{aligned}$$

In equilibria with "switching strategies" an agent invests if and only if $x \geq x^*(y)$ and the sovereign defaults if and only if $\theta \leq \theta^*(y)$. Hence an equilibrium is identified with functions $x^*(y), \theta^*(y)$ and $y = Y(\theta, \varepsilon_y)$. The uniqueness condition becomes $\sigma_y^2 \sigma_x \sqrt{2\pi} > 1$.

Proposition 4 *(Angeletos and Werning 2006) There exists a unique equilibrium and* $\theta^*(y)$ *is determined by* $\theta^* = \Phi\left(\frac{1}{\sigma_x}\left(\frac{1}{\sqrt{\alpha_x + \frac{1}{(\sigma_x\sigma_y)^2}}}\Phi^{-1}\left(1 - \frac{R-1}{\Delta}\right) + \frac{\frac{1}{(\sigma_x\sigma_y)^2}}{\alpha_x + \frac{1}{(\sigma_x\sigma_y)^2}}\sigma_x y\right)\right) - \psi.$

Proof. In an equilibrium with "switching strategies" the mass of investors equals $A(y,\theta) = 1 - \Phi\left(\frac{1}{\sigma_x}(x^*(y) - \theta)\right)$. Using the definition of public signal, $y = \Phi^{-1}(1-A) + \sigma_y\varepsilon_y = \frac{1}{\sigma_x}(x^*(y) - \theta) + \sigma_y \varepsilon_y$ and, therefore $x^*(y) - \sigma_x y = \theta - \sigma_x\sigma_y\varepsilon_y$. This expression can be seen as a function that relates y and $z \equiv \theta - \sigma_x\sigma_y\varepsilon_y$. Given y, agents are able to infer z where $\sigma_z = \sigma_x\sigma_y$. An agent invests if and only if $x \geq x^*(y)$ where $x^*(y)$ solves $R - \Phi\left(\sqrt{\alpha_x + \alpha_z}\left[\theta^* - \left(\frac{\alpha_x}{\alpha_x+\alpha_z}x^* + \frac{\alpha_z}{\alpha_x+\alpha_z}z\right)\right]\right)\Delta = 1$ with $\alpha_z = \frac{1}{\sigma_z^2}$. This expression can be rewritten as

$$R - \left[1 - \Phi\left(\sqrt{\alpha_x + \alpha_z}\left[x^* - \theta^* - \frac{\alpha_z}{\alpha_x + \alpha_z}\sigma_x y\right]\right)\right]\Delta = 1. \tag{2}$$

The sovereign defaults if and only if $\theta < \theta^*(y)$ where $\theta^*(y)$ solves $\psi + A(\theta, y) + \theta = 1$, or equivalently

$$\theta^* = \Phi\left(\frac{x^* - \theta^*}{\sigma_x}\right) - \psi. \tag{3}$$

Substituting (2) into (3) I get $\theta^* = \Phi\left(\frac{1}{\sigma_x}\left(\frac{1}{\sqrt{\alpha_x+\alpha_z}}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)+\frac{\alpha_z}{\alpha_x+\alpha_z}\sigma_x y\right)\right)-\psi$. This expression yields a unique solution $\theta^*(y)$ and substituting this solution into (3) I obtain the unique solution $x^*(y) = \theta^* + \frac{1}{\sqrt{\alpha_x+\alpha_z}}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)+\frac{\alpha_z}{\alpha_x+\alpha_z}\sigma_x y = \Phi\left(\frac{1}{\sigma_x}\left(\frac{1}{\sqrt{\alpha_x+\alpha_z}}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)+\frac{\alpha_z}{\alpha_x+\alpha_z}\sigma_x y\right)\right) - \psi + \frac{1}{\sqrt{\alpha_x+\alpha_z}}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)+\frac{\alpha_z}{\alpha_x+\alpha_z}\sigma_x y$.

Finally, I confirm that $F(y) = x^*(y) - \sigma_x y$ is indeed a function. Substituting $x^*(y)$ yields $F(y) = \Phi\left(\frac{1}{\sigma_x}\left(\frac{1}{\sqrt{\alpha_x+\alpha_z}}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)+\frac{\alpha_z}{\alpha_x+\alpha_z}\sigma_x y\right)\right) - \psi + \frac{1}{\sqrt{\alpha_x+\alpha_z}}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right) + \left(\frac{\alpha_z}{\alpha_x+\alpha_z}-1\right)\sigma_x y$ and computing the sign of $F'(y)$ it is easy to show that $F(y)$ is monotonic. ■

Just as in the benchmark model of Section 2.2, equilibrium depends on the credit rating. There is a fundamental difference, though, as the *new* information provided by the CRA is now endogenous.

Financial markets. As in the Section 3, a financial market opens in the first stage and reveals the price of the derivative. In this setup, it remains to characterize the public signal released by the CRA. Signal y about the aggregate level of investment comprises two types of information. First, it includes information embedded in market prices because these signal aggregate behavior. Were this the only type of information disclosed by the CRA and $y = \Phi^{-1}(1-A) + \frac{\sigma_p}{\sigma_x}\varepsilon_s$; this type of information is redundant since it conveys the same information as prices. The second type of information contained in signal y is *new* information, independent of the information contained in prices. Signal y is informative as long as it carries information beyond market prices. In this case the noise in y - parametrized by $\sigma_y\varepsilon_y$ - is less than the noise in prices. I restrict $\sigma_y^2\gamma^2\sigma_s^2\sigma_x^5\sqrt{2\pi} > \sigma_y^2\sigma_x^2 + \gamma^2\sigma_s^2\sigma_x^2 - \sigma_y^2$.

Proposition 5 *(Equivalence Principle) In a market-based financial system, the equilibrium obtained when the CRA follows investor opinion is equivalent to the equilibrium obtained when the CRA discloses a private signal ρ.*

Proof. As shown in the proof of Proposition 4, given y, agents are able to infer the public signal $z \equiv \theta - \sigma_x\sigma_y\varepsilon_y = \theta - \sqrt{\frac{1}{\alpha_p+\alpha_{\tilde{\rho}}}}\varepsilon_y$. Variable z incorporates information about p and the new information produced by the CRA. Given that z and p are normally distributed, the new information can be represented by a signal $\widetilde{\rho} = \theta + \sigma_{\widetilde{\rho}}\varepsilon_{\widetilde{\rho}}$ where $\varepsilon_{\widetilde{\rho}}$ is standard normal, independent of θ, ε_s and ξ_i and with $\sigma^2_{\widetilde{\rho}} = \frac{1}{\alpha_{\widetilde{\rho}}}$. Hence $z = \frac{\alpha_{\widetilde{\rho}}}{\alpha_p+\alpha_{\widetilde{\rho}}}\widetilde{\rho} + \frac{\alpha_p}{\alpha_p+\alpha_{\widetilde{\rho}}}p$ and, after the first stage, the new prior has precision $\alpha_p + \alpha_{\widetilde{\rho}}$. The investment problem is equivalent to the second stage of the model of Section 3. Hence Proposition 3 holds with $\widetilde{\rho}$ replacing ρ. The uniqueness condition becomes $\gamma^2\sigma_s^2\sigma_x^3\sqrt{2\pi} > 1 + \alpha_{\widetilde{\rho}}\gamma^2\sigma_s^2\sigma_x^2$ which is equivalent to $\sigma_y^2\gamma^2\sigma_s^2\sigma_x^5\sqrt{2\pi} > \sigma_y^2\sigma_x^2 + \gamma^2\sigma_s^2\sigma_x^2 - \sigma_y^2$. ■

It follows that the results regarding nonfundamental volatility hold with this form of "herding". The main issue is whether CRAs improve the precision of the information provided by financial markets or if they just reproduce the information already contained in prices.

New information released by the CRA about the mass of investors can be represented by the signal $\widetilde{\rho} = \theta + \sigma_{\widetilde{\rho}}\varepsilon_{\widetilde{\rho}}$ where $\varepsilon_{\widetilde{\rho}}$ is standard normal, independent of θ, ε_s and ξ_i and with $\alpha_{\widetilde{\rho}} = \frac{1}{\sigma^2_{\widetilde{\rho}}}$ being a measure of precision. The standard deviation in the public signal y is $\sigma_y = \frac{1}{\sigma_x}\sqrt{\frac{1}{\alpha_p+\alpha_{\widetilde{\rho}}}}$. As $\alpha_{\widetilde{\rho}} \to 0$, the signal y becomes uninformative and I obtain the equilibrium in financial markets without CRA. When $\alpha_{\widetilde{\rho}} > 0$, signal y is informative and $\sigma_y < \frac{\sigma_p}{\sigma_x}$, that is, the CRA improves the precision of the information contained in prices.

5 Hardwiring

One key concern is whether downgrades destabilize financial markets because ratings are embedded in many regulations and private contracts. Prudential regulations typically allow for less capital or liquidity to be held against highly rated securities. Central banks use ratings to determine which assets can serve as collateral in their money market operations. Suitability standards, which discipline fund managers by restricting investments to assets with certain risk characteristics, are often based on rating thresholds. Credit ratings are used as triggers for collateral calls in margin agreements in financing transactions. In these ways ratings drive institutional demand and market liquidity.

The preceding Sections contain descriptions drawn from individual investor optimal behavior. This Section considers the mechanical use of credit ratings in investment decisions. To do this I reinterpret ψ as the amount of debt in the hands of institutional investors who have a long term horizon *and use ratings as "buy-sell triggers"*. As in Section 3, the price of the derivative security is determined before the CRA discloses ρ. Let ψ depend on the price p and the signal ρ so that $\psi(p,\rho) = \Phi\left(\rho + \frac{\alpha_p}{\alpha_\rho}p\right)\overline{\psi}$; function $\psi(p,\rho)$ is increasing in the public signals ρ and p and takes values in the interval $\left(0,\overline{\psi}\right)$ with $\overline{\psi}$ denoting the maximum amount of debt that can be rolled over using credit ratings as *"buy-sell triggers"*. Following the same steps and using the same assumptions as in Section 3, I obtain the following result.

Proposition 6 *(Hardwiring) There exists a unique equilibrium and $\theta^*(p,\rho)$ is implicitly determined by* $\theta^* = \Phi\left(\sigma_x\left[\sqrt{\alpha_x+\alpha_p+\alpha_\rho}\Phi^{-1}\left(1-\frac{R-1}{\Delta}\right)+(\alpha_p+\alpha_\rho)\left(\theta^* - \frac{\alpha_p}{\alpha_p+\alpha_\rho}p - \frac{\alpha_\rho}{\alpha_p+\alpha_\rho}\rho\right)\right]\right) - \Phi\left(\rho+\frac{\alpha_p}{\alpha_p}p\right)\overline{\psi}$.

It could be argued that market practises, laws and regulations that hardwire buy or sell decisions to rating thresholds make the amount of debt held by institutional investors ψ vary with the credit rating $\widehat{\rho}$ and not with ρ or p. In the current setup both representations are equivalent because ρ and $\widehat{\rho}$ have the same informational content once the price p is known. Represent the relationship between ψ and $\widehat{\rho}$ as a function $\widehat{\psi}\left(\widehat{\rho}\right)$. The degree of hardwiring of investment decisions to credit ratings is given by the slope of this function, that is $\widehat{\psi}'\left(\widehat{\rho}\right) = \frac{\partial\psi/\partial p}{\partial\widehat{\rho}/\partial p} = \frac{\partial\psi/\partial\rho}{\partial\widehat{\rho}/\partial\rho} > 0$; lower ratings diminish the amount of debt in the hands of those investors who use ratings as "buy-sell triggers", which is a desirable property for any model of hardwiring.

Repeating the comparative-statics analysis performed earlier, reveals that hardwiring amplifies the response of the credit rating and the default threshold to shocks in prices (ε_s) and to shocks in the information disclosed by the CRA (ε_ρ). Effects are measured by the following derivatives:

$$\begin{aligned}
\frac{\partial\widehat{\rho}}{\partial\varepsilon_s} &= -\phi\left(\Phi^{-1}\left(\widehat{\rho}\right)\right)\left(\sqrt{\frac{\alpha_p}{\alpha_p+\alpha_\rho}} + \frac{\sqrt{\alpha_p}\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\sqrt{\alpha_p+\alpha_\rho}}{1-\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\left(\alpha_p+\alpha_\rho\right)} + \right. \\
&\quad \left. + \frac{\phi\left(\rho+\frac{\alpha_p}{\alpha_p}p\right)\frac{\sqrt{\alpha_p}}{\alpha_\rho}\overline{\psi}\sqrt{\alpha_p+\alpha_\rho}}{1-\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\left(\alpha_p+\alpha_\rho\right)}\right) < 0, \\
\frac{\partial\widehat{\rho}}{\partial\varepsilon_\rho} &= \phi\left(\Phi^{-1}\left(\widehat{\rho}\right)\right)\left(\sqrt{\frac{\alpha_\rho}{\alpha_p+\alpha_\rho}} + \frac{\sqrt{\alpha_\rho}\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\sqrt{\alpha_p+\alpha_\rho}}{1-\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\left(\alpha_p+\alpha_\rho\right)} + \right. \\
&\quad \left. + \frac{\phi\left(\rho+\frac{\alpha_p}{\alpha_p}p\right)\overline{\psi}\sqrt{\frac{\alpha_p+\alpha_\rho}{\alpha_p}}}{1-\phi\left(\Phi^{-1}\left(\theta^*+\psi\right)\right)\sigma_x\left(\alpha_p+\alpha_\rho\right)}\right) > 0,
\end{aligned}$$

and, for $\overline{\psi} < \frac{\alpha_\rho \sqrt{2\pi}}{\alpha_p + \alpha_\rho}$,

$$\frac{\partial \widehat{\theta}}{\partial \varepsilon_\rho} = -\frac{\phi\left(\Phi^{-1}\left(\widehat{\theta}+\psi\right)\right)\frac{\sigma_x}{\sigma_\rho} + \phi\left(\rho + \frac{\alpha_p}{\alpha_\rho}p\right)\overline{\psi}\sigma_\rho}{1-\phi\left(\rho+\frac{\alpha_p}{\alpha_\rho}p\right)\overline{\psi}\left(1+\frac{\alpha_p}{\alpha_\rho}\right)} < 0$$

$$\frac{\partial \widehat{\theta}}{\partial \varepsilon_s} = \frac{\phi\left(\Phi^{-1}\left(\widehat{\theta}+\psi\right)\right)\frac{\sigma_x}{\sigma_p} + \phi\left(\rho + \frac{\alpha_p}{\alpha_\rho}p\right)\frac{\alpha_p}{\alpha_\rho}\overline{\psi}\sigma_p}{1-\phi\left(\rho+\frac{\alpha_p}{\alpha_\rho}p\right)\overline{\psi}\left(1+\frac{\alpha_p}{\alpha_\rho}\right)} > 0.$$

Comparing these results with those in Section 3.1, shows that the *"coordination effect"* of credit ratings is exacerbated by market practises, laws and regulations that hardwire buy or sell decisions to rating thresholds. This hardwiring contributes significantly to market reliance on ratings, reinforcing their role as focal points. It is a cause of herding in market behavior, because regulations effectively require or motivate large numbers of market participants to act in similar fashion, especially when downgrades cross into non investment grade categories. Omitting references to ratings in regulation would thus reduce their use as sell-triggers and could stabilize financial markets.

The same results hold for regulations and rules that rely on market-based indicators like financial prices. Some have suggested replacing credit ratings with CDS premia and credit spreads, but these too may increase the coordination motive and bring instability to financial markets. Hence, recent proposals to use CDS information to estimate the risk taking by banks should be carefully evaluated; market discipline is important but has limitations when applied to regulation as it may unduly amplify the effect of errors.[12]

6 Welfare and policy implications

In order to investigate welfare effects and examine policy trade-offs, I restrict attention to the model with a CRA presented in Section 2.2. When $\theta \geq \theta^*$ social gains equal $R(A+\psi)+1-A-\psi$ and when $\theta < \theta^*$ social gains equal $(R-\Delta)(A+\psi)+1-A-\psi$. Expected welfare equals $1+(R-1)\left[\psi+\int_{\theta^*}^{+\infty} Af(\theta)\,d\theta\right] - \Delta\left[\psi+\int_{-\infty}^{\theta^*} Af(\theta)\,d\theta\right]$ where $f(\theta)$ denotes the distribution of the fundamental θ conditional on the public signals z and ρ.

Interpret ψ as financial assistance. Its impact on welfare illustrates a fundamental trade

[12] In June 2007, CDS prices for the banking sector were at a record low level and, in 2009, sovereign debt prices for countries like Ireland, Greece, Portugal, Italy and Spain were the same as for Germany.

off in the model. On the one hand, when the fundamental is unambiguously low, it is better to have perfect coordination among investors and set $\psi = 0$. On the other hand, when the fundamental θ is near the default threshold, assistance can change the final outcome of the game; a positive ψ can be welfare enhancing because it decreases the value of the threshold θ^*.

To keep the analysis tractable, I will be interested in the limiting case when the private signals of short term creditors become very precise. This corresponds to the case where $\alpha_x \to \infty$, in which case the credit rating is irrelevant. From its definition, the threshold θ^* satisfies $\theta^* = 1 - \frac{R-1}{\Delta} - \psi$. The fact that the parameters are related in this way is a result of the payoff normalization, and should not be read literally. Of more importance is the observation that inefficiencies persist despite perfect coordination among short term creditors; all short term creditors invest if and only if $\theta \geq \theta^*$. Since $1 - \frac{R-1}{\Delta} > 0$, $\theta^* > -\psi$ so that there are states between $-\psi$ and θ^* at which the sovereign defaults even when it is fundamentally sound. Private signals reveal what the underlying state θ is, but strategic uncertainty - uncertainty over the actions of other short term creditors – is not resolved.

Recall from Section 2.1 that the efficient outcome is rolling over if and only if $R + \theta \geq 1$. A welfare increase can be achieved with official interventions, in the spirit of Morris and Shin (2006). The IMF does not intervene when $\theta < 1 - R$; when $1 - R \leq \theta < 1 - \frac{R-1}{\Delta}$, it is efficient to intervene and the IMF sets $\psi = 1 - \frac{R-1}{\Delta} - \theta$ so that the sovereign does not default (because $\theta = \theta^*$) and, when $\theta \geq 1 - \frac{R-1}{\Delta}$, IMF intervention is not needed.

Disclosure of information. Credit ratings and their precision - determined by α_ρ - have mixed effects on welfare, preventing clear cut answers regarding the best disclosure policies. The reason is that credit ratings play one role when the country is fundamentally solvent or insolvent, and play a different role when there is a strong possibility of sovereign default. When fundamentals are unequivocally strong or weak, credit ratings help agents to make informed decisions and to coordinate their actions. To take one example, when the fundamental is strong and it is optimal that every short term creditor rolls over, credit ratings provide useful information about the fundamental and reduce the uncertainty about what other creditors will do; precise ratings improve the allocation of capital and increase welfare because they reduce the probability of inefficient default.

But the focus of this paper is on tail risk and on the perceptions of tail risk. Reducing this type of uncertainty is a main concern for policy makers, in particular when faced with extreme events like sovereign default. In such events, short term creditors overreact to public information, and can magnify the damage caused by noise. The dilemma posed by the potential for overreaction to public information is well-known to government officials with high public visibility. Central bankers have developed specific communication skills, knowing how their public statements may disproportionately influence financial markets. And yet, no restrictions have ever been imposed on the communication strategies of CRAs, which have allowed them to unduly influence financial markets.

There is scope for rethinking the disclosure policies of CRAs in terms of how much information should be disclosed, how it should be disclosed and when it should be disclosed. The results in this paper lend support to some of the reforms sought by the European Commission such as giving the European markets regulator the power to approve rating methods and to decide the appropriate timing for the publication of sovereign credit ratings, and in particular the power to suspend credit ratings of a country undergoing an international bailout programme.

Yet, censorship has an important drawback. At a crucial moment the agencies had to declare that they were unable to provide a rating of a country, it would be as clear a signal to the markets as a downgrade itself. Hence, the optimal disclosure policy may include smoothing practises to avoid volatile ratings, and endorsing accurate smoothing methods could be part of the enhanced regulatory oversight. This task is more important as there is significant rating instability during periods of market stress, suggesting that smoothing techniques work less well during such times - I have mentioned why these techniques may be more successful in *"crisis zone B"*. Smoothing rules are part of the communication strategies of CRAs, but finding their optimal strategies is beyond the scope of this contribution.

Europeans have also called for the creation of an independent European (eventually public) CRA, but it is likely that its ratings would become a focal point and substitute other credit opinions, exacerbating problems of overreliance on ratings and a lack of diversity in credit judgements. Even absent conflicts of interest, a rating agency may have an incentive to keep a rating higher than justified by the fundamental in recognition that the implications of a rating downgrade may be serious (particularly as the rating nears the investment-grade threshold, see Mählmann 2011). A public authority would expose itself to natural criticism if ratings proved unreliable. Anticipating the effects that a wrong grade would have on financial markets, the CRA would have little incentives to provide public information and it would delay downgrades for too long.

Extensions. So far the feedback effect from credit ratings to financial prices has been muted; prices were determined in the first stage and did not respond to subsequent developments in financial markets. Instead, ρ can be disclosed before the derivative is traded, and the market price will reflect private information as well as information released by the CRA. The informativeness of the price would be improved, but agents would be able to disentangle the two sources of information.

Yet, if the return in the first stage is endogenously determined by the coordination game - as would be the case in the secondary market for sovereign bonds - the overall effect of credit ratings becomes more complex. First, a higher price realization in the first stage makes agents more willing to invest in the coordination game. If this raises the return on the asset traded in the first stage, the demand for the asset can increase with its price and there is a backward-bending demand curve and multiplicity of equilibria is possible. Second, credit ratings affect the price of the asset in the first stage through the impact on investment decisions in the coordination game. Moreover, prices are hardwired into the regulatory framework and financial contracts, creating further feedback loops; margin requirements often rely on prices to define haircuts and higher haircuts lead agents to sell off their bonds. In this context, a small shift in the fundamental or in the credit rating may have a disproportionate impact on the bond price in the secondary market.

I have maintained the cost of finance fixed for the sovereign. Relaxing this assumption would have two important consequences. First, one might think that when $\theta < \theta^*$ the sovereign will be tempted to raise R, thereby reducing the value for the default threshold. Second, countries that are fundamentally solvent but have lost the confidence of bondholders can quickly go bust if their borrowing cost rise too fast. Corporate rating changes often have a more immediate effect on borrowing costs due to the rating-based performance pricing in loan and bond contracts. Letting the sovereign adjust the return R would convey information about the fundamental θ.

7 Conclusion

With external ratings becoming reference points, ratings inform and at the same time influence the probability of default of borrowers who must roll over their debts. As CRAs take into account the feedback effects on credit quality, credit ratings become volatile and prone to cause financial instability in the crisis zones and near the default threshold. I have described the nonlinear response of credit ratings and default probabilities to nonfundamental volatility - like noise in prices and flawed ratings. I have proved that transparent public information increases instability in financial markets and credit ratings, bringing new challenges to the industry. I have also shown how important it is for a sovereign to maintain an extremely good rating so as to avoid the crisis zones.

It is one thing to identify the weaknesses of credit ratings, quite another to find solutions and alternative standards that are clearly better. Part of the solution, it seems, is to mitigate the coordination motive and the feedback effects. The less embedded into deal-documentation ratings are, the lower the impact of credit ratings on investment decisions and the less focal credit ratings will be.[13] Ending the contribution of credit ratings to financial instability calls for the reduction of the references to credit ratings in regulation and rules. Counter-intuitively, some industry leaders back these moves. Standard & Poor's has publicly backed the LeMieux-Cantwell amendment which essentially removes the federal government's seal of approval from rating agencies. Its former president, Deven Sharma (2010), insists "we support removing investor rating requirements and believe the market - not government mandates - should decide the value of our work".

But, in many areas, there are no alternative measures of creditworthiness that are as transparent and simple to use, that allow for consistent implementation across banks and markets, and that effectively differentiate risk as credit ratings. Several alternative approaches that remove references to ratings entirely have been considered in the debate, but no satisfactory substitutes have yet been identified. For example, the use of market-based indicators, such as CDS premia and credit spreads, may increase the coordination motive and bring instability to financial markets. Even if the scope for hardwiring were reduced, it is likely that credit ratings would retain a significant influence in financial markets. Small and less-sophisticated investors that do not have the economies of scale to do their own credit analyses will continue to rely extensively on credit ratings and it is plausible that many institutional investors would

[13] The concentration of the industry in a reduced number of big (and focal) rating agencies might have aggravated these problems in the past. Increasing their number may be part of the solution.

The conditions imposed by regulators for designating a CRA as an external credit assessment institution often require that the market already places substantial weight on the judgment of a rating agency. By giving the market a role in selecting rating agencies, regulators exacerbate the focal role of CRAs.

be reluctant to do their own credit assessments and would continue to rely on ratings even if these were pulled from the regulations.

Credit ratings do their job well outside the crisis zones and there are no simple alternatives to their *certification role*. For as long as ratings retain their widespread influence throughout the financial system there seems to be a sound economic rationale for regulating CRAs. Rather than prohibiting their use, I argue in favor of a flexible use of credit ratings for regulatory purposes and this paper provides an economic rationale behind some of the reforms being sought by the European Commission. Encouraging accurate smoothing rules and suspending the use of credit ratings as soon as they become volatile (an indicator that the borrower has entered a crisis zone) could help stabilizing financial markets and force agents to rely more on their own private information. Also, liquidity provision by official institutions is far more effective in the crisis zones, where credit ratings are not reliable and can precipitate default; hence the CRAs' communication strategies should be monitored closely in the these zones. Michael Barnier, internal market commissioner, argued in favor of such restrictions "It is not the thermometer that causes the fever," he said. "But the thermometer has to work properly to ensure you do not exaggerate the fever."

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