Additional Appendices

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Appendix C A Setup with Active Credit Rating Agencies

In the benchmark model, CRAs are just seen as a technology that does not make any decision decision on the fee α, nor on the accuracy π. In this appendix, we consider three alternative setups.

1. The fee α is exogenous, but the accuracy π is chosen by a monopolist CRA.
2. Both α and π are chosen by a monopolist CRA.
3. Both α and π are chosen by a competitive CRAs.

C.1 A monopolist CRA choosing π

A monopolist operates a rating technology that provides information about the quality of the asset. The rating fee is still fixed which is a constant fraction α of the price offered by the dealer. But the accuracy parameter π is chosen by the CRA, who needs to pay a rating cost $k(\pi)$ per unit of the asset, with $k'(\pi) < 0$. In this setup, the trading in the secondary market remains unchanged and, thus, Proposition 2 is still valid. In the primary market, dealers no longer choose π directly. Instead they take π and α as given and determine whether to make an unconditional offer, a conditional offer or no offer at all. This leads to a slightly modified version of Proposition 3.

Proposition C.1. *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.

The rating accuracy π is now chosen by the rating agency. 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

Figure 1: Distribution of Equilibrium in (q, π) space (δ=2, β=0.9, x=0.55, α=0.1, y=0.8)

the demand (as a function of π) as given and sets its accuracy π such as to maximize its profits. Fix the average quality of assets q. Then, from Proposition C.1 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 assume here that issuing ratings always leads to non-negative profits.[1] The rating agency will then maximize demand for its ratings which leads to the following characterization of equilibrium.

Proposition C.2. *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 a measure $q\frac{x}{\delta - x}$ *of bad assets if* $q \in (\underline{q}, \bar{q})$.

The green line in Figure 1 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 ratings 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.

C.2 A monopolist CRA choosing π and α

Suppose now that the monopolist 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, under our assumptions, dealers do not intermediate the market. Since ratings are costly, for any given fee α, the CRA chooses an accuracy equal to

$$\pi = \max\{\alpha, \tilde{\pi}(q)\}. \quad \text{(C.1)}$$

[1] See equation (C.7) below for a sufficient condition that guarantees that this assumption is fulfilled.

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

$$\alpha \leq \frac{y-x}{\delta - x}. \tag{C.2}$$

Second, there is an extensive margin. If $\alpha \geq \bar{\pi}(q)$, only the fraction q of good issuers will 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.[2]

Proposition C.3. *For $q \in (1 - \frac{x}{y}, \bar{q})$, the CRA sets fees to*

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

and the accuracy to $\pi^* = \bar{\pi}(q)$ 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 $\alpha^* = \pi^* = \bar{\pi}(q)$ to achieve a pooling equilibrium.

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

$$\alpha = \frac{y-x}{\delta - x} \leq \bar{\pi}(q) = \frac{q}{1-q}\frac{x}{\delta - x} \tag{C.3}$$

or

$$q \geq 1 - \frac{x}{y} \tag{C.4}$$

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 $\alpha = \pi = \bar{\pi}(q) < \alpha^*$ yields a pooling equilibrium. The former yields a larger profit if and only if

$$\left(\frac{y-x}{1-\beta}\right) - k(\alpha^*) \geq \frac{x}{(1-q)\delta - x}\left(\frac{\delta - y}{1-\beta}\right) - \frac{k(\bar{\pi}(q))}{q}. \tag{C.5}$$

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

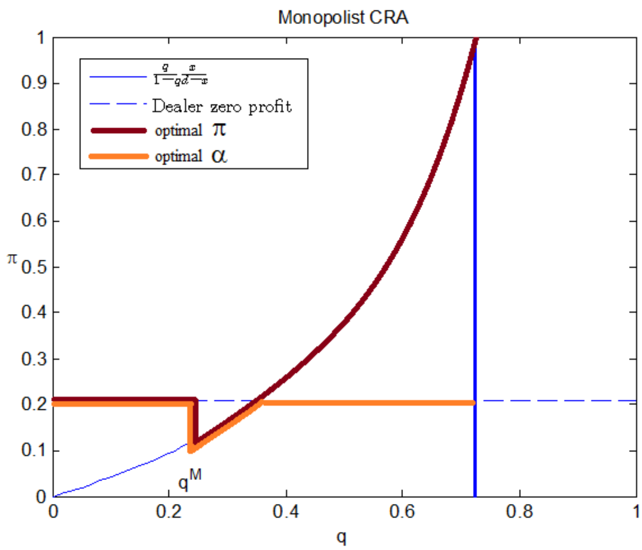

Figure 2: Equilibrium with optimal fee α^*

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. $\square$

Figure 2 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.

C.3 Competitive 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

$$\alpha p_\sigma = k(\pi). \tag{C.6}$$

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 $\pi = \max\{\alpha, \bar{\pi}(q)\}$ in equilibrium. If this were not the case (i.e. $\pi < \alpha$ or $\pi < \bar{\pi}$), then a CRA could decrease its accuracy (higher π) and assume all demand from dealers when $\bar{\pi}(q) > \alpha$ or lower its costs when $\alpha > \bar{\pi}(q)$. 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

$$\frac{\alpha^C}{1-\alpha^C}\frac{\delta - y}{1-\beta} = k(\alpha^C). \tag{C.7}$$

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 $\pi = \max\{\alpha, \bar{\pi}(q)\}$, 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 C.4. *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* $\alpha < \pi = \bar{\pi}(q)$.

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

Proof. Consider first that $\alpha = \alpha^C < \bar{\pi}(q)$. Zero profits in any pooling equilibrium imply then that $\alpha < \alpha^C < \pi = \bar{\pi}(q)$. Consider any combination of (α, π) that constitutes a separating equilibrium. This would require a higher fee $\alpha = \bar{\pi}$ 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 $\alpha^C \geq \bar{\pi}(q)$. 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 $\pi \leq \bar{\pi}(q)$ then requires that $\alpha > \pi$. Hence, such a deviation is not feasible. $\square$

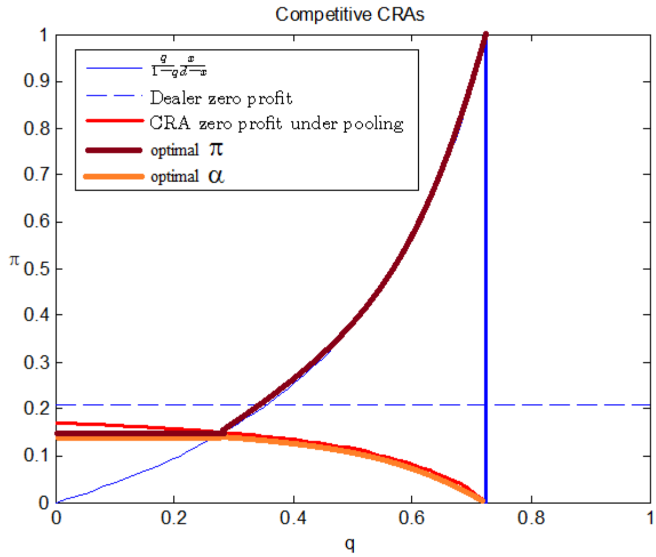

Figure 3: Equilibrium with competitive fee α^C

Figure 3 shows the resulting equilibria with competition among CRAs. For low quality assets, zero profit equilibria with pooling are not feasible. Consequently, equilibrium are such that only good assets are being issued and traded. However, when the quality of assets improves sufficiently, 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 lemons to be issued, 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 may lead to more lemons being issued for some intermediate levels of quality q. This can be interpreted as a race to the bottom in ratings quality and prices.

Appendix D Optimal Contracts in the Primary Market

In the benchmark model, we have focused on a specific market structure, pricing arrangement and surplus sharing rule. We now show that the main idea of our results also arises in a more general setting. To do so, we consider the following optimal contracting problem. The CRA and the dealer jointly design and offer a contract to issuers in the primary market. They maximize and share their joint payoffs, and take into account the effect of their choices on equilibrium trading in the secondary market. As such we are not concerned on how these joint profits are shared between the CRA and the dealer, so that the optimal contract looks at how to extract the most surplus from intermediating the assets. We maintain the assumption that buyers in the secondary market make a take-it-or-leave-it-offer to dealers.

The CRA & dealer ask issuers to report their types and possibly conduct ratings. Conditional on the report and rating outcome, the CRA & dealer then make transfers $T_{ij} \in \{T_{\ell\ell}, T_{\ell s}, T_{s\ell}, T_{ss}\}$ to the issuer, where T_{ij} is the transfer to an issuer who reports that he belongs to type $i \in (\ell, s)$ and gets a type $j \in (\ell, s)$ rating. Importantly, we assume that transfers T_{ij} can be negative, but need to stay above a finite negative lower bound, i.e. $\bar{T} \in (-\infty, 0)$. We focus on the interesting case where ratings are needed for trade, i.e., $q \in (0, \bar{q})$.

Finally, we need to assume a cost function for ratings. The cost function depends on the rating accuracy and is continuously differentiable. Furthermore, we make the following standard assumptions:

- $k'(\pi) < 0$ (i.e. cost are increasing in accuracy)
- $k''(\pi) > 0$ (i.e. marginal costs are increasing in accuracy)
- $k'(0) = -\infty$, $k'(1) = 0$, and $k(1) = 0$.

We will solve for the optimal contract in two steps. First, we derive the joint maximum payoffs for the CRA and dealer payoffs for two different scenarios, when only good assets are rated and when all assets are rated.[3] We then obtain the optimal rating arrangement by comparing these two

[3]The remaining two cases are suboptimal. First, when $q < \bar{q}$, not rating any assets implies no trade in the secondary market. Second, rating only bad assets is always dominated. Ratings are costly and there will be no trade of rated assets in the secondary market, since all investors know that they would not make a profit buying a rated asset.

payoffs. Finally, we discuss how to implement these optimal contracts.

D.1 Only good assets are rated

This case refers to the separating equilibria in the main analysis. Lemons have no incentives to acquire ratings, so that when buying a rated asset the investor knows he will buy a good asset. Hence, lemons are never traded. The objective function for the CRA & dealer pair is then given by

$$-(1-q)T_\ell - qT_{ss} - qk(\pi) + q(\delta - x)/(1-\beta). \tag{D.1}$$

Since lemons are not rated, all of them will receive the same transfer, T_ℓ. Good issuer will always be rated and will by our assumption always get a good rating. Hence, they receive T_{ss} and all good assets are rated and traded in the secondary market. Bad assets, on the other hand are not rated and will not be traded.

Next, we develop the constraints for the optimal contract problem. The good issuer's truth-telling constraint is given by

$$T_{ss} - T_\ell \geq 0. \tag{D.2}$$

Since only good assets are rated, the lemon's truth-telling constraint is given by

$$T_\ell - (1-\pi)T_{s\ell} - \pi T_{ss} \geq 0. \tag{D.3}$$

Next the two participation constraints are

$$T_{ss} - (\delta - y)/(1-\beta) \geq 0 \tag{D.4}$$

$$T_\ell \geq 0. \tag{D.5}$$

We note here that only the lower bound for $T_{s\ell}$ can potentially be binding. Hence, we have

$$T_{s\ell} - \bar{T} \geq 0. \tag{D.6}$$

We first proof that we need to have an interior solution for the rating accuracy π.

Lemma D.1. *For all $q \in (0, q)$, we have $\pi \in (0,1)$ in any optimal contract where only good assets acquire ratings.*

Proof. First, set $\pi = 0$. We then have that $T_\ell = 0$ and $T_{ss} = \frac{\delta - y}{1-\beta}$ are feasible and maximize joint profits. This follows from the fact that we can set $0 > T_{sl} = \bar{T}$. Now consider setting $\pi = \epsilon > 0$, where ϵ is sufficiently small. Note first that for ϵ sufficiently close to 0, $T_\ell = 0$ and $T_{ss} = \frac{\delta - y}{1-\beta}$ are still feasible. Since $k'(\pi) < 0$, $\pi = 0$ cannot be optimal.

Next, set $\pi = 1$. The truth-telling constraints imply that $T_\ell = T_{ss} > 0 = (\delta - y)/(1-\beta)$. Suppose we set then $\pi = 1 - \epsilon$ for ϵ sufficiently small. We can set

$$T_\ell = \epsilon \bar{T} + (1-\epsilon) T_{ss} = \epsilon \bar{T} + (1-\epsilon)\left(\frac{\delta - y}{1-\beta}\right)$$

which is feasible. Consider the change in joint profits which is given by

$$\begin{aligned}\Delta &= -qk(1) - (1-q)T_{ss} - \big(-qk(1-\epsilon) - (1-q)\epsilon\bar{T} + (1-\epsilon)T_{ss}\big) \\ &= qk(1-\epsilon) + (1-q)\epsilon(\bar{T} - T_{ss}).\end{aligned}$$

Dividing by ϵ, we obtain

$$\lim_{\epsilon \to 0} q \frac{k(1-\epsilon)}{\epsilon} + (1-q)(\bar{T} - T_{ss}) < 0$$

since $k'(1) = 0$ and $\bar{T} < 0$. Hence, $\pi = 1$ cannot be optimal. $\square$

We establish next that when only good asset obtain ratings, lemons receive a zero profit. In order to accomplish this one needs to assume that the bound $\bar{T} < 0$ is sufficiently negative given any cost function $k(\pi)$. One can set then $T_{s\ell} = \bar{T}$ small enough so that lemons have no incentive to acquire ratings. This corresponds to the fee α in the main analysis, where lemons are afraid that – provided the accuracy π is large enough – they do not expect to recover the fee which is sunk for them when asking for a rating.

Lemma D.2. *Suppose only good assets are rated. If $|\bar{T}|$ is sufficiently large, the optimal contract is given by*

$$\begin{aligned}T_\ell &= 0 \\ T_{ss} &= (\delta - y)/(1-\beta) \\ \pi &= -\bar{T}/(-\bar{T} + T_{ss}).\end{aligned}$$

The CRA & dealer payoff is given by

$$\Pi_1 = -qk(\pi) + q(y-x)/(1-\beta).$$

Proof. The Largragian is given by

$$
\begin{aligned}
\mathcal{L} = &-(1-q)T_\ell - qT_{ss} - qk(\pi) + q(\delta - x)/(1-\beta) \\
&+ \lambda_1(T_{ss} - T_\ell) \\
&+ \lambda_2[T_\ell - (1-\pi)T_{s\ell} - \pi T_{ss}] \\
&+ \lambda_3[T_{ss} - (\delta - y)/(1-\beta)] \\
&+ \lambda_4 T_\ell \\
&+ \lambda_6(T_{s\ell} - \bar{T})
\end{aligned}
$$

The FOC are then

$$T_{s\ell}: \quad -\lambda_2(1-\pi) + \lambda_6 = 0 \tag{D.7}$$

$$T_{ss}: \quad -q + \lambda_1 - \lambda_2\pi + \lambda_3 = 0 \tag{D.8}$$

$$T_\ell: \quad -(1-q) - \lambda_1 + \lambda_2 + \lambda_4 = 0 \tag{D.9}$$

$$\pi: \quad -qk'(\pi) + \lambda_2(T_{s\ell} - T_{ss}) = 0 \tag{D.10}$$

Claim: $T_{ss} > T_\ell$ and, hence, $\lambda_1 = 0$.

If $\lambda_4 > 0$, we have that $T_\ell = 0$ and the result follows. Let $\lambda_4 = 0$, but suppose to the contract that $\lambda_1 > 0$. The FOC (D.9) implies that $\lambda_2 = \lambda_1 + (1-q) > 0$. By assumption, $\lambda_1 > 0$ and, hence, $T_{ss} = T_\ell$. This implies that $T_{ss}(1-\pi) = T_{s\ell}(1-\pi)$. Since $\pi < 1$, we have $T_{ss} = T_{s\ell}$ and hence $T_{s\ell} > 0$ implying $\lambda_6 = 0$ which contradicts the FOC (D.7).

This implies that there only can be two possible solutions, corresponding to $\lambda_4 = 0$ and $T_\ell > 0$ or $\lambda_4 > 0$ and $T_\ell = 0$.

Claim: If $|\bar{T}|$ is sufficiently large, the optimal contract sets $T_\ell = 0$.

Suppose not. Then, $T_\ell > 0$ and $\lambda_4 = 0$. We then have $\lambda_2 = 1 - q > 0$. From the FOC (D.7), it follows that $\lambda_6 > 0$ and, thus, $T_{s\ell} = \bar{T} < 0$. The FOC (D.8) implies again that $T_{ss} = (\delta - y)/(1-\beta)$. The lemon's truth-telling constraint then requires that

$$\pi > \frac{\bar{T}}{\bar{T} - T_{ss}}$$

so that

$$k'(\pi) > k'(\frac{\bar{T}}{\bar{T} - T_{ss}}).$$

We also have from (D.10) that at the solution it must be the case that

$$(1-q)[\bar{T} - T_{ss}] = qk'(\pi).$$

Define now $\hat{T}(q)$ as the unique solution to

$$(1-q)[\hat{T}(q) - T_{ss}] = qk'(\frac{\hat{T}(q)}{\hat{T}(q) - T_{ss}}).$$

Observe that the left-hand side is decreasing in $\hat{T}(q)$ and the right-hand side is increasing in $\hat{T}(q)$. Hence, for any $\bar{T} \leq \hat{T}(q)$, we have

$$k'(\pi) > k'(\frac{\bar{T}}{\bar{T} - T_{ss}}) > \left(\frac{1-q}{q}\right)(\bar{T} - T_{ss})$$

which is a contradiction provided $\bar{T} < \hat{T}(q)$.

Finally, observe that $d\hat{T}(q)/dq < 0$. Hence, one can set $\bar{T} = \hat{T}(\bar{q})$, since we have assumed $q < \bar{q}$.

Claim: If $|\bar{T}|$ is sufficiently large, the optimal contract sets $\pi = -\frac{\bar{T}}{T_{ss} - \bar{T}}$.

Since $T_\ell = 0$, condition (D.8) implies that $\lambda_3 = q + \lambda_2 \pi > 0$ and, hence, $T_{ss} = (\delta - y)/(1-\beta)$. The FOC (D.10) then requires that $-qk'(\pi) + \lambda_2[T_{s\ell} - (\delta - y)/(1-\beta)] = 0$ and, hence, $\lambda_2 > 0$ and $\lambda_6 > 0$. By the lemon's truth-telling constraint, we have $\pi = -\bar{T}/(-\bar{T} + T_{ss})$. □

We briefly discuss how to implement the optimal contract where only good assets acquire ratings. The CRA collects a fixed rating fee $\phi = -\bar{T}$ from all issuers that request a rating. The rating accuracy is set to

$$\pi = \frac{\phi}{\phi + \frac{\delta - y}{1-\beta}}. \tag{D.11}$$

Issuers receive a fixed price

$$P = \frac{\delta - y}{1-\beta} + \phi \tag{D.12}$$

from dealers conditional on obtaining a good rating that also reimburses them for the rating fee. Note that by construction, lemons have no incentive to acquire ratings, since the expected surplus from doing so is negative. Profits can be split between the CRA and dealers according to a fixed fee

$$\Phi \in [0, q\Big((\delta - x)/(1-\beta) - \phi\Big)]$$

paid from dealers to the CRA.

D.2 All assets are rated

When all asset obtain a rating and are traded, the objective function of the CRA & dealer is given by

$$-(1-q)(T_{\ell\ell}(1-\pi) + T_{\ell s}\pi) - qT_{ss} - k(\pi) + (q + (1-q)\pi)(\delta - x)/(1-\beta).$$

The payment to the lemons now depend on the outcome of the rating. The constraints for the CRA & dealer are again the truth-telling constraints for both types

$$\begin{aligned} &T_{ss} - T_{\ell s} \geq 0 \\ &T_{\ell\ell}(1-\pi) + T_{\ell s}\pi - (1-\pi)T_{s\ell} - \pi T_{ss} \geq 0 \end{aligned}$$

and the participation constraints for both types

$$\begin{aligned} &T_{ss} - (\delta - y)/(1-\beta) \geq 0 \\ &T_{\ell\ell}(1-\pi) + T_{\ell s}\pi \geq 0. \end{aligned}$$

In addition, in order to support trading in the secondary market, the rating accuracy has to satisfy

$$\bar{\pi} - \pi \geq 0.$$

Since transfers in the primary market are public information, payments to assets with good ratings have to be the same independent of the report by the issuer in order to induce investors to buy all assets with a good rating in the secondary market. If this were not the case, investors can deduce the asset type from the observable payments. Hence,

$$T_{\ell s} = T_{ss}.$$

This gives us the following result.

Lemma D.3. *Suppose all assets are rated. The optimal contract is given by*

$$T_{ss} = \frac{\delta - y}{1-\beta}$$
$$T_{\ell\ell} = \max\{\frac{-\bar{\pi}}{1-\bar{\pi}} T_{ss}, \bar{T}\}$$
$$T_{s\ell} = \bar{T}$$
$$\pi = \bar{\pi}$$

if $\bar{T} \geq -\frac{y-x}{1-\beta}$.

The CRA & dealer payoff is

$$\Pi_2 = -(1-q)(1-\pi)T_{\ell\ell} + (q + (1-q)\bar{\pi})((y-x)/(1-\beta) - k(\bar{\pi}).$$

Proof. Note that it is always optimal to set $T_{s\ell} = \bar{T}$ since $T_{s\ell}$ does not enter the objective function and lower values for it relax the lemon's incentive constraint. This leaves us with the following Lagrangian

$$\begin{aligned}
\mathcal{L} = &-(1-q)[T_{\ell\ell}(1-\pi) + T_{ss}\pi] - qT_{ss} - k(\pi) + (q + (1-q)\pi)(\delta - x)/(1-\beta) \\
&+ \lambda_2(T_{\ell\ell} - \bar{T}) \\
&+ \lambda_3(T_{ss} - (\delta - y)/(1-\beta)) \\
&+ \lambda_4(T_{\ell\ell}(1-\pi) + T_{ss}\pi) \\
&+ \lambda_5(\bar{\pi} - \pi)
\end{aligned}$$

The FOCs are

$$T_{\ell\ell}: \quad -(1-q)(1-\pi) + \lambda_2 + \lambda_4(1-\pi) = 0 \tag{D.13}$$
$$T_{ss}: \quad -(1-q)\pi - q + \lambda_3 + \lambda_4\pi = 0 \tag{D.14}$$
$$\pi: \quad (1-q)T_{\ell\ell} - (1-q)T_{ss} - k'(\pi) + (1-q)(\delta - x)/(1-\beta) - \lambda_4 T_{\ell\ell} + \lambda_4 T_{ss} - \lambda_5 = 0 \tag{D.15}$$

Claim: $T_{ss} = \frac{\delta - y}{1-\beta}$

Suppose not, then $\lambda_3 = 0$. The FOC (D.14) and the constraint that $\pi \leq \bar{\pi}$ together with $q \in [0, \bar{q})$ imply that $\pi \in (0,1)$. This implies that $\lambda_2 = -q(1-\pi)/\pi < 0$ which is a contradiction.

This allows us to rewrite our problem as follows

$$\max_{\{\pi, T_{\ell\ell}\}} -k(\pi) + q(y-x)/(1-\beta) - (1-q)T_{\ell\ell} + (1-q)\pi((y-x)/(1-\beta) + T_{\ell\ell})$$

subject to

$$T_{\ell\ell} \geq \bar{T}$$

$$T_{\ell\ell} \geq -\left(\frac{\pi}{1-\pi}\right) T_{ss}$$

$$\bar{\pi} \geq \pi.$$

Suppose now that $\bar{T} \geq -\frac{y-x}{1-\beta}$. This implies that the objective function is increasing in π. Also, the constraint set is relaxed as π increases. This implies that $\bar{\pi} = \pi$ at an optimal solution. Moreover, The objective function is decreasing in $T_{\ell\ell}$. Hence,

$$T_{\ell\ell} = \max\{-\frac{\bar{\pi}}{1-\bar{\pi}} T_{ss}, \bar{T}\}$$

which completes the proof. $\square$

We again look at how to implement the optimal contract. Note first that the accuracy is always set to $\pi = \bar{\pi}$. Hence, the CRA is able to determine a fee $\phi = T_{\ell\ell}$. The dealer chooses to purchase all asset with good ratings at a price equal to

$$P = T_{ss} - \phi.$$

Finally, the CRA and the dealer split the profits according to a fee being paid by the dealer in the range

$$\Phi \in [0, (q + (1-q)\bar{\pi})\Big((y-x)/(1-\beta) - \phi\Big)].$$

D.3 Choice of Optimal Contact

Finally, we turn to the choice between the two contracts. The difference in payoffs between rating all assets and rating only good assets is given by

$$\Pi_2(q) - \Pi_1(q) = (1-q)\bar{\pi}\left(\frac{y-x}{1-\beta}\right) - (1-q)(1-\bar{\pi})T_{\ell\ell} - k(\bar{\pi}) + qk(-\frac{\bar{T}}{\bar{T} + (\delta - y)/(1-\beta)})$$

which is increasing in q. Let $q \to \bar{q}$. Then, $\bar{\pi} \to 1$ and $k(\bar{\pi}) \to 0$. Hence, there exists $\hat{q} \in (0, \bar{q})$ such that for all $q \geq \hat{q}$ rating all assets is profit-maximizing for the CRA and dealer.

This confirms that our main result from the benchmark model does not depend on any particular assumptions we have made about the interaction between dealers, CRAs and issuers.

D.4 Example

Lemma B.2 puts an upper bound on $\bar{T}$ while Lemma B.3 puts a lower bound on $\bar{T}$. We now consider an example in which there is a non-empty set of $\bar{T}$ satisfying both conditions.

Suppose $k(\pi) = \pi - \log(\pi) - 1$. Note that it satisfies all the assumed properties. Lemma B.2 requires that $\bar{T} < \hat{T}$ which satisfies

$$(1-q)(\hat{T} - T_{ss}) = q\frac{T_{ss}}{\hat{T}}$$

or

$$(1-q)\hat{T}^2 - (1-q)T_{ss}\hat{T} - qT_{ss} = 0.$$

The condition is thus

$$\bar{T} < \hat{T} = 0.5[T_{ss} - \sqrt{T_{ss}^2 + 4qT_{ss}/(1-q)}].$$

Lemma B.3 requires that

$$\bar{T} \geq -\frac{y-x}{1-\beta}$$

Therefore, the set of $\bar{T}$ satisfying both conditions is non-empty if

$$-\frac{y-x}{1-\beta} < 0.5\left[\frac{\delta-y}{1-\beta} - \sqrt{\left(\frac{\delta-y}{1-\beta}\right)^2 + 4\frac{q}{1-q}\frac{\delta-y}{1-\beta}}\right]$$

or

$$-2(y-x) < \delta - y - \sqrt{(\delta-y)^2 + 4\frac{q(\delta-y)(1-\beta)}{1-q}}$$

This is satisfied for sufficiently large β.

Appendix E Dynamic Information Choice

We sketch here the analysis when every investor has to acquire information himself. Again, given rating accuracy π, investors can detect a fraction $(1-q)\pi$ of bad assets at a cost κ. The acquired information is now private to each investor. To facilitate the analysis, we assume, however, that all investors upon spending κ will detect the same additional lemons.

We first look at the investor's decision to acquire information. An investor takes as given that other investors tomorrow invest in information. His payoff from acquiring information is given by

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

The payoff for an investor not acquiring information is given by

$$\Gamma_0(\pi|q) = \frac{q}{q+(1-q)\pi}v_o + \frac{(1-q)\pi}{q+(1-q)\pi}v_\ell - v_s. \tag{E.2}$$

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 can only sell a lemon if it is not detected tomorrow by an investor so that

$$v_\ell = \rho\beta v_s. \tag{E.3}$$

With probability ρ, the lemon will not be detected by future buyers and be sold for v_s. With probability $1-\rho$, the lemon will always be detected and can never be sold, so that the payoff is zero. This is due to our assumption that the in-house technology always detects the same lemons. 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.

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

$$\Gamma_1(\pi|q) \geq 0 \tag{E.4}$$

and that they have no incentive to deviate

$$\Delta_1(\pi|q) = \Gamma_1(\pi|q) - \tilde{\Gamma}_1(\pi|q) = \frac{(1-q)(1-\rho)\pi}{q+(1-q)\pi}\left(\frac{\delta - x}{1-\beta}\right) - \kappa \geq 0, \tag{E.5}$$

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

$$\Gamma_0(\pi|q) \geq 0 \tag{E.6}$$

and no incentive to deviate

$$\Delta_0(\pi|q) = \Gamma_0(\pi|q) - \tilde{\Gamma}_0(\pi|q) = \kappa - \frac{(1-q)(1-\rho)\pi}{q+(1-q)\pi}(\delta - x) \geq 0, \tag{E.7}$$

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, multiple equilibria are possible. This is due to the strategic complementarity in the investors' decision to acquire information. It is then straightforward to characterize trade equilibria with pooling in the secondary market.

Finally, taking as given the investors' decisions to acquire information, one can characterize as before which accuracy dealers choose in the primary market. One complication arises here that – following the dealers' choice of π – there are multiple equilibria possible. Consequently, the dealer's optimal choice will depend on his belief about which equilibria (with or without information acquisition) will arise in the secondary market.