Queen's Economics Department Working Paper No. 1335

Livin' on the Edge with Ratings: Liquidity, Efficiency and Stability

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12-2014

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December 2014

Abstract

We look at the role of credit ratings when assets are issued in a primary market and sold by dealers into a secondary, over-the-counter market in order to study regulatory proposals for rating agencies. Credit ratings are used to overcome a lemons problem. When the lemons problem is moderate, ratings are used to screen issuers, but are inefficiently inaccurate. Hence, too many lemons are issued in order for dealers to profit from rate shopping where low rating standards lead to high volume, but fragile trading in the secondary market. This inefficiency arises from dealers not properly taking into account the informational rents paid indirectly by investors in the secondary market to primary issuers. We use our framework to show that in-house ratings by investors or competition in the secondary market can lead to more accurate ratings and more stable trading, while promoting in-house ratings by dealers and competition among rating agencies are ineffective. Holding dealers liable or having investors pay for accurate ratings ex-post can also improve efficiency and stability.

*The views expressed in this paper are not necessarily the views of the Bank of Canada. Thorsten Koeppl acknowledges financial support from the SSHRC Insight Grant program.

1 Introduction

The modern financial system has moved towards a market-based financing model (e.g. Brunnermeier, 2009) where issuers (borrowers) obtain funds by securitizing assets and selling these off to investors (lenders). A crucial element of modern financial system is that these customized or specialized securities can be retraded after they have been issued so that investors have access to liquidity when needed in the short-run. Trading itself is organized in an "over-the-counter" (OTC) market where investors have to find counterparties and bilaterally negotiate the prices at which these securities are traded. These features give rise to a "dark" market, where investors lack important information for trading: the securities themselves are opaque and there is no public information about the trading (price or volume) of the securities. For this reason, credit rating agencies (CRAs) are hired by issuers to provide an assessment (or rating) of how risky these assets are for investors in terms of the expected cash flow (Coval et al., 2009).

The recent financial crisis, however, demonstrated how fragile trading in such markets can be. When investors realized that they had relied on inaccurate information about the average quality of the securities, trading in these markets came under severe stress. Many investors faced considerable costs as they could not obtain necessary liquidity anymore from selling the securities. A common view is that CRAs contributed to the crises by providing inaccurate ratings and aggravated the crisis by suddenly adjusting their ratings. For example, the Financial Crisis Inquiry Commission concluded that "This crisis could not have happened without the rating agencies. Their ratings helped the market soar and their downgrades through 2007 and 2008 wreaked havoc across markets and firms." As a consequence, several efforts are under way to improve the regulation of CRAs, with the objective to increase the stability of short-term financing markets. For instance, steps are being taken by the Financial Stability Board to promote market participants' in-house credit assessment capabilities and reduce their reliance on CRA ratings.

Despite policy makers' concerns over these issues, guidance provided by economic theory is limited. It remains unclear what sorts of economic frictions or market failures are underlying the aforementioned trading inefficiency and fragility, and whether the proposed regulatory reforms are appropriate for addressing these frictions. Against this background, we develop a dynamic model of asset trading and information acquisition in an OTC market for studying the interaction between the issuance and trading of opaque assets, and the acquisition and quality of credit ratings.

The model is then used to analyze the liquidity, efficiency and stability of asset trading and rating acquisition, and to evaluate whether various reform proposals are effective in improving market resilience without compromising efficiency.

We consider an environment in which issuers create assets and sell them to intermediaries ("dealers") in the primary market. Dealers will then offload these assets to the secondary market where assets are traded among investors with time-varying liquidity needs. Both markets are subject to a lemons problem because only a fraction of issuers can create good assets, and the quality of assets is private information of their owners. Credit ratings by CRA are thus useful for *imperfectly* certifying the quality of assets and support their trading in the secondary market. The investors' incentives to trade these opaque assets in the secondary market depend on the average quality of assets that are bought by dealer in the primary market as well as the accuracy of ratings chosen by the CRA. If too many bad assets are issued and credit ratings are too inaccurate, then investors are subject to high credit risk, and hence are unwilling to purchase assets, leading to a market freeze. However, issuers, rating agencies and dealers do not have proper incentives to fully internalize the effects of issuing bad assets and offering inaccurate ratings on trading in the secondary market. As a result, the equilibrium can be inefficient. In particular, the CRA can set an inefficiently lax standard and allow the issuance of too many bad assets – a situation which looks like "rate shopping".[1] At the same time, such lax standards can make the market outcome extremely fragile in the sense that even a small shock to asset quality can freeze the secondary market and generate a large welfare loss.

In our model, credit ratings perform two functions. First, they work as a signalling device for good asset issuers. This function is at work in a separating equilibrium in which only good assets are issued, bought by dealers and then sold to the secondary market. This outcome minimizes the credit risk faced by investors, but a volume in the primary market implies low revenue for dealers and the CRA. Second, credit ratings can also function as a screening device. This function is at work in a pooling equilibrium in which both good and bad assets are issued and traded in the secondary market. In this case, investors are subject to higher credit risk, but a high volume increases profits for dealers and the CRA. Hence, the interests of investors, dealers and CRAs are

[1] A World Bank policy brief on crisis response discussed the failures of CRA on rating structured securities and pointed out that "pressures to maintain market share and increase profits appear to have prompted them to relax their own criteria and to avoid hiring new staff or investing in costly new databases and rating models." (Katz, Salinas and Stephanou, 2009).

misaligned.

The equilibrium effects of credit ratings on the liquidity, efficiency and fragility of the asset market are intricate, and critically depend on the severity of lemons problem – the fraction of issuers creating bad assets. At one extreme where the lemons problem is very mild, credit ratings are not needed at all. Asset issuance volume is high in the primary market, while trading in the secondary market is liquid and efficient. Even though some bad assets are issued and traded, investors are still subject to low credit risk, and hence the market is resilient to small quality shocks. At the other extreme where the lemons problem is very severe (i.e., the fraction of bad issuers is very high), accurate ratings are offered, and thus there is a welfare loss due to high rating cost involved. In this case, a separating equilibrium is supported where bad assets are not issued at all, so that both issuance and trading volumes are low. Since credit risk is completely eliminated, the asset market is again resilient to small quality shocks.

Inefficiency and fragility arise in the intermediate case. When the lemons problem is moderate, ratings are acquired but offered at an inefficiently low accuracy. As a result, too many bad assets are issued and traded in the secondary market. Consequently, investors are exposed to too much credit risk and hence the market is very fragile – even a small quality shock can freeze the market. This outcome is interesting because it captures the observation of "rating shopping" and is consistent with policy makers' view that credit rating agencies' lax standards allow the issuance of too many securities of poor credit quality. This is also consistent with the view of Calomiris (2009) who argues that inaccurate ratings are desired by institutional investors who do not fully internalize the negative effects on the ultimate investors and encourage debasement of ratings.

We then use our model to analyze the effectiveness of various policy proposals. Promoting in-house ratings has non-trivial implications on dealers decision to acquire assets in the primary market and the CRA's rating decision. The effects of this proposal on market efficiency and fragility depend on whether the in-house ratings are carried out by dealers in the primary market or by investors in the secondary market.

We find that when dealers buy assets in the primary market, they do not have the incentive to perform in-house ratings. While such ratings can help screen out bad assets for investors, they are neither profitable nor credible for dealers to engage in, because dealers do not bear the credit risk and hence have no need to limit their exposure by internal rating. In addition, when dealers perform in-house ratings to screen out bad assets, their actions and rating outcomes are not verifiable by

investors. As a result, as long as the secondary market remains liquid, dealers do not have an incentive to use internal ratings because it is costly to do so and will only reduce the volume – and thus profit – from intermediation. Interestingly, with in-house ratings dealers may have an incentive to identify good assets in order to keep good assets on their books rather than selling them to investors in the secondary market. Given our environment, where investors have lower holding costs, this will result in good assets being misallocated. As a conclusion, requiring dealers to have in-house rating capabilities cannot discipline CRAs to issue ratings with higher accuracy, nor will it improve efficiency or stability.

In the second case, investors can use in-house ratings to screen out bad assets offered by dealers. As a result, dealers are exposed to credit risk since they may pick up some bad assets which investors refuse to buy. For trading in the secondary market, there are now multiple equilibria due to a strategic complementarity in the decision of investors to acquire information. For intermediate levels of asset quality, when dealer profits from intermediation are low, the CRA is forced to raise the accuracy of its ratings to prevent the market from exclusively relying on in-house ratings by investors. When dealer profits are large, however, the CRA can reduce the accuracy of its ratings so as to force investors to also use their own in-house information for trading. When doing so, the CRA can extract profits from dealers. One advantage of promoting investor in-house rating is that the market can become more resilient as now the combined amount of information in the market is sufficient to sustain small shocks to asset quality when trading in the secondary market. However, relying on in-house ratings by investors can be inefficient as unlike CRA ratings, information acquisition is decentralized and private. This implies that in-house ratings cannot be communicable to future buyers and hence lead to an information loss. Furthermore, information acquisition is subject to a coordination problem. Specifically, when an investor performs in-house ratings before purchasing an opaque asset, it becomes more difficult for lemons to be resold in the market. As a consequence, other investors have now higher incentives to perform in-house ratings in order to avoid picking up an illiquid lemon. An individual investor thus does not internalize this external effect, and hence the lack of coordination in information acquisition can generate inefficiently high information acquisition due to a strategic complementarity.

We then look at market reform. Competition among rating agency in fees and accuracy make the problem worse when dealers have market power in the sense that they can require issuers to acquire ratings from a particular CRA. Competition lowers fees, thereby encouraging rate shopping without

encouraging more accurate ratings. Dealers prefer such rate shopping as it increases the amount of assets they can profitably intermediate. Interestingly, when also making secondary markets fully competitive one restore efficiency and make the market more stable. With dealers having now market power so that they can extract all surplus from trading in the secondary market, they internalize the redistributive effect associated with informational rents. Thus, they prefer fully informative ratings without rate shopping.

Finally, we look at the possibility to directly provide incentives to achieve efficiency and more stable markets. When dealers face a fine for selling lemons once they are detected, one can improve the accuracy of ratings. The mechanism here is that dealers need sufficiently accurate ratings when faced with ex-post fine in order to intermediate the market profitably. This is interesting as the fine is akin to liquidity provision to the market by repurchasing (bad) assets. Even if CRAs cannot be held liable, one can still provide direct incentives to them. We show that a payment from investors to the CRA once the asset matures can improve efficiency and stability as well. Importantly, the payment is on top of initial payments by issuers to the CRA and needs to be conditional on market performance in the secondary market.

Recent regulatory efforts have spurred renewed interest in CRAs among financial economists.[2] Broadly speaking, on the theoretical side recent contributions can be classified into three different groups. The first one looks at the relationship between CRAs and investors from the perspective of a principal-agent problem. Representative examples are the works by Mathis et al. (2009) and Bolton et al. (2012) who analyze the incentives for CRAs to maintain their reputation and how competition affects these incentives. The second group concerns itself with the problem of rate shopping – the process where multiple ratings are being sought by issuers, but only good ones are being published. A nice contribution in this area is Skreta and Veldkamp (2009) who find that complex securities make the incentives to shop for ratings worse and that competition among CRAs compounds this problem. The final research area is about changes in ratings having amplifying effects. The very recent contribution by Manso (2013) analyzes so-called "cliff effects" where a downgrade can push a borrower into default, even though the borrower would remain in good standing without a downgrade. Bar-Isaac and Shapiro (2013) focus on the time dimension of rating changes and ask whether CRAs cause procyclical effects as they change their ratings over the business cycle.

[2]For an overview see Jeon and Lovo (2013) and White (2010).

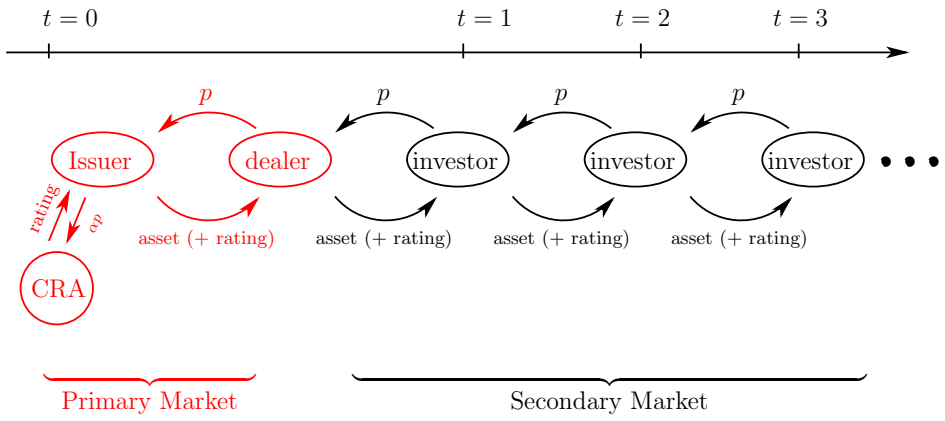


Figure 1: Time line

2 Environment

Our set-up captures an environment where assets are first issued in the primary market and then are sold by intermediaries to investors who in turn trade these assets in the secondary market. There are two markets and three different, large mass of economic actors – issuers, dealers and investors, as well as a credit rating agency. At $t = 0$, there is a *primary market* where issuers sell assets to dealers, and where subsequently dealers sell these assets on to investors. For $t > 0$, there is a *secondary market* where investors trade these assets among themselves. All actors are risk-neutral and discount the future by $\beta \in (0, 1)$. Figure 1 illustrates the time line.

Issuers are endowed with one unit of an asset. A fraction q of these issuers have assets of high quality. These assets generate a cash flow of $\delta > 0$ every period, but issuers also incur a per period holding cost $y < \delta$. The remaining fraction of issuers $1 - q$ have bad assets – called lemons – that do not produce any cash flow. While the average quality of assets is publicly known, the quality of any asset is private information for the issuer.[3]

In the primary market, dealers are bilaterally matched with issuers and make a take-it-or-leave-it offer to issuers for buying the cash flow. They are then matched with investors who in turn make

[3]There is an alternative interpretation of this set-up: each issuer is endowed with an investment project. A good investment leads to the creation of a good asset which generates a cash flow of δ every period, but requires an initial outside investment of $(\delta - y)/(1 - \beta)$. A bad investment leads to the creation of a bad asset which generates zero cash flow and requires zero investment. Issuers do not have initial wealth and thus need to raise funding in the primary market.

a take-it-or-leave-it offer to dealers to purchase an asset that promises to pay a dividend δ. Once dealers have purchased an asset, they perfectly learn its quality.[4] Their valuation of the cash flow of a good asset is given by $\delta - x > 0$ where $x < y$ is the holding cost of dealers. Therefore, there is gain from transferring high quality assets from an issuer to a dealer. Dealers do not value lemons as they do not yield any cash flow.

The secondary market is a simplified version of Chiu and Koeppl (2011) and captures dynamic trading on an OTC platform where trading is bilateral and assets are opaque. Every period investors without an asset (buyers) are matched with investors that have an asset (seller) and make a take-it-or-leave-it offer to purchase the asset. For simplicity, we assume that investors go through a life-cycle. When an investor buys a high quality asset, he learns its quality. The investors value the dividend at $\delta > 0$ for one period with his valuation dropping to $\delta - x > 0$ in future periods. Thus, there is gain from transferring a high quality asset from a seller to a buyer. Lemons again have no intrinsic value. Finally, after each match, an investor without an asset (i.e., a seller after selling or a buyer without buying) leaves the economy.

To introduce the possibility to acquire information, we add a technology that provides information about the quality of the asset. This information is in the form of a signal σ about the type (s for good and ℓ for lemon) of the asset where

$$Prob(\sigma = s|s) = 1$$

and

$$Prob(\sigma = \ell|\ell) = 1 - \pi.$$

The signal is thus asymmetric. Good assets are never interpreted as lemons, but the reverse is not true: with probability π a lemon is regarded as a good asset. The probability π can thus be interpreted as the accuracy of the signal. The extreme cases are of course full detection ($\pi = 0$) and the signal being completely uninformative ($\pi = 1$). The cost for the signal is given by a $k(\pi)$ per unit of the asset, with $k'(\pi) < 0$. We assume that the technology is operated by a *rating agency* that chooses π and receives a payment from the issuer of the asset that is a fixed fraction α of the price offered by the dealer.[5] We interpret the signal as a *rating* as it is publicly observed in the secondary market.

[4]This assumption is made for convenience to keep the nature of adverse selection at both ends of the primary market the same.

[5]This assumption is made for convenience, but reflects current pricing practices of rating agencies that charge a fixed proportion of the price at which an asset is issued for their ratings. Also, the size of the rating fee α will be

In what follows, we will look first at trading in the secondary market for different levels of information about assets π. We then analyze what happens in the primary market when dealers can request ratings from issuers that are produced by rating agencies. All formal proofs are relegated to an appendix.

3 Ratings and Trading

3.1 Trade in the Secondary Market

We first look at trading in the secondary market. We denote the value functions by v_o, v_s and v_ℓ depending on whether the investor is an owner valuing the dividend at δ, a seller valuing it at $\delta - x$ or has a lemon that does not pay a dividend.[6] A buyer without an asset that is matched with an asset holder will make an offer at some price p if and only if

$$E[q|\mathcal{I}, p]v_o + (1 - E[q|\mathcal{I}, p])v_\ell - p \geq 0 \tag{1}$$

where $E[q|\mathcal{I}, p]$ is the expected probability of buying a good asset at p given the information available in the secondary market. Due to adverse selection in the market, the expected probability of buying a good asset is given by

$$E[q|\mathcal{I}, p] = \begin{cases} 0 \text{ if } p < v_s \\ \frac{q}{q+(1-q)\mathbf{1}_\sigma \pi + (1-q)\mathbf{1}_0} \text{ if } p \geq v_s \end{cases} \tag{2}$$

where $\mathbf{1}_\sigma$ is an indicator function for both lemons and sellers having acquired ratings, while $\mathbf{1}_0$ is an indicator for no one having acquired ratings. There are three possible cases: (i) separating ($\mathbf{1}_\sigma = \mathbf{1}_0 = 0$): only sellers of high quality assets have acquired ratings; (ii) pooling with ratings ($\mathbf{1}_\sigma = 1, \mathbf{1}_0 = 0$): both sellers and lemons have obtained ratings; (iii) pooling without ratings ($\mathbf{1}_\sigma = 0, \mathbf{1}_0 = 1$): both sellers and lemons have not acquired ratings.

A seller always has the option to keep the asset and not sell. The bargaining protocol implies that $v_s = (\delta - x)/(1 - \beta)$ in all cases. Hence, a buyer will obtain a good asset only if he at least compensates the seller with $p \geq v_s$. Lemons, however, will always be selling as their value of a lemon is lower (i.e. $v_s \geq v_\ell$). Furthermore, since lemons do not pay a dividend, they will never

endogenized below.

[6] These values are evaluated before current period dividends arrive.

be traded if investors can observe their quality. Therefore, in case (i), buyers will either not make an offer, or make an offer $p = v_s$ only to an asset with a rating. Since $v_o = \delta + \beta v_s > v_s$, good assets are always traded, but lemons are never traded. In case (ii), given a rating with level of accuracy π, there are q good assets and $(1-q)\pi$ lemons in the market. Since the buyer can make a take-it-or-leave-it offer, he will either not make an offer or his offer will be $p = v_s$. In an equilibrium with trade in the secondary market, the value functions in a steady state are given by

$$v_o = \delta + \beta v_s \tag{3}$$

$$v_s = \frac{\delta - x}{1 - \beta} \tag{4}$$

$$v_\ell = \beta v_s \tag{5}$$

This corresponds to a pooling equilibrium[7] where the cost of acquiring a lemon is that there is no dividend for one period before the lemon is sold again in the market at its original purchase price. In an equilibrium without trade, we have $v_\ell = 0$, and v_o, v_s as given above. To characterize the conditions for trading in the secondary market, one only needs to verify that, conditional on lemons having acquired ratings with certain accuracy π, the surplus from making an offer is positive. Finally, in case (iii), all assets in the market are without rating. The value functions are again given by the above equations. Without rating, the average quality q has to be sufficiently high to support trading in the secondary market.

This yields the following result for trading in the secondary market (see also Figure 2).

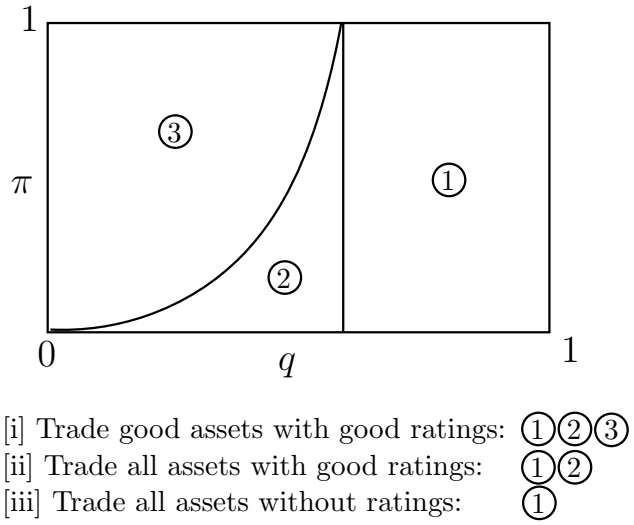
Proposition 1. *(i) If only good assets have a rating but lemons do not, trade only of assets with a rating in the secondary market is always an equilibrium.*

(ii) If all assets have a rating, trade only of assets with a good rating in the secondary market is an equilibrium if and only if $\pi \leq \frac{q}{1-q}\frac{x}{\delta - x}$.

(iii) If no assets have ratings, trade all assets in the secondary market is an equilibrium if $q \geq 1 - \frac{x}{\delta} \equiv \bar{q}$.

Proof. See appendix. □

[7] One can show that a separating offer (by using lotteries) is dominated by a pooling offer. For details, see Chiu and Koeppl (2011).



[i] Trade good assets with good ratings: ①②③
[ii] Trade all assets with good ratings: ①②
[iii] Trade all assets without ratings: ①

Figure 2: Trading in the Secondary Market

Trading in the secondary market depends on the information set $\mathcal{I}$ of the buyer. Without ratings, he only knows the average quality q of assets in the population which needs to be sufficiently high to incur the cost from purchasing sometimes a lemon that does not yields a dividend. Ratings are informative in the sense that they screen out lemons. Importantly, such screening has *two dimensions*. First, when lemons do not acquire a rating, but good assets do, ratings perfectly signal the quality *independent* of accuracy π. Second, when all assets have a rating, there is an additional screening function which depends on its accuracy π. Moreover, since screening is imperfect, the average expected quality of assets falls in between q and 1.[8]

3.2 Primary Market

At $t = 0$, a dealer is first matched with an issuer in the primary market and makes a decision about obtaining an asset. After that, he can immediately resell it to an investor (i.e., a buyer) who can in turn trade the asset in the secondary market in the following period. If the asset is not sold in the primary market, the dealer also has the option to sell it at $t > 0$ in the secondary market, just like any other investors. Therefore, the dealer's value of entering the secondary market at $t > 0$ is $v_s = (\delta - x)/(1 - \beta)$ since he also has a holding cost x per period, and has no bargaining power.

[8] In general, there are multiple equilibria due to a strategic complementarity that arises from resale of assets. For further details on this issue, see Chiu and Koeppl (2011). We focus here entirely on trade equilibria in the secondary market.

Given this continuation value, in a match with a buyer at $t = 0$, a dealer with a good asset has reservation price $p = v_s$, while a dealer with a lemon can potentially earn an informational rent v_s as he has private information on the quality of the asset. As a consequence, in a match with a dealer at $t = 0$, a buyer decides whether to make an offer $p = v_s$ in order to purchase an asset from the dealer given his expectation about the quality of the asset, $E[q|\mathcal{I}]$. Proposition 1 implies that the buyer has no incentive to buy an asset with a bad rating because it cannot be resold.

When purchasing an asset from the issuer, the dealer can make two types of offers. An *unconditional* offer specifies a price p_0 at which the dealer commits to buy the asset at that price. A *conditional* offer, however, specifies a price p_σ where the dealer commits to purchase the asset at that price if and only if the issuer obtains a good rating.[9] Any take-it-or-leave-it offer by the dealer will extract the expected surplus from trading with the issuer. Hence,

$$p_0 = \frac{\delta - y}{1 - \beta} \tag{6}$$

$$p_\sigma = \frac{1}{1 - \alpha} \frac{\delta - y}{1 - \beta} \tag{7}$$

for a conditional offer and an unconditional offer, respectively. The key difference between these two offers is that a conditional offer helps screen out (some) lemons, but at a cost since the issuer has to pay a fee αp_σ for the rating. Hence, such offers need to reimburse the issuer for the cost of acquiring a rating.

How effective such screening is depends on the accuracy of the signal π. A conditional offer will always be accepted by issuers with a good asset: they get always reimbursed for a rating since there are no type I errors. For issuers with bad assets, however, there is the additional cost of obtaining a bad rating. Hence, they will accept a conditional offer if and only if

$$\pi p_\sigma - \alpha p_\sigma \geq 0. \tag{8}$$

Incurring the cost for the rating is sunk for issuer. However, he can only sell the asset with a good rating which occurs with probability π. Consequently, if the rating is sufficiently accurate ($\pi \leq \alpha$), conditional offers perfectly screen out lemons, while otherwise they only improve the average quality of assets that can be sold to investors and traded in the secondary market.

[9] In general, a dealer can also commit to pay a positive price to purchase an asset with bad rating. This offer is dominated because assets with a bad rating do not generate dividends and cannot be resold.

Proposition 2. *Lemons acquire a rating if and only if the rating is sufficiently inaccurate ($\pi \geq \alpha$). With ratings, the expected quality of assets in the secondary market is thus given by*

$$E[q|\mathcal{I}] = \begin{cases} 1 \text{ if } \pi \leq \alpha \\ \frac{q}{q+(1-q)\pi} \text{ if } \pi > \alpha \end{cases} \tag{9}$$

Therefore, depending on the accuracy of rating, the dealer's conditional offer can induce different outcomes in the secondary market. When $\alpha \leq \pi$, a conditional offer can only support imperfect screening and hence lead to a pooling outcome with ratings in the secondary market (case (ii) in the previous section). When $\alpha > \pi$, however, a conditional offer can support perfect signalling and hence lead to a separating outcome in the secondary market (case (i)). Furthermore, an unconditional offer can only lead to a pooling outcome in the secondary market (case (iii)). These different outcomes matter not only for the functioning of the secondary market, but also for the number of assets intermediated by the dealer.

Next, we consider the dealer's decision on the offers made in the primary market. Notice that, if there is trading in the secondary market, the resale price of an asset is $p = v_s = (\delta - x)/(1 - \beta)$, and the bid price in the primary market under an unconditional offer is $p_0 = (\delta - y)/(1 - \beta)$. So the dealer earns a bid-ask spread $\Delta = (y - x)/(1 - \beta)$ from an unconditional offer. Similarly, the bid-ask spread from a conditional offer is $\Delta - \alpha p_\sigma$ which is narrower due to the rating cost.

Assumption 3. *The fees for ratings α and the bid-ask spread $y-x$ satisfy the following restrictions*

$$\bar{q} \leq \frac{\delta - y}{\delta - x} \leq (1 - \alpha). \tag{10}$$

These restrictions on parameter values rule out two uninteresting outcomes. The first inequality ensures that it is not profitable for dealers to make unconditional offers (no ratings) and hold the securities forever. The second inequality restricts how expensive the rating can be. It ensures that dealers have non-negative profits from conditional offers provided there is trade in the secondary market where they can sell all assets that they buy from issuers.

Under this assumption, the dealer's optimal offer is then determined by considering both intensive and extensive margins. First, holding the number of assets transacted constant, unconditional offers imply a wider bid-ask spread. Second, given a positive bid-ask spread, intermediating more assets

is more profitable. Therefore, when it is feasible, an unconditional offer maximizes both margins. When it is infeasible, rating can be used at the cost of narrowing the bid-ask spread and reducing the number of transactions through screening and (possibly) signalling.

Proposition 4. *If $q \geq 1 - \frac{x}{\delta}$, dealers make unconditional offers and there is trade of all assets in the secondary market. If $q < 1 - \frac{x}{\delta}$:*

a. *For $\alpha \geq \pi$, dealers use conditional offers. Only good assets acquire ratings so that a fraction q of assets are traded in the secondary market.*

b. *For $\alpha < \pi$, dealers use conditional offers whenever $\pi \leq \frac{q}{1-q}\frac{x}{\delta - x}$. All issuers acquire ratings so that a fraction $q + (1-q)\pi$ assets are traded in the secondary market.*

Otherwise, there is no trade.

Figure 3 below shows the different regions for trading in the parameter space (q, π). For high enough quality, trading of all assets can take place without ratings (region (1)). This is the best outcome for dealers since they can earn a bid-ask spread and intermediate all assets. For lower average quality, trading can only take place with ratings. For very accurate ratings, conditional offers induce full screening so that dealers can only intermediate good assets (region (2)). When ratings get less accurate, dealers face a trade-off. On the one hand, they would like to transact as many assets as possible to earn the spread $(y - x)$. However, they need to ensure that information in the secondary market is sufficiently accurate which can only be the case with ratings. This leads to conditional offers where lemons also acquire ratings (region (3)). For low quality and inaccurate ratings, there can never be trade in the secondary market (region (4)). Our assumptions also ensure here that in equilibrium buying and holding the assets is always a dominated choice for a dealer.

3.3 Equilibrium Accuracy of Ratings

The analysis so far takes as given the accuracy of credit ratings. How does the rating agency determine the accuracy π of its ratings? Recall that the payment for a rating is a fixed fraction of the issuance price p_σ. Hence, the rating agency takes price for its ratings and the demand (as a function of π) as given and sets its accuracy π such as to maximize its profits.[10]

[10] Below, we discuss how price for ratings is determined in different market settings.

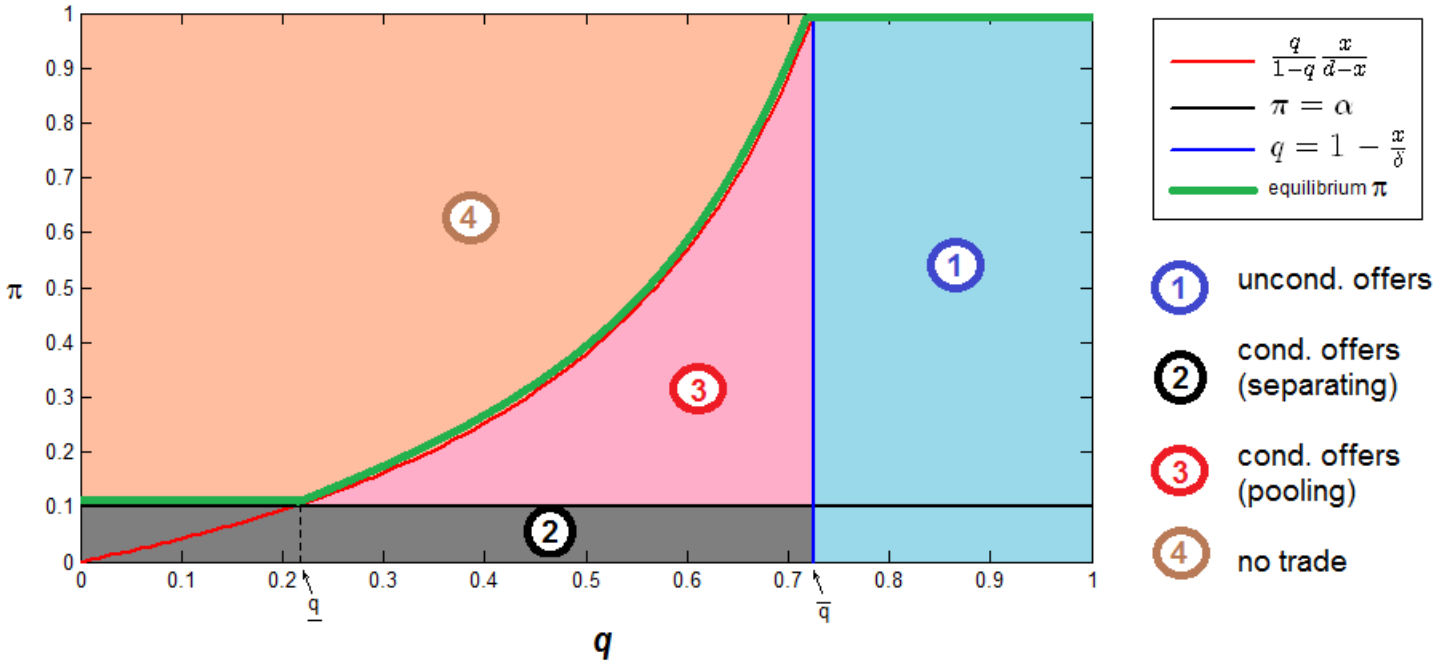


Figure 3: Distribution of Equilibrium in (q, π) space (δ=2, β=0.9, x=0.55, α=0.1, y=0.8)

Fix the average quality of assets q. Then, from Proposition 4 it follows that there is no demand for ratings by issuers for sufficiently high q. For a lower average quality of assets, however, there is a positive demand for ratings provided ratings are sufficiently accurate. In particular, the demand for ratings depends on whether lemons acquire ratings or not. Notice that the profit per rating issued is given by $\alpha p_\sigma - k(\pi)$. We now impose the following restrictions on the fees for and the cost of ratings so that issuing ratings always lead to non-negative profits.[11] The rating agency will then maximize demand for its ratings which leads to the following characterization of equilibrium.

Proposition 5. *The equilibrium is given by*

(i) trade without ratings of all assets if $q \geq \bar{q} = 1 - \frac{x}{\delta}$

(ii) trade with ratings of all good assets if $q \leq \underline{q} = \frac{\alpha(\delta - x)}{\alpha\delta + (1-\alpha)x}$

(iii) trade with ratings of all good assets and measure $q\frac{x}{\delta - x}$ *of bad assets if* $q \in (\underline{q}, \bar{q})$.

[11] This is guaranteed whenever $\alpha > \alpha^C$, where α^C is the unique solution to

$$\frac{\alpha^C}{1-\alpha^C}\frac{\delta - y}{1-\beta} = k(\alpha^C).$$

The green line in Figure 3 indicates the optimal choice of rating accuracy by the rating agency – and, hence, the equilibrium outcome in the (q, π) space. The ratings agency has an incentive to be "on the edge" of the region where trading is an equilibrium with ratings. Hence, the accuracy of the rating is just enough to enable trading of the largest amount of assets. The reason is that lowering the accuracy will reduce the demand for ratings, while raising the accuracy will only increase its cost. This is consistent with the view that CRA relaxed rating standards before the crisis to increase profits and reduce ratings costs (Katz, Salinas and Stephanou, 2009).

For low enough q, ratings need to be so precise that only good assets have an incentive to acquire them. Lemons do not seek ratings and are, hence, not traded. For assets of intermediate average quality, ratings are imprecise enough so that lemons also acquire them. Note that more precise ratings are feasible; the rating agency, however, has no incentives to increase the accuracy as this is more costly and would lead to a fall in the demand for ratings as π falls below the threshold α. This outcome is consistent with observers and policy makers' views that credit rating agencies' lax standards allow the issuance of opaque securities that are highly rated but of poor credit quality. It also somewhat captures the practice of "rating shopping" in the sense that low quality issuers also try to hire rating agencies in the hope of being (wrongly) offered a favorable credit rating.

Notice that, the actual quality of assets issued and traded in the market is given by $q/[q + (1 - q)\mathbf{1}_\sigma \pi + (1-q)\mathbf{1}_0]$, which is non-monotonic with respect to q. In a market with $q \in [\bar{q}, 1]$, fraudulent assets are not a big concern for investors. An example is the market for high-quality treasury securities. All assets can be issued and traded even without ratings, and the average quality in the secondary market is given by $q \geq \bar{q}$. In a market with $q \in [0, \underline{q}]$, fraudulent assets become a big concern. An example is the sales of asset-backed securities since the financial crisis. Under a tight rating standard, only good quality assets can be issued and traded, and hence the average quality of assets traded in the secondary market is maximized at 1, but the quantity is small. For intermediate $q \in (\underline{q}, \bar{q})$, a lax rating standard is applied. Some bad assets can be issued and traded, and the average quality of assets traded in the secondary market is equal to $\bar{q}$. An example is the market for subprime mortgage bonds before 2008 when ratings shopping is common.

4 Liquidity, Efficiency and Stability

We now specify a social welfare function that arises from the fundamentals of our model. Having good assets being issued and traded has benefits due to the improvement in asset allocation, captured by y and x. Furthermore, information is costly while intermediation through dealers per se does not increase welfare.[12] Since we are only looking at stationary equilibria with trade, the welfare function can be written as

$$W = qy/(1-\beta) - [q\mathbf{1}_{\{\sigma|s\}} + (1-q)\mathbf{1}_{\{\sigma|\ell\}}]k(\pi). \tag{11}$$

We have that in equilibrium good assets are always traded.[13] The per period return from issuing the asset is y, while holding costs x do not arise when there is trading. Furthermore, the costs of information acquisition through ratings depends on how many issuers seek a rating. This is reflected by the indicator functions $\mathbf{1}_{\{\sigma|\cdot\}}$, which capture whether good and bad assets have ratings or not. Importantly, reallocating the asset involves only lump-sum transfers between investors and generates welfare only indirectly by avoiding the holding cost x. Ratings are costly when being used, but they do not increase welfare directly.

We define liquidity in the secondary market as the number of trades that are conducted each period.[14] For given q, in equilibrium liquidity is always maximized. For sufficiently high q, all assets are traded, while for lower values of quality, the maximum number of assets with ratings are being traded.

The reason for this result comes from the incentives of dealers and the rating agency. Dealers make profits as they buy assets at a low price – p_0 or p_σ – and sell at a higher price $p = v_s$. Furthermore, they make these profits *on all* assets that are issued, not only good ones. Hence, their profit of making a pooling, conditional offer is given by

$$\begin{aligned} \Pi_D &= (q + (1-q)\pi)\left(\frac{\delta - x}{1-\beta} - \frac{1}{1-\alpha}\frac{\delta - y}{1-\beta}\right) \\ &= (q + (1-q)\pi)\left(\frac{y - x}{1-\beta} - \alpha p_\sigma\right) \end{aligned} \tag{12}$$

[12] We could also introduce a small costs of carrying and trading lemons. However, we do not do so as this would unnecessarily complicated the analysis and would not lead to different insights.

[13] The welfare for a no-trade equilibrium is normalized to $W = 0$.

[14] We could introduce other frictions in the secondary market so that liquidity would not only depend on the total number of assets traded.

These profits are merely zero-sum payments from investors and as such simply redistribute payoffs. Hence, in equilibrium, dealers earn a spread $y - x$ minus the costs for the ratings (if any). The rating agency's profits are increasing in the demand for ratings given any fixed level of accuracy π and is decreasing in the accuracy of the signal itself. Hence, the rating agency prefers to issue as many ratings as possible at the lowest level of accuracy that still achieve trading in the secondary market. This yields the following result for $\hat{q} \in [\underline{q}, \bar{q}]$.

Proposition 6. *The accuracy of ratings is inefficiently low in equilibrium for $[\underline{q}, \hat{q}]$, so that there is too much liquidity in the secondary market.*

The inefficiency for intermediate levels of q arises from the fact that more ratings are issued than necessary for trading. Keeping the accuracy of ratings at $\pi = \alpha$, the total cost of very accurate ratings increases as the fraction of good assets q rises. At the same time, the total cost from rating shopping diminishes as the accuracy of ratings declines with q. This leads to a trade-off between the extensive and the intensive margins associated with ratings costs.

The inefficient equilibrium outcomes come from three basic features of the model: (a) opaque assets (asymmetric information), (b) credit rating decision is made in-advance, and (c) bargaining in the OTC market. When assets are opaque, ratings have values for investors. However, the rating decision is made in-advance in the primary markets by issuers, dealers and the CRA who may not fully internalize the benefits of ratings to investors. Specifically, due to bargaining, transaction prices in the secondary market do not provide them with the right incentives. As a result, the equilibrium level of rating can be inefficient. From the issuance of bad assets with rating, potential investors suffer an expected loss of $\pi(\delta - x)/(1 - \beta)$, while the dealer earns an expected profit $\pi((y - x)/(1 - \beta) - \alpha p_\sigma)$, the rating agency earns $\alpha p_\sigma - k(\pi)$, and the bad asset issuer earns $\pi(\delta - y)/(1 - \beta) - (1 - \pi)\alpha p_\sigma$. Overall, this is a non zero-sum wealth transfer because of the deadweight cost $k(\pi)$ associated with rate shopping.[15]

Dealers and the rating agency are constrained by creating a liquid secondary market for the assets. As shown in Figure 3, for low quality levels, they have no choice than rely on ratings with high accuracy in order to have a liquid secondary market. For intermediate qualities, however, they can encourage rate shopping by lowering the accuracy of the ratings, so that lemons are also traded

[15] We could introduce a small cost for transacting lemons in the secondary market. This would imply a direct welfare cost from trading lemons without affecting our reasoning at all.

in the secondary market. Investors are negatively affected by the decrease in the informativeness of ratings. They purchase lemons at high prices with both dealers, issuers and the rating agency profiting from bringing more assets in the secondary market. For high levels of quality, ratings are not needed for a secondary market, so that dealers have no demand for them.

Our equilibrium has also implications for market fragility. Consider an unanticipated shock to quality at $t > 0$ (i.e., after issuance). We ask about how large an unexpected drop in quality has to be to cause a market freeze in the secondary market where there is no trading any longer given the new level of average quality. To be more concrete, suppose some previous good assets turn to lemons so that the quality falls from q to q_0. Any ratings in equilibrium become less informative. If all assets had been traded without rating before the shock, there are now $(1 - q_0)$ lemons (case (iii)). If lemons had been screened out through ratings, there are now lemons in the market that are not identified by the rating (case (i)). If $(1 - q)\pi$ lemons had been traded before the shock, there are now $(1 - q)\pi + (q - q_0)$ lemons in the market (case (ii)). For the latter case, ratings were set to a level of accuracy that one was at the edge of the trading region. Hence, any negative, unexpected shock will lead to a freeze in the secondary market, resulting in a welfare loss of $-x/(1 - \beta)$.

Proposition 7. *For $q \in (\underline{q}, \bar{q}]$, any unexpected, arbitrarily small fall in quality q will lead to no trade in the secondary market.*

For $q \leq \underline{q}$, no trade in the secondary market is the unique equilibrium if $q_0 < q\left(1 - \frac{x}{\delta}\right)$.

For $q > \bar{q}$, no trade in the secondary market is the unique equilibrium if $q_0 < 1 - \frac{x}{\delta}$.

This results points out that due to the rating agency's incentives to lower the accuracy of ratings, markets are particularly fragile for intermediate levels of quality where rate shopping takes place. To the contrary, separating equilibria – where only good assets acquire ratings – are more stable as they can sustain shocks that are not too big. The result also hints at a potential trade-off between efficiency and stability. For $q \in [\hat{q}, \bar{q}]$, ratings with low accuracy are efficient, since more informative ratings are more expensive and trading is still feasible in the secondary market at such ratings. However, the market is fragile with respect to shocks to asset quality. Hence, one can argue that it might be optimal to raise the accuracy of ratings for stability purposes.[16]

[16]This last result offers a chance to assess how ratings should react to changes in fundamentals. In our framework, any negative shock to quality would hint to a *tightening* of ratings in the sense that they need to become more

For the remainder of the paper, we assume that rate shopping is always socially wasteful. Specifically, we assume that

$$\bar{q}k(\alpha) \leq \underline{k} \tag{13}$$

where $\lim_{\pi \to 1} k(\pi) = \underline{k} > 0$. Hence, there are some fixed costs for rating assets that are sufficiently large to always make separating equilibria efficient. As a consequence, there is no trade off between stability and efficiency when we analyze several regulatory proposals next.

5 In-house Assessment: Dealers Acquire Information

Recent regulatory proposals[17] have pushed the idea that in-house investment analysis could complement ratings of third-party rating agencies. In this section, we first evaluate the implications of dealers having in-house capabilities to undertake credit assessments. While a CRA rating is publicly observable by all (including investors in the secondary market), an in-house rating is only privately observable by the dealer. Moreover, instead of paying a rating fee to the CRA, a dealer has to incur the rating cost directly. Specifically, the cost of acquiring an in-house rating with accuracy π^D is given by $k(\pi^D)$. Therefore the cost function for a dealer is the same as that for the CRA.

In the primary market discussed before, a dealer has three options: no offer, unconditional offer (without CRA rating), and conditional offer (with CRA rating). In addition, a dealer can now choose to make an unconditional offer and obtain an in-house rating, or to make a conditional offer and obtain an in-house rating.[18] If the dealer makes an unconditional offer and obtains an in-house rating, he will forgo the advantage of using ratings as a signalling device in a separating equilibrium. As a consequence, a dealer will always need to incur the cost $k(\pi^D)$ for rating each asset rather than the CRA only rating good assets (in a separating equilibrium).

If the dealer makes a conditional offer and obtains an in-house rating, the dealer may be able to improve the screening function of the CRA rating in a pooling equilibrium. The CRA rating alone can identify $(1-q)(1-\pi)$ lemons. Specifically, we assume that a level $\pi^D < \pi$ allows the dealer to

accurate in order to support trading in the secondary market. This could be helpful in framing the discussion about pro-cyclical effects of ratings.

[17] See FSB (2011).

[18] We assume that CRA ratings and dealers use the same rating technology and their ratings take place at the same time.

identify an *additional* number of $(1-q)(\pi-\pi^D)$ of the lemons. On the other hand, when $\pi \leq \pi^D$, we assume that the in-house rating cannot provide additional information.[19]

We first show that – for a given rating accuracy $\pi \in [0,1]$ – the dealer having made a conditional offer will have no incentive to improve his information through in-house investment analysis when there is trade in the secondary market. This implies that the dealer cannot credibly signal that he has made an additional investment in information which he has used to acquire fewer lemons.

Proposition 8. *In any equilibrium with trade, dealers do not invest in in-house ratings and the belief of investors making offer $p_1 = v_s$ is given by*

$$E[q|\mathcal{I}] = \frac{q}{q+(1-q)\pi}. \tag{14}$$

The proposition implies that dealers will consider in-house ratings only to make an unconditional offer. With such an offer there is no rating by a rating agency so that $\pi = 1$. Hence, there cannot be trading in the secondary market whenever $q \leq 1 - \frac{x}{\delta}$, since there is no public information. Consequently, the belief with trading must be that $E[q|\mathcal{I}] = q$.

We deal next with the CRA's incentives to choose their rating accuracy when the fee for the rating is fixed at αp_σ. Dealers can forgo a rating and, hence, acquire in-house ratings. When doing so, there will be no secondary market and dealers will have to hold the security. With a conditional offer, however, there is trade in the secondary market and liquidity will be largest – and, hence, a dealer's profit as well – with the least accurate rating that can sustain trade. Hence, rating agencies have no incentive to deviate from the original ratings when dealers have access to in-house ratings.

Proposition 9. *The rating agency has no incentive to increase the accuracy of its ratings when dealers can acquire in-house ratings.*

This result tells us that in-house ratings for dealers are not enough of a threat to change the rating agencies behaviour. The reason is straightforward. The dealers profits are decreasing in the

[19] This can be justified as follows. We can think about lemons being ranked by how difficult they are to be detected. Hence, any investment in the technology to detect lemons will first detect the same lemons that are easy to find. Investing more allows one to detect additional lemons.

accuracy of ratings for conditional offers, provided that there is trade in the secondary market. Recall that this profits are given by

$$\Pi^D = \left(q + (1-q)\pi \mathbf{1}_{\{\pi>\alpha\}}\right)\left(\frac{y-x}{1-\beta} - \frac{\alpha}{1-\alpha}\frac{\delta-y}{1-\beta}\right). \tag{15}$$

Hence, dealers always prefer higher volume with a conditional offer. This implies that they prefer public ratings to stay on the edge. We can now go a step further and show that unconditional offers by dealers together with in-house ratings do not improve welfare over public ratings. Proposition 8 implies that, in any equilibrium with in-house rating, there must be no trade in the secondary market. This can thus lead to a welfare loss due to misallocation of assets – assets are allocated to the dealer rather than the investors who have the highest valuation.

Proposition 10. *Welfare decreases whenever dealers make unconditional offers with in-house ratings.*

The basic idea is that replacing CRA ratings by in-house ratings can lower the rating cost incurred by the dealer. However, the information made publicly available for investors by CRA ratings will now vanish, leading to inefficient freeze of the secondary market. This inefficient outcome can arise because dealers again do not fully internalize the benefits from allocating the asset in the secondary market. If the fee for public ratings are too large, they rather forgo a liquid secondary market and hold the asset instead with sufficient information acquired to weed out some lemons. However, the level of costs for ratings αp_σ is a pure transfer between dealers and rating agencies and, thus, not relevant for welfare at all. Overall, we show that requiring dealers to have in-house rating capabilities may reduce the usage of CRA, but it will not discipline rating agencies to issue ratings with higher accuracy, nor will it improve welfare.

6 In-house Assessment: Investors Acquire Information

Consider now that investors can detect a fraction π^B of bad assets at a cost κ. As before, investors obtain the information from ratings π for free. As a consequence, in-house ratings are only valuable if $\pi^B < \pi$. For simplicity, we assume that investors always detect the same lemons and concentrate on the case where $\pi^B > \alpha$.[20] The decision for investors to acquire information introduces two

[20] This leaves separating equilibria unaffected. The other case does not provide more insights and is available upon request.

different strategic interactions. First, incentives to acquire information increase when an investor cannot sell lemons easily again tomorrow since others investors also acquire information. Second, the CRA has an incentive to reduce the informativeness of its ratings provided investors acquire sufficient additional information for there to be trade in the secondary market. In what follows, we make two assumptions. First, the costs are sufficiently low and the informativeness of the signal π^B sufficiently high, so that there are incentives for investors to use in-house ratings. And second, the bid-ask spread is sufficiently low and the informativeness of in-house ratings sufficiently high, so that dealers have no incentive to make unconditional offers and rely exclusively on in-house ratings by investors for a liquid secondary market.

Assumption 11. *The costs and informativeness of in-house ratings satisfy the restriction*

$$\frac{\kappa}{x} \leq \bar{q}(1-\pi^B). \tag{16}$$

The bid-ask spread and informativeness of in-house ratings satisfy the restriction

$$\frac{y-x}{x} \leq \bar{q}(1-\pi^B). \tag{17}$$

6.1 Trading in the Secondary Market

We first look at the investor's decision to acquire information. We only look at $q \leq \bar{q}$, since for higher average quality, one can trade without ratings or in-house information. An investor takes as given that other investors tomorrow invest in information. His payoff from acquiring information is given by

$$\Gamma_1(\pi, q) = -\kappa + \frac{q}{q+(1-q)\pi} v_o + \frac{(1-q)\pi^B}{q+(1-q)\pi} v_\ell - \frac{q+(1-q)\pi^B}{q+(1-q)\pi} v_s. \tag{18}$$

Note that the investor only acquires information conditional on a positive rating by the CRA where we allow for the case of an uninformative rating $\pi = 1$ as well. With probability $\frac{q+(1-q)\pi^B}{q+(1-q)\pi}$ the investor will make an offer, while with probability $\frac{(1-q)(\pi-\pi^B)}{q+(1-q)\pi}$ he will not make an offer having identified a lemon for sure. The payoff for an investor not acquiring information is given by

$$\Gamma_0 = \frac{q}{q+(1-q)\pi} v_o + \frac{(1-q)\pi}{q+(1-q)\pi} v_\ell - v_s. \tag{19}$$

We assume here that the investor will always make an offer given a good rating issued by the CRA, since we only look at equilibria with trade in the secondary market.

The value of a lemon now depends critically on the decision of future investors to acquire information as well. When other investors do not acquire information, one can sell lemons tomorrow *irrespective* of whether having information acquire today. Hence, the continuation value is given by $v_\ell = \beta v_s$. When other investors acquire information, however, the value of acquiring a lemon *is higher* when an investor acquires information himself. If he also invests in information, he can resell all lemons that he acquires today again in the market tomorrow, i.e. $v_\ell = \beta v_s$. Without information acquisition, he only can sell a fraction of lemons, so that

$$v_\ell = \frac{\pi^B}{\pi}\beta v_s. \tag{20}$$

With probability π^B, the lemon will not be detected by future buyers and be sold for v_s. With probability $\pi - \pi^B$, the lemon will always be detected and can never be sold, so that the payoff is zero. This is again due to our assumption that the in-house technology always detects the same lemons.[21]

This leads to two possible stationary equilibria in the secondary market. For an equilibrium with information acquisition by investors, we need that investors have a positive surplus from acquiring information

$$\Gamma_1(\pi, q) \geq 0 \tag{21}$$

and that they have no incentive to deviate

$$\Delta_1(\pi, q) = \Gamma_1(\pi, q) - \tilde{\Gamma}_1(\pi, q) = \frac{(1-q)(\pi - \pi^B)}{q + (1-q)\pi}\left(\frac{\delta - x}{1-\beta}\right) - \kappa \geq 0, \tag{22}$$

where $\tilde{\Gamma}_1(\pi, q) = \frac{q}{q+(1-q)\pi}x - \frac{(1-q)\pi^B}{q+(1-q)\pi}(\delta - x)$ is the payoff from deviating. For an equilibrium without information acquisition, we need the corresponding conditions of positive surplus

$$\Gamma_0(\pi, q) \geq 0 \tag{23}$$

and no incentive to deviate

$$\Delta_0(\pi, q) = \Gamma_0(\pi, q) - \tilde{\Gamma}_0(\pi, q) = \kappa - \frac{(1-q)(\pi - \pi^B)}{q + (1-q)\pi}(\delta - x) \geq 0, \tag{24}$$

[21] Note that it is important here that the same lemons are detected in every period. Dealers will not be able to sell some lemons that they acquire in the first period, but can return to the market in future periods where they cannot be distinguished from other sellers. Since these lemons will be detected every period again, there is no chance for the dealer to sell them in the market after $t = 0$. Notwithstanding, buyers still need to acquire the information to detect these lemons.

where $\tilde{\Gamma}_0(\pi, q) = \Gamma_1(\pi, q)$ is again the payoff from deviating.

Note that there is a wedge between the surplus functions Δ_0 and Δ_1. Hence, there are multiple equilibria possible for quality levels q that are sufficiently close to $\bar{q}$. This is due to the strategic complementarity in the investors' decision to acquire information. Formally, we can characterize trade equilibria with pooling in the secondary market as follows.

Proposition 12. *For $q \leq \frac{\pi^B(\delta-x)}{\pi^B(\delta-x)+x}$, there exists a pooling equilibrium without in-house ratings if $\pi \leq \tilde{\pi}$, but no pooling equilibrium with in-house ratings.*

For $q \in (\frac{\pi^B(\delta-x)}{\pi^B(\delta-x)+x}, \bar{q}]$, there exists a pooling equilibrium without in-house ratings if and only if

$$\pi \leq \min\{\tilde{\pi}, \bar{\pi}_0(q)\}, \tag{25}$$

where $\bar{\pi}_0(q) = \pi^B + \frac{\kappa(q+(1-q)\pi^B)}{(1-q)(\delta-x-\kappa)}$, and a pooling equilibrium with in-house ratings if and only if

$$\underline{\pi}_1(q) \leq \pi \leq \bar{\pi}_1(q). \tag{26}$$

where $\underline{\pi}_1(q) = \pi^B + \frac{\kappa}{(1-q)\left(\frac{\delta-x}{1-\beta}-\kappa\right)}$ and $\bar{\pi}_1(q) = \frac{q}{1-q}\left(\frac{x-\kappa}{\kappa}\right) - \pi^B\left(\frac{\delta-x}{\kappa}\right)$.

The key insight here is that information is a strategic substitute for the CRA. The fact that investors can acquire costly information themselves allows the CRA to economize on information. As shown in Figure 4, there are two equilibrium regions. Assumption 11 ensures that there is a region in which investors have an incentive to acquire in-house ratings. Above a critical level of quality defined by

$$q^0 = \frac{\pi^B(\delta - x)}{\pi^B(\delta - x) + x - \kappa\left(\frac{\delta}{\delta - x}\right)}, \tag{27}$$

the CRA can choose a lower level of accuracy and still induce trade in the secondary market. The reason is that when CRA ratings are inaccurate, investors have an incentive to increase the accuracy through in-house information. Between $\bar{\pi}_1$ and $\underline{\pi}_1$ is the region that supports a pooling equilibrium with in-house ratings. For the same reason, above this critical level of quality q^0, the CRA needs to choose a higher accuracy if it intends to discourage investors from acquiring their own information. The region that supports a pooling equilibrium without in-house rating is bounded above by $\underline{\pi}_0$. In general, when the quality is sufficiently close to $\bar{q}$, there can be trade without any CRA ratings, but only in-house ratings. For sufficiently low quality levels, in-house ratings play no role and pooling equilibria in the secondary market are as before.

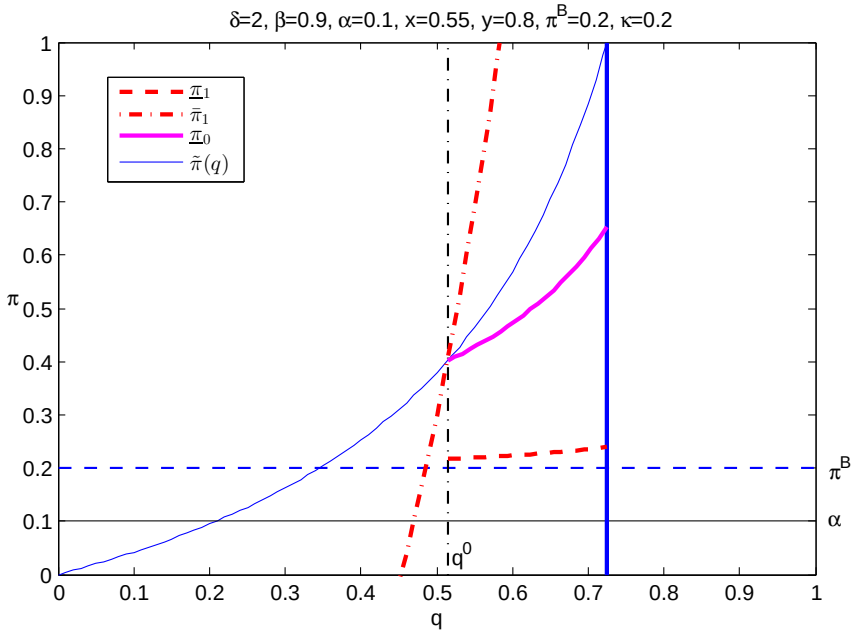


Figure 4: Equilibrium with Investor In-house Assessment

6.2 Dealer Demand and Equilibria

Based on the analysis so far, the CRA would choose a lower level of accuracy. However, the CRA also needs to ensure that there is a demand for its ratings, which is the case only if dealers prefer to make conditional offers. A conditional offer delivers a payoff for dealers given by

$$\Psi_1(\pi, q) = -(q + (1-q)\pi)\frac{1}{1-\alpha}(\delta - y) + (q + (1-q)\min\{\pi, \pi^B(\pi)\})(\delta - x). \tag{28}$$

Hence, dealers take into account whether investors also acquire information in house. If so ($\pi^B < \pi$)[22] dealers cannot sell all lemons they acquire which reduces their profits. An unconditional offer delivers

$$\Psi_0(\pi, q) = -(\delta - y) + (q + (1-q)\pi^B \mathbf{1}_{\{\pi^B(\pi=1)\}})(\delta - x). \tag{29}$$

Now dealers can still sell some lemons without ratings whenever investors acquire information in house which is captured by the indicator function in the expression. If investors do not trade solely based on their own information, then dealers need to hold all assets, as the secondary market is illiquid as in the benchmark case. This implies that the CRA faces the constraints that dealers

[22] It is understood that $\pi^B = 1$ whenever investors do not acquire ratings in house.

make non-negative profits from conditional offers and prefer them

$$\Psi_1 \geq 0 \tag{30}$$

$$\Delta_D(\pi, q) = \Psi_1 - \Psi_0 \geq 0. \tag{31}$$

Assumption 11 ensures that unconditional offers are not feasible; i.e., $\Psi_0(\pi, q) \leq 0$ for all $q \leq \bar{q}$. Hence, the only relevant constraint for the CRA when choosing its accuracy is given by $\Psi_1(\pi, q)$. For convenience, we define

$$\frac{1}{\phi} = \frac{\delta - y}{\delta - x} \frac{1}{1 - \alpha}. \tag{32}$$

Again, the CRA would like to choose the lowest level of accuracy (highest π), that still leads to a demand for ratings. We assume that – given any π set by the CRA – investors coordinate on the equilibrium with the lowest cost for them. This yields the following result where it is understood that $\pi < 1$.[23]

Proposition 13. *For $q \leq q^0$, no in-house ratings are being used and the CRA sets the level of accuracy to $\pi = \min\{\alpha, \tilde{\pi}\}$.*

Let $q^0 \leq \bar{q}$. No in-house ratings are being used if and only if

$$\left(1 - \frac{1}{\phi}\right) \leq \frac{\kappa}{\delta - x} \tag{33}$$

in which case the CRA sets the level of accuracy to $\pi = \bar{\pi}_0(q)$. Otherwise, in-house ratings are being used and the CRA sets the level of accuracy to

$$\pi = \min\{(\phi - 1)\frac{q}{1 - q} + \phi\pi^B, \bar{\pi}_1(q)\}. \tag{34}$$

Figure 5 depicts the equilibrium set for the two cases. For low levels of quality, nothing changes relative to the benchmark case. For higher levels of quality, conditional offers become less attractive for dealers, because investors can now acquire information, too. This erodes dealer profits, as they can sell fewer lemons. There are two possibilities. In the first case, the accuracy of the ratings

[23] We need to require that

$$\phi \leq \frac{1}{q + (1 - q)\pi^B}$$

and

$$q \leq \frac{\pi^B(\delta - x) + \kappa}{\pi^B(\delta - x) + x}$$

for the choice of the CRA to be less than 1.

increases even though in-house ratings are not being used. The CRA needs to set a high enough level of accuracy to prevent investors from acquiring ratings in-house. If its ratings are too inaccurate, investors would acquire information which makes it not profitable for dealers to intermediate the market anymore. Hence, in-house ratings act as a threat that leads the CRA to raise its accuracy. In the second case, the CRA can lower its accuracy relative to the benchmark case. Here, dealers will intermediate the market even if investors acquire information. Hence, the CRA saves costs by forcing investors to acquire ratings themselves. The CRA sets its level of accuracy as low as possible being constrained by inducing trading in the secondary market and zero profits for dealers whichever is tighter. Interestingly, for large bid ask spreads or when fees are large ($1/\phi$ is low) credit ratings become less informative.

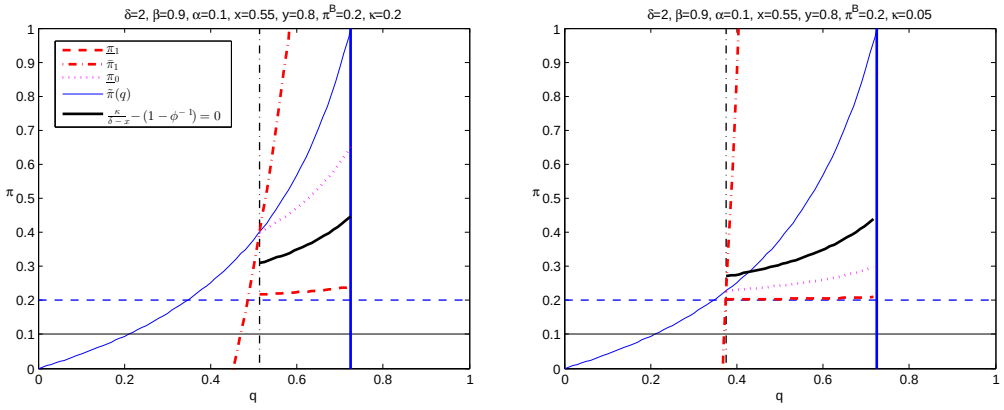


Figure 5: Equilibrium with Investor In-house Assessment: (i) Increase in accuracy, (ii) decrease in accuracy

This result yields insights for liquidity, fragility and efficiency. For any $q \in (q^0, \bar{q})$, there is more information in the secondary market – either through more informative ratings or through in-house ratings that add to CRA ratings. As a consequence, the market appears less liquid, i.e., there is less trade volume. If the CRA increases its accuracy, the market becomes more stable, but trading is also more costly. When in-house ratings are being used, these effects are less clear. The CRA saves costs by shifting some of the information provision that is necessary for trade in the secondary market to investors. In-house ratings need to be repeated as they are private; hence, they tend to be expensive.[24] Still, depending on parameters, the market can be less fragile.

[24]The overall costs for trading depend on κ, the discount factor and the accuracy of the CRA.

7 Market Reform

7.1 Optimal Fees

Suppose now that the CRA can choose its fee α and its accuracy π jointly. The CRA is again constrained by having a sufficiently accurate rating so that there is trade in the secondary market. Otherwise, by assumption **??**, dealers do not intermediate the market. Since ratings are costly, for any given fee α, the CRA chooses an accuracy equal to

$$\pi = \max\{\alpha, \tilde{\pi}(q)\}. \tag{35}$$

For setting the fee α, the CRA needs to take into account the demand for ratings when dealers make conditional offers. Hence, the CRA faces two margins when deciding on the optimal fee. First, an increase in the fee α raises the revenue per ratings issued. Here, the constraint is that dealers make positive profits per individual transaction, or

$$\alpha \leq \frac{y-x}{\delta - x}. \tag{36}$$

Second, there is an extensive margin. If $\alpha \geq \tilde{\pi}(q)$, only the fraction q of good issuers will demand ratings so that there is no rate shopping where all issuers demand ratings. Otherwise, all issuers acquire ratings so that the demand increases. Hence, there is a trade-off between the profits per ratings – the intensive margin – and the number of ratings that are demanded. This yields the following proposition.[25]

Proposition 14. *For $q \in (1 - \frac{x}{y}, \bar{q})$, the CRA sets fees to*

$$\alpha^* = \frac{y-x}{\delta - x}$$

and the accuracy to $\pi^* = \tilde{\pi}(q)$ so that there is a pooling equilibrium.

There exists a cut-off point $q^M < 1 - \frac{x}{y}$ such that for $q \leq q^M$, the CRA sets

$$\alpha^* = \pi^* = \frac{y-x}{\delta - x}$$

so that there is separating equilibrium.

For intermediate levels of q, the CRA sets $\alpha^* = \pi^* = \tilde{\pi}(q)$ to achieve a pooling equilibrium.

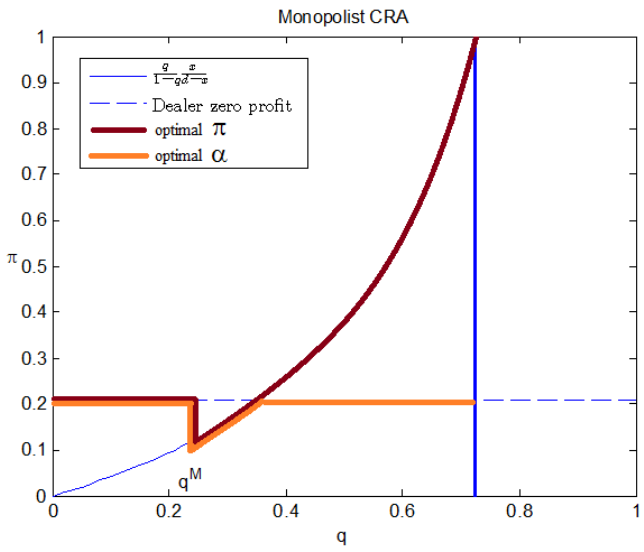


Figure 6: Equilibrium with optimal fee α^*

Figure 6 summarizes the optimal choice of α and the overall equilibrium. For high values of q, there is no trade-off for the CRA. It can set fees that leave dealers with zero profits from intermediating the market, and at the same time choose a level of accuracy that just achieves a pooling equilibrium with trade in the secondary market. For low values of q, the CRA prefers to have a separating equilibrium, but at a high price for a rating. The intuition is that in order to increase the extensive margin, the CRA would have to lower its fee substantially. For intermediate levels of quality, however, this is optimal. A small decrease in the revenue per rating, coupled with a small increase in the accuracy of ratings achieves a sufficient increase in the demand for ratings to compensate the CRA for the loss in revenue per rating and the increase in costs. In other words, it is optimal for the CRA to forego some revenue to encourage rate shopping. Interestingly, dealers are better off in this case as well, as they then obtain positive profits from intermediating the market.

7.2 Competition Among Rating Agencies

A common proposals among regulators is to increase competition among ratings agencies. To see whether this proposal has merit, we look at equilibria where profits are zero for ratings agencies, or where

$$\alpha p_\sigma = k(\pi). \tag{37}$$

[25] We can always adjust the cost function k so that the monopoly fee $\alpha^*(q)$ is feasible for all levels of quality.

An equilibrium is defined as a pair (α, π) such that there is no incentive for a CRA to deviate with a different pair (α', π') and thereby to increase its profits. We assume that dealers can require a rating from a particular CRA offering (α, π) when making a conditional offer to issuers.

Dealers will prefer a CRA that has a lower fee α and is less accurate (higher π) subject to the requirement that there is trade in the secondary market. This implies immediately that for any α, it must be the case that $\pi = \max\{\alpha, \tilde{\pi}(q)\}$ in equilibrium. If this were not the case (i.e. $\pi < \alpha$ or $\pi < \tilde{\pi}$), then a CRA could decrease its accuracy (higher π) and assume all demand from dealers when $\tilde{\pi}(q) > \alpha$ or lower its costs when $\alpha > \tilde{\pi}(q)$. Similarly, for any given level of π where there is trade in the secondary market, dealers prefer a lower fee α. This implies that there can only be equilibria with zero profits.

The zero-profit condition implies that there exists a unique $\alpha^C \in (0, 1)$ such that

$$\frac{\alpha^C}{1-\alpha^C}\frac{\delta - y}{1-\beta} = k(\alpha^C). \tag{38}$$

We assume now that $\frac{\delta-y}{\delta-x} < 1 - \alpha^C$ so that at zero profits for the rating agencies, dealers will have an incentive to make conditional offers. Given that $\pi = \max\{\alpha, \tilde{\pi}(q)\}$, this value α^C pins down a quality threshold below which there are only separating equilibria and above which there are only pooling equilibria.

Proposition 15. *With perfect competition, in any equilibrium CRAs make zero profits.*

For $q \in (\frac{\alpha^C(\delta-x)}{\alpha^C(\delta-x)+x}, \bar{q}]$, *we have a pooling equilibrium with* $\alpha < \pi = \tilde{\pi}(q)$.

For $q \leq \frac{\alpha^C(\delta-x)}{\alpha^C(\delta-x)+x}$, *we have a separating equilibrium with* $\pi = \alpha = \alpha^C$.

Figure 7 shows the resulting equilibria with competition among CRAs. For low quality assets, there is no rate shopping, as zero profit equilibria with pooling are not feasible. However, for better quality assets, pooling equilibra with rate shopping emerge again as in our benchmark case with the fee α being exogenous. The intuition for this result is clear. The problem occurs in the primary market and not in the relationship between CRAs and issuers. Dealers want cheap and inaccurate ratings. Such ratings encourage rate shopping, thereby increasing the volume of trading in the secondary market. Indeed, with competition among CRAs the situation gets worse relative to the monopoly case. Since the fee α^C must be lower than the monopoly fee α^*, competition leads to

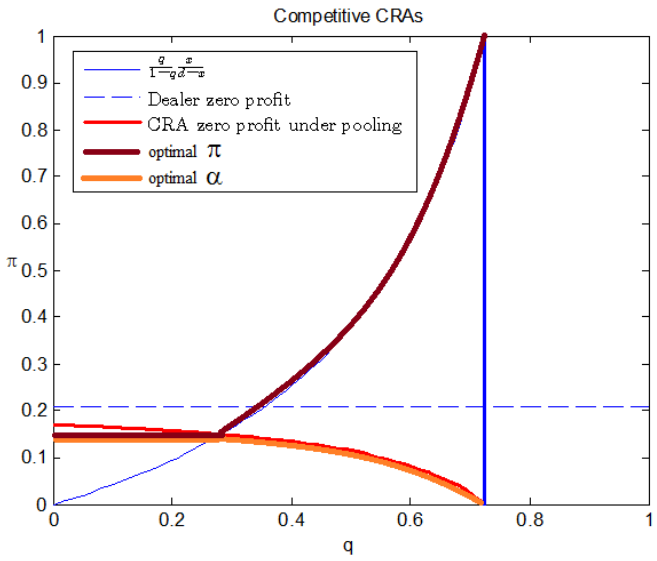


Figure 7: Equilibrium with competitive fee α^C

more rate shopping for some intermediate levels of quality q thereby increasing the inefficiency from issuance of assets with ratings and making the market more fragile. This can be interpreted as a race to the bottom in ratings quality and prices.

7.3 Market Power for Dealers in the Secondary Market

The inefficiency arises from the failure of dealers to internalize the effects of ratings on final investors. Ratings with low accuracy are desirable for dealers, as it increase the volume of assets that they can intermediate. Dealers have nothing at stake, since they do not hold the assets and sell off assets at their reservation value.[26]

Suppose now that the secondary market is competitive, in the sense that there is a large number of potential buyers for the securities which take the prices for buying the security as given. In equilibrium, buyers need to be indifferent between buying a security or not. Given ratings with accuracy π, the equilibrium price then satisfies

$$\frac{q}{q+(1-q)\pi}v_o + \frac{(1-q)\pi}{q+(1-q)\pi}v_\ell - p_0 = 0. \tag{39}$$

[26]Requiring dealers to hold assets for a certain of time is costly, since their valuation is lower than in the secondary market.

or, taking into account that there is trade at p in the future,

$$p_0 = \frac{q}{q + (1-q)\pi} \frac{\delta}{1-\beta} \tag{40}$$

Note that the price is decreasing in π and that in order for trade, we need to ensure that $p_0 \geq v_s$. This yields again our original condition

$$\pi \leq \frac{q}{1-q} \frac{x}{\delta - x} \tag{41}$$

Again, there is a separating equilibrium with $\pi = \alpha$. Since only good assets acquire a rating, the price for the security in the secondary market is given by

$$v_o - p = 0 \tag{42}$$

or

$$p = \frac{\delta}{1-\beta}. \tag{43}$$

Hence, the equilibrium structure is exactly as before.

Now dealers' profits are strictly higher in the separating equilibrium. The extra profit is given by $\left(\frac{1}{1-\alpha}\right)\left(\frac{\delta - y}{1-\beta}\right)$ which is the costs saved from buying lemons in the primary market. With competition among rating agencies, the only equilibrium is then a separating equilibrium with zero profits. The reason is simply that a rating agency can attract all demand by offering a separating equilibrium with some $\alpha = \pi > \alpha^C$ relative to any pooling equilibrium with zero profits.

Proposition 16. *Suppose the secondary market is perfectly competitive so that dealers can extract all profits from trading. When there is competition among rating agencies, the unique equilibrium is given by*

$$\alpha^C = \pi \tag{44}$$

for all $q < \bar{q}$.

As a consequence, the market will be less fragile in general and also more efficient for intermediate levels of quality. For levels of q close to $\bar{q}$, however, there can be too much information in the market in the sense that accurate ratings are too expensive relative to a pooling equilibrium with less information. Giving dealers all market power makes them internalize the problem that rate shopping leads to informational rents. Dealers now fully take into account the informational rent

that lemons obtain when there is rate shopping. This is the case, since they can extract all surplus from trading in the secondary market. Before, dealers do not extract the full surplus from secondary market trades because they can only earn a fixed spread $y - x$ per asset traded – irrespective of the total volume of trade. Hence, there was implicit collusion between the CRA and dealers to increase the volume through less accurate ratings that lead to rate shopping.

8 Liability and Direct Incentives

Market characteristics are hard to change in practice. Hence, we view that fostering competition among rating agencies and at the same time in the secondary market is not realistic. The previous section was instructive, however, to identify precisely where the problem stems from. A different approach is to change the incentive structure directly.

One proposal that has been discussed is to switch back to an investor-pays-model for ratings as it was the case before 1970. Our framework, however, makes it clear that such a move can neither achieve a more stable, nor a more efficient market. When investors pay for ratings, one loses separating equilibria altogether. With ratings that are *costly for issuers* and sufficiently accurate, lemons have no incentive to acquire them. Furthermore, with investors paying for ratings, one reduces the surplus from trading which in turn will require more accurate ratings to support pooling equilibria. Importantly, these incentives redistribute resources away from dealers or investors. Due to linearity in payoffs, these have no consequences neither on efficiency nor overall welfare.

8.1 N Trading Rounds

To analyze *direct* incentives for dealers and the CRA, we change our framework slightly to one where there are only N trading rounds and no discounting. The idea is here to structure extra payments to and from investors to induce more accurate ratings. Consider first the N-th trading round. With accuracy π, there is a pooling equilibrium if and only if

$$\frac{q}{q+(1-q)\pi} v_o(N) + \frac{(1-q)\pi}{q+(1-q)\pi} v_\ell(N) \geq v_s(N). \tag{45}$$

We have now that $v_o(N) = \delta$, $v_\ell(N) = 0$ and $v_s(N) = \delta - x$. Solving, we again obtain that

$$\pi \leq \frac{q}{1-q} \frac{x}{\delta - x}. \tag{46}$$

Next, consider the previous stage, $N-1$. We have the identical conditional for a pooling equilibrium, but now the value functions are given by $v_o(N-1) = \delta + v_s(N)$, $v_\ell(N-1) = v_s(N)$ and $v_s(N-1) = (\delta - x) + v_s(N)$, where the last value function reflects the fact that one can wait one period to sell the security. It is straightforward to verify, that we obtain the same condition in period $N-1$. Backward induction yields the same condition for each of the N rounds of trading.

Again, there is a separating equilibrium, whenever $\pi \leq \alpha$, since $v_o(n) - v_s(n) = x > 0$. The pay-offs from such an equilibrium are given by $v_o(n) = \delta + v_s(n+1)$. Hence, we obtain the same equilibrium structure as in the previous parts of the paper. Dealer pay-offs per rating are now equal to

$$-\frac{1}{1-\alpha} N(\delta - y) + N(\delta - x) \tag{47}$$

where we have taken into account that the reservation value for a dealer is to hold a good security forever or $N(\delta - x) = v_s(1)$.

8.2 Dealer Incentives

We assume that securities that are lemons can be identified after the N-th trading stage. Consider a payment τ from dealers to lemon holders in this period so that

$$v_\ell(N) = \tau. \tag{48}$$

where we require that $\tau < \delta - x$. The idea is that after some trading, it becomes perfect knowledge which securities are non-performing. The payment can be interpreted as making dealers liable for intermediating lemons.

The trading constraint with pooling in the last trading period is now given by

$$\pi \leq \frac{q}{1-q} \frac{x}{\delta - x - \tau} \tag{49}$$

so that *less accurate* ratings are required for a pooling equilibrium. For efficiency, we need to ensure that all good assets will be traded in every period. Since $\tau < \delta - x$, investors prefer to sell lemons rather than to hang on to them until the last stage. Conditional on trading in every period, we again have for the first $N-1$ periods that there is a pooling equilibrium if and only if

$$\pi \leq \frac{q}{1-q} \frac{x}{\delta - x}. \tag{50}$$

Furthermore, one can show that if there is no trade in some trading rounds, to have trade between dealers and investors, the accuracy of the signal needs to be higher (lower π).[27] Hence, the CRA faces again the same constraints as before and the choice of accuracy remains the same for the CRA *irrespective* of τ as long as $N \geq 2$.

Even though there is no direct effect of τ on the CRA, there is an indirect one. Dealer profits from a pooling equilibrium are now given by

$$(q + (1-q)\pi)\left(-\frac{1}{1-\alpha}N(\delta - y) + N(\delta - x)\right) - (1-q)\pi\tau. \tag{51}$$

The pay-off for dealers is positive with a separating equilibrium. This yields the following result.

Proposition 17. *The unique equilibrium is a separating one for all $q < \bar{q}$ if and only if*

$$(1-\alpha) < \frac{N}{N-1}\left(\frac{\delta - y}{\delta - x}\right), \tag{52}$$

where $N \geq 2$.

Hence, making dealers liable for lemons can indirectly induce CRAs to discourage rate shopping. Recall that for a monopolistic CRA, we have that

$$(1-\alpha^*) = \left(\frac{\delta - y}{\delta - x}\right). \tag{53}$$

This implies that for any N there is an appropriate payment from dealers to investors for lemons independent of the maturity of the security. More generally, with an exogenously given fee α, the shorter the maturity the easier it is to give dealers incentives not to intermediate lemons, thereby disciplining the CRA.[28]

[27] We have that the condition for a pooling equilibrium when there is no trade in the last n periods is given by

$$\pi \leq \frac{q}{1-q}\frac{x}{n(\delta - x) - \tau}$$

which is a tighter constraint for $n \geq 2$.

[28] It is interesting to link the fee τ to the requirement for dealers to make the market, i.e. provide liquidity, in case investors cannot sell the securities. In the past, such liquidity provisions existed, but could not be enforced in practice due to legal issues. We have not investigated such clauses here, as we do not consider market breakdowns explicitly.

8.3 CRA Incentives

We start from the premise that investors can neither directly contract with the CRA, nor can they hold the CRA liable for its ratings.[29] However, we consider here that investors can be charged a fee τ at maturity by the CRA. Importantly, this fee is on top of the rating fee α charged to issuers. The fee $\tau(q)$ is to be paid only if all securities turn out to be good and if they have remained liquid over the entire horizon until their maturity.[30] [31]

We have now that in the N-th stage there is a pooling equilibrium if and only if

$$\pi \leq \frac{q}{1-q}\frac{x-\tau}{\delta-x} \tag{54}$$

where we have assumed that $x > \tau$. Since there is no payment τ due if there is no trade in any previous period, it must be the case that a pooling equilibrium exists in any other periods if $\pi \leq \tilde{\pi}(q)$ once again. Hence, the equilibrium structure is as before except for that in the N-th round of trading, the condition is tighter.

The CRA needs to decide now whether to choose a lower π and maintain liquidity in the N-th stage which yields an additional payoff, or stick with the old and cheaper choice of $\tilde{\pi}(q)$. For $\tau(q)$ sufficiently large, we again achieve a separating equilibrium. For given α, the CRA will choose such an equilibrium if

$$q\tau(q) + q(\alpha p_\sigma - k(\alpha)) \geq (q + (1-q)\tilde{\pi})(\alpha p_\sigma - k(\tilde{\pi})) \tag{55}$$

or if

$$\tau(q) - \left(\frac{x}{\delta - x}\right)\alpha p_\sigma \geq k(\alpha) - \frac{k(\tilde{\pi})}{\bar{q}}. \tag{56}$$

We have that the tightest condition is given for $\bar{q}$ and that $\tau \leq x$. This yields the following result.

Proposition 18. *Suppose the CRA obtains a payment from investors with good assets of τ in the N-th period conditional on there being continuous trade. There is a unique separating equilibrium if and only if*

$$x\left(1 - \frac{\alpha}{1-\alpha}N\left(\frac{\delta - y}{\delta - x}\right)\right) \geq k(\alpha) - \frac{\underline{k}}{\bar{q}}. \tag{57}$$

[29] In the past, law suits that tried to sue CRAs for inaccurate or false ratings were unsuccessful. Ratings are considered mere "opinions" about the quality of an issuer or a security.

[30] An alternative arrangement is that the fee depends only on the quality, but not the liquidity, of the securities. The current set-up is simpler in terms of derivation.

[31] This can be interpreted as a rule that relies on an average for default among a group of securities having the same rating and characteristics.

where $\tau = x$.

Suppose the CRA has a monopoly and, hence, sets $\alpha^* = \frac{\delta - y}{\delta - x}$. Then, a sufficient condition for a separating equilibrium is given by

$$1 \geq N\left(\frac{y-x}{\delta - x}\right) \tag{58}$$

since the right-hand side of the inequality in the previous proposition is negative whenever there are fixed costs for issuing ratings. One can provide proper incentives to the CRA provided both, the bid-ask spread of dealers and the maturity of the security are sufficiently small. The intuition is as before. Dealers have market-power, but the CRA can extract some of the surplus from dealers which is increasing in the volume of trade. With the additional payment, the CRA now directly obtains some of the surplus from trade *conditional* on a rating that ensures the quality and liquidity of the security throughout its lifetime. This requirement indirectly tightens the CRA's constraint for achieving a liquid secondary market. Provided this payment can be made large enough, we can get back to efficiency and stable trading in the form of a separating equilibrium.[32]

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[32] It is possible that smaller levels of τ can give the CRA an incentive to increase its accuracy albeit not to the level of α. While this pushes one closer to efficiency, it does not necessarily increase stability in the market. The reason is that with the payment τ after small shocks to q, trading will break down, if the CRA just ensures that buyers are indifferent about buying the security. Here the (anticipated) size of the shock matters for the CRA to adjust its accuracy to avoid a market breakdown. This is an interesting idea for further research.

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A Proofs

Proof of Proposition 1

Suppose first that there are no ratings. Then, a buyer will make a take-it-or-leave-it offer with if and only if

$$qv_o + (1-q)v_\ell - p \geq 0 \tag{59}$$

where $v_\ell = \beta v_s$. Using $p = v_s$, we obtain

$$q \geq 1 - \frac{x}{\delta}. \tag{60}$$

Suppose next that only good assets are traded in the secondary market. Any offer with $p < v_s$ will be rejected by a seller. An offer with $p = v_s$ is always better than not trading for a buyer, since

$$v_o - v_s \geq 0. \tag{61}$$

Finally, consider a secondary market with a rating of accuracy π. There are $(1-q)\pi$ lemons in the market, so that a buyer will make an offer if and only if

$$qv_o + (1-q)\pi v_\ell - v_s \geq 0. \tag{62}$$

This is the case whenever

$$\pi \leq \frac{q}{1-q}\frac{x}{\delta - x}. \tag{63}$$

Proof of Proposition 4

Suppose first that $q \geq 1\frac{x}{\delta}$. Since $p_0 > p_\sigma$ and all assets are purchased by investors without ratings in the secondary market, dealers' profit is maximized by making an unconditional offer.

For $q \leq 1 - \frac{x}{\delta}$, there can only be trade in the secondary market with sufficiently accurate (i.e. low π) ratings. With trade in the secondary market, dealers need to decide whether to make an unconditional offer and hold the security or to make a conditional offer and selling assets with a good rating in the secondary market.

Set $\pi < \alpha$. A conditional offer will only be accepted by good assets and is feasible if and only if

$$qv_s - qp_\sigma = q\left(v_s - \frac{1}{1-\alpha}\frac{\delta - y}{1-\beta}\right) > 0 \tag{64}$$

Hence,

$$y - x \geq \frac{\alpha}{1-\alpha}(\delta - y) \tag{65}$$

which is fulfilled by Assumption 3. An unconditional offer implies that dealers need to hold the security as there cannot be trade in the secondary market. This is dominated by a conditional offer if and only if

$$qv_s - p_0 < q(v_s - \frac{1}{1-\alpha}V_s) \tag{66}$$

or

$$q < 1 - \alpha \tag{67}$$

which again is ensured by Assumption 3.

Consider now $\pi \geq \alpha$ and $\pi \leq \frac{q}{1-q}\frac{x}{\delta - x}$. The only difference is now that volume for the dealer of a conditional offer is $q + (1-q)\pi > q$ which simply scales up his profit relative to the previous case. Hence, Assumption 3 ensure again that the conditional offer is optimal for dealers.

Finally, for $\pi \geq \alpha$ and $\pi > \frac{q}{1-q}\frac{x}{\delta - x}$ there cannot be trade in the secondary market so that there is no trade. One can easily check that with Assumption 3 dealers have no incentives to buy and hold securities neither with conditional nor with unconditional offers.

Proof of Proposition 5

For $q \geq \bar{q}$, there is trade without ratings. Hence, dealers do not make conditional offers as they are more costly.

Set $\alpha = \frac{q}{1-q}\frac{x}{\delta - x}$. This defines the threshold $\underline{q}$. Let $q \in (\underline{q}, \bar{q})$. Since costs are decreasing when ratings become less accurate ($k'(\pi) < 0$, we have that rating agencies in order to maximize profits will choose the highest π such that all issuers acquire ratings.

Finally for $q \leq \underline{q}$, ratings need to be informative enough so that only good assets acquire them. Otherwise, dealers will not make conditional offers.

Proof of Proposition 6

Assumption **??** ensures that issuing ratings at $\pi = \alpha$ yields a positive profit for the rating agency. We compare now the welfare with an equilibrium accuracy where all issuers acquire a rating and the one where only good assets acquire a rating. Having a high accuracy with only good assets

acquiring ratings yields higher welfare if and only if

$$k(\bar{\pi}(q)) \geq qk(\alpha) \tag{68}$$

where $\bar{\pi}(q) = \frac{q}{1-q}\frac{x}{\delta-x}$. As k decreases in π and $\bar{\pi}$ increases with q, we have that there exists $\hat{q}$ such that the equality above holds with equality. Furthermore, at $\pi = \alpha$, the inequality is clearly satisfied as $q < 1$ which completes the proof.

Proof of Proposition 8

Fix any rating π. Consider investors offering $p_1 = v_s$ with the belief that

$$E[q|\mathcal{I}, \pi^D] = \frac{q}{q + (1-q)\pi^D} \tag{69}$$

where $\pi^D < \pi$ so that investors believe that the dealer has acquired more information. Given this belief, for trade to be optimal we need that

$$E[q|\mathcal{I}, \pi^D]v_o - (1 - E[q|\mathcal{I}, \pi^D])v_\ell - v_s \geq 0. \tag{70}$$

Given that there is an offer, the dealer will not acquire additional information, since this has a positive cost $k(\pi^D)$ for doing so and selling any asset he has acquired with a good rating gives him the positive pay-off

$$\frac{y-x}{1-\beta} - \frac{\alpha}{1-\alpha}\frac{\delta-y}{1-\beta}. \tag{71}$$

But then the belief is not consistent with the dealer's optimal strategy. Hence, with a rating π and trade in the secondary market, in equilibrium the dealer will not use in-house investment analysis.

Proof of Proposition 10

Suppose first that $q \leq \underline{q}$. Since rating agencies have no incentives to change their accuracy from the original equilibrium value, a conditional offer yields higher welfare whenever

$$q\frac{y}{1-\beta} - qk(\alpha) > q\frac{y-x}{1-\beta} - k(\hat{\pi}^D) \tag{72}$$

or equivalently

$$q\frac{x}{1-\beta} \geq qk(\alpha) - k(\hat{\pi}^D) \tag{73}$$

where $\hat{\pi}^D$ is the optimal level of accuracy for in-house ratings chosen by the dealer.

Similarly, for $q \in (\underline{q}, \bar{q})$, we have that a conditional offer yields higher welfare whenever

$$q\frac{x}{1-\beta} \geq qk(\hat{\pi}) - k(\hat{\pi}^D) \tag{74}$$

where $\hat{\pi} = \frac{q}{1-q}\frac{x}{\delta - x}$. Note that for higher q the advantage of offering a separating equilibrium goes away. Notwithstanding, we need sufficiently lower accuracy of in-house ratings to improve welfare. The reason is that we forgo the benefits from trading the asset in the secondary market.

Hence, it suffices to show that in-house ratings would lead to $\hat{\pi}^D < \pi$ so that the accuracy – and, hence, the costs – for acquiring information increases. For $q \leq \underline{q}$, the unconditional offer is preferred by dealers whenever

$$q\frac{\alpha}{1-\alpha}\frac{\delta - y}{1-\beta} \geq (1-q)\pi^D\frac{\delta - y}{1-\beta} + k(\pi^D) \tag{75}$$

Since $\alpha \leq \frac{x}{\delta}$ so that $q \leq 1 - \alpha$, we got

$$q\frac{\alpha}{1-\alpha} \leq q\frac{x}{\delta - x} \tag{76}$$

Hence, for a unconditional offer to be better, it must be the case that $\pi^D < \frac{q}{1-q}\frac{x}{\delta - x} \leq \alpha = \hat{\pi}$. But then, accuracy and costs of in-house ratings must be larger. Hence, welfare is lower.

Next, consider $q \in (\underline{q}, \bar{q})$. Then a conditional offer is better if and only if

$$q\frac{\alpha}{1-\alpha}\frac{\delta - y}{1-\beta} + (1-q)\pi\left(\frac{\alpha}{1-\alpha}\frac{\delta - y}{1-\beta} - \frac{y - x}{1-\beta}\right) \geq (1-q)\pi^D\frac{\delta - y}{1-\beta} + k(\pi^D) \tag{77}$$

where the second term is *negative* by our earlier assumption. But then the identical argument from the first case applies and we again have $\pi^D < \frac{q}{1-q}\frac{x}{\delta - x} = \hat{\pi}$. Again, welfare is lower.

Proof of Proposition 12

Proof. For the first statement, whenever $\max\{\alpha, \tilde{\pi}(q)\} \leq \pi^B$, we have that for all $\pi \leq \max\{\alpha, \tilde{\pi}(q)\}$ no in-house ratings are acquired. Hence, for any such π, the old equilibrium is still an equilibrium. Setting $\tilde{\pi}(q) = \pi^B$ and solving for q yields the cut-off point.

We are left to show that for $q \leq \frac{\pi^B(\delta - x)}{\pi^B(\delta - x) + x}$, there does not exist an equilibrium with $\pi > \pi^B$ and in-house ratings. We have that $\Gamma_1 \geq 0$ if and only if

$$\pi \leq \frac{q(x - \kappa) - (1-q)\pi^B(\delta - x)}{(1-q)\kappa}. \tag{78}$$

Hence, for Γ_1 to be positive at some $\pi \geq \pi^B$, we need that

$$q \geq \frac{\pi^B(\delta - (x - \kappa)}{(x - \kappa) + \pi^B(\delta - (x - \kappa))} > q_0(\pi^B) \tag{79}$$

since $x > \kappa$. Consequently, there does not exist an equilibrium with in-house ratings.

For the second statement, consider first the conditions for an equilibrium without in-house ratings. We have that $\Gamma_0 \geq 0$ if and only if $\pi \leq \tilde{\pi}(q)$ and $\Delta_0 \geq 0$ if and only if

$$\pi \leq \frac{\kappa q + (1-q)\pi^B(\delta - x)}{(1-q)(\delta - x - \kappa)} \equiv \pi(\Delta_0). \tag{80}$$

For equilibria with in-house ratings, we need that $\Gamma_1 \geq 0$ which is the case whenever

$$\pi \leq \frac{q(x-\kappa) - (1-q)\pi^B(\delta - x)}{(1-q)\kappa)}. \tag{81}$$

and $\Delta_1 \geq 0$ which is the case whenever

$$\pi \geq= \frac{q\kappa + (1-q)\pi^B \frac{\delta - x}{1-\beta}}{(1-q)\left(\frac{\delta - x}{1-\beta} - \kappa\right)} \equiv \pi(\Delta_1). \tag{82}$$

Note that $\pi(\Delta_1) < \pi(\Delta_0)$. This completes the proof. □

Proof of Proposition 13

Proof. The first part follows immediately, since equilibria where in-house ratings are used require more accurate ratings.

For the second part, the CRA will set its level of accuracy to the lowest one subject to the constraint that ratings are acquired with conditional offers and that there is trade in the secondary market. Assumption 11 ensures that we only need to show that $\Psi_1(\pi, q) \geq 0$. For

$$\pi \leq \pi^B + \frac{\kappa}{(1-q)(\delta - x - \kappa)} \tag{83}$$

there is trade in the secondary market where investors do not acquire in-house ratings. Furthermore, conditional ratings are feasible since $\phi < 1$. For

$$\pi > \pi^B + \frac{\kappa}{(1-q)(\delta - x - \kappa)} \tag{84}$$

investors acquire ratings in-house in any trade equilibrium. The CRA will set its level of accuracy such that for any q, $\Gamma_1(\pi, q) = 0$ and $\Psi_1(\pi, q) \geq 0$. The latter condition holds if and only if

$$\frac{q + (1-q)\pi^B}{q + (1-q)\pi^0} \geq \frac{1}{\phi}. \tag{85}$$

Hence, we need

$$\pi^B + \frac{\kappa}{(1-q)(\delta - x - \kappa)} < (\phi - 1)\frac{q}{1-q} + \phi\pi^B. \tag{86}$$

Rewriting, this condition is then fulfilled if and only if

$$\left(1 - \frac{1}{\phi}\right) > \frac{\kappa}{\delta - x}. \tag{87}$$

Consequently, under this condition, the CRA can set a higher π being constrained only by $\Gamma_1(\pi, q) \geq 0$ and $\Psi_1(\pi, q) \geq 0$ which both are decreasing in π. This completes the proof. □

Proof of Proposition 14

Proof. For $\alpha^* = \frac{y-x}{\delta-x}$, the CRA extracts all surplus from dealers. Hence, as long as

$$\alpha = \frac{y-x}{\delta-x} \leq \tilde{\pi}(q) = \frac{q}{1-q}\frac{x}{\delta-x} \tag{88}$$

or

$$q \geq 1 - \frac{x}{y} \tag{89}$$

the CRA can maximize demand for ratings and extract all surplus from dealers per rated security at the same time.

Suppose then that $q < 1 - \frac{x}{y}$. Setting the fee $\alpha = \pi = \alpha^*$ achieves a separating equilibrium, while setting $\alpha = \pi = \tilde{\pi}(q) < \alpha^*$ yields a pooling equilibrium. The former yields a larger profit if and only if

$$\left(\frac{y-x}{1-\beta}\right) - k(\alpha^*) \geq \frac{x}{(1-q)\delta - x}\left(\frac{\delta-y}{1-\beta}\right) - \frac{k(\tilde{\pi}(q))}{q}. \tag{90}$$

The right-hand side is continuous and strictly increasing in q. For $q \to 0$, the inequality is fulfilled. For $q \to 1 - \frac{x}{y}$, it is violated which yields the result. □

Proof of Proposition 15

Proof. Consider first that $\alpha = \alpha^C < \tilde{\pi}(q)$. Zero profits in any pooling equilibrium imply then that $\alpha < \alpha^C < \pi = \tilde{\pi}(q)$. Consider any combination of (α, π) that constitutes a separating equilibrium. This would require a higher fee $\alpha = \tilde{\pi}$ which is not preferred by dealers as both the profit per issued asset and the total volume of trade falls. Hence, such a deviation is not feasible.

Consider next that $\alpha^C \geq \tilde{\pi}(q)$. Zero profits in any separating equilibrium requires that $\alpha^C = \pi$. For any pooling equilibrium, we would need that $\alpha < \pi$. But positive profits for the CRA for any $\pi \leq \tilde{\pi}(q)$ then requires that $\alpha > \pi$. Hence, such a deviation is not feasible. □

B Buy and Hold Equilibria

We concentrate here on the case where there cannot be trade in the secondary market and show which equilibria in the primary market are possible. Hence, we have the following parameter restrictions:

(i) $q \leq 1 - \frac{x}{\delta}$

(ii) $\pi \geq \alpha$

(iii) $\pi > \frac{q}{1-q}\frac{x}{\delta-x}$.

A conditional offer is feasible if and only if

$$qv_s - (q + (1-q)\pi)\frac{1}{1-\alpha}V_s \geq 0 \tag{91}$$

An unconditional offer is feasible if and only if

$$qv_s - V_s \geq 0 \text{ or } q \geq \frac{\delta - y}{\delta - x} \tag{92}$$

Hence, a conditional offer is preferred if and only if

$$1 - \alpha > q + (1-q)\pi \text{ or } \pi < \frac{1 - q - \alpha}{1 - q} \tag{93}$$

Hence, we know immediately that for α close to 0 unconditional offers will be relevant only if π is sufficiently close to 1.

More generally, conditional trade and hold is an equilibrium if and only if

$$\pi < \frac{1 - q - \alpha}{1 - q} \tag{94}$$

$$y - x > \frac{1}{1-\alpha}(\delta - y)\left[\alpha + \frac{(1-q)}{q}\pi\right] \tag{95}$$

and unconditional trade if and only if

$$\pi > \frac{1 - q - \alpha}{1 - q} \tag{96}$$

$$q \geq \frac{\delta - y}{\delta - x}. \tag{97}$$

Otherwise there is no trade.

Figure 8[33] below shows which equilibria are now possible in the region where there is no trade in the secondary market and we relax the assumption that

$$y - x \leq \frac{1}{1-\alpha}(\delta - y)\left[\alpha + \frac{x}{\delta - x}\right] \tag{98}$$

in Assumption 3. Note that we have conditional offers with dealers holding on to all assets that have good ratings when π is above, but sufficiently close to the locus where there would be trading in the secondary market. For this case it is optimal for the rating agency to lower the accuracy of ratings and have dealers hold assets with good ratings. For sufficiently low accuracy of ratings, dealers will make unconditional offers if the quality q is sufficiently high and otherwise no offers at all.

[33]Eq.1: Unconditional offer in primary market. Trade in secondary market; Eq.2: Conditional offer in primary market (separating). Trade in secondary market; Eq.3: Conditional offer in primary market (pooling). Trade in secondary market; Eq.4: Conditional offer in primary market (pooling). No trade in secondary market; Eq.5: Unconditional offer in primary market. No trade in secondary market; Eq.6: No offer in primary market. No trade in secondary market.

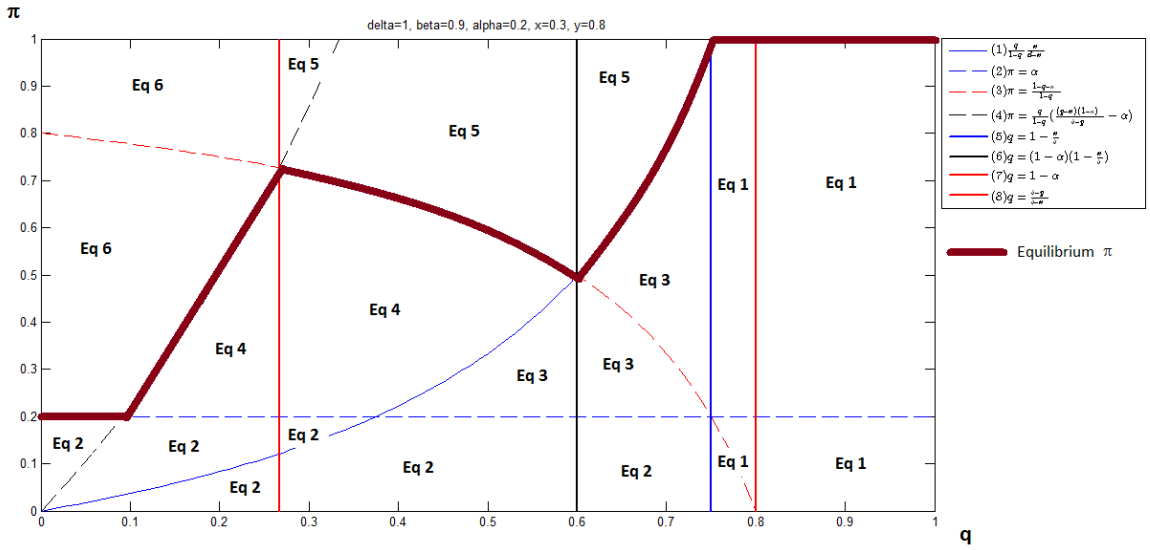

Figure 8: Distribution of Equilibrium in (q, π) space