Credit Ratings and Market Stability – The Role of Market Structure and Disincentives to Acquire Information*

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Abstract

We study how credit ratings affect market efficiency and stability when assets are issued in a primary market and sold by dealers into a secondary, over-the-counter (OTC) market. Even in the absence of rating inflation and rating shopping, we find that the market structure and bad incentives for dealers lead to inaccurate ratings so that assets are opaque and secondary markets appear liquid, but are extremely fragile. Existing regulatory proposals to enhance rating transparency cannot get to the root of this problem. Instead, we show that market reform, credit assessments by investors and credit enhancements by dealers can make OTC markets that rely on ratings more stable.

Keywords: Ratings, Dealers, Credit Assessments, Credit Enhancements, Market Stability

JEL Classification: G01, G24, G28

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1 Introduction

The financial crisis in 2008 demonstrated that trading in over-the-counter (OTC) markets can be fragile. This was the case especially in markets for structured finance products where the underlying assets are opaque and where there is little public information about the trading (price or volume) of these assets. For this reason, ratings are used to reduce such opaqueness by providing information on the credit quality of the assets. A common view is that, in the build-up to the crisis, there were problems throughout the credit rating process that contributed to the fragility in these markets (see for example White (2010) and Coval, Jurek and Stafford (2009)). In particular, discussions have focused on the credit agencies' (CRA) incentives to misrepresent information (aka rating inflation) and the issuers' incentives to selectively disclose ratings (aka rating shopping).[1] As a consequence, the Financial Stability Board has encouraged regulators to look into reducing the reliance on CRA ratings and to strengthen the disclosure of ratings. These measures thus focus on improving the incentives on the sell-side of the asset markets to provide investors with accurate information, but neglect other important factors such as the buy-side of the market and the market structure itself.

In this paper, we suggest that the linkage between the issuance of ratings in primary markets and the trading in secondary OTC markets is crucial for understanding why inaccurate ratings are issued and how low quality ratings contribute to market fragility. The key idea is here that a *lack of buy-side discipline to acquire information* and the *market structure* – think of dealers in the primary market – can lead to inaccurate ratings so that assets are unnecessarily opaque and secondary markets appear to be liquid, but at the same time are extremely fragile in the sense that even small shocks can lead to a market freeze where trading stops completely. Importantly, this inefficiency and fragility can arise even when CRAs cannot misrepresent their information and issuers cannot withhold their information.[2] Hence, to make OTC markets more resilient, regulators cannot focus only on CRAs and issuers' incentive problems. Instead, we show that one needs to consider market reform, credit assessments by investors and credit enhancements by dealers in order

[1]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."

[2]This is somewhat consistent with the view of Calomiris (2009) and Calomiris and Mason (2009). They argue that a principal-agent problem arises from conflicts of interest on the buy-side of the market, between intermediaries and ultimate investors. Inaccurate ratings are desired by institutional investors (aka dealers) who do not fully internalize the negative effects on the ultimate investors and encourage low-quality of ratings.

to make OTC markets that rely on ratings more stable.

To formalize the idea of a lack of buy-side discipline, we develop a dynamic model of information acquisition and asset trading.[3] Opaque assets are first issued in the primary market and then intermediated by dealers to the secondary market. A key feature of the model is that ratings are acquired in the primary market and provide information to support trading in the secondary market. Since dealers are on the buy-side of the primary market, they are responsible for disciplining the quality of ratings and the quality of assets being issued and traded. The dealers' incentives, however, depend on the trading and pricing arrangements of the secondary, OTC market. As a result, this particular market structure influences how opaque the assets are and how fragile the markets are.

In our model, dealers buy assets from issuers in the primary market and then offload these assets for profit in a secondary market where assets are traded bilaterally among investors with time-varying liquidity needs. Trading in both markets is subject to a lemons problem because only a fraction of issuers have good assets, and the quality of assets is private information of the seller – being the issuer, dealer or investor depending on the market and transaction. Due to the OTC structure of the secondary market, in the absence of ratings, all transactions are conducted at the same price independent of the quality of assets, leading to a pooling equilibrium.[4] An investor's incentive to purchase these opaque assets in the secondary market hence depends on the average quality of assets circulating in the market. Credit ratings are useful here as they can – potentially imperfectly – certify the quality of assets. If there are too many bad assets and credit ratings are unreliable, investors are subject to high credit risk, and hence are unwilling to purchase assets.

Investors in the secondary market rely on dealers to discipline the quality of ratings and assets in the primary market. However, due to the pricing arrangement in the secondary market, dealers do not fully internalize the value of better information for investors when asking for ratings.[5] Dealers' profits arise from a mark-up when intermediating assets. Accurate ratings reduce their profits in two respects. First, more accurate ratings screen out more bad assets and reduce the volume of assets dealers can intermediate. And second, dealers indirectly bear the costs of rating assets, as

[3]Our model is based on a simplified version of Chiu and Koeppl (2016) which formalizes trading with adverse selection in OTC markets, but focuses on the possibility of a market freeze for a given degree of opaqueness of assets.

[4]This outcome is due to the bilateral nature of trading as well as the lack of commitment under bargaining.

[5]We entirely abstract from CRAs in the paper. See the online appendix where we explicitly model the decisions by CRAs and show that the results do not change.

they need to reimburse issuers for these costs which reduces the mark-up.

This implies that dealers prefer to intermediate as many assets with as little information as possible into the secondary market. The equilibrium rating accuracy then depends on the average quality of assets (i.e., the fraction of issuers creating good assets). When the average quality of assets is sufficiently high, ratings are not necessary for trade at all in the secondary market and dealers choose not to ask issuers for ratings. For intermediate levels of quality, however, ratings are necessary to support trade. Dealers prefer an accuracy of ratings that makes investors just indifferent to trade in the secondary market. For very low levels of quality, ratings need to be so accurate that issuers of bad assets have no incentive to acquire ratings. In this case, ratings acts as a perfect screening device.

For intermediate levels of quality, the equilibrium outcome is inefficient and makes trading in the secondary market fragile. The inefficiency arises from the deadweight loss of issuing and rating too many bad assets.[6] Markets are also extremely fragile as investors are just indifferent between trading and not trading assets. Hence, even a very small, negative shock to quality of the assets being traded would lead to a complete market freeze. For high levels of quality, ratings are not being used. This maximizes efficiency, but does not necessarily maximize market stability. This points to a trade-off between more efficient markets and more stable markets.[7] When there are many bad assets so that the average quality is sufficiently low, ratings are so accurate that only issuers with good assets acquire them making trading efficient and markets stable.

In summary, ratings are not informative enough for intermediate levels of asset quality. Can one use regulation to induce ratings that are sufficiently accurate to make markets more stable and trading more efficient? The first idea we look at is to give dealers more market power. If dealers could extract all surplus from trading in the secondary market, they would internalize the value of information for investors and, consequently, choose ratings that are accurate enough to screen out all bad assets. While clarifying the nature of the problem, it is hard to imagine how one could achieve such a reform of OTC markets in practice. Hence, we look at two other ideas for regulation that rely on forcing dealers to have skin in the game.[8]

[6]Trading of bad assets in the secondary market just redistributes surplus. We could easily introduce a cost of trading which would strengthen this result.

[7]Introducing a cost for trading bad assets would weaken this trade-off.

[8]In the online appendix, we look at other approaches such as fostering competition among CRAs and show that such regulation is unable to establish buy-side discipline.

Investors could conduct their own credit assessments in-house to screen out additional lemons in the secondary market. Such assessments force dealers to have skin in the game, since dealers will not be able to sell off bad assets that have been screened out by investors. In other words, credit assessments introduce a cost for dealers intermediating bad assets. When credit assessments are sufficiently accurate and mark-ups are small, dealers will be induced to ask for more accurate ratings. Otherwise, to maximize their profits, dealers will simply reduce rating accuracy and force investors to conduct their own assessment for trading in the secondary market, even if this implies that dealers will not be able to sell all bad assets acquired in the primary market.

With credit assessments, markets become more stable for intermediate and high levels of quality as overall more bad assets are being screened out. For low levels of quality, however, when credit assessments are used, dealers do not have incentives anymore to use very accurate ratings to screen out all bad assets with the consequence that markets become less stable. This implies that neither lower rating accuracy, nor the use of credit assessments signal necessarily that markets have become more stable. The effects on efficiency are ambiguous and depend on the relative costs of public ratings and privately conducted credit assessments.

Dealers could also be required to employ credit enhancements when selling assets into the secondary market. One possibility is a liquidity backstop that forces dealers to purchase assets if trading in the market stops. Such a backstop has value for investors and, thus, allows dealers to *reduce* the accuracy of ratings in order to sell assets in the secondary markets. The backstop, however, also involves an expected cost for dealers. This implies that requiring a backstop will make markets more stable whenever this cost is large enough so that dealers stop intermediating bad assets altogether by using very accurate ratings.

A second possibility is to require that dealers sell a bundle to investors, consisting of the asset itself and a priced credit default swap (CDS) where the payout is triggered by a loss in resale value of the asset due to a market freeze. Compared to the backstop, this introduces an additional revenue source for dealers in addition to the expected cost of the CDS. If the CDS premium is large enough – more specifically, if it exceeds the fair value of the CDS –, dealers have an incentive to extract surplus from investors by increasing the accuracy of ratings and cashing in on the CDS premium, once again increasing market stability.[9]

[9] Dealers' reputation can also be a potential device for disciplining their incentives. However, it becomes less effective in an OTC trading environment where trade information is opaque and it is hard to coordinate decentralized

We introduce an entirely new aspect to the recent literature on ratings. Dealers use ratings to create a liquid, secondary market, but have no incentives to ensure that trading in these markets remains stable by having ratings that are accurate.[10] We believe that this insight is pivotal for understanding how credit ratings for structured products contributed to the recent financial crisis and where regulation needs to start in order to make markets that rely on ratings more stable.

The existing literature has instead focused on another important issue – rating bias or rating inflation – that derives from an incentive problem for either CRAs or issuers. A bias in ratings can arise in the context of the decision of issuers to not disclose a bad rating and instead seek a better rating from another agency. Whenever bad ratings are withheld by issuers, information about the quality of investment is then biased upward. This process is commonly referred to as rate shopping. Selective disclosure issues have been analyzed by Skreta and Veldkamp (2009), Bolton, Freixas and Shapiro (2012) and Sangiorgi and Spatt (2015) among others. Here, the discussion about how to regulate ratings has predominantly focused on whether competition alleviates or compounds the problem.

Ratings tend also to be inflated when CRAs misrepresent their information. Here one assumes either that the quality of the rating agency (adverse selection) or that the effort in providing a signal (moral hazard) cannot be observed by investors. Mathis, McAndrews and Rochet (2009), Opp, Opp, and Harris (2013) and Fulghieri, Strobl and Xia (2014) are main examples in the literature that establish such an upward bias in ratings based on different incentive reasons. A recent contribution by Cole and Cooley (2014), however, has pointed out that rating agencies tend to have strong reputational incentives to keep misreporting at bay. In this context, optimal compensation schemes have recently received renewed interest as a regulatory tool to provide proper incentives for ratings agencies (see for example the work by Kashyap and Kovrijnykh (2016)).[11]

By assuming that CRAs cannot misreport ratings and issuers cannot withhold information, our paper intentionally abstracts from the issues of rating inflation and rating shopping. Our findings

traders. Credit assessments and credit enhancements, however, can still be useful in the absence of reputation.

[10] There is ample evidence in the empirical literature that ratings have been inaccurate. See Benmelech and Dlugosz (2009), Becker and Milbourn (2011), Griffin and Tang (2012), Kartasheva and Yilmaz (2013) among others.

[11] Recently, a new research area has emerged that has looked at how changes in ratings can have amplifying effects. Manso (2013) analyzes so-called "cliff effects" where a downgrade can push borrowers into default, even though they 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. While potentially interesting, we have abstracted here from any cyclical issues in trading and ratings.

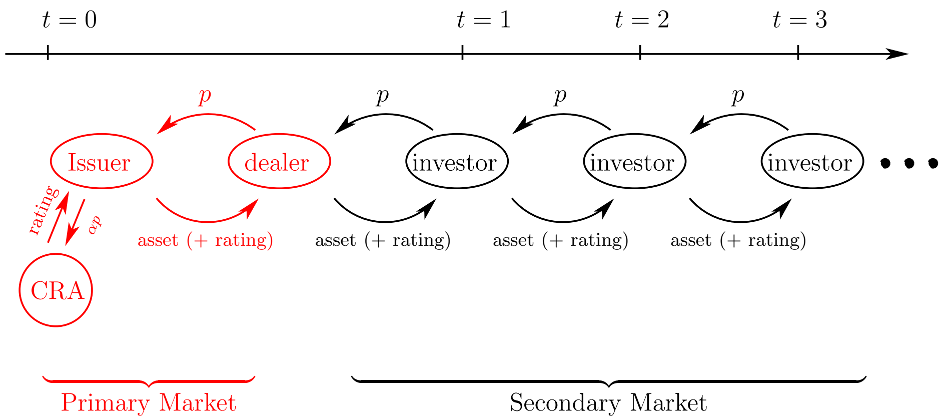


Figure 1: Time line

highlight that, even in the absence of these sell-side problems, ratings can still lead to inefficiency and fragility due to a lack of buy-side discipline. As a result, regulatory proposals to enhance rating transparency by disclosure requirements may not get to the root of the problem. Moreover, our insights shift the emphasis away from competition among ratings agencies and issuer-vs.-investor-pay models to making sure that dealers and CRAs have skin in the game. Credit assessments by investors can play this role effectively, even though they might lead to less precise ratings, as dealers and CRAs partially shift the burden of information provision for liquid and stable secondary markets to investors.[12] Similarly, we point out that credit enhancements can give dealers appropriate incentives to seek accurate ratings directly, thereby improving market stability.

2 Environment

Our setup captures an environment where assets are first issued in a primary market and then sold by intermediaries to investors who in turn trade these assets in a secondary market. There are two markets and three different groups of people – 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. For $t \geq 0$, there is a *secondary market* where investors buy these assets and trade them among themselves. All actors are risk-neutral and discount the future by $\beta \in (0, 1)$. Figure 1 illustrates the time line.

We introduce two frictions that are associated with the issuing and trading of assets. First, the

[12] According to the FSB's "Principles for Reducing Reliance on CRA Ratings" (FSB (2010)), banks should enhance their capacity for internal credit assessment.

quality of the asset is private information for the seller which is first the issuer, then the dealer and finally any investor who sells the asset.[13] Second, assets are traded bilaterally among people, where buyers are assumed to make a take-it-or-leave-it offer so that they have market power. The specifics of our trading environment are as follows.

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 specific asset is private information for the issuer.[14]

In the primary market, dealers are bilaterally matched with issuers and make a take-it-or-leave-it offer to issuers for the asset. Once dealers have purchased an asset, they perfectly learn its quality. Dealers value the cash flow of a good asset by $\delta - x > 0$ where $x < y$ is interpreted as a cost for the dealer to keep the asset. After purchasing an asset, the dealers are then matched in the secondary market with investors who in turn make a take-it-or-leave-it offer for the asset.

The secondary market is a simplified version of Chiu and Koeppl (2016) and captures a dynamic over-the-counter (OTC) market where trading is bilateral and the quality of the asset being traded is private information of the seller. In the first period, investors are bilaterally matched with dealers and make a take-it-or-leave-it offer. Every period thereafter, investors without an asset (buyers) are matched with investors that have an asset (sellers) 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 an asset, he also perfectly learns its quality. Investors with a good asset value the dividend at $\delta > 0$ for one period with the valuation then dropping to $\delta - x > 0$ in future periods. Finally, after each match, any investor without an asset (i.e., a seller after selling or a buyer without buying) leaves the economy.

Trade in our environment is beneficial as high quality assets are transferred from people with low

[13] This assumption is made for convenience to keep the nature of adverse selection the same throughout trading in the primary and secondary market.

[14] An alternative interpretation of our setup is that 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 no investment. Issuers do not have initial wealth and thus need to raise funding in the primary market.

valuation to ones with high valuation. First, dealers can earn a spread as the holding cost of issuers exceeds their own ($x < y$). Second, investors temporarily have a high valuation and thus are willing to acquire the asset from dealers or investors that have a lower valuation due to the holding costs ($x > 0$). Lemons provide no cash flow, but due to private information problem can have value whenever they are sold at a positive price to investors.

To introduce ratings, we add a technology that provides public information about the quality of the asset. This information arrives in the form of a publicly observable 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 as 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 ($\pi = 1$). We interpret the public signal as a *rating* that can be produced at any level of accuracy π.

Dealers can make one of two offers which are observed by investors in the secondary market. They can make an *unconditional offer* buying the asset from the issuer independent of a rating. Alternatively, they can make a *conditional offer* where the asset is purchased conditional on the issuer demanding a rating with accuracy π and indeed receiving a good rating. We assume here that issuers need to pay a fixed fraction α of the price offered by the dealer for obtaining a rating.[15] Finally, we make the following assumption on the parameters of the model.

Assumption 1. *Define $\bar{q} = 1 - \frac{x}{\delta}$. The rating fee α and the spread for dealers $y - x$ satisfy the following restrictions*

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

[15] We do not model the interaction between issuers, dealers and rating agencies. This is not a shortcoming of our model as we can easily extend the model to rating agencies that decide on the accuracy and pricing of ratings under different assumption on market structure (see Online Appendix). As explained in the introduction, we neither allow for the possibility of rate shopping where issuers obtain, but do not disclose any unfavourable ratings, nor for rating agencies to misrepresent the results of their rating analysis.

These restrictions rule out two uninteresting outcomes. The first inequality ensures that it is not profitable for dealers to make unconditional offers, forgo 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.

3 Ratings and Trading

We study now how ratings in the primary market interact with trading decisions in the secondary market.[16] This involves solving for a Perfect Bayesian Nash Equilibrium. The equilibrium consists of

(i) an optimal trading strategy for investors of making and accepting offers at p in the secondary market;

(ii) an optimal choice for dealers of rating accuracy π and of making an unconditional offer at p_0 or a conditional offer at p_σ in the primary market and accepting investors' offers in the secondary market;

(iii) an optimal decision for issuers to obtain ratings and to accept dealers' offers.

We then show that the equilibrium is neither efficient nor does it necessarily lead to market stability. The reason is that dealers lack market power in the secondary market and, consequently, do not take into account efficiency and stability of trading.

3.1 Trade in the Secondary Market

Consider first trading in the secondary market. We denote the value functions of an investor by v_o, v_s and v_ℓ depending on whether the investor is an owner of a good asset valuing the dividend at δ, is a seller of a good asset valuing it at $\delta - x$ or has a lemon that does not pay a dividend. When matched with an investor, a buyer cannot observe the quality of the asset that is for sale, but can observe the rating acquired in the primary market. Hence, he will make an offer at price p if and

[16]We relegate all proofs to the Appendix, unless the results follow directly from the exposition in the text.

only if

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

where $E[q|\mathcal{I},p]$ is the expected probability of buying a good asset at p given the information set $\mathcal{I}$ that depends on the actual rating the asset has received and the accuracy π of the rating. Note that a seller of a good asset always has the option to not sell, but keep the asset. The outside option for the seller is thus given by $v_s = (\delta - x)/(1 - \beta)$. A buyer will then obtain a good asset only if he compensates the seller by offering a price $p \geq v_s$. This implies that the expected probability of buying a good asset is given by

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

where $\mathbf{1}_\sigma$ and $\mathbf{1}_0$ are indicator functions for which issuers have acquired ratings such that $\mathbf{1}_\sigma = 1$ when all issuers acquire ratings and $\mathbf{1}_0 = 1$ when no issuers acquire ratings.

As will become clear later, there are three possible outcomes from the rating decisions in the primary market.[17] The first one corresponds to a separating outcome where only issuers with good assets acquire ratings ($\mathbf{1}_\sigma = \mathbf{1}_0 = 0$) so that investors in the secondary market do not face any adverse selection. In this case, lemons will never be traded as investors can perfectly infer the asset quality from observing that assets have been rated. Consequently, buyers always make an offer to assets with a rating at $p = v_s$, so that $v_o = \delta + \beta v_s > v_s$. Good assets are always traded, while lemons are never traded ($v_\ell = 0$).

The other two cases correspond to pooling outcomes from the rating game, where trading depends on the average quality of assets that are for sale. The value functions for a pooling outcome are given by[18]

$$v_o = \delta + \beta v_s \tag{2}$$

$$v_s = \frac{\delta - x}{1 - \beta} \tag{3}$$

$$v_\ell = \beta v_s \tag{4}$$

[17] Since good issuers acquire ratings whenever lemon issuers have an incentive to do so, there are three possible equilibrium outcomes: ratings are acquired by (i) good issurs only ($\mathbf{1}_\sigma = \mathbf{1}_0 = 0$), (ii) all issuers ($\mathbf{1}_\sigma = 1, \mathbf{1}_0 = 0$), or (iii) no issuers ($\mathbf{1}_\sigma = 0, \mathbf{1}_0 = 1$).

[18] One can show that with adverse selection a separating offer with lotteries is dominated by a pooling offer. For details, see Chiu and Koeppl (2016).

since acquiring a lemon is costly for the reason that the buyer receives no dividend for one period before he can sell the lemon again in the market at its original purchase price p. For there to be trading in the secondary market, the expected surplus from making an offer at $p = v_s$ needs to be positive for the buyer given the accuracy of ratings π. This is only the case when the average quality of the assets that are for sale is sufficiently high. When all issuers have acquired ratings ($\mathbf{1}_\sigma = 1, \mathbf{1}_0 = 0$), there are q good assets in the market and $(1-q)\pi$ lemons that have been declared as good assets by ratings. When no one has acquired ratings ($\mathbf{1}_\sigma = 0, \mathbf{1}_0 = 1$), the average quality is given by the fraction of good assets q. This yields the following result for trading in the secondary market.[19]

Proposition 2. *Trade in the secondary market depends on the information set $\mathcal{I}$.*

(i) If good assets have a rating but lemons do not, only assets with a rating are traded in the secondary market.

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

(iii) If no assets have ratings, there is trade in the secondary market if and only if $q \geq \bar{q}$.

The price of assets in the secondary market, however, is independent of the information set $\mathcal{I}$ and given by $p = \frac{\delta - x}{1-\beta}$.

Proof. See appendix. □

This result implies that equilibrium trading in the secondary market imposes a constraint on the dealer. Specifically, a dealer can resell an asset in the secondary market only if ratings are sufficiently accurate so that investors are ensured that the average quality of assets that are offered for sale is high enough. To determine the accuracy of ratings, we turn next to the primary market at $t = 0$.

[19] In general, there are multiple equilibria due to a strategic complementarity that arises from the resale of assets. For further details on this issue, see Chiu and Koeppl (2016). We focus here entirely on equilibria with trade in the secondary market.

3.2 Primary Market

When matched with an issuer, a dealer can either make an unconditional offer to buy the asset outright at price p_0. Alternatively, he can make a conditional offer to buy the asset at a price p_σ if and only if the issuer obtains a good rating for some specified level of accuracy π. Good issuers will sell their asset only if the price is higher than their outside option. Since the dealer makes a take-it-or-leave-it offer, we have

$$p_0 = \frac{\delta - y}{1-\beta} \tag{5}$$

$$p_\sigma = \frac{1}{1-\alpha}\frac{\delta - y}{1-\beta} \tag{6}$$

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 the cost of a rating fee αp_σ that the issuer has to pay and for which he will be reimbursed by the dealer's offer. We define the ratio of the price in the secondary market and the price in the primary market with ratings as

$$\phi = \frac{p_\sigma}{p} = \frac{1}{1-\alpha}\frac{\delta - y}{\delta - x} \tag{7}$$

Note that this is the inverse of the mark-up $1/\phi \geq 1$ that dealers charge when selling assets in the secondary market.

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 always get reimbursed for a rating since they never receive a bad rating. For issuers with bad assets, however, there is a cost of obtaining a bad rating. 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 the issuer. However, a bad issuer can only sell the lemon if he obtains 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. With ratings, the expected quality of assets in the secondary market is thus given by

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

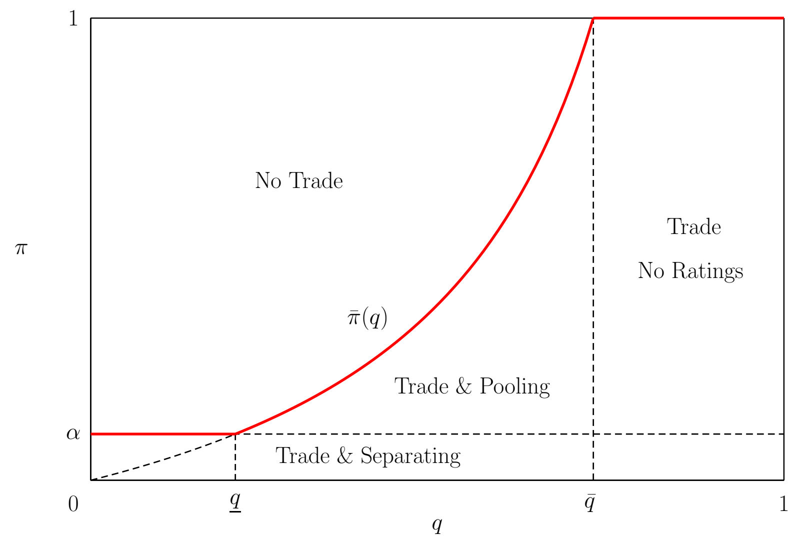


Figure 2: Equilibrium for asset quality q and rating accuracy π

Consider now a dealer's decision on what offer to make in the primary market. A dealer's expected payoff is simply the product of trade volume (the expected quantity of assets intermediated) and the profit per trade (the difference between prices in the secondary and primary markets). In particular, the payoff is $q(p - p_\sigma)$ when only good assets are rated and traded, is $[q + (1 - q)\pi](p - p_\sigma)$ when all assets are rated and traded, and is $p - p_0$ when all assets are traded without ratings.

As long as the asset can be sold to investors in the secondary market, ratings reduce a dealer's payoff through both the extensive and intensive margins. First, as ratings screen out bad assets, dealers' trade volume drops when conditional offers are made and is decreasing in the accuracy of ratings. Second, recall that the resale price of an asset is $p = v_s = (\delta - x)/(1 - \beta)$. This implies that the profit per trade is $(y - x)/(1 - \beta)$ from an unconditional offer. Similarly, the profit from a conditional offer is $(y - x)/(1 - \beta) - \alpha p_\sigma$ which is lower due to the rating cost. The dealer, however, is also constrained by investors requiring a sufficiently high average quality ratings in the secondary market (see Proposition 2). This implies that dealers need to require ratings with a sufficiently high accuracy. This leads to the following characterization of equilibrium in both markets.

Proposition 3. *If $q \leq \underline{q} = \frac{\alpha(\delta - x)}{\alpha\delta + (1-\alpha)x}$, dealers make conditional offers requiring accuracy $\pi = \alpha$*

and there is trade of only good assets in the secondary market.

If $q \in (\underline{q}, \bar{q})$*, dealers make conditional offers requiring accuracy* $\bar{\pi}(q)$ *and there is trade of all assets with good ratings.*

If $q \geq \bar{q}$*, dealers make unconditional offers and there is trade of all assets without ratings in the secondary market.*

Proof. See Appendix. □

The intuition for this result is best explained by looking at Figure 2. When the average quality of the assets is above $\bar{q}$, ratings are not necessary for trading in the secondary market. Consequently, dealers will simply make unconditional offers which maximize both the trade volume and the profit per trade. For lower levels of quality, ratings need to be used to screen out at least some lemons since only assets with good rating outcomes can be resold. Screening however reduces the trade volume, so dealers have an interest to make ratings as inaccurate as possible. The minimum level of accuracy necessary for trade in the secondary market is given by $\bar{\pi}(q)$ which also maximizes the chance for the dealer to buy an asset with a good rating – be it a lemon or a good asset. Finally, if the proportion of lemons is large enough, the accuracy of the rating needs to be sufficiently high relative to the fee ($\pi < \alpha$) so that lemons do not have an incentive anymore to obtain a rating. Hence, conditional offers will lead to a separating outcome where only good assets obtain ratings and are traded. The red solid line in Figure 2 summarizes the equilibrium outcome of rating accuracy given an average quality q of assets.[20]

3.3 Efficiency and Market Stability

The equilibrium outcome has some features that allow us to view ratings as being not sufficiently accurate. Asymmetric information prevents trade when the average quality of assets is too low. Hence, ratings allow for the trading of assets which leads to an efficient allocation of assets where all good assets are being allocated to investors with the highest marginal valuation. The fact that some lemons will also be traded in equilibrium is irrelevant, since this simply redistributes surplus

[20] When a separating equilibrium occurs, dealers are indifferent between any level of accuracy $\pi \in [0, \alpha]$. We assume here that dealers pick the least accurate one with $\pi = \alpha$ which is inconsequential for any of our results.

between investors in the secondary market and dealers or issuers in the primary market. However, for intermediate levels of quality, ratings are also being sought by lemons in equilibrium. This can be seen as inefficient if it is costly to produce ratings and if a higher accuracy leads to only good issuers acquiring ratings.[21]

Consider then that ratings are costly to produce – say at some cost k that is sufficiently small.[22]

We therefore say that the accuracy of ratings π is *efficient* if it minimizes the costs of ratings subject to having good assets being traded. The cost of issuing and trading per good asset can be expressed as

$$\frac{q\mathbf{1}_{\{\sigma|s\}} + (1-q)\mathbf{1}_{\{\sigma|\ell\}}}{q} k, \tag{10}$$

where the indicator functions $\mathbf{1}_{\{\sigma|\cdot\}}$ express whether good assets and lemons acquire ratings.

Proposition 4. *For all $q \in [0, \bar{q})$, it is efficient to have ratings set at $\pi = \alpha$ so that only good assets are issued. For all $q \in (\bar{q}, 1]$, it is efficient to have no ratings at all ($\pi = 1$).*

The accuracy of ratings is inefficiently low in equilibrium for all $q \in (\underline{q}, \bar{q})$.

Figure 3 shows the cost of trading per good asset in equilibrium. For high and low levels of quality ($q \leq \underline{q}$ and $q \geq \bar{q}$) the ratings accuracy in equilibrium is efficient. In the first case, ratings are necessary for trading, but only acquired by good assets. In the second case ratings are not necessary for trading and not being used in equilibrium (see Proposition 3). For intermediate values of quality, however, lemons also obtain ratings and are traded which increases the costs of ratings above k per good asset which is shown in the middle part of the graph. It is efficient for such quality levels to screen out lemons through sufficiently accurate ratings.

We can also take a stance on whether ratings are sufficiently accurate in equilibrium so that trading in the secondary market is resilient to shocks. Consider an unexpected fall in quality q after issuance and initial resale of the asset to an investor. To be more concrete, suppose some previously good

[21] Alternatively, we could also have introduced a cost of issuing and trading assets. We would again obtain that it is not efficient to have lemons reach the market.

[22] We make this assumption for convenience. For example, a decreasing function $k(\pi)$ that satisfies the restriction that $\bar{q}k(\alpha) \leq \lim_{\pi\to 1} k(\pi) \equiv \underline{k}$ would give equivalent results. Dropping this restriction would introduce a trade-off for the overall cost of ratings between the number of ratings being issued and their accuracy, but would not alter our results fundamentally.

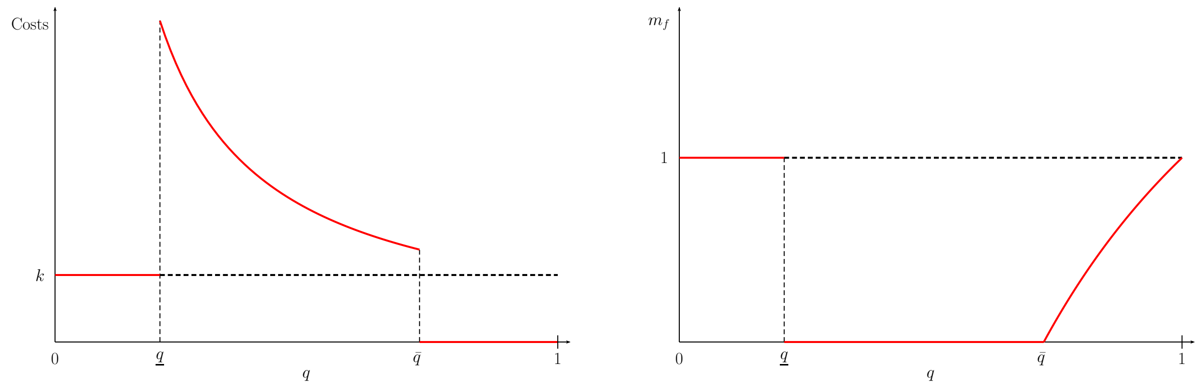


Figure 3: Equilibrium – Efficiency and Market Stability

assets turn to lemons so that initial ratings become less informative. If $(1-q)\pi$ lemons had been traded before the shock, there are now $(1-q)\pi + (q-q_0)$ lemons in the market. For a large enough fall in quality, there will be no trade in the secondary market which results in a welfare loss of $-x/(1-\beta)$ as good asset are not traded anymore to people with the highest valuation.

Our measure of *market stability* is then given by the percentage drop in quality that is required to cause a market freeze

$$m_f(q) = \left(\frac{\delta}{x}\right)\left(\frac{q - q_0(q)}{q}\right), \tag{11}$$

where $q_0(q)$ is the critical level of quality where a market freeze occurs. Using the factor δ/x simply rescales our measures so that $m_f \in [0,1]$. Hence, a market is more stable (or less fragile) the larger the index m_f is or, equivalently, the larger the shock is that is required to cause a trading freeze. Applying this measure to the equilibrium in our economy we have the following result.

Proposition 5. *For all $q \in [0, \bar{q})$, trading in the secondary market is most stable with $m_f = 1$ when ratings are set so that only good assets are issued.*

In equilibrium, markets are extremely fragile with $m_f = 0$ for $q \in (\underline{q}, \bar{q})$. Any unexpected, arbitrarily small fall in quality q will lead to a market freeze.

This is reflected in Figure 3 which shows our measure of stability as a function of the average quality of assets q. For $q < \bar{q}$, there is no trade-off between stability and efficiency. When only good assets are issued and traded, one achieves both efficiency and the most stable market. For intermediate values of asset quality, we can thus view ratings as being inefficiently accurate in equilibrium. Ratings are not accurate enough to increase the stability of trading by screening out all lemons or give disincentives for lemons to acquire ratings which are socially costly.[23] We demonstrate next that it is the market structure that is responsible for this equilibrium outcome. More precisely, bilateral trading causes the distribution of market power to matter for the incentives to acquire information.

3.4 The Role of Market Structure for Inefficiency and Fragility

Suppose contrary to our set up that sellers in the secondary market have market power in the sense that they can extract all surplus from trade. A seller now meets with $n \geq 2$ buyers who compete by simultaneously making take-it-or-leave-it offers. Such competition will leave zero surplus for the buyers and results in a price

$$p = E[q|\mathcal{I}, p]v_o + (1 - E[q|\mathcal{I}, p])v_\ell. \tag{12}$$

If there is trade in the secondary market, we have that $v_o = \delta + \beta p$ and $v_\ell = \beta p$. Consequently, the price a dealer obtains depends now positively on the average quality of assets that reach the market

$$p = E[q|\mathcal{I}, p]\frac{\delta}{1 - \beta}. \tag{13}$$

where with a conditional offer $E[q|\mathcal{I}, p]$ is again given by Equation (9). This yields the following result.

Proposition 6. *Suppose there is price competition among buyers in the secondary market.*

For $q < 1 - \alpha$, dealers make conditional offers with $\pi \leq \alpha$ so that only good assets are issued and traded in the secondary market. This is efficient for $q \leq \bar{q}$ and makes markets more stable.

For $q \geq 1 - \alpha$, dealers make unconditional offers so that all assets are traded without ratings in the secondary market.

[23] For $q \geq \bar{q}$ when ratings are not used in equilibrium, market stability depends on the initial level of quality and is given by $m_f(q) = \frac{q - \bar{q}}{q}$. Hence, there is a trade-off between efficiency and stability. Ratings are not necessary for trading, but can make the market more stable. One can argue that it might be optimal to raise the accuracy of ratings for stability purposes even though this is not necessarily efficient.

Giving dealers market power in the secondary market thus leads to an efficient equilibrium with a stable secondary market for all $q < \bar{q}$. Dealers can now no longer profit from lowering the accuracy of ratings, since this lowers the price at which lemons can be resold. For $q \in [\bar{q}, 1-\alpha)$, dealers are however too conservative in that they acquire ratings even though trading would be possible without ratings because the cost of buying lemons is larger than the cost α associated with ratings. While this is inefficient, markets still become more stable. Finally, for $q \in [1-\alpha, 1)$, no ratings are being used which is efficient.

Why does market structure matter for the efficient provision of information? When buyers have full market power, dealers take the sale price $p = v_s$ as given which neither depends on the quality nor the rating accuracy. Dealers would then like to sell as many lemons as possible in the secondary market and do not take into account that it is optimal for investors that only good assets are traded in the secondary market. They are, however, constrained by achieving trading in the secondary market which results in an inefficient accuracy of $\bar{\pi}(q)$. Ratings are then inefficiently accurate, with too many ratings being issued to bad assets which causes trading to be fragile in secondary markets. In contrast, when dealers have full market power they can extract all surplus from future buyers of the assets, and, thus, internalize the benefits of more accurate ratings to investors.

We next look at two alternative ways for improving the accuracy of ratings since we believe that changing the market structure for decentralized trading of assets is generally not feasible. The first one looks at investors acquiring private information in the secondary market. Such *credit assessments* are different from ratings as this information cannot be publicly communicated to other investors. The second one considers making dealers liable for intermediating assets that ultimately turn out to be lemons. This can be achieved in the form of *credit enhancements* such as a liquidity backstop or a credit default swap.

4 Credit Assessments: Investors Acquire Information

Recent regulatory proposals[24] have pushed the idea that investors could complement ratings of third-party rating agencies with their own credit assessments. In this section, we evaluate the implications for efficiency and stability when investors have in-house capabilities to undertake such assessments. Using an in-house technology allows the investor to screen out an additional fraction

[24] See for example FSB (2010).

of $1-\rho \in (0,1)$ lemons. Hence, for any given rating accuracy π, an additional fraction $(1-q)(1-\rho)\pi$ lemons are detected by the in-house technology, while the remaining $(1-q)\rho\pi$ lemons survive both with a good rating and a good private credit assessment. The cost for operating this technology is given by a fixed cost κ. We require that the cost is sufficiently low and the effectiveness of the technology sufficiently high, so that credit assessments are a viable option for investors for all $q < \bar{q}$.

Assumption 7.

$$\frac{\kappa}{x} < (1-\rho)\bar{q}$$

There are two differences between CRA ratings and credit assessments. First, while a CRA rates an asset only once in the primary market, different investors can potentially evaluate the same asset sequentially over time in the secondary market. Second, while a rating is publicly observable by all investors in the secondary market, the outcome of a credit assessment is typically private information of the investor involved. For simplicity[25], we will therefore assume that only the first investor can use credit assessments and that the transaction between the dealer and the first investor is publicly observable. As a consequence, the first transaction in the secondary market will fully reveal the outcome of the credit assessment and lemons that have been detected privately by the first investor will not be traded in the secondary market.[26]

4.1 Secondary Market

We again only consider trading equilibria. By our assumption, only the first buyer acquires information. The expected surplus from doing so for a given level of quality q and accuracy π is given by

$$\Gamma_1(\pi|q) = -\kappa + \frac{q}{q+(1-q)\pi}v_o + \frac{(1-q)\rho\pi}{q+(1-q)\pi}v_\ell - \frac{q+(1-q)\rho\pi}{q+(1-q)\pi}v_s \tag{14}$$

where $v_\ell = \beta v_s$. Note that the investor only acquires information conditional on the asset having received a positive rating. With probability $(q+(1-q)\pi\rho)/(q+(1-q)\pi)$ the investor will make an

[25]The general case where credit assessments are repeated by investors and are private information complicates the analysis, but leads to similar insights. See the Online Appendix.

[26]Note that the first buyer receives a negative payoff when he chooses to buy a lemon. If he pays $p = v_s$ for a lemon, he will have a negative payoff since he is not earning a cash flow and can only gets expected payoff βv_s from reselling the asset. If he buys at $p < v_s$, future buyers will know that the asset is a lemon and do not make an offer for the asset. Consequently, the asset cannot be resold and the first buyer will again gets a negative payoff.

offer, while with probability $(1-q)\pi(1-\rho)/(q+(1-q)\pi)$ he will not make an offer having identified a lemon for sure. Acquiring information is feasible whenever the surplus $\Gamma_1(\pi|q)$ is positive or

$$\kappa \leq \frac{q}{q+(1-q)\pi}x - \frac{(1-q)\rho\pi}{q+(1-q)\pi}(\delta - x). \tag{15}$$

Hence, there is a threshold of ratings quality $\pi_{\max}(q)$ below which the investor has a positive payoff when acquiring information.

If the first investor does not acquire information, his expected surplus is given by

$$\Gamma_0(\pi|q) = \frac{q}{q+(1-q)\pi}v_o + \frac{(1-q)\pi}{q+(1-q)\pi}v_\ell - v_s \tag{16}$$

where again $v_\ell = \beta v_s$. Hence, the first investor has an incentive to acquire information whenever

$$\kappa \leq \frac{(1-q)\pi}{q+(1-q)\pi}(1-\rho)(\delta - x). \tag{17}$$

Once again there is a threshold $\pi^o(q)$ above which investors acquire credit assessments.

Assumption 7 ensures that $\pi^o(q) < \bar{\pi}(q) < \pi_{\max}(q)$ for all $q \in (0, \bar{q})$, so that information acquisition by dealers and investors are strategic substitutes. When $\pi > \bar{\pi}(q)$ ratings are insufficiently accurate for trading. Consequently, a credit assessment by investors is necessary for trade which yields a surplus only if $\pi \leq \pi_{\max}(q)$. For $\pi \leq \bar{\pi}(q)$, ratings are sufficiently accurate for trading. But investors still have an incentive to conduct a credit assessment if $\pi > \pi^o(q)$. Hence, when ratings are sufficiently accurate, credit assessments do not increase the expected surplus for investors. A special case occurs again when $\pi \leq \alpha$ so that we obtain a separating equilibrium in the primary market. Then there is no need to acquire information via credit assessments in the secondary market. Finally, since investors cannot conduct credit assessments after $t > 0$, they always trade whenever the first investor has an incentive to.

4.2 Primary Market

Dealers now have to take into account that they cannot sell all lemons anymore if investors conduct credit assessments. However, they can prevent investors from acquiring information by setting a sufficiently high accuracy of ratings. From equation (17), this threshold is given by either $\pi^o(q)$ or α whichever is lower, where the latter leads to a separating equilibrium.

Lemma 8. *Dealers can prevent credit assessments by setting* $\pi = \max\{\pi^o(q), \alpha\}$ *for all* $q \in (0, \bar{q})$.

This allows dealers to earn a minimum profit from intermediating assets with rating accuracy $\pi^o(q)$. This minimum profit is increasing in the cost κ and decreasing in the effectiveness $(1-\rho)$ of credit assessments. Choosing a lower accuracy affects a dealer's expected profits in two ways. Less accurate ratings increase the probability of a transaction in the primary market. But less accurate ratings also induce investors to obtain information making it harder to offload a lemon to them. This trade-off is reflected in the profit function given by

$$\frac{1}{1-\beta}p_\sigma\left[(q+(1-q)\rho\pi)\frac{1}{\phi}-(q+(1-q)\pi)\right]. \tag{18}$$

for $\pi \in (\pi^o(q), 1)$. A dealer will be stuck with $(1-q)(1-\rho)\pi$ lemons which he cannot sell anymore whenever investors acquire information. Hence, we have the following result.

Lemma 9. *When investors use credit assessments, dealer profits are increasing when ratings get less accurate if and only if*

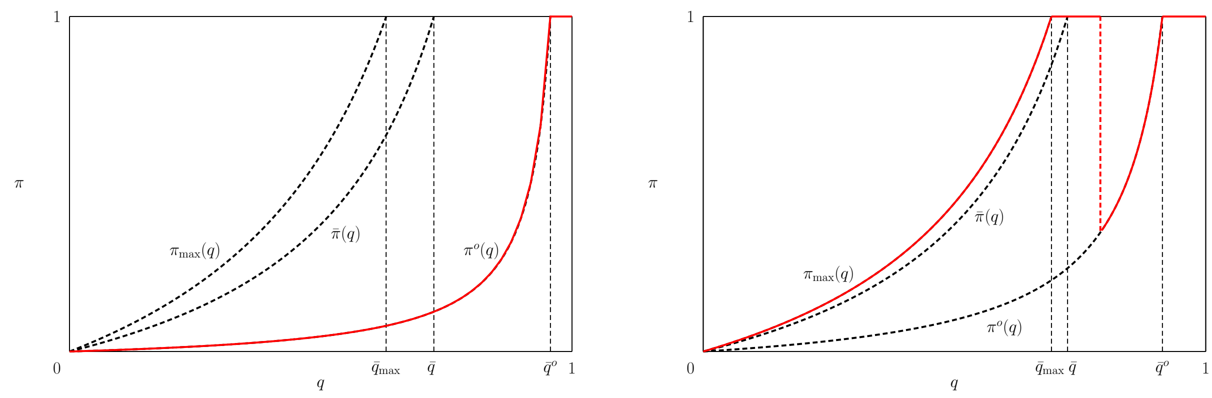
$$\rho > \phi.$$

This is intuitive. If the investor's technology for screening out lemons is not very good (ρ is large) and the mark-up is large (ϕ is small), the expected profit from bringing an extra lemon to the market is positive. Hence, dealers will ask for inaccurate ratings *despite* investors conducting credit assessments. In other words, ratings accuracy is replaced by credit assessments. To the contrary, when those credit assessments are very accurate (ρ small), dealers have an incentive to improve ratings because the assessments are a strategic threat that reduces expected profits.

4.3 Do Credit Assessments Improve Efficiency and Market Stability?

When investors acquire information, dealers face a trade-off between maximizing the volume of trade or minimizing their skin in the game. By choosing an accuracy of $\pi \leq \pi^o(q)$, dealers prevent investors from engaging in credit assessments. They then intermediate less assets, but do not get stuck with lemons that they are unable to sell in the secondary market. The alternative for dealers is to lower the accuracy to $\pi_{\max}(q)$. More assets are then intermediated, but dealers will make a loss of p_σ on a fraction of $(1-\rho)\pi_{\max}(q)$ of lemons that they cannot sell.

What complicates the analysis is that for low levels of quality setting a high accuracy while avoiding credit assessments can lead to a very low volume of trade as only good assets will acquire ratings.



(a) $\rho \leq \phi$

(b) $\rho > \phi$

Figure 4: Equilibrium for $\alpha = 0$

Moreover, for high enough levels of quality dealers can now forego ratings altogether thereby forcing investors to acquire information. This can be profitable, since it decreases the price a dealer needs to offer to an issuer. We only summarize the main findings here and relegate the formal analysis to the Appendix.

To abstract from these complications, we first consider the case where $\alpha = 0$.[27] Hence, ratings are costless and there are no separating equilibria. Figure 4 distinguishes between the cases when the effectiveness of credit assessment ρ is large or small relative to the mark-up ϕ from intermediating assets. The figure shows the two critical values for credit assessment to take place. Above the curve $\pi_{\max}(q)$, there is no trade in the secondary market. Hence, dealers can never choose $\pi > \pi_{\max}$ if they want to sell lemons to investors. Below the graph $\pi^o(q)$, all assets can be resold in the secondary market without investors conducting credit assessments. We denote the values of quality where $\pi^o(q)$ and $\pi_{\max}(q)$ reach 1 by $\bar{q}^o$ and $\bar{q}_{\max}$.

When $\rho \leq \phi$ dealers have no incentive to decrease the accuracy of their ratings. Hence, it is optimal for them to set $\pi = \pi^o(q)$ for all $q \leq \bar{q}^o$. This maximizes the volume of assets and prevents investors to acquire information. The threat of credit assessments makes it optimal for dealers to increase

[27]We view this as the limit case $\alpha \to 0$ where fees are small compared to the face value of securities being issued which seems to be empirically relevant.

the accuracy of ratings. When $\rho > \phi$, dealer profits will increase with lower accuracy. Dealers prefer to maximize the volume of trade by making an unconditional offer if and only if

$$\rho > \phi + \frac{\pi^o(q)}{\pi_{\max}(q)}(1 - \phi). \tag{19}$$

The ratio $\pi^o(q)/\pi^{\max}(q)$ is independent of q for $\pi_{\max}(q) < 1$ and increasing in q when $\pi_{\max}(q) = 1$. Hence, dealers choose a higher accuracy of ratings only above a sufficiently high level of quality as shown in the right-hand graph.

We now turn to the general case where $\alpha > 0$. Recall that this introduces two complications. First, when $\pi \leq \alpha$, we obtain a separating equilibrium. Second, when $\pi = 1$, the profit function of dealers jumps up discretely as they make unconditional offers thereby avoiding the costs of ratings altogether. When $\rho \leq \phi$, it is never profitable for dealers to decrease ratings unless they can forego ratings altogether and make unconditional offers. Hence for $q < \bar{q}_{\max}$, dealers prevent credit assessments by requiring ratings with high accuracy. This is reflected in Figure 5 by the choice $\pi = \alpha$. Once dealers can make unconditional offers, however, their profit margin increases from intermediating all assets. As shown in the example of Figure 5, they will do so, since the effectiveness of credit assessments is not too high, i.e. ρ is sufficiently close to ϕ.[28]

The situation changes when $\rho > \phi$. For low levels of quality, preventing investors from acquiring information would allow dealers only to intermediate good assets. However, intermediating more assets is profitable, even if some cannot be sold in the secondary market. Consequently, $\pi^* = \pi_{\max}(q)$ and investors conduct credit assessments. As shown in the graph, for higher levels of quality, dealers can intermediate some lemons when preventing credit assessments by setting $\pi = \pi^o(q) > \alpha$. As shown in Figure 5, this can be preferable as long as

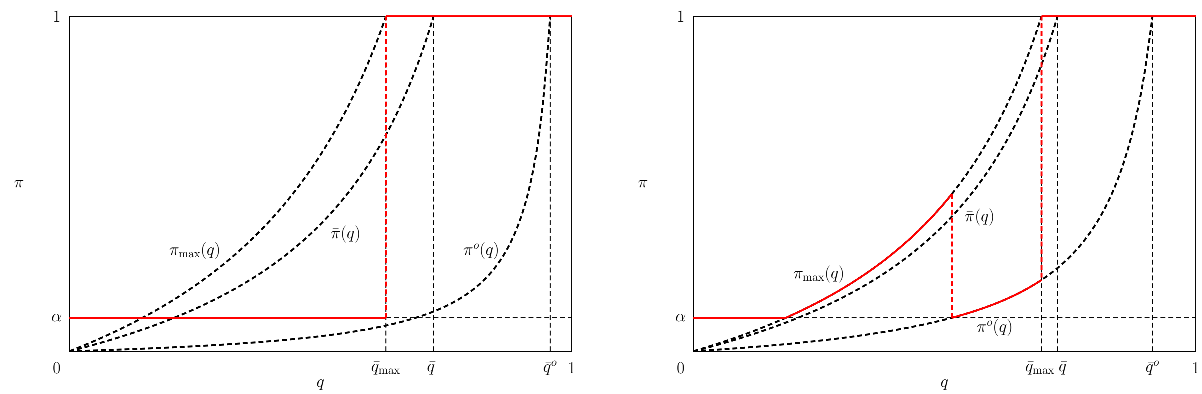
$$\rho < \phi + \frac{\pi^o(q)}{\pi_{\max}(q)}(1 - \phi) \tag{20}$$

and $q < \bar{q}_{\max}$ so that the ratio $\pi^o(q)/\pi^{\max}(q)$ is again a constant. At a level of quality equal to $\bar{q}_{\max}$ dealers can once again increase profits by making unconditional offers.

These results allow us to characterize how effective credit assessments are in promoting market stability. By Assumption 7, either ratings or credit assessments will be used for any $q \leq \bar{q}^o$. Furthermore, it is straightforward to verify that

$$\rho \min\{\pi_{\max}(q), 1\} < \bar{\pi}(q) < \min\{\pi_{\max}(q), 1\}$$

[28] See the appendix for the exact condition.



(a) $\rho \leq \phi$

(b) $\rho > \phi$

Figure 5: Equilibrium for $\alpha > 0$

for all $q < \bar{q}$. This implies that less lemons will reach the secondary market for any level of quality $q > \underline{q}$. Consequently, our measure of market fragility m_f will increase. Markets become more stable no matter whether credit assessments are only a threat to increase ratings accuracy or are in fact carried out.

For low levels of quality ($q < \underline{q}$), however, credit assessments can make markets more fragile provided that these assessments are not very effective (ρ large). The reason is that without credit assessments being available, dealers have to use very accurate ratings to screen out all lemons in order to create a liquid secondary market. With credit assessments, dealers can reduce the accuracy of ratings, so that some lemons reach the secondary market. This is for example the case in the right-hand graph of Figure 5 when $\pi_{\max}(q)$ is close to, but above α.

Proposition 10. *For $q > \underline{q}$, markets always become more stable.*

For $q < \underline{q}$, markets become less stable whenever credit assessments are being used.

Turning to efficiency, credit assessments do not necessarily lead to an equilibrium where only good assets are issued. Costs can then increase for two reasons. If credit assessments are not used, ratings are more accurate and, hence, more expensive. Once credit assessments are used, there is a duplication of costs which – depending on parameters – can lead to a cost increase. Hence, this gives rise to a trade-off between market stability and efficiency. For low levels of quality, one can achieve full efficiency and more stability only when credit assessments are cheap and very effective (both κ and ρ are low). To the contrary, for high levels of quality ($q > \bar{q}$), credit assessments are being conducted even though trading in the secondary market would be possible without them. While the market becomes again more stable, trading is always less efficient.[29]

A final remark is in place with respect to market structure. Suppose future investors cannot observe the initial transaction between dealers and investor, but can also acquire information through credit assessments. In such a set-up, the investors' decision to acquire information become a strategic complements.[30] If future investors acquire information, today's investors have a larger incentive to also acquire information. Upon buying a lemon, there is a probability $(1-\rho)$ that a future investor will be detecting the lemon. Assuming that investors always detect the same lemons when acquiring information, the value of a lemon for an investor is then given by $v_\ell = \rho\beta v_s < \beta v_s$. Consequently, investors have more incentive to acquire information. Notwithstanding, another equilibrium is supported by future investors not acquiring information tomorrow when today information is not being acquired either. Hence, a more general set-up leads to equilibrium outcomes that are identical to the one studied here and would strengthen our results.

5 Credit Enhancements and Dealer Incentives

Markets for tradeable debt have often put in place credit enhancements that are provided by dealers that intermediate the issuance of such assets. Should trading in secondary markets dry up, these enhancements require dealers to make the market and buy the asset at some – often preagreed – price from investors. Such provisions, if enforceable, could change the incentives for dealers to intermediate assets. Being faced with the prospect of buying back bad assets, dealers once again have skin in the game.

To analyze credit enhancements, we make one important change to the environment. Every period after the initial sale of assets into the secondary market, with probability $1-\gamma$ an event occurs

[29] We have abstracted here from the issue that ratings are a public good, while in-house assessments are usually private. Hence, another inefficiency is that in-house assessments – unlike ratings – need to be replicated whenever an asset is being traded.

[30] See for example Hellwig and Zhang (2012) in the context of the set-up studied by Chiu and Koeppl (2016).

such that trading in the secondary market stops. This causes the accuracy of ratings necessary for trading without credit enhancements to be given by

$$\pi \leq \bar{\pi}_\gamma = \frac{q}{1-q}\left(\frac{x}{\delta - x}\right)\left(\frac{1-\beta}{1-\gamma\beta}\right) \tag{21}$$

since lemons can only be resold with probability γ while good assets still have a value of v_s to an investor even without trading. This threshold is the new equilibrium accuracy for ratings without credit enhancements.

In what follows, we look at two different enhancements. With the first one, dealers offer a *liquidity backstop* where investors can sell their assets at a pre-agreed price when trading stops. With the second one, dealers sell assets in combination with a *credit default swap* that insures against purchasing a bad asset that cannot be sold anymore in the market.[31]

5.1 Liquidity Backstop

Suppose dealers are required to repurchase assets from investors at a predetermined price of τv_s, where $\tau \in (0, 1]$, in the event that assets are not traded anymore in the secondary market. Note that the liquidity backstop is worthless for investors with good assets, since their valuation of the asset is v_s. Consequently, the backstop does not add any value in a separating equilibrium and we concentrate on the case where $q > \underline{q}$.

Since trading stops with probability $1 - \gamma$, an investor is willing to purchase an asset if and only if

$$\frac{q}{q + (1-q)\pi} v_o + \frac{(1-q)\pi}{q + (1-q)\pi}(\gamma\beta v_s + (1-\gamma)\beta\tau v_s) - p \geq 0 \tag{22}$$

whenever the accuracy of ratings satisfies $\pi > \alpha$. This takes into account that investors value the option of being able to sell lemons to dealers when trading on the secondary market shuts down. Investors will make an offer of $p = v_s$ – and, consequently, there will be trade in the secondary market – whenever

$$\pi \leq \left(\frac{q}{1-q}\frac{x}{\delta - x}\right)\left(\frac{1-\beta}{1-\gamma\beta-(1-\gamma)\tau\beta}\right). \tag{23}$$

Hence, the option to obtain liquidity ($\tau > 0$) relaxes the constraint for trading in the secondary market allowing dealers to set a lower accuracy of ratings.

[31]Note that the stop in trading is not related to an unanticipated change in the quality of assets that we have used to define our measure of market stability. Removing asset thus does not influence whether trading resumes after the shock.

Dealers then face again two margins. Increasing the backstop τ allows them to reduce rating accuracy so that more lemons can be issued in the primary market and sold off to investors in the secondary market. This, however, decreases the expected revenue for dealers per transaction as dealers might have to buy back lemons in the future. This expected cost of the backstop is

$$\left(\frac{1-\gamma}{1-\gamma\beta}\right)\beta\tau v_s \tag{24}$$

per lemon that is being sold by a dealer in the secondary market. The dealer's profit is given by

$$(q+(1-q)\pi)\,(p-p_\sigma)-(1-q)\pi\left(\frac{1-\gamma}{1-\gamma\beta}\right)\beta\tau v_s. \tag{25}$$

which – using the binding constraint (23) – is decreasing in τ. The expected costs of the backstop outweigh the gains from intermediating more assets. Consequently, dealers have no incentive to agree to a liquidity backstop.[32] Requiring a backstop, however, can induce dealers to choose more accurate ratings so that the market becomes more stable.

Proposition 11. *If $\phi \geq \frac{1-\beta}{1-\gamma\beta}$, there exists a sufficiently high value τ for the liquidity backstop such that dealers choose an efficient ratings accuracy ($\pi = \alpha$) and that the market is stable with $m_f = 1$. Otherwise, the accuracy of ratings will be lower with a required liquidity backstop leaving the market as fragile as without the backstop ($m_f = 0$).*

With a required backstop at any level $\tau \in (0,1]$, dealers can face expected losses from intermediating lemons. This is the case whenever the backstop is sufficiently likely to come into effect (γ low) and the mark-up earned from intermediating assets is sufficiently small (ϕ close to 1). Consequently, a sufficiently high τ will induce dealers to increase the accuracy of ratings to obtain a separating equilibrium. The backstop, however, cannot exceed $\tau = 1$ which means that assets cannot be bought back at a price above v_s.[33] This explains the condition given in the proposition. Interestingly, the backstop can, however, lead to a fall in the accuracy of ratings. If the backstop is not expensive enough, dealers still have positive profits from intermediating lemons. In this case, they have an incentive to lower the accuracy of ratings so that more lemons are traded in the market.

[32] This appears to be inconsistent with the structure of many asset-backed securities where dealers explicitly provide a liquidity backstop. Such backstops, however, proved to be not enforceable in the financial crisis as dealers refused to acknowledge that market circumstances were consistent with applying the backstop.

[33] Any requirement with $\tau > 1$ is not consistent with trading on the secondary market, as good asset would not be traded anymore, but immediately sold back to dealers. This is inefficient and dealers would have no incentive to intermediate the market.

5.2 Credit Default Swaps

Credit default swaps (CDS) insure against losses on debt instruments. When selling assets, dealers are now required to sell such a contract to investors that purchase an asset. We make two assumptions with respect to the CDS contract. First, the insurance will only kick in when assets cannot be sold in the secondary market.[34] Second, the payout from the contract is $v_s = (\delta - x)/(1-\beta)$ and a fee α_0 must be paid to the dealer whenever the asset is being resold on the market.[35] These assumptions keep the analysis simple, since the price of an asset when it is being resold among investors is $p = v_s$ and investors with good assets do not have an incentive to exercise the CDS contract.

The underlying asset and the CDS are, thus, sold as a "bundle" and cannot be split into two separate transactions. After the initial sale by dealers, investors will purchase the bundle in the secondary market if and only if

$$\frac{q}{q+(1-q)\pi}(v_o - \alpha_0) + \frac{(1-q)\pi}{q+(1-q)\pi}(v_\ell - \alpha_0) - p \geq 0, \tag{26}$$

where p is paid to the seller of the asset and α_0 to the dealer. The value of a lemon is given by $v_\ell = \beta v_s$ since either the lemon can be resold or the CDS kicks in. Trade in the secondary market thus requires

$$\pi \leq \frac{q}{1-q}\left(\frac{x-\alpha_0}{\delta - x + \alpha_0}\right). \tag{27}$$

Hence, the CDS premium being a cost of trading tightens the constraint for trade in the secondary market.

When lemons get issued, the fair value of the insurance is given by

$$\alpha_0 = (1-\gamma)\beta v_s \left(\frac{(1-q)\pi}{q+(1-q)\pi}\right), \tag{28}$$

since the probability of a market breakdown next period is $1-\gamma$ in which case an investors receives the value of the asset v_s conditional on holding a lemon. Using this in our expression for the minimum accuracy we have that $\pi = \bar{\pi}_\gamma$. In other words, when the CDS is fairly priced, the expected cost and benefit from the insurance just net out. Similarly, the constraint for dealers

[34] The insurance is against the asset losing its resale value, and not against missing a periodic payment from the asset.

[35] Since assets are resold once per period, this corresponds to a premium per period.

on inducing trade in secondary markets becomes tighter if and only if the insurance is less than actuarially fair. Investors pay too much for the insurance which reduces their surplus from trade.

In the initial purchase of assets in the secondary market, investors can now pay less than $v_s = (\delta - x)/(1-\beta)$, since dealers can now obtain revenue from two sources – the initial sale and the future premiums of the CDS contract. The expected benefit from the CDS premiums is given by

$$\frac{\alpha_0}{1-\gamma\beta}$$

so that the initial purchase price of investors is given by

$$\tilde{p} = v_s - \frac{\alpha_0}{1-\gamma\beta}. \tag{29}$$

The investor thus pays a total of $\tilde{p} + \alpha_0$ to the dealer. Importantly, a dealer with a good asset will have no expected gain from selling the CDS contract. To the contrary, selling a lemon involves the expected cost from the CDS contract which is given by

$$\left(\frac{1-\gamma}{1-\gamma\beta}\right)\beta v_s.$$

This yields the following result.

Proposition 12. *If $\phi \geq \frac{1-\beta}{1-\gamma\beta}$, dealers will choose the efficient ratings accuracy ($\pi = \alpha$) so that markets are stable ($m_f = 1$), when required to sell assets together with a CDS contract in a bundle.*

Otherwise, the rating accuracy and market stability will improve if and only if the CDS premium is more expensive than its actuarially fair value.

Since dealers have no market power, they can generate only a total of v_s in revenue from the sale of an asset. Dealers, however, need to obtain this revenue partly from the CDS contract. The payoffs from this contract are different depending on the quality of the asset being sold. When the expected cost of writing such a contract also for lemons is larger than the mark-up ϕ from intermediating such assets, there is no incentive to do so. In this case, dealers choose to screen out all lemons.[36] Interestingly, this result is independent of the pricing of the CDS contract and depends only on the fact that lemons carry an additional cost when being intermediated. The pricing of the bundle implies that part of the revenue for dealers comes from future transactions.

[36] Note that in equilibrium, the CDS contract could then be cheap. In fact, $\alpha_0 = 0$ would be the actuarially fair premium, since the contract has no value for investors.

5.3 Comparing Backstop and CDS

Both types of credit enhancements cause dealers to have skin in the game. Issuing lemons is costly for dealers when trading in the secondary market is disrupted. However, the two measures work very differently, with the backstop being a punishment and the CDS contract a profit opportunity. This is reflected how these enhancements change the incentives for investors to trade in the secondary market. With a backstop less accurate information is required for trading in the secondary market as it gives a pure benefit to investors. To the contrary, for a CDS contract more accurate information is required, since investors need to pay an insurance premium.

Turning to the incentives for dealers, the backstop is a pure liability arising from intermediating the assets. With a backstop, dealers will have to buy assets back and reimburse investors that cannot sell lemons in the market. While dealers have no incentive to agree to such a backstop, once required to do so their margin to increase profits by intermediating more lemons shrinks. In other words, the backstop works like a penalty from intermediating lemons. If the expected cost from the backstop is large enough, dealers have an incentive to only intermediate good asset by setting $\pi = \alpha$ so that lemons never reach the market.

The CDS contract, however, offers an additional profit opportunity for dealers. They can now extract surplus from both transactions, issuing aasets and writing insurance. The question for dealers thus becomes how to best extract surplus from investors – either selling insurance or intermediating more lemons. When CDS contracts are fairly priced, issuing good assets has no cost for dealers, while issuing lemons involves a cost due to the expected payout from the CDS contract. If the margin from intermediating asset is sufficiently small, they will have no incentive to bring lemons to the secondary market.[37]

[37] We have only analyzed here how the accuracy of ratings changes when these enhancements are employed. A related question is how trading *in the future* is influenced by such enhancements when there are unanticipated shocks to quality and dealers need to purchase back bad assets. Here we only point out that, as the accuracy of ratings increases, our measure of market stability m_f increases. This simply means that larger shocks to quality are required to bring trading to a halt in the secondary market. Such a shock, however, is unrelated to the market disruption which occurs with a positive probability γ.

6 Conclusion

This paper shows that inaccurate ratings arise whenever assets are traded in an OTC market structure where dealers have bad incentives to provide investors with sufficient information on these assets. Our main conclusion is consistent with the narrative of Calomiris and Mason (2009) who point out that "... conflicts of interest on the buy side of the market, between intermediaries and ultimate investors, offer the best explanation for persistent, prevalent low-quality ratings."

Having a structural model in hand allows us to evaluate various regulatory proposals from this perspective. We find that existing proposals to enhance rating transparency are unlikely to solve the problem of insufficiently accurate ratings that undermine market stability. Instead, regulation needs to force dealers to have skin in the game by introducing market reform, credit assessment by investors or credit enhancements by dealers.

While we intentionally keep the model simple and tractable, its main conclusions are robust to several modifications. As shown in the Online Appendix, introducing CRAs formally – no matter whether there is a single or multiple competing CRAs – and endogenizing the rating fee will not affect the message of the paper. Similarly, our results do not depend on specific assumptions about the details of the market structure and pricing arrangements. In the Online Appendix, we consider a general optimal contracting problem where the CRA and the dealer jointly design and offer a contract to issuers in the primary market. Our conclusions remain unchanged.

Finally, we have abstracted from some potentially interesting aspects. First, we assume exogenous endowments of good and bad assets. Hence the model cannot study how inaccurate credit ratings might generate bad incentives for the creation of bad assets. We doubt, however, that including this channel would overturn our results. Second, we only focus on initial ratings when assets are first issued. By allowing dynamic rating adjustments, one can examine the behaviour of credit rating cycles and investigate whether ratings can be excessively procyclical over time. We leave this interesting question for future work.

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A Appendix – Formal Analysis for Section 4

The following result summarizes the use of credit assessments in equilibrium as a function of the parameters (α, ρ, κ). Note that the cost κ influences the functions $\pi_{\max}(q)$ and $\pi^o(q)$.

Proposition A.1. *Dealers choose $\pi^* = \max\{\alpha, \pi^o(q)\}$ if and only if one of the following conditions is met:*

(i) $\alpha \geq \pi_{\max}(q)$

(ii) $\pi_{\max}(q) > \alpha \geq \pi^o(q)$ *and* $q < \bar{q}_{\max}$ *and* $\rho \leq \phi$

(iii) $\pi_{\max}(q) > \alpha \geq \pi^o(q)$ *and* $q \geq \bar{q}_{\max}$ *and* $\rho \leq \phi\left(1 - \frac{\alpha}{1-q}\right)$

(iv) $\alpha < \pi^o(q)$ *and* $q < \bar{q}_{\max}$ *and* $\rho \leq \phi + \frac{\pi^o(q)}{\pi_{\max}(q)}(1-\phi)$

(v) $\alpha < \pi^o(q)$ *and* $q \geq \bar{q}_{\max}$ *and* $\rho \leq \left(1 - \frac{\alpha}{1-q}\right)\phi + \pi^o(q)(1-\phi)$.

In all these case, ratings become more accurate and investors do not carry out credit assessments.

We establish this result by proving the following two lemmata.

Lemma A.2. *Suppose $\rho \leq \phi$.*

For $q \in [0, \bar{q}_{\max})$, dealers set the accuracy of ratings to $\pi^* = \max\{\alpha, \pi^o(q)\}$ and no credit assessments take place.

For $q \in [\bar{q}_{\max}, \bar{q}^o)$, dealers set the accuracy of ratings to $\pi^* = 1$ so that credit assessments take place

(i) if $\alpha \geq \pi^o(q)$ and

$$\rho > \left(1 - \frac{\alpha}{1-q}\right)\phi$$

and

(ii) if $\alpha < \pi^o(q)$ and

$$\rho > \left(1 - \frac{\alpha}{1-q}\right)\phi + \pi^o(q)(1-\phi).$$

Otherwise, $\pi^* = \max\{\alpha, \pi^o(q)\}$ and no credit assessments take place.

Proof. For the first statement, we have $\pi_{\max}(q) < 1$.

When $\pi_{\max}(q) \leq \alpha$, only separating equilibria are feasible. For $\pi^o(q) \leq \alpha < \pi_{\max}(q)$, we have that

$$q(p - p_\sigma) > (q + (1-q)\rho)p - (1-\alpha)p_\sigma$$

for all π since $\rho \leq \phi$. Hence, dealers prefer to set $\pi^* = \alpha$. For $\alpha < \pi^o(q)$ the left-hand side increases by $(1-q)\pi^o(q)$ since dealers can now also sell some lemons.

For the second statement, we have that $\pi_{\max}(q) = 1$ and dealers can make unconditional offers. Note that Finally, note that $\pi^o(q)$ is preferred to any $\pi \in (\pi^o(q), 1)$ since $\rho \leq \phi$.

Consider first $\pi^o(q) \leq \alpha$. Dealers prefer $\pi^* = 1$ when

$$q(p - p_\sigma) < (q + (1-q)\rho)p - (1-\alpha)p_\sigma$$

or, equivalently, when

$$\rho > \left(1 - \frac{\alpha}{1-q}\right)\phi.$$

Next consider $\alpha < \pi^o(q)$. Then, dealers can sell and additional amount of $(1-q)\pi^o(q)$ lemons with a conditional offer. Dealers prefer $\pi^* = 1$ when

$$(q + (1-q)\pi^o(q))(p - p_\sigma) < (q + (1-q)\rho)p - (1-\alpha)p_\sigma$$

or, equivalently, when

$$\rho > \left(1 - \frac{\alpha}{1-q}\right)\phi + \pi^o(q)(1-\phi).$$

□

Lemma A.3. *Suppose $\rho > \phi$.*

When $\alpha \geq \pi^o(q)$ and $q < \bar{q}_{\max}$, dealers set the accuracy of ratings to $\pi^* = \max\{\alpha, \pi_{\max}(q)\}$ so that credit assessments take place whenever $\alpha < \pi_{\max}(q)$. When $\alpha \geq \pi^o(q)$ and $q \geq \bar{q}_{\max}$, dealers set the accuracy of ratings to $\pi^* = 1$.

When $\alpha < \pi^o(q)$, dealers set the accuracy of ratings to

(i) $\pi^* = \pi_{\max}(q)$ if $q < \bar{q}_{\max}$ and

$$\rho > \phi + \frac{\pi^o(q)}{\pi_{\max}(q)}(1-\phi)$$

and

(ii) $\pi^* = 1$ *if* $q \geq \bar{q}_{\max}$ *and*

$$\rho > \left(1 - \frac{\alpha}{1-q}\right)\phi + \pi^o(q)(1-\phi).$$

In these cases, credit assessments take place.

Otherwise, $\pi^* = \pi^o(q)$ *and no credit assessments take place.*

Proof. For $\pi_{\max}(q) \leq \alpha$, any $\pi \leq \alpha$ maximizes a dealer's profits. Note that profits are increasing for dealers in lowering the accuracy of ratings whenever $\pi > \pi^o(q)$ since $\rho > \phi$.

Consider next the case where $\pi^o(q) \leq \alpha < \pi_{\max}(q)$. For any $\pi < 1$, dealers prefer to lower the accuracy if

$$q(p - p_\sigma) < (q + (1-q)\rho\pi)p - (q + (1-q)\pi)p_\sigma$$

or

$$\rho > \phi.$$

When $\pi = 1$, dealers can make unconditional offers which lowers the price to $(1-\alpha)p_\sigma$. This completes the proof of the first statement.

Consider now the case where $\alpha < \pi^o(q)$. For $q < \bar{q}_{\max}$, dealers prefer to set $\pi = \pi_{\max}(q)$ whenever

$$(q + (1-q)\pi^o(q))(p - p_\sigma) < (q + (1-q)\rho\pi_{\max}(q))p - (q + (1-q)\pi_{\max}(q))p_\sigma.$$

For $q \geq q_{\max}$, the condition is given by

$$(q + (1-q)\pi^o(q))(p - p_\sigma) < (q + (1-q)\rho)p - (1-\alpha)p_\sigma.$$

This proves the second statement. □

B Appendix – Omitted Proofs

Proof of Proposition 2

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

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

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

$$q \geq 1 - \frac{x}{\delta}. \tag{B.2}$$

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

$$v_o - v_s \geq 0. \tag{B.3}$$

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

$$qv_o + (1-q)\pi v_\ell - v_s \geq 0. \tag{B.4}$$

This is the case whenever

$$\pi \leq \frac{q}{1-q}\frac{x}{\delta - x}. \tag{B.5}$$

□

Proof of Proposition 3

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

For $q \leq 1 - \frac{x}{\delta} = \bar{q}$, there can only be trade in the secondary market if $\pi \leq \max\{\bar{\pi}(q), \alpha\}$. Note that the critical value for $\bar{\pi} = \alpha$ is given by

$$\underline{q} = \frac{\alpha(\delta - x)}{\alpha\delta + (1-\alpha)x}.$$

Suppose first that $q < \underline{q}$ or, equivalently, that $\bar{\pi}(q) \leq \alpha$. This implies that trade in the secondary market is only possible with a separating offer where $\pi \leq \alpha$. The dealer thus compares an unconditional offer and holding the security with making a conditional offer and selling assets with a good rating in the secondary market. The profit function for a dealer is given by

$$q(p - p_\sigma) = q\left(v_s - \frac{1}{1-\alpha}\frac{\delta - y}{1-\beta}\right) > 0 \tag{B.6}$$

Hence,

$$y - x \geq \frac{\alpha}{1-\alpha}(\delta - y) \tag{B.7}$$

which is fulfilled by Assumption 1. An unconditional offer implies that dealers need to hold the security as there cannot be trade in the secondary market. If the dealer holds the asset, he only derives a payoff v_s from a good asset, but none from the lemons. The cost from acquiring an asset is given by p_0. The expected payoff from an unconditional offer and holding the asset is dominated by a conditional offer if and only if

$$qv_s - p_0 < q\left(v_s - \frac{1}{1-\alpha}\frac{\delta - y}{1-\beta}\right) \tag{B.8}$$

or

$$q < 1 - \alpha \tag{B.9}$$

which is again ensured by Assumption 1.

Suppose next that $q \in (\underline{q}, \bar{q})$ or, equivalently, $\alpha < \bar{\pi}$. For a conditional offer, the profit function for a dealer is now given by

$$(q + (1-q)\pi)(p - p_\sigma)$$

and, thus, is increasing in π. Hence, the optimal choice of π is $\bar{\pi}$ to have trade in the secondary market. Since the volume for the dealer with a conditional offer is now $q + (1-q)\pi > q$, Assumption 1 ensures again that the conditional offer is preferred by dealers over an unconditional offer and holding the security. □

Proof of Proposition 6

Proof. The dealer chooses between making a conditional offer with $\pi > \alpha$ (partial screening), a conditional offer with $\pi \leq \alpha$ (perfect screening), and a unconditional offer.

First, a conditional offer with $\pi \leq \alpha$ dominates one with $\pi > \alpha$ if and only if

$$q\left(\frac{\delta}{1-\beta} - p_\sigma\right) - (q + (1-q)\pi)\left(\frac{q}{q+(1-q)\pi}\frac{\delta}{1-\beta} - p_\sigma\right)$$
$$= (1-q)\pi p_\sigma,$$

which is strictly positive so that dealers prefer perfect screening.

Next, a conditional offer with $\pi \leq \alpha$ dominates an unconditional offer if and only if

$$q\left(\frac{\delta}{1-\beta} - p_\sigma\right) - \left(q\frac{\delta}{1-\beta} - p_0\right),$$

or

$$1 - \alpha > q$$

which completes the proof. □

Proof of Proposition 11

Proof. A dealer's additional expected revenue from intermediating lemons is given by

$$(1-q)\pi\left[p - p_\sigma - \left(\frac{(1-\gamma)\beta}{1-\gamma\beta}\right)\tau p\right].$$

This expression is negative whenever

$$\tau \geq (1-\phi)\left(\frac{1-\gamma\beta}{(1-\gamma)\beta}\right).$$

The proposition now follows from the requirement that $\tau \in (0, 1]$. □

Proof of Proposition 12

Proof. A dealer compares the profits from buying only good assets ($\pi = \alpha$) with intermediating also lemons by an accuracy $\pi > \alpha$. The former is preferred if and only if

$$q(\tilde{p} + \frac{\alpha_0}{1-\gamma\beta} - p_\sigma) \geq (q + (1-q)\pi)(\tilde{p} + \frac{\alpha_0}{1-\gamma\beta} - p_\sigma) - (1-q)\pi\left(\frac{1-\gamma}{1-\gamma\beta}\right)\beta v_s,$$

where the last term reflects the fact that CDS contracts are only costly when selling lemons into the secondary market. Since $\tilde{p} = v_s - \alpha_0/(1-\gamma\beta)$, this reduces again to the condition

$$\phi \geq \left(\frac{1-\beta}{1-\gamma\beta}\right).$$

Note that this expression is independent of the value α_0. If the condition does not hold, it follows directly that dealers have an incentive to increase the accuracy of ratings will increase if and only if

$$\alpha_0 > (1-\gamma)\beta v_s \left(\frac{x}{x + v_s(1-\gamma\beta)} \right)$$

where the right-hand side of the inequality is the actuarially fair value of insurance. $\square$