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ABSTRACT

For decades credit rating agencies were viewed as trusted arbiters of creditworthiness and their ratings as important tools for managing risk. The common narrative is that the value of ratings was compromised by the evolution of the industry to a form where issuers pay for ratings. In this paper we consider both an investor-pays and an issuer-pays set-ups and show that if the investor-pays version can overcome the free-rider problem it is efficient, and otherwise leads to under-provision of information; while if the issuer-pays can force disclosure, it is efficient, but otherwise it leads to less revealing information because of the systematic distortion in revealed information along with over-investment in information. We show that in both these arrangements credit ratings have value in equilibrium and how reputation insures that, in equilibrium, ratings will reflect sound assessments of credit worthiness. We argue that regulatory reliance on ratings and the increasing importance of risk-weighted capital in prudential regulation have more likely contributed to distorted ratings than the matter of who pays for them.

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1 Introduction

Credit ratings, which are described as forward looking "opinions" of the relative credit worthiness of an entity or debt issue, are signals of the likelihood that the terms of a credit contract will be fully honored. They are important elements in the allocation of capital in the economy because they can influence the cost of borrowing for issuers and the rate of return for investors.[1] In this paper we study how credit signals are provided and why they have value in equilibrium.

Many commentators on the financial crisis of 2007-2009 have argued that the major credit rating agencies – Fitch, Moody's, and Standard & Poor's – played a role in the crisis by assigning unrealistically high ratings to mortgage-backed securities, in particular to the upper tranches of collateralized debt obligations. Credit rating agencies are singled out in the Dodd-Frank Financial Reform Act as requiring further regulation and oversight. The Financial Crisis Inquiry Commission, which studied the root causes of the financial crisis, attributed many of the failures in financial markets to the fact that " ...major firms and investors blindly relied on credit rating agencies as their arbiters of risk."[2] This view of credit ratings and the firms that provide them as villains in the financial system represents a remarkable turnaround. For more than a century the credit rating agencies were viewed as important and valuable agents in the system, a view that was underscored by the fact that regulators at all levels relied on them to manage risk-taking in markets.

The ratings business began in 1909 when John Moody first began to offer ratings on corporate bonds. He was followed in 1916 by the Poor's Publishing Company, in 1922 by the Standard Statistics Company and in 1924 by Fitch Publishing Co. All of these publishers initially sold their ratings directly to investors. These credit ratings clearly had value for investors because they provided an independent assessment of the likelihood that the terms of debt contracts would be honored and investors continued to purchase the ratings.

Financial regulators also began to view credit ratings as a valuable tool for managing risk-taking in financial markets. The first distinction between investment grade and non-investment

[1] This sentence waffles a bit because the direction of influence is not always the one anticipated– for example, where sovereign ratings are concerned. These are essentially anomalies.

[2] Financial Crisis Inquiry Commission, 2011

grade securities in regulation was made in 1931 when the Office of the Controller of the Currency (OCC) ruled that bonds rated BBB or better could be carried on the balance sheets of banks at book value but lower rated bonds had to be marked to market. In 1936, the Federal Reserve Board and the OCC extended the reliance on ratings by ruling that banks could not hold bonds that were not rated investment grade by at least two agencies. From that point on the use of the distinction between investment grade and non-investment grade gradually spread. Throughout the 1940's and 1950's the insurance industry, whose companies were regulated by the states, moved toward a system of rule-based capital requirements where ratings played the crucial role.

A major shift in the regulatory reliance on ratings occurred in 1975 when the Securities and Exchange Commission introduced the concept of Nationally Recognized Statistical Ratings Organizations (NRSROs), initially Moodys, Standard & Poor's, and Fitch. At the same time the SEC imposed on broker-dealers capital requirements that relied on ratings issued by NRSRO's. Beginning in 1982 the SEC also simplified disclosure requirements for issuers of investment grade securities. In 1974 the Employee Retirement and Income Security Act was passed and signed into law initiating another major category of regulatory reliance on ratings. Administered by the Department of Labor, ERISA began to reference ratings. ERISA has been amended several times and since 1989 the DOL has permitted pension funds to invest in asset backed pass-through securities provided they are rated in one of the three highest categories by at least one of the four largest NRSROs. In 1989 the Financial Institutions Reform, Recovery and Enforcement Act prohibited Savings and Loan organizations from investing in non-investment grade securities. And in 1991 the Investment Company Act of 1940 was amended to require money market mutual funds to limit their investments to securities that are rated in one of the two highest categories by at least two NRSROs. There were other modifications to regulations that further increased the reliance on ratings but the ones just cited enshrined the use of ratings by NRSROs into the regulatory architecture in the U.S.

Although they increased the reliance on ratings steadily over time, regulators also began to view the ratings agencies themselves as requiring regulation when the business model changed from the "investor pays" structure to an "issuer pays" model in the 1970s.[3] We will construct a model within which we can illustrate how the investor-pays arrangement can be efficient if the free rider problem with respect to information generation via the ratings is overcome, but inefficient with too little information generated if it is not. We will also show that issuer-pays model can be efficient if the issuer has to truthfully reveal the information acquired, but inefficient if the issuer chooses whether or not to reveal its information, with too much information being being generated. Thus, the switch itself introduces potentially introduces inefficiencies with respect to information acquisition/revelation and portfolio allocations.

Next, we will provide a microfoundation for the information generation mechanism by developing a reputation based model of ratings agencies which applies equally to both the investor- and issuer- pays versions of our model. How did the view of credit rating agencies evolve from one of trusted arbiters of credit worthiness to suspect players in the financial system? In this paper we show how credit signals have value by describing a financial market the includes firms, investors and providers of signals. We show that these signals have value in equilibrium regardless of who pays for them. What causes the signals to become suspect? We argue that the reliance on them by regulators combined with an increase in the demand for "safe" assets relative to the supply are important factors in explaining the evolution of the industry and the informativeness of ratings.

The standard concern with respect to the credit ratings agencies is the issuer both chooses the agency to rate its securities and pays for the rating. The issuers of credit instruments clearly want higher ratings to lower their cost of raising capital and can shop among firms to issue that rating. This conflict of interest has been the focus of most suspicion and criticism of the ratings business. But, credit rating agencies base their existence on their ability to provide objective assessments of the credit risk of securities. It is important to understand how this apparent conflict between the issuers of ratings and issuers of debt instruments gets resolved.[4]

[3] Many reasons have been offered for this evolution but a prominent one is that the advent of the Xerox machine undermined the rating agencies' intellectual property protection and that there was a collective action problem for the many investors that made it easier for the ratings agencies to turn to the issuers. Perhaps an equally important reason is that the number of firms seeking access to capital markets increased over time. There was a problem for small and new firms who found it difficult to get rated unless they paid for it. The rating agencies were happy to respond to this need.

[4] It is important to recognize as well that the "investor pays" model would also be subject to conflicts. Currently

We will argue that distortions introduced by the regulatory reliance on ratings cab impair the information quality of credit ratings. Within the investor-pays context, investor will be more willing to pay for information that, while biased, aids them in circumventing regulatory limits on their asset purchases, especially if they know clearly which assets are subject to this bias. Within the issuer-pays context, the issuer wants ratings that raise the demand for their asset and having inflated ratings which allow regulated investors to purchase these assets when they would not be able to under truthful reporting.

Opp, Opp, and Harris (2013), and Bongaerts, Cremers and Goetzman (2013) have also cited the regulatory reliance on ratings as a factor in the buildup of problems with the CRAs. Skreeta and Veldkamp (2009) argue that ratings shopping when combined with more complex securities can generate a systematic bias in the disclosed ratings in an issuer-pays market.

2 Environment

We begin by studying the problem of a firm that wants to sell a contingent claim on the output of a production project. The attributes of the claim can be learned with costly effort. Our goal is to understand the role that independent assessments - by rating agencies - play in the market for these claims. To do that, we present a model that includes firms, investors, and providers of signals (rating agencies). We start by analyzing the behavior of the firms and investors, leaving aside the role of ratings agencies. We consider first a one period model with two subperiods. Later we describe a model in which the period is infinitely repeated and where we can consider the behavior of ratings agencies.

Consider an economy where there is a single final or consumption good in each subperiod. Investors are endowed with a storable consumption good in the first subperiod. Firms are endowed with a Lucas fruit tree which produces output in the second subperiod. In the first subperiod the firms sell their claims on the tree to investors. The firms care only about consumption in the first subperiod and eat the proceeds of their sale right away. The investors care only about second

debt markets are dominated by a few very large firms which have significant market power.

subperiod consumption They invest some of their endowment good in claims on the trees of the firms. Their consumption is the sum of the payouts of their acquired claims and the amount of their endowment good that they stored.

We assume that there is a unit measure of firms. Each firm starts out owning a Lucas fruit tree which produces a stochastic dividend y. There are N different types of trees. The output of a tree of type n is the common draw of a lognormally distributed random variable with mean ϕ_n and s.d. σ_n. The measure of each type is given by μ_n for $n = 1, ..., N$. We normalize the total number of firms to 1; i.e. $\sum_n \mu_n = 1$. We will assume that ϕ_n and σ_n are both increasing in n, so firms with higher index trees are riskier but promise a higher expected return $(e^{\phi_n + \sigma_n^2/2})$.[5]

We assume that there are also a continuum of investors, but that the number of investors is large relative to the number of firms. This will lead the price of any individual firm's security to be high enough that an individual investor can only accumulate a small number of claims on any one firm. We will assume that these investors are risk averse, have CRRA preferences, and we denote their initial wealth by W. We will assume that there are I different types of these investors, where types differ in terms of their risk aversion. We let α_i denote the risk aversion of a type i investor and g_i their measure. We denote the total number by $G = \sum_{i=1}^{I} g_i$.

We will assume that the investors *cannot sell insurance to each other* and *cannot short sell claims on the firms*. The first assumption implicitly rules out any conditional ex post trades. As a result of these assumptions, and the fact that investors have different degrees of risk aversion, there can be an efficiency gain to acquiring knowledge about the risk-type of the firms so as to get the right allocation of claims among the investors.

We assume that a fraction of the firms' types are known, and that a firm or an investor can get more information about a firm whose type is unknown by acquiring a signal at a cost c. For simplicity, we will assume that the signal is a good proxy for the level of creditworthiness and completely reveals the type of a tree (and hence of the firm). We assume that the purchasing of signals cannot be observed. We also assume that an investor cannot bond its actions by showing its portfolio (because, for instance, they can change their position afterwards). We denote by

[5] As the referee noted, these assumptions are not needed.

$\underline{\gamma} \in [0,1]$ the fraction of firms whose type is automatically known. So long as $\underline{\gamma} > 0$, the structure of asset markets is not determined by information acquisition and revelation decisions since all asset types are automatically in positive net supply. However the supply of each of these assets will be affected. So long as $\underline{\gamma} < 1$, there is a potential role for information acquisition because there are firms whose types are not known.

Remark 1 *We have made a number of simplifying assumptions purely for expositional purposes. We have assumed that we have a continuum of firms so that we can apply the law of large numbers. This makes things analytically neat but is not essential. We could think of the firms of a given type as also being subject to an idiosyncratic shock but, because there are a continuum of each type, the investors can diversify away this idiosyncratic risk. Hence, we will ignore it. We could assume that there was some prior information about the type of our firms. For example, we could have assumed that there are red and green firms, and that these firms have their own distribution of types. In this case, unrated firms would end up trading at different prices; a red firm price and a green firm price. This would complicate the notation but not change any results.*

3 No Information Acquisition

We first consider the case in which there is no additional information acquisition and hence the fraction of known firm types is $\underline{\gamma}$. All firms whose type is unknown are ex ante identical from the perspective of an investor, and hence will trade at the same price. In addition, the firms whose type is unknown are distributed the same as in the overall population, and hence the fraction of type n is given by μ_n given our normalization that the total measure of firms is one. An investor will find it efficient to spread his claims in this fashion since he has no information about these firms. Hence, an investor who acquires q^U evenly distributed claims on these firms is getting a claim on their average output which we denote by Y^U. Henceforth, we will assume that investors always efficiently diversify their holdings of unrated firms.

A investor of type i can be thought of as choosing a vector of investment quantities $\{q_n^i\}_{n=1}^N$ in known firm types and $q^{i,U}$ of the unknown firm types, given the vector of prices $\{p_n\}_{n=1}^N$ of the known firms and p^U of the unknown firms. The problem of a type i investor is given by

$$\max_{\{q_n\},q^U} E\left\{u^i\left(x+\sum_n q_n y_n + q^U Y^U\right)\right\} \text{ subject to} \tag{1}$$

$$x = W - \sum_n q_n p_n - q^U p^U \geq 0 \text{ and} \tag{2}$$

$$q_n \geq 0 \text{ and } q^U \geq 0, \tag{3}$$

and given that

$$Y^U = \sum_n \mu_n y_n. \tag{4}$$

The market clearing conditions are

$$\sum_i g_i q_n^i = \underline{\gamma}\mu_n \text{ for each } n = 1, ..., N, \tag{5}$$

and

$$\sum_i g_i q_i^U = \left(1-\underline{\gamma}\right). \tag{6}$$

An equilibrium here consists of quantities $\{q_n^i\}$ and $q^{i,U}$ for each i and prices $\{p_n\}_{n=1}^N$ and p^U such that (i) the quantity choices are optimal for each investor i, and (ii) markets clear.

Proposition 1 *So long as* $\underline{\gamma} \in (0,1)$,

$$p^U \leq \sum_n p_n \mu_n. \tag{7}$$

Proof. To see this, assume otherwise. Then, note that some investor must be holding a positive quantity of the unknown firms; i.e. $q^{i,U} > 0$. Then this investor could reduce this quantity by ε, s.t. $q^{i,U} - \varepsilon > 0$, and acquire claims directly through purchasing $\varepsilon\mu_n$ on each firm of type n. This would replicate the pattern of claims on firms while increasing his storage level. This would raise the investor's payoff. Hence, no one would be willing to hold a claim on a firm whose type was unknown, which contradicts market clearing. ■

Remark 2 *The reverse arbitrage may not hold, and hence (7) can hold as a strict inequality. This is because reverse arbitrage would require that there was an investor i who is not at a corner with respect to his direct holdings of each type of firm; i.e. $q_n^i > 0$ for all n. This may not occur in equilibrium. As a result claims on the unknown firms can trade below their arbitrage values.*

Remark 3 *If $\underline{\gamma} = 0$ and there is no information about the different firms, then each investor is only investing a positive quantity in storage or the unknown type. In this case, the marginal valuation of the different firm types $1, .., N$ will not be equalized across investors and the price p_n will correspond to the highest marginal valuation across the investor types i for a firm of type n. This will ensure that all of the investors will optimally choose to invest 0 at these prices. It will also reflect the price that a firm should anticipate receiving if it could issue a security of type n and sell it competitively to this highest valuation investor type. Given this, it would not be surprising that (7) held as a strict inequality.*

4 Full Information

Consider next the case in which $\underline{\gamma} = 1$ and there is full information about all of the firms. This is simply a special case of the prior model where $q^{i,U} = 0$ for each investor. Denote by $\left\{p_n^{FI}\right\}$ and $\left\{q_n^{FI,i}\right\}$ the full information equilibrium prices and quantities. From this full information equilibrium we can always set the price of the unknown firm claims equal to their arbitrage price, or

$$p^U = \sum_n p_n^{FI} \mu_n, \tag{8}$$

since at this price all of the investors weakly prefer holding a composition of claims on known firms - with weights μ_n - to holding a diversified claim on the unknown firms. Hence, we are free to set $q^{i,U} = 0$.

The full information outcome can be supported without any information acquisition for any $\underline{\gamma} > 0$ if there are no short sale constraints.[6] To see this, conjecture that the price of an unknown

[6] I appreciate the referee pointing out that we need a positive measure of known firm types to determine what

firm, p^U, is given by (8) and that the price of a type n firm is still p_n^{FI}. If each investor acquires their per capita share of the unknown firms, $q_i^U = 1/\sum_i g_i$, and $\{q_n^i\}$ of the various types, where

$$q_i^U \mu_n + q_n^i = q_n^{FI,i}. \tag{9}$$

Given these quantities it follows that all markets clear since

$$\sum_i g_i q_i^U = 1,$$

and

$$\sum_i g_i q_n^i = \sum_i g_i \left[q_n^{FI,i} - q_i^U \mu_n \right] = \sum_i g_i q_n^{FI,i} - \mu_n = 0.$$

Thus, the full information equilibrium is always an equilibrium of an economy without short-sales constraints. This highlights the critical role of short-sale constraints in generating a motivation to acquire information about the types of the firms.

The full-information can also be supported so long as there is sufficient information. To be precise, so long as there exists quantity vectors $\left[q^{i,U}, \{q_n^i\}\right]$ such that (i) (5) and (6) hold, and (ii) $q_n^i \geq 0$ for each i and n, then we have supported the full information equilibrium allocation at prices $p^{FI,i}$ and with p^U given by (8). The key requirement here is that we do not violate the short sales constraint. It is trivial to see that so long as $q_n^{FI,i} > 0$ for all i and n; i.e. each investor holds a strictly positive quantity of each asset; then there will exist $\gamma < 1$ such that, so long as $\underline{\gamma} \geq \gamma$, we can support the full information outcome. To understand this result note that we need to have assets of type n in sufficiently positive supply and the unknown asset in sufficiently small supply that each investor can adjust their overall distribution of fundamental claims so as to replicate the distribution under full information. Note also, that so long as $\underline{\gamma}$ is below this threshold, there is a potential gain to information acquisition.

the type-specific outcomes were. This way we can know what was the realized payoff of an i-type firm was, and hence determine the ex post payments an investor had contracted to provide.

5 Investor Information Acquisition

Here we examine an investor who is considering buying information about the unknown firms. The advantage of doing so is that the investor can buy claims on this firm at the price of an unrated firm, p^U. The disadvantage is that it must pay the information cost. If the investor gathers no information then her payoff is still given by the solution to (1) subject to (2-4). While if she acquires one signal, then her expected payoff conditional on drawing a signal for the firm of type n and acquiring $\tilde{q}$ claims on that firm, is given by the solution to the equation

$$\max_{\{q_n\},q^U,\tilde{q}} \mathbf{E}\left\{u^i\left(x+\sum_n q_n y_n + q^U Y^U + \tilde{q} y_n\right)\right\} \text{ subject to}$$

$$x = W - \sum_n q_n p_n - q^U p^U - \tilde{q} p^U - c \geq 0 \text{ and}$$

$$q_n \geq 0,\ q^U \geq 0,\ \text{and } \tilde{q} \geq 0,$$

where Y^U is still given by (4).[7] Hence, the unconditional payoff is given by the sum of its conditional payoffs weighted by their probabilities, or

$$V_1^i = \sum_{j=1}^{N} \left\{ \begin{array}{c} \max_{\{q_n\},q^U,\tilde{q}} \mathbf{E} u^i \left(\begin{array}{c} W - \sum_n q_n p_n - q^U p^U - \tilde{q} p^U - c \\ +\sum_n q_n y_n + q^U Y^U + \tilde{q} y_j \end{array} \right) \\ \text{subject to} \\ W - \sum_n q_n p_n - q^U p^U - \tilde{q} p^U - c \geq 0 \text{ and} \\ q_n \geq 0,\ q^U \geq 0,\ \text{and } \tilde{q} \geq 0 \end{array} \right\} \mu_j.$$

Now we want to consider the possibility of an investor buying a signal about multiple trees. Because the unknown trees all appear to be the same, the investor can buy information about the same type of tree with positive probability. This is, of course, inefficient, from the investor's perspective. When we consider how the investor decides on buying more than one signal, we will

[7] We are assuming that a firm is large relative to an investor and hence the investor can acquire as many shares in the firm as it desires.

assume for simplicity that they decide the number of signals to buy ex ante and not sequentially. With this simplification the payoff from buying two signals is given by

$$V^{2,i}=\sum_{k=1}^{N}\sum_{j=1}^{N}\left\{\begin{array}{c}\max_{\{q_n\},q^U,\tilde{q}_1,\tilde{q}_2}\mathbf{E}u^i\left(\begin{array}{c}W-\sum_n q_np_n-q^Up^U-(\tilde{q}_1+\tilde{q}_2)\,p^U-2c\\ +\sum_n q_ny_n+q^UY^U+\tilde{q}_1y_j+\tilde{q}_2y_k\end{array}\right)\\ \text{subject to}\\ W-\sum_n q_np_n-q^Up^U-(\tilde{q}_1+\tilde{q}_2)\,p^U-2c\geq 0 \text{ and}\\ q_n\geq 0,\ q^U\geq 0,\ \text{and } \tilde{q}_1,\tilde{q}_2\geq 0.\end{array}\right\}\mu_j\mu_k.$$

Continuing in this fashion we can define $V^{l,i}$ for $l=1,2,3,...$ up to the limit implied by the wealth constraint, which is $l\leq W/c$. Denote by $V^{0,i}$ the value of the solution to (1) where the investor does not buy any signals. Because investors are small relative to firms, once an investor has acquired a signal for each type of tree, there is no further gain to more signals. Since the probability of I distinct signals in I trials is positive, it follows that the value of more signals goes to zero with probability one in a finite number of draws.

Assumption 1 *We will assume that the opportunity cost c of buying a signal is large relative to an individual investor, and hence that*

$$V^{0,i}>V^{l,i} \text{ for } l\leq\frac{W}{c} \text{ and for all } i=1,...,I.$$

As a result of this, no investor wants to buy a signal just for himself. (Note that the presence of idiosyncratic risk would make purchasing a signal about a finite number of firms even less valuable.)

In equilibrium no investor will be able to buy a signal and then sell the information to other investors at profit. There are two basic arguments for why this is so. First, we assumed that the investor who buys a signal from another investor cannot verify whether or not the selling investor actually bought the signal. Hence the seller of information would have an incentive to sell information when they have not bought it, and to sell more information than they have bought. Second, since information can be costlessly duplicated and resold, this implies that if the information was sold to more than two investors its price must be zero by Bertrand competition.

5.1 Pareto Efficiency

To construct the set of constrained Pareto optimal allocations, consider a planner's problem in which investor of type $i \leq I$ has Negishi weight λ_i, while each type of firm has weight Λ_n and Λ^U. The planner's objective is the weighted sum of the payoff's. Here the planner is constrained to pick an investor's portfolio subject to the quantity constraints and the overall resource constraint. The Lagrangian for the planner is

$$\begin{aligned}\mathcal{L} = \max_{\{q_n^i\},q^{i,U},P_n,P^U} \; min_{\kappa_n,\kappa^U} \mathbf{E} \sum_{i\leq I} \lambda_i g_i \left\{ u^i \left(x_i + \sum_{n\leq N} q_n^i y_n + q^{i,U} Y^U \right) \right\} \\ + \sum_{n\leq N} \Lambda_n \underline{\gamma} \mu_n P_n + \Lambda^U \left(1 - \underline{\gamma}\right) P^U \\ + \sum_n \kappa_n \left[\underline{\gamma} \mu_n - \sum_i g_i q_n^i \right] + \kappa^U \left[\left(1 - \underline{\gamma}\right) - \sum_i g_i q_i^U \right] \\ + \zeta \left[GW - \sum_n \underline{\gamma} \mu_n P_n - \left(1 - \underline{\gamma}\right) P^U - \sum_i x_i g_i \right]\end{aligned}$$

subject to the short-sales constraints (3)

The quantities P_n and P^U are the per capita payments to the different firms based upon their observable type. The first-order conditions include

$$\mathbf{E} \lambda_i u^{i\prime}(c^i) y_n - \kappa_n \leq 0 \tag{10}$$

$$\mathbf{E} \lambda_i u^{i\prime}(c^i) Y^U - \kappa^U \leq 0 \tag{11}$$

$$\Lambda_n - \zeta = 0 \tag{12}$$

$$\Lambda^U - \zeta = 0. \tag{13}$$

The last two conditions pin down the weights on the firms because in equilibrium transfers to the firms will be positive. Given this, we can rescale the weights on the various agents and the constraints by multiplying the Lagrangian by $1/\zeta$. In which case, one gets that the implicit price of a tree is κ_n/ζ and κ^U/ζ respectively, and the multiplier on investor i's budget constraint is $1/(\lambda_i\zeta)$. The competitive equilibrium corresponds to the weights at which the implicit transfers among the investors are 0, so their budget constraints (2) holds at the implicit prices, and the payments to the firms are equal to the implicit price times the quantity; i.e.

$$\kappa_n \sum_i g_i q_n^i = \zeta \underline{\gamma} \mu_n P_n \quad \text{and} \quad \kappa^U \sum_i g_i q_i^U = \zeta \left(1 - \underline{\gamma}\right) P^U$$

Next we want to take account of the possibility of producing information about firms/trees. For simplicity, we set the initial set of trees whose type is known, $\underline{\gamma} = 0$, and and denote by Γ the measure of trees that the planners acquires information about at the cost c. In making this change, we must take account of the resource costs of information acquisition. The planner's problem can now be written as

$$\begin{aligned}\mathcal{L} = \max_{\{q_n^i\}, q^{i,U}, P_n, P^U, \Gamma} \quad & min_{\kappa_n, \kappa^U} \mathbf{E} \sum_{i \le I} \lambda_i g_i \left\{ u^i \left(x_i + \sum_{n \le N} q_n^i y_n + q^{i,U} Y^U \right) \right\} \\ & + \sum_{n \le N} \Lambda_n \Gamma \mu_n P_n + \Lambda^U (1 - \Gamma) P^U \\ & + \sum_n \kappa_n \left[\Gamma \mu_n - \sum_i g_i q_n^i \right] + \kappa^U \left[(1 - \Gamma) - \sum_i g_i q_i^U \right] \\ & + \zeta \left[GW - \sum_n \Gamma \mu_n P_n - (1 - \Gamma) P^U - \sum_i x_i g_i - \Gamma c \right] \\ & \text{subject to the short-sales constraints (3)}\end{aligned}$$

Note that in this problem the new first-order condition w.r.t. Γ is

$$\begin{aligned}\sum_{n \le N} \Lambda_n \mu_n P_n - \Lambda^U P^U + \sum_n \kappa_n \mu_n - \kappa^U - \zeta \sum_n \mu_n P_n + \zeta P^U - c = 0 \\ \Rightarrow \sum_n \kappa_n \mu_n - \kappa^U - \zeta c = 0, \qquad (14)\end{aligned}$$

where we made use our f.o.c.s from the initial version of the problem. Condition (14) implies that efficient information accumulation will lead to $\sum_n p_n \mu_n = p^U + c$.

6 An Efficient Investor-Pays Decentralization

Individual information acquisition is inefficient. An efficient alternative would be for a mutual fund to buy information about a subset of firms, buy all the claims on these firms, and then offer investors, the opportunity to buy these claims on these firms at an internal price that cleared the market. Since all investors of a given type would pick the same portfolio, this is equivalent to targeted type-specific funds which would allow them to invest efficiently. Let $\tilde{g}_i$ the measure of each type of investor who participate at a given mutual fund company, Let Γ denote the measure of firms that the fund company acquires information on and consequently buys all of their claims. To keep things simple, assume that there is no information about firms without information acquisition, or $\underline{\gamma} = 0$.

Each investor of type i can be thought of as choosing a vector of investment quantities $\{\tilde{q}_n^i\}_{n=1}^N$ in the mutual fund's firm's types and $\tilde{q}^{i,U}$ of the unknown firm types, given the vector of prices that the mutual fund charges on its known types of claims $\{\tilde{p}_n\}_{n=1}^N$ and the price p^U of the unknown firms. The internal market clearing conditions for a mutual fund are given by

$$\sum_i \tilde{g}_i \tilde{q}_n^i = \mu_n \Gamma \text{ for each } n = 1, ..., N, \tag{15}$$

And their breakeven condition is given by

$$\sum_i \left[g_i \sum_n \tilde{q}_n^i \tilde{p}_n \right] - \Gamma \left[p^U + c \right] \geq 0. \tag{16}$$

As one can see from the clearing and breakeven conditions, a mutual fund is simply a technology for turning a unit of unknown firm types into a unit of known types (with appropriate type shares) at a cost of c. Competition between mutual funds will mean that the fund just breaks even, so

(16) will hold as an equality. Given this we can focus on a single representative mutual fund that just breaks even, and that all investors participate in this fund.

The problem of a type i investor participating in the representative mutual fund is essentially the same as in (1), except the type prices are those of the fund:

$$\max_{\{\tilde{q}_n\},q^U} \mathbf{E}\left\{u^i\left(x + \sum_n \tilde{q}_n y_n + q^U Y^U\right)\right\} \text{ subject to} \tag{17}$$

$$x = W - \sum_n \tilde{q}_n \tilde{p}_n - q^U p^U \geq 0 \text{ and} \tag{18}$$

$$\tilde{q}_n \geq 0 \text{ and } q^U \geq 0, \tag{19}$$

The market clearing condition is in terms of the unknown firms

$$\sum_i g_i q_i^U + \Gamma = 1. \tag{20}$$

An equilibrium here consists of quantities $\{\tilde{q}_n^i\}$ and $q^{i,U}$ for each i and prices $\{\tilde{p}_n\}_{n=1}^N$ and p^U such that (i) the quantity choices are optimal for each investor i, and (ii) mutual funds markets for each type clear, (iii) the fund breaks even, and (iv) the overall unknown type market clears.

Proposition 2 *In equilibrium, if an investor i has $x > 0$ then*

$$\frac{\mathbf{E}\left\{u^{i\prime}\left(x + \sum_n \tilde{q}_n^i y_n + q^{iU} Y^U\right) y_j\right\}}{\mathbf{E}\left\{u^{i\prime}\left(x + \sum_n \tilde{q}_n^i y_n + q^{iU} Y^U\right)\right\}} \leq \tilde{p}_j,$$

and this is a strict equality if she buys a positive quantity of an asset j. This result includes the case where $j = U$ and hence $y_j = Y^U$ and $p_j = p^U$. If the investor buys a positive quantity of two claims j and k then if these claims are type-specific

$$\frac{\mathbf{E}\left\{u^{i\prime}\left(x + \sum_n \tilde{q}_n y_n + q^U Y^U\right) y_j\right\}}{\mathbf{E}\left\{u^{i\prime}\left(x + \sum_n \tilde{q}_n y_n + q^U Y^U\right) y_k\right\}} = \frac{\tilde{p}_j}{\tilde{p}_k}$$

while if it is a type-specific asset j and unknown asset U we get that

$$\frac{\mathbf{E}\left\{u^{i\prime}\left(x+\sum_n \tilde{q}_n y_n + q^U Y^U\right) y_j\right\}}{\mathbf{E}\left\{u^{i\prime}\left(x+\sum_n \tilde{q}_n y_n + q^U Y^U\right) Y^U\right\}} = \frac{\tilde{p}_j}{\tilde{p}^U}.$$

If $\Gamma > 0$ *then*

$$p^U = \sum_n \tilde{p}_n \mu_n - c. \tag{21}$$

Proof. The MRS conditions follows trivially from the investor's optimality conditions, while the breakeven condition plus the mutual fund's clearing condition imply the final pricing result (21). Condition (21) is equivalent to our constrained Pareto efficiency condition (14). It is easy to see that an equilibrium for the efficient investor-pays decentralization can be mapped in a solution to the constrainted Pareto problem with information acquisition, implying that it is a constrained Pareto optimum. ■

7 An Efficient Issuer-Pays Decentralization

Firms can have an incentive to acquire information about their type and make it public even when an individual investor does not. the reason is that a firms gains from *all of its shares* selling at a higher price, while the individual investor only benefits from the information on the *shares that it buys* which by assumption are a fraction of the total.

Consider an alternative decentralization in which the firm which issues the security can pay for a signal to be generated about it. Assume here that the information in the signal is automatically public information. So there is no revelation decision. Assume also that the firm has the same prior about its own type as the investors. Then, the gain to the firm from generating a signal about its type is that its share will trade at the revealed-type prices, and the expected gain is given by

$$\sum_n p_n \mu_n - c - p^U \tag{22}$$

In equilibrium if this expected gain is negative (positive) then no (all) firm(s) will want to acquire a signal, hence it must be 0 if there is a positive interior amount of signal acquisition. In this version of the model the investor's problem is the same as in (17). Given this, the fact that the same equilibrium allocation can be supported follows fairly trivially.

Proposition 3 *Because of the arbitrage condition (21), the efficient "investor-pays" outcome could also emerge as an equilibrium if the firm's directly paid for an independent agency to examine its type at a cost c. However, this would critically require that the firm be forced to reveal what the independent agency found.*[8]

We turn next to a more realistic decentralizations in which the mutual fund may face a free-rider problem in the investor-pays model and the revelation of the signal is a choice in the issuer-pays model.

8 The Free Rider Problem

Consider again the issuer-pays version of our model. Crucially, we assumed that the mutual fund could buy all of the claims on the securities that it acquired information on. To illustrate how relaxing this assumption will change our outcomes, assume that it could only buy the fraction ζ of the outstanding securities. Assume that the information that was generated was public, so, if it acquired a signal about a security, then the fraction $1-\zeta$ claims on the security would be traded with investors knowing the type of the security. Arbitrage will imply that the mutual fund's type-specific securities will have the same price and the residual claims trading under information about their type. As a result, the market clearing conditions (15) and the optimization problem of the investors (17) will be unchanged. However, the breakeven condition of the mutual fund will become (16) will become

$$\zeta \left\{ \sum_i \left[g_i \sum_n \tilde{q}_n^i \tilde{p}_n \right] - \Gamma p^U \right\} - \Gamma c \geq 0. \tag{23}$$

[8] We are assuming that the firm has the same prior as to its type as the investors. If the firm, for example, knew its type, then the arbitrage condition becomes type-specific; $p_n \mu_n - c - p^U \gtreqless 0$. With an informational advantage, there are possibilities for both more efficient signal buying but also more inefficient rent seeking.

It is easy to see that starting from the original, equilibrium with $\zeta = 1$, reducing ζ will lower the return to the mutual fund and hence depress information creation. Thus, the extent of the free-rider problem as measured by the degree to which ζ is less than 1 will reduce the amount of information in equilibrium.

9 Signal Buying and Revealing

Consider next an arrangement in which a firm whose type is unknown pays some intermediary to buy a signal as to their type and then make it public if the firm so chooses. Remember that these signals are a good proxy for creditworthiness and assume for now that rating agencies will only report honestly or not at all. A firm will want to make it's reported type public so long as this will raise its price relative to a firm with no reported type, or $p_n \geq p^U$. To determine the firm's optimal reporting decision, let $I\{\}$ denote the indicator function which takes on a value of 1 if the statement is true and 0 if false. Then we can express the firm's expected payoff from buying a signal and employing the optimal revelation rule is

$$\sum_n \left[p_n I\left\{p_n \geq p^U\right\} + p^U I\left\{p_n < p^U\right\}\right] \mu_n - c. \tag{24}$$

The firm's payoff from not buying the signal is simply p^U. It will choose to buy a signal or not depending upon which of these two payoffs is larger.

Under this arrangement an investor is choosing how much to buy of each type of firm whose type is known - either because they were initially known or bought a rating and choose to report it - and those whose type is unknown The firms whose types are unknown are firms who did not buy a rating or bought a rating and choose to not report it. Hence the composition of these firms will be subject to adverse selection arising from the firms' reporting decisions. So, to construct the output of a diversified claim to all of the unknown firms we need to determine their type composition. To do so, first denote by κ the fraction of firms whose type is initially unknown and choose to buy a signal. Second, note that the number of firms of type n who have no reported rating is $(1-\underline{\gamma})\mu_n \left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]$; i.e. the firms of type n that bought a rating and did not report it plus those who did not buy a rating and hence cannot report one. This implies that the output of a diversified claim will be given by

$$Y^U = \sum_n \frac{\left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]\mu_n}{\sum_n \left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]\mu_n} y_n, \tag{25}$$

where

$$\frac{\left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]\mu_n}{\sum_n \left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]\mu_n}$$

is the fraction of firms of type n in the pool of firms whose type is unknown. It is easy to see that if $\kappa = 0$ then the composition will be determined by the pure type distribution, μ_n, and adverse selection will not play a role. However, as κ increases, then the composition will be increasingly sensitive to the reporting decisions of the firms. When $\kappa \to 1$, the unknown firms will only consist of types who do not choose to report a rating.

Proposition 1 implies that the price of a firm whose type is unknown will satisfy

$$p^U \leq \sum_n \frac{\left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]\mu_n}{\sum_n \left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]\mu_n} p_n,$$

and must be strictly equal if there is any investor type who holds a strictly positive quantity of claims on all types of firms.

The problem of a type i investor is very similar to the no information acquisition case, with the only difference coming from the need to take account of the impact of adverse selection on the composition of firms who do not have a known type. Their problem still involves maximizing (1), and is still subject to the budget constraint (2) and the short-sales constraint (3), but now the output of a diversified claim to the unknown firms is given by (25).

Taking as given the fraction of firms whose type is initially known, $\underline{\gamma}$, the price of reports, c, and that all reports are unbiased, we can define an equilibrium here as consisting of prices $\left[\{p_i\}_{i=1}^N, p^U\right]$, quantities $\left[\{q_n^i\}_{n=1}^N, q^{i,U}\right]$ for each investor type $i = 1, ..., I$, and the fraction of κ firm's who buy the signal. For these objects to be an equilibrium:

1. $\left[\{q_n^i\}_{n=1}^N, q^{i,U}\right]$ must solve investor i's problem given the prices,

2. The firm's signal buying choice must be optimal, so

$$\begin{aligned}
\text{if } 0 &< \kappa < 1, \text{ then } \sum_n \left[p_n I\left\{p_n \geq p^U\right\} + p^U I\left\{p_n < p^U\right\}\right]\mu_n - c = p^U, \\
\text{if } \kappa &= 0 \text{ then } \sum_n \left[p_n I\left\{p_n \geq p^U\right\} + p^U I\left\{p_n < p^U\right\}\right]\mu_n - c \leq p^U, \\
\text{if } \kappa &= 1 \text{ then } \sum_n \left[p_n I\left\{p_n \geq p^U\right\} + p^U I\left\{p_n < p^U\right\}\right]\mu_n - c \geq p^U.
\end{aligned}$$

3. The prices must clear the markets

$$\sum_i g_i q_n^i = \left[\underline{\gamma} + (1-\underline{\gamma})\kappa I\left\{p_n \geq p^U\right\}\right]\mu_n \text{ for each } n = 1, ..., N$$

and

$$\sum_i g_i q_i^U = \left(1-\underline{\gamma}\right)\left[\kappa I\left\{p_n < p^U\right\} + (1-\kappa)\right]\mu_n.$$

Note that in the market clearing conditions, the claims on a firm of type n where $p_n < p^U$ consist solely of those firms whose type was initially known. Hence, these types of firm are in zero net supply if the fraction of firms whose type is initially known is zero. Note also that the supply of claims on firms who did not report a rating depends both on how many of the firms bought ratings and the extent to which these types choose to report those ratings.

10 A Nice Example

Assume that there are just two types of agents with CRRA coefficients 0 (risk neutral) and greater than 0 (so risk averse). Assume that the risk neutral investors are in large enough supply that they determine all prices. Assume that $\underline{\gamma} > 0$ so that all types of assets are in positive supply. Assume that there are three kinds of assets/firms with (ϕ_n, σ_n) given by $n = l, m, h$ meaning low, medium and high risk/return. Assume that the expected returns are such that

$$p_m < \mu_h p_h + \mu_m p_m + \mu_l p_l, \tag{26}$$

so that the price of the middle type is lower than population weighted expected type.

10.1 Investor Pays

Start first with the efficient investor-pays decentralization. The price of a known type security is simply its expected payout, or

$$p_n = e^{\phi_n + \sigma_n^2/2}. \tag{27}$$

The price of the unknown security is also equal to its expected payout

$$p^U = \sum_n \mu_n e^{\phi_n + \sigma_n^2/2} \tag{28}$$

Hence the arbitrage condition (22) must fail in equilibrium for $c > 0$ and no signals will be acquired. The risk averse investor will not acquire any of the risky securities, and all of the risky securities will be held by the risk neutral investor. Note that this equilibrium allocation does not depend upon the free-rider problem being completely overcome (i.e. $\zeta < 1$)

10.2 Issuer Pays

Turn next to the issuer-pays decentralizations. If any signal is public, then the equilbrium allocation is the same as the the investor-pays allocation. Assume therefore that the issuer can choose whether or not to reveal its signal. The type price will still be given by (27) but now the unknown security price will be given by

$$p^U = \sum_n \frac{\left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]\mu_n}{\sum_n \left[I\left\{p_n < p^U\right\}\kappa + (1-\kappa)\right]\mu_n} p_n.$$

There are three cases:

1. If c is so high that no firm chooses to become informed, then $\kappa = 0$. In which case p^U is

given by (28). Finally, it must be the case that the expected return from buying a rating is nonpositive, or

$$\left[p_h - p^U\right]\mu_h \leq c.$$

2. If c is low enough then $\kappa > 0$. Given (26), only firms of type h report their type. In which case

$$p^U = \frac{(1-\kappa)\,\mu_h p_h + \sum_{n=l,m}\left[\kappa + (1-\kappa)\right]\mu_n p_n}{(1-\kappa)\mu_h + \sum_{n=l,m}\left[\kappa + (1-\kappa)\right]\mu_n} < \mu_h p_h + \mu_m p_m + \mu_l p_l.$$

   Since p^U is declining in κ, to rationalize this reporting strategy we need κ to be small enough that $p_m < p^U$. Since this inequality holds at $\kappa = 0$, this is trivially possible. Finally, we need c to be such that

$$\left[p_h - p^U\right]\mu_h \geq c$$

   and with equality if we are not at a corner with every firm acquiring a signal.

3. $\kappa > 0$ and both firms of type h and m report their types. In which case

$$p^U = \frac{\sum_{n=m,h}(1-\kappa)\,\mu_n p_n + \left[\kappa + (1-\kappa)\right]\mu_l p_l}{\sum_{n=m,h}(1-\kappa)\,\mu_n + \left[\kappa + (1-\kappa)\right]\mu_l},$$

   and to rationalize this reporting strategy we need κ to be big enough so that $p_m > p^U$. This is possible since as $\kappa \to 1$, $p^U \to p_l$. Finally, we need c to be such that

$$\left[p_h - p^U\right]\mu_h + \left[p_m - p^U\right]\mu_m \geq c,$$

   and, again, with equality if we are not at a corner.

Since in case 3, $p_m \geq p^U$, it follows that the unrated price is lower than in case 1 or 2 and therefore the upper bound on c for case 3 is strictly higher than the value required for case 2. Hence this simple example trivially admits multiple equilibria coming through the strategic externality created by the adverse selection effect. If we compare case 1 and 2, then the composition of the unrated pool is the same, and the fraction of firms that buy a rating rises as the cost falls. When we compare case 2 and 3, the composition of the pool changes and this can lower p^U and thereby raise the incentive to buy a rating. As a result, there may not be a simple monotone relationship between κ and c.

In this example, information acquisition is completely inefficient. Since the price is always the risk-neutral price, the risk averse agent will buy none of the claims on the firm. Hence, there are no social gains from knowing the firm's type. There are distributional or "rent-seeking" gains since some firms will be worth more than others. This type of inefficiency arises in the issuer-pays decentralization because the firm is buying the rating rather than a mutual fund. With a richer version of the model in which both types of agents are risk-averse and there is a free-rider problem with respect to the investor-pays decentralization ($\zeta < 1$) it is easy to generate examples with under-investment.

11 The Ratings Agencies

We will now analyze the behavior of ratings agencies that specialize in rating firms. To do so, assume now that the periods are repeated over and over with new investors and firms in each period. Assume that the type of a firm's tree is publicly observable at the end of each period. Assume that there exist infinitely lived agents who can become a ratings agency by paying a fixed cost f and that upon doing so, the cost of producing a rating for a firm is e. We will assume that the maximum number of ratings that a ratings agency can produce is capped by $\bar{x}$.

There always exists a zero-reputation equilibrium in which no one buys a rating because no one believes that the ratings firms issue informed reports.[9] Given that they don't expect anyone to buy a rating in the future, any ratings agency would optimally choose to shirk and produce a random rating. In light of this no investor would change their demand in response to a ratings report and hence no one will choose to pay the cost of becoming a ratings agency. However there

[9]It is worth being clear about what we mean by "informed" here and throughout this discussion. "Informed" as used in this paper is meant to imply that the rating is an optimal forecast of creditworthiness(type) given the information available at the time the rating is issued. Of course, knowing the distribution from which one is drawing is not equivalent to knowing the ex-post outcome. Hence, there is still uncertainty even with informed ratings.

also exist other reputational equilibria in which reputations have positive value. We turn next to them.

We want to construct a reputational equilibrium in which ratings firms issue informed reports and hence these reports have positive value. To do so, start by considering the net benefit from becoming a ratings agency, let c denote the amount a ratings agency charges a firm to rate them.[10] Then the payoff to becoming a ratings agency that *conscientiously* produces x reports is given by

$$\frac{x(c-e)}{1-\beta} - f$$

where β is the agency's discount factor. The payoff to a ratings agency who shirks and simply issues random ratings without paying the cost to produce informed ratings is

$$xc - f.$$

This is because with $x > 0$, the agency is rating a *positive measure* of firms, and hence they will only be able to do this once before being detected.[11] The ratings agencies will always prefer to produce unbiased ratings so long as

$$\frac{(c-e)}{1-\beta} > c.$$

The equilibrium can be one of two types depending upon whether the capacity constraint or the incentive constraint binds in equilibrium. In a **type 1 equilibrium**, the ratings agencies just break even and weakly prefer to issue informed ratings. Since the agency will always want to lower its price by a tiny amount if this will enable it to sell at capacity, it follows that all rating agencies will be at capacity. Since consumers are indifferent over agencies, so long as they think that they are producing informed reports, all ratings agencies will have to charge the same price.

[10]Because we are micro-founding the production of information, we choose to have the price, c, that the ratings agency charges be the cost of information to buyer of information in the earlier analysis.

[11]On an individual false rating they would have a probability $1/N$ of getting the correct rating. But with j ratings being correct all j times would be $(1/N)^j$ which rapidly goes to zero. This is doubly true here since only deviations of positive measure affect their payoffs.

This implies that $x = \bar{x}$, and the equilibrium charge, c^*, is such that

$$\frac{\bar{x}\left(c^* - e\right)}{1-\beta} = f,$$

and

$$\frac{\left(c^* - e\right)}{1-\beta} \geq c^*.$$

The equilibrium number of ratings agencies, X, is given by

$$X = \frac{\kappa(1-\underline{\gamma})}{\bar{x}},$$

where $\kappa(1-\underline{\gamma})$ is the measure of firms who buy a rating in equilibrium.

In a **type 2 equilibrium**, the requirement that the ratings agencies prefer to issue informed reports binds. In this case,

$$\frac{\left(c^* - e\right)}{1-\beta} = c^*$$

and the quantity that a ratings agency produces, x, must satisfy $x \leq \bar{x}$ and

$$\frac{x\left(c^* - e\right)}{1-\beta} \geq f.$$

In a type 2 equilibrium the ratings agencies can earn positive rents. They do not compete away these rents because lowering their prices will remove their incentive to produce independent reports. The number of reports that each agency produces is indeterminate, modulo the fact that their scale has to be large enough to ensure that they break even.

The fact that the ratings industry has long been dominated by three firms suggests that the minimum size criterion for either the type 1 or type 2 equilibrium must be fairly big to account for this. One of the main cost factors for the ratings agencies is the need to maintain a staff of analysts with detailed knowledge of specific industries and able to manage the large quantities of data and other information necessary to independently assess the creditworthiness of individual firms and securities. Depending on whether one thinks of these costs as being fixed or variable with the scale of reports, they suggest that it is plausible to believe that f is large and hence the minimum size for the type 1 equilibrium is large, or that e is large, and hence the rents per report are small, and this necessitates a large size for the type 2 equilibrium. In recent years, there has been some entry though the industry continues to be dominated by a few firms. This fact suggests that the most plausible interpretation is that e is large and that the type 2 equilibrium may be the most accurate description of the outcomes we observed.

Remark 4 *This microfoundation for our ratings agencies is equally applicable to the investor-pays and the issuer-pays version of our model.*

12 Reporting Incentives

We have assumed that investors are free to buy assets in whatever proportion they desire consistent with their budget constraint. As we detailed in the introduction, government regulation frequently acts to limit regulated investors like banks, insurance companies and company retirement funds on their asset choices or to impose penalties for more risky ones. At the same time, because of regulatory features like deposit insurance or pension guarantees (via Pension Benefit Guaranty Corporation), these investors often have a strong incentive to engage in risky investments. To capture the impact of these sorts of incentive distortions in our model, assume that the government decides to restrict type I investors who are the least risk averse to only buying firms who have signaled that their type is 1 (the safest).

In this case, if these investors utilize ratings from an agency that is independent and "informed" (in the sense that we have defined it), their payoff is

$$V^{I*} = \max_{q_1} E_{y_1} \left\{ u^I \left(W - q_1 p_1 + q_1 y_1 - c \right) \right\}.$$

However, imagine that there was a ratings agency that would rate some collection of types as type 1. Denote the set of types that it so rates by J, and since all these firms are ex ante identical, they trade at the same price, p_1^J. Assume that everyone knows how this agency is behaving, so they will correctly realize that a diversified claim to the assets in set J will yield

$$Y_1^J = \sum_n \frac{I\{n \in J\}\mu_n}{\sum_n I\{n \in J\}\mu_n} y_n, \tag{29}$$

given that the ratings agency randomly chooses some fraction of initial firms to rate in this fashion and hence the composition of the pool is the same as in the population.

Assume that arbitrage held, and that the price of these securities is given by

$$p_1^J = \sum_n \frac{I\{n \in J\}\mu_n}{\sum_n I\{n \in J\}\mu_n} p_n. \tag{30}$$

If the set J consisted of a single type of asset, then arbitrage must hold. For this to hold, it must not only be the case that the set J is not "too large", but also that the number of type I investors were not too large, and may end up trading above their arbitrage price if the supply constraint binds. Given this arbitrage assumption, the optimization problem of the type I investor is given by

$$\max_{q_1} \mathbf{E}_{y_1} \left\{u^I \left(W - p_1 q_1 + q_1 y_1 - q_1^J p_1^J + q_1^J Y_1^J - c\right)\right\} \text{ s.t. } (29, 30)$$

(As always, we have imposed that the investor will optimally hold a diversified set of the claims rated type 1 by our deviating agency.) It is easy to construct cases in which the type I investors are better off buying the assets rated type 1 by the "randomizing" rating agency than buying accurately rated assets. The type I investors will be (weakly) worse off under this arrangement than the one in which they were unrestricted (taking the prices $p_1, ..., p_n$ and p^U as given, while the other investors will be indifferent. However, since agencies can compete over which set J they might offer, competition will lead this special agency to choose the set J so as to maximize the payoff of the I type investors. Denote this optimum set by J^*. This competition might reflect the ability of the ratings agency to "credibly" distort their ratings, and hence it may not be completely optimal from the perspective of the type I investors.

Why would a ratings agency want to distort its ratings? It might have an incentive to do so in order to increase sales of its ratings. In the process it would be distorting its ratings to help the type J investors undo the impact of regulation on their investment choices. This would be most naturally true within a type 2 equilibrium in which the rating agency is not supply constrained and is earning positive rents on each ratings, but is barred by its incentive constraint from lowering the price of a rating. What about how this agency rates other types of firms? Note that there is no such incentive with respect to all of the other assets that the agency rates. Hence, the price of the firms rated type 1 by the randomizing agency will differ from those rated by the informed ratings companies. However, the price of their other ratings will be the same and and hence $p_n^J = p_n$ for all $n > 1$.

Given this, what would happen to the investment demands of investors who are not type I? The other types of investors will not want to acquire firms rated type 1 by our special rating agency since arbitrage will imply that there is no price advantage, and they can always do better by using the ratings of an informed agency because it will enable them to obtain their desired portfolio. However, they will be indifferent between any firm rated $n > 1$ by our randomizing agency vs. that rated by a independent agency.

What are the reputational consequences for our deviating agency? In the real world, It seems like the ratings agencies suffered a loss of reputation *only* with respect to the ratings they got wrong, that is on MBS securities. Moreover, these securities were distinct, their market was initially quite large, but, when the bad realizations manifest themselves, this market rapidly shrank. Hence, it would seem like the reputational trade-off was tilted sharply in favor of deviating. This may explain why all of the major ratings agencies appear to have done so.

A key point to note here is that increased ratings demand from distorting ratings to aid regulatorily constrained investors does not depend on whether we are in an investor-pays or an issuer-pays decentralization. In either case, the ratings distortion will make these ratings attractive for constrained investors. Thus in both cases the ratings agencies would have an incentive to distort their ratings on certain assets in order to "supply" their customers with the ratings they wanted.

13 The Demand for Ratings and the Supply of Safe Assets

The example just cited is pertinent to the issues that arose during the financial crisis. The problems arose when the ratings agencies rated bundles of credit instruments that had been assembled in the form of Residential Mortgage Backed Securities (RMBS) or CDO's based on them. As argued in Acharya et. al.(2009) the key ingredient in the financial crisis was the fact that financial firms were happy to retain highly rated tranches of mortgage backed securities they created in special purpose vehicles because of the yield they offered. In the context of our model the type J investors actually leveraged their securities while meeting the quality requirements imposed by the government. This was how they managed to manufacture the tail risk that eventually caused the financial system to nearly collapse.

The increasing reliance on ratings in order to risk weight assets for prudential regulation purposes increased the demand for "safe" assets - assets that met regulators standards. At the same time the growth of shadow banking and the increased use of derivatives and repo markets dramatically increased the demand for safe assets as collateral for repo transactions and derivative positions. Repo and derivative transactions increased sharply in the 1990s and through 2007 and this increased demand for safe assets as collateral for short-term funding ran up against a limited supply of government issued safe assets. In 2001 the Bank for International Settlements pointed out that the increase in collateralized transactions that required collateral with inherently low credit and liquidity risk had outstripped the supply of safe assets (Gorton and Ordonez 2012).

What has happened to the supply of safe assets and investment grade securities over time? In earlier periods, the private sector and the Treasury supplied the needs of markets quite well. But, over time, the supply of investment grade debt from the corporate sector declined relative to the demand (Gorton and Ordonez, 2012) and the supply of Treasury debt has fluctuated over time.

Between fiscal 1992 and fiscal 1997, strong economic growth and rising tax receipts pushed the deficit down from \$290 billion to \$22 billion. In fiscal 1998 the federal government recorded a surplus of \$70 billion for the first time in almost thirty years.The Congressional Budget Office at the time predicted that the surplus would increase steadily over the next ten years and would reach

$381 billion in fiscal 2009. The shrinking deficit, and subsequent surplus, led to a concomitant decline in Treasury financing needs. Treasury officials reduced their monthly offerings of 2-year notes from $181.2 billion in 1996 to as little as $12 billion in 1998. Over the same interval, quarterly offerings of 3-year notes fell from $19 billion to $10 billion and weekly offerings of 13- and 26-week bills fell from around $14 billion each to $5.4 and $7.4 billion, respectively.[12]

The demand for safe assets has led to financial innovation and the creation of privately created "nearly riskless" assets that could fill the role of government backed safe assets and investment grade corporate debt.

Gorton, Llewellen and Metrick (2010) showed that privately issued substitutes for government debt and highly rated privately issued debt, together, are a roughly constant fraction of all debt since the 1950's. Krishnamurthy and Vissing-Jorgenson (2012) also document the relationship over time between government debt and private issued asset-backed near riskless private debt. They show that the net supply of privately issued debt is negatively correlated with the net supply of government debt.

Many have argued that it was the complexity of the CDO's of RMBS that enabled the agencies to rate collections of securities of different risks as being of high quality even though the returns reflected higher risks. Skreeta and Veldkamp (2009) argue that it was the complexity of these securities that facilitated ratings shopping by the financial institutions that were issuing them. It is also important to note that the regulated investors had access to inexpensive capital through the Federal Reserve if the rated securities created liquidity problems for them. In addition it is obvious ex-post that they had access to unpriced too big to fail insurance that made it even more attractive to hold assets of higher risk but with higher ratings.

It is important to note that, as in the model, the ratings agencies continued to rate literally millions of more plain vanilla securities, corporate debt, sovereign debt and so on, where low performing ratings would be far more apparent.

[12]There is currently concern over a similar shortage of safe debt because the Fed is buying over 90% of new issuance by the Treasury

14 Conclusion

We have laid out the ingredients for an efficient outcome with either investor-pays and issuer-pays formats. The requirements are fairly stringent and unlikely to be met in practice. As a result, the investor-pays format is likely to feature under-investment in information in proportion to the severity of the free-rider problem, while the issuer pays features underutilization of the information acquired and, potentially, over-investment in information acquisition. However, the credit ratings agencies are unlikely to exacerbate these issues so long as their ratings are not used for regulatory purposes, since reputational concerns both in theory and in practice seemed to have been sufficient to generate accurate ratings for the bulk of their operation.

References

Acharya, Viral, Thomas Cooley, Matthew Richardson, and Ingo Walter, 2009, “Manufacturing Tail Risk” *Foundations and Trends in Finance* 4(4), 247-325

Bongaerts, Dion, 2013, “Can alternative business models discipline credit rating agencies,” Working Paper, Erasmus University.

Gorton, Gary, Stefan Lewellen & Andrew Metrick, 2012 “The Safe Asset Share ” *American Economic Review* 102(3)) 101-06, May

Gorton, Gary,and Guillermo Ordonez, 2012 “The Supply and Demand for Safe Assets ” NBER Working Paper 18732

Gourinchas, Pierre-Olivier, and Olivier Jeanne, 2012 “Global Safe Assets.” Working Paper, U.C. Berkeley

Krishnamurthy, Arvind and Annette Vissing-Jorgensen, 2012 “ The Aggregate Demand for Treasury Debt” *The Journal of Political Economy* 120(2):233-267.

Mathis, J., McAndrews, J. and Rochet, J-C :2009, “Rating the raters: Are reputation concerns powerful enough to discipline ratings agencies,” *Journal of Montary Economics* 56(5), 657-674.

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

Skreeta, Vasiliki, and Laura Veldkamp, 2009 “Ratings Shopping and Asset Complexity ” *Journal of Monetary Economics* 56(5), 678-695.

The Financial Crisis Inquiry Commission, 2011 , “The Financial Crisis Inquiry Report ” U.S. Government Printing Office

White, Lawrence, 2010 “Markets: The Credit Rating Agencies ” *Journal of Economic Perspectives* 24(2), 211-226