Strategic certification*

Eloïc Peyrache[†] Lucía Quesada[‡]

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Abstract

In this paper we analyze the role of certification intermediaries as institutions that reduce informational asymmetries. A seller has the possibility to be certified by an institution that owns a technology to discover the true quality and can credibly commit to a disclosure rule. We study the incentives of this institution to disclose information to the buyers. Intermediaries cannot play any role when sellers have alternative efficient ways to signal themselves. Otherwise, intermediaries always play a role. If ex ante nobody is willing to pay for information the intermediary strategically hides the information he acquires and he plays the same role as a signaling device. We then analyze two situations in which information is valuable. First, information works as an insurance for buyers against low quality goods. So, if buyers are risk averse they are willing to pay for information. Second, information works as a differentiation device for sellers, so sellers competing à la Bertrand are willing to pay for information. In both cases, there is some revelation of information, but only partial. Indeed the intermediary discloses information up to the point where the cost of disclosing more information becomes larger than the price agents are willing to pay for it.

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[†]University of Toulouse 1, GREMAQ and CREST-LEI. Manufacture des tabacs, 21 Allée de Brienne, 31000 Toulouse, France. E-mail: eloic.peyrache@univ-tlse1.fr

[‡]University of Toulouse 1, GREMAQ. Manufacture des tabacs, 21 Allée de Brienne, 31000 Toulouse, France. E-mail: lucia.quesada@univ-tlse1.fr

1 Introduction

Certification intermediaries are present in many markets, as agents who provide, among other things, information about quality of goods or services offered by firms. Reputation is the main asset of such certification agents, since this is what makes their announcements credible for receivers. This implies that certification intermediaries who do act strategically will make true reports if they want to keep their reputation. As an illustration of such a firm, JD Power, a powerful US certification intermediary on the car, telecoms and other industries first defines an index that represents the average quality offered by the industry. Then, on the car market, for example, it only discloses information for cars that offer a better quality than this average and classifies cars in alphabetical order for those below the industry average. The goal of this paper is to try to rationalize such strategic behavior in a context in which certification intermediaries cannot afford to lose their reputation by making false reports.

Crawford and Sobel (1982), in their seminal paper, analyze how the amount of information transmitted from a given agent (the sender) to his counterpart (the receiver) is related to the similarity of their interests. The sender strategically chooses the amount of information he wants to transmit to the receiver, which is an increasing function of the convergence of their interests. In many occasions, however, these two parties have completely conflicting interests or cannot credibly communicate information. A third party, such as a certification intermediary with no conflicting interests might then play this role. However, as the sender in Crawford-Sobel's model, the intermediaries are strategic when deciding how much information they want to reveal. The strategic choice of the amount of information disclosed by these intermediaries and its relation to the structure of the market are the concerns of this paper.

Examples of such intermediaries abound. Banks audit and disclose information about the economic situation and perspectives of firms to all potential buyers of their stocks. Rating agencies such as Standard and Poor's disclose information regarding the financial situation of firms or States. Marketing information service companies sell studies to manufacturers and provide consumers with quality assessments, market research, forecasting and consulting about different products they offer.

Our model is related to Lizzeri (1999), who shows that when trade is efficient in all states of nature there always exists an equilibrium in which all types of seller ask for certification and no information is revealed in equilibrium. Moreover, under certain reasonable conditions on the distribution of types, this equilibrium is unique. The monopolistic intermediary captures all the extractable surplus, without revealing any valuable information, and the seller chooses to be certified only to avoid being taken as a low quality seller. It is only when trade might be inefficient that the intermediary will increase social welfare by certifying types for which trade becomes efficient. However, the disclosure policy still entails no direct disclosure of information and the equilibrium just reveals whether trade is efficient or not.

As in Lizzeri (1999), we model the interaction among three types of agents. A seller receives an informative signal about the quality of a good he owns, but this quality is totally unknown to potential buyers. However, there exists an intermediary who owns a technology that enables him to test the good and discover the true quality offered by the seller. He proposes a certification contract to the seller composed of a price of certification and a disclosure rule specifying an information transmission policy. If the seller accepts to be certified, the intermediary discovers the quality and implements the disclosure rule. Buyers then pay for the good depending on the amount of information they received.

Strauzs (2003) analyzes the impact of reputation in certification markets. He shows that reputation effects exhibit increasing returns to scale, which implies that the certification industry is a natural monopoly. Therefore, in our model we consider monopolistic intermediaries.

In the first part of the paper, we assume that the seller has a way to communicate some information to the buyers through a warranty contract. Facing an informed principal problem in common values à la Maskin and Tirole (1992), we show that this contract is so efficient for the seller to signal his quality that the intermediary cannot improve upon it. Hence, the seller is not willing to pay for certification and the intermediary cannot play any role. Therefore in the rest of the paper, we assume that the seller has no other means than certification to transmit information.

There are basically two ways in which information is transmitted to the buyers. First, actions may convey some information. As long as in equilibrium different types undertake different actions, observing a particular action reveals something about types. This is the classical signaling effect, and we will often call it *indirect transmission of information*. Second, information can be transmitted through announcements. Both the seller and the intermediary may make announcements about the quality of the good, but only the intermediary's announcements are credible for the buyers. If in equilibrium the intermediary announces something about the quality of the good, we say that there is *direct transmission of information*.

We first show that in the case of one seller and risk neutral buyers, if there is any transmission of information at equilibrium, it has to be indirect. Indeed, direct transmission of information by the intermediary would impose a cost through the "rent leaving effect" to high quality sellers, but no benefit since no agent is willing to pay for information. The reason is that the seller's extractable surplus in the market does not increase when the intermediary makes announcements. In equilibrium, the intermediary partitions the support representing the seller's private information by offering a different contract to each partition. A seller in a partition chooses the contract that is intended to him and therefore his action reveals the partition to which he belongs. However, the equilibrium is not unique. There are out of equilibrium beliefs that sustain any possible partition of the set of types as an equilibrium. Moreover, all equilibria are payoff equivalent for all agents in the market and the most informative equilibrium is one in which each type of seller chooses a different contract.

In a second step, we consider risk averse buyers. In this case, revelation of information improves welfare since it enables better risk sharing between the buyers and the seller implying that the intermediary can extract a higher rent. Transmission of information plays the role of insurance against low quality goods, and risk averse buyers are willing to buy insurance. We show that in such setting, there is always some direct revelation of information in equilibrium. More precisely, in all equilibria the intermediary offers a menu of contracts in which the information will be fully disclosed for all types above a certain threshold and no disclosure is made for the others. Revealing all the information would maximize total surplus but given that the intermediary would have to leave some rents for the seller to self-select, he is not able to capture all this extra surplus. Therefore, the amount of information transmitted in equilibrium is in general suboptimal.

Finally, we extend the model to consider multiple intermediaries and multiple sellers. On the one hand, we assume that intermediaries have some capacity constraints that prevent them from certifying a large number of sellers. With such assumption we maintain some monopoly power on the intermediation side. On the other hand, we assume that sellers compete à la Bertrand in order to sell their goods to a single buyer. Therefore, revelation of information may help sellers to differentiate from each other and charge a positive price. Sellers are then willing to pay for some information to be disclosed. However, we show that at equilibrium there is direct transmission of information only for high quality sellers since with full revelation of information intermediaries make zero profits.

The paper is organized as follows. In Section 2, we sketch the main structural features of the model. In Section 3 we investigate the role of the intermediary in a context in which the seller has an alternative to certification. In Section 4, we develop the model with S different signals and risk neutral buyers and we characterize the equilibria of the game. In Section 5, we introduce risk averse buyers and show that there is always some direct revelation of information at equilibrium. In Section 6 we look at the case of multiple capacity constrained intermediaries and multiple sellers. Finally, some concluding remarks are given in Section 7.

2 The model

Consider an economy with one seller, an intermediary and b buyers. The seller produces a good of quality τ, which is valued τ by the buyers but for which neither the seller nor the intermediary have any value.

The seller does not know the quality of the good he offers but receives a partially informative signal $\sigma \in S$.[1] Since the true quality offered by the seller is unknown, all

[1] This assumption allows us to conduct a broader analysis that includes the case where the signal is

the agents will have a prior on the value of τ represented by the cumulative distribution $F(\cdot)$ on the closed support $[\underline{\tau}, \overline{\tau}]$, where $\overline{\tau} > \underline{\tau} \geq 0$. Once he has observed the signal, the seller updates his beliefs about the quality of his good. Let $G_i(\cdot)$ be the assessment about this quality if signal σ_i is received.

The signal can take $S+1$ values, $S = \{\sigma_0, ..., \sigma_S\}$, and the ex post probability distributions

$$G_i(t) = \Pr\left(\tau < t / \, \sigma = \sigma_i\right)$$

satisfy

$$G_i(t) \geq G_{i+1}(t) \quad \forall t, \forall i < S,$$

that is, G_{i+1} first order stochastically dominates G_i. In other words, receiving a high signal is a good news in Milgrom (1981) sense.

Define ρ_i as the unconditional probability of receiving σ_i. Note that

$$\sum_i \rho_i G_i(t) = F(t) \quad \forall t. \tag{1}$$

The intermediary has a technology to test the quality of the good provided by the seller at a fixed cost normalized to 0. If the good is tested, the intermediary discovers τ which becomes hard information, that is, the intermediary has verifiable evidence of the quality of the good.[2] The hard information assumption in this static model plays the same role as reputation in a dynamic model. Indeed, any false announcement is identified with probability 1 and the intermediary will be punished by a court of justice rather than by the loss of his reputation.

Timing of the game

- At date 0, the intermediary commits to a menu of (at most) $S+1$ categories of contracts. Each category entails a price P and a disclosure rule D.

perfectly informative. Our results still hold if the seller is perfectly informed about the quality of his good.

[2]The assumption that the intermediary can perfectly discover the true quality is not essential. All our results would hold as long as the information acquired by the intermediary is slightly better than the precision of the signal. One could interpret this using the fact that the quality of the good is usually a subjective parameter and, in such setting, the intermediary can have a larger expertise for such concerns.

- At date 1, the seller receives the signal σ on the quality of the good.
- At date 2, the seller decides not to have his product tested ($x = N$) or, he chooses contract j among the menu ($x = Y_j$) for some $j \in \{0, ..., S\}$.
- At date 3, the intermediary observes the type if $x \neq N$. He discloses the information he has committed to disclose. We call $R(\tau, D)$ the information revealed given the type observed and the disclosure rule.
- At date 4, the buyers observe x and the information disclosed by the intermediary, $R(\tau, D)$. More precisely, buyers observe the category chosen by the seller but not the exact terms of the contract.
- At date 5, buyers bid independently and simultaneously for the good.

Strategies and equilibria

A strategy for the intermediary is a choice of (P, D) where $P \in \mathbb{R}_+^{S+1}$ and $D \in \Psi^{S+1}$, the set of all possible disclosure rules. Since τ is hard information once the good is certified, we can restrict our attention to disclosure rules of the form "the information is perfectly revealed ($R(\tau, D) = \tau$) with probability α and nothing is revealed ($R(\tau, D) = \emptyset$) with probability $1 - \alpha$".[3] Without loss of generality, we can set $\Psi = [0, 1]$ and the parameter α, the probability of fully revealing the true quality, completely identifies the disclosure rule.

A strategy for the seller is a function $x(P, D, \sigma) : \mathbb{R}_+^{S+1} \times [0, 1]^{S+1} \times S \rightarrow \{Y_0, ..., Y_S, N\}$. When a menu of contracts is offered, the seller has a richer set of strategies that includes the choice of the particular contract.

Buyers will bid the expected value of the good conditional on the information disclosed by the intermediary and the category chosen by the seller. Hence, a strategy for the buyer is a function $\beta(\cdot) : \{Y_0, ..., Y_S, N\} \times \emptyset \cup [\underline{\tau}, \overline{\tau}] \rightarrow \mathbb{R}_+$. We have assumed that buyers only observe the number of categories offered by the intermediary but not the price or

[3] This result would not hold anymore if there were some uncertainty about what the intermediary knows (Shin (1994)).

the disclosure rule associated with each of them. Therefore, the intermediary can modify the terms of the contract within a particular category without changing the beliefs of the buyers, because they do not observe the modification. This is obviously true for any $\alpha < 1$. However, if the equilibrium contract involves full disclosure, any deviation in the disclosure rule, even if not observed, is detected with probability 1. This implies that buyers could infer anything from this deviation. Nevertheless, by continuity, we assume that associated to any equilibrium contract with full disclosure, there always exists a probability $\eta \to 0$ that the intermediary will not reveal any information and, therefore, buyers keep the equilibrium beliefs.

The ex post beliefs of a buyer about the seller's type are a function $\nu(\cdot)$: $\{Y_0, ..., Y_S, N\} \to \Delta(S)$, where $\Delta(S)$ is the set of probability distributions over the set of types, S.

We will call $E[\tau/\sigma_i]$, the expected quality when σ_i is received, $E[\tau]$ the ex ante expected quality and $E[\tau/Y_j]$, the quality expected by buyers given that they observed a choice Y_j by the seller.

3 Signaling through contracts vs. certification

Before going to the main model, we start by analyzing the case in which the seller has an alternative to certification to signal his quality. In particular, we assume that if the seller rejects the intermediary's offer, he can make a take-it-or-leave-it offer to the buyers, which will determine the seller's outside option. When looking at the contract offered by the seller we are facing an informed principal problem in common values as defined by Maskin and Tirole (1992). We will show that there is no positive price that the intermediary could charge to attract any type of seller. Indeed, the seller can signal himself at no cost and, therefore, the intermediary cannot capture any rent.

We slightly modify the model defined in the previous section by assuming that with a certain probability the good sold may be damaged in which case its value for the buyer goes to zero. We denote by δ_i the probability of a damage given that the seller received signal σ_i. This probability is larger the smaller the signal: $\delta_i > \delta_j$ if and only if $i < j$.

If the seller does not ask for certification, he offers a menu of contracts $(\beta(\widetilde{\sigma}_i), t(\widetilde{\sigma}_i))_{\widetilde{\sigma}_i \in S}$ where $\widetilde{\sigma}_i$ is the announcement made by the seller about his type, $\beta_i = \beta(\widetilde{\sigma}_i)$ is the price asked to the buyer and $t_i = t(\widetilde{\sigma}_i)$ is a transfer from the seller to the buyer in case of damage.

The utility of a seller of type i who announces type j is

$$\beta_j - \delta_i t_j.$$

We know that in any equilibrium the seller will truthfully announce his type, so the utility of the buyer when he contracts with a type σ_i seller is

$$(1-\delta_i) E[\tau/\sigma_i] + \delta_i t_i - \beta_i.$$

In order to find the equilibria of this contract offer game, we invoke Theorem I of Maskin and Tirole (1992), which states that the set of equilibria is equal to the set of direct revelation mechanisms that are incentive compatible for the seller, individually rational for the buyer and Pareto dominate the Rothschild-Stiglitz-Wilson (RSW) allocation.

The RSW allocation is defined as the solution of the following problem:

$$\max_{(\beta_i, t_i)} \sum_{i=0}^{S} (\beta_i - \delta_i t_i)$$

subject to

$$\beta_i - \delta_i t_i \geq \beta_j - \delta_i t_j \quad \forall i, j,$$

$$(1-\delta_i) E[\tau/\sigma_i] + \delta_i t_i - \beta_i \geq 0 \quad \forall i$$

Proposition 1 *There is a continuum of equilibria characterized by the following conditions:*

$$\begin{aligned}
t_i &= \frac{(1-\delta_i) E[\tau/\sigma_i] - (1-\delta_{i-1}) E[\tau/\sigma_{i-1}]}{\delta_{i-1} - \delta_i} \quad \forall i \geq 1, \\
t_0 &\in \left[0, \frac{(1-\delta_1) E[\tau/\sigma_1] - (1-\delta_0) E[\tau/\sigma_0]}{\delta_0 - \delta_1}\right) \\
\beta_i &= \frac{\delta_{i-1}(1-\delta_i) E[\tau/\sigma_i] - \delta_i (1-\delta_{i-1}) E[\tau/\sigma_{i-1}]}{\delta_{i-1} - \delta_i} \quad \forall i \geq 1, \\
\beta_0 &= (1-\delta_0) E[\tau/\sigma_0] + \delta_0 t_0.
\end{aligned}$$

In all equilibria a type i seller gets a payoff equal to $(1-\delta_i) E[\tau/\sigma_i]$.

Proof.

The RSW allocation is an equilibrium itself. So, we first compute the RSW allocation. This is a linear programming problem, so the solution is at a corner of the feasible set. Suppose that the binding constraints are all the individual rationality constraints and the upward adjacent incentive compatibility constraints: $\forall i$

$$\begin{aligned}(1-\delta_i) E[\tau/\sigma_i] + \delta_i t_i - \beta_i &= 0, \\ \beta_i - \delta_i t_i &= \beta_{i+1} - \delta_i t_{i+1}.\end{aligned}$$

Solving this system of $2S+2$ unknowns and $2S+1$ equations leads to the claimed solution. Notice that $t_i > E[\tau/\sigma_{i-1}] > t_{i-1}$ $\forall i$.[4]

This is indeed the solution if all the other incentive constraints are satisfied:

$$\beta_i - \delta_i t_i \geq \beta_{i+k} - \delta_i t_{i+k} \quad \forall k \geq 2, \tag{2}$$

$$\beta_i - \delta_i t_i \geq \beta_{i-k} - \delta_i t_{i-k} \quad \forall k \geq 1. \tag{3}$$

Using the binding incentive constraints and the fact that $\beta_0 = \delta_0 t_0 + (1-\delta_0) E[\tau/\sigma_0]$, it is straightforward to show that

$$\beta_i = \delta_i t_i + \sum_{j=0}^{i-1} (\delta_j - \delta_{j+1}) t_{j+1} + (1-\delta_0) E[\tau/\sigma_0].$$

This implies that (2) is equivalent to

$$\sum_{j=i}^{i+k-1} (\delta_j - \delta_{j+1}) (t_{i+k} - t_{j+1}) \geq 0,$$

which is true because $t_{i+k} > t_i$ $\forall k \geq 1$ $\forall i$.

Similarly, (3) is equivalent to

$$\sum_{j=i-k}^{i-1} (\delta_j - \delta_{j+1}) (t_{j+1} - t_{i-k}) \geq 0,$$

which is true because $t_i > t_{i-k}$ $\forall k \geq 1$ $\forall i$.

Following Maskin and Tirole (1992), the RSW allocations are the unique equilibria of the game if they are interim efficient relative to the prior beliefs. An allocation is interim efficient relative to beliefs $\widehat{\rho}$ if it is the solution to the following program:

[4] t_0 is not defined by the solution of the system. However, we need $t_0 < t_1$ to avoid that type 1 announces that he is type 0.

$$\max_{(\beta_i,t_i)} \sum_{i=0}^{S} (\beta_i - \delta_i t_i)$$

subject to

$$\beta_i - \delta_i t_i \geq \beta_j - \delta_i t_j \quad \forall i, j,$$

$$\sum_{i=0}^{S} \widehat{\rho}_i \left[(1-\delta_i) E[\tau/\sigma_i] + \delta_i t_i - \beta_i \right] \geq 0 \quad \forall i.$$

Given that all individual rationality constraints were binding at the RSW allocations, the RSW allocations are trivially interim efficient relative to prior beliefs. ■

The ability to make a take-it-or-leave-it offer to the buyer constitutes a very efficient way for the seller to signal his type. Indeed, his expected utility is $(1-\delta_i) E[\tau/\sigma_i]$, which is the maximum expected price he could get if the buyer knew his type. In such setting, the seller is not ready to pay any positive price to be certified which leads to the following proposition.

Proposition 2 *If the seller can credibly make a take-it-or-leave-it offer to the buyer, there is no role for intermediation.*

To analyze the market for certification, we assume, in the rest of the paper, that the seller does not have any alternative means to signal his type other than certification.

4 Direct versus indirect information transmission

Contrary to what we have shown in the previous section, if certification is the only way to signal the seller's type, there is always a role for the intermediary. Indeed, suppose there is a pooling equilibrium in which no seller goes through the intermediary. Because buyers do not learn anything new, they will be willing to pay the expected value, $E[\tau]$ for the good. If the buyers observe a seller going through the intermediary and no information is revealed, they will think that he is a σ_i seller with probability ν_i (out-of-equilibrium).

So, a seller of type i does not go through the intermediary if

$$E[\tau] \geq (1-\alpha) \sum_j \nu_j E[\tau/\sigma_j] + \alpha E[\tau/\sigma_i] - P. \tag{4}$$

The payoff of the intermediary when offering (P, D) is equal to 0. Now, this is an equilibrium if there are no alternative price and disclosure rule that could increase the payoff of the intermediary. Consider the following deviation:

$$\begin{aligned} P' &= E[\tau / \sigma_S] - E[\tau] - \varepsilon \\ \alpha' &= 1, \end{aligned}$$

with ε small.

Then, a seller of type S will go to the intermediary since

$$\begin{aligned} E[\tau] &< (1-\alpha') \sum_j \nu_j E[\tau / \sigma_j] + \alpha' E[\tau / \sigma_S] - P' \\ &< E[\tau] + \varepsilon. \end{aligned}$$

But then, the profit of the intermediary is at least equal to

$$P' \rho_S > 0,$$

and therefore, this is a profitable deviation for the intermediary for ε small. This is true whatever the out-of-equilibrium beliefs. Then, in any equilibrium of this game at least one type of seller will choose to be certified. The following lemma goes even further.

Lemma 1 *There is no equilibrium in which more than the lowest type of seller does not ask for certification.*

Proof.

Suppose the contract (P, α) is offered and the equilibrium is such that

$$\begin{aligned} x &= Y_1 \quad \text{for all } \sigma_i \text{ with } i \geq j > 1, \\ x &= N \quad \text{for all } \sigma_i \text{ with } i < j, \end{aligned}$$

and, according to Bayes' rule, the ex post beliefs of the buyers are

$$\begin{aligned} \nu_i(N) &= \Pr(\sigma = \sigma_i / x = N) = \begin{cases} \frac{\rho_i}{\sum_{k<j} \rho_k} & \text{if } i < j \\ 0 & \text{if } i \geq j \end{cases} \\ \nu_i(Y_1) &= \Pr(\sigma = \sigma_i / x = Y_1) = \begin{cases} 0 & \text{if } i < j \\ \frac{\rho_i}{\sum_{k \geq j} \rho_k} & \text{if } i \geq j \end{cases} \end{aligned}$$

These are equilibrium strategies if the following incentive compatibility conditions are satisfied:

$$\begin{aligned}\alpha E\left[\tau/\,\sigma_j\right]+(1-\alpha)\,E\left[\tau/\,Y_1\right]-P &\geq E\left[\tau/\,N\right],\\ \alpha E\left[\tau/\,\sigma_{j-1}\right]+(1-\alpha)\,E\left[\tau/\,Y_1\right]-P &\leq E\left[\tau/\,N\right],\end{aligned}$$

so, all types from j to S prefer to accept the contract and all types from 0 to $j-1$ prefer to reject it.

This is an equilibrium only if there is no other contract that would increase the intermediary's profit. So, for this to be an equilibrium we need to have $\alpha = 0$. Otherwise, the intermediary could change the contract by proposing a lower α and a higher price that would still satisfy the incentive compatibility conditions. Second, given $\alpha = 0$, the intermediary chooses the highest possible price (otherwise, there would be another contract with a slightly higher price that would satisfy incentive compatibility and increase the intermediary's profit).

So, if this is an equilibrium the price has to be:

$$P_{SSJ} = E\left[\tau/\,Y_1\right] - E\left[\tau/\,N\right].$$

The expected profit of the intermediary is

$$E\left(\pi_{SSJ}\right) = P_{SSJ}\sum_{k=j}^{S}\rho_k.$$

Consider now the following deviation. The intermediary offers a contract $(P', 0)$ with $P' = P_{SSJ} - \varepsilon$. Any type $i \leq j-1$ accepts this contract because

$$\begin{aligned}E\left[\tau/\,Y_1\right]-P' &= E\left[\tau/\,Y_1\right]-P_{SSJ}+\varepsilon\\ &= E\left[\tau/\,N\right]+\varepsilon\\ &> E\left[\tau/\,N\right].\end{aligned}$$

The expected profit of the intermediary is then

$$E\left(\pi'\right) = P' = E\left(\pi_{SSJ}\right) - \varepsilon\sum_{i\geq j}\rho_i + \sum_{i<j}\rho_i P'.$$

So

$$E\left(\pi'\right) > E\left(\pi_{SSJ}\right)$$

for ε small enough. Therefore, this deviation is profitable and the proposed strategies and beliefs do not form an equilibrium of the game. ∎

We are now ready to analyze the complete equilibrium of the game. For this purpose we assume that the intermediary can offer a menu of contracts $\{(P_i, \alpha_i)\}_{i=1}^{S}$ and we look for equilibria in which a seller chooses contract (P_i, α_i) after receiving signal σ_i.[5]

Proposition 3 *For any $n \in \{1, ..., S\}$, there is an equilibrium in which the intermediary offers a menu of n contracts with no disclosure of information for all types $i < S$. If types m and k choose the same contract $h = (P_h, \alpha_h)$ then, any type j such that $m \leq j \leq k$ chooses also contract h. These equilibria are the unique ones and are payoff equivalent for the intermediary.*

Proof.

Type m and k choose contract h, implying that for any other contract h',

$$\alpha_h E[\tau/\sigma_m] + (1-\alpha_h) E[\tau/Y_h] - P_h \geq \alpha_{h'} E[\tau/\sigma_m] + (1-\alpha_{h'}) E[\tau/Y_{h'}] - P_{h'}, \quad (5)$$

$$\alpha_h E[\tau/\sigma_k] + (1-\alpha_h) E[\tau/Y_h] - P_h \geq \alpha_{h'} E[\tau/\sigma_k] + (1-\alpha_{h'}) E[\tau/Y_{h'}] - P_{h'}, \quad (6)$$

Suppose there is a type j with $m \leq j \leq k$ that does not choose contract h. This means that, for some h'

$$\alpha_{h'} E[\tau/\sigma_j] + (1-\alpha_{h'}) E[\tau/Y_{h'}] - P_{h'} \geq \alpha_h E[\tau/\sigma_j] + (1-\alpha_h) E[\tau/Y_h] - P_h. \quad (7)$$

So, according to (5) and (7) we have that a necessary condition for incentive compatibility is that $\alpha_h \leq \alpha_{h'}$. According to (6) and (7), we need that $\alpha_h \geq \alpha_{h'}$, meaning that

$$\alpha_h = \alpha_{h'}.$$

Replacing this in (6) and (7) gives that

$$(1-\alpha_h)(E[\tau/Y_h] - E[\tau/Y_{h'}]) \geq P_h - P_{h'} \geq (1-\alpha_h)(E[\tau/Y_h] - E[\tau/Y_{h'}]),$$

so $P_h = P_{h'}$. Therefore, contract h is equal to contract h'.

Consider now 2 successive types: m, k with $k = m + 1$. Suppose m and k choose the same contract: (P_h, α_h). On the other hand, all remaining types, $i \neq m, k$ self-select by choosing

[5] We allow for bunching where the intermediary could offer the same price and the same disclosure rule to two sellers who received different signals.

contract (P_i, α_i). So,

$$\begin{aligned} x(\sigma_i) &= Y_i \quad \forall i \notin \{0, m, k\}, \\ x(\sigma_m) &= x(\sigma_k) = Y_h, \\ x(\sigma_0) &= N. \end{aligned}$$

The equilibrium beliefs are

$$\begin{aligned} \nu_i(N) &= \Pr(\sigma = \sigma_i / x = N) = \begin{cases} 1 & \text{if} \quad i = 0 \\ 0 & \text{if} \quad i \geq 1 \end{cases} \\ \nu_i(Y_j) &= \Pr(\sigma = \sigma_i / x = Y_j) = \begin{cases} 1 & \text{if} \quad i = j \quad j \neq h \\ 0 & \text{if} \quad i \neq j \quad j \neq h \end{cases} \\ \nu_i(Y_h) &= \Pr(\sigma = \sigma_i / x = Y_h) = \begin{cases} \frac{\rho_i}{\rho_m + \rho_k} & \text{if} \quad i \in \{m, k\} \\ 0 & \text{if} \quad i \notin \{m, k\} \end{cases} \end{aligned}$$

The strategy of the seller is optimal if the following incentive compatibility conditions are satisfied $\forall i \notin \{m, k\}$

$$\begin{aligned} \alpha_h E[\tau/\sigma_m] + (1 - \alpha_h) E[\tau/Y_h] - P_h &\geq \alpha_i E[\tau/\sigma_m] + (1 - \alpha_i) E[\tau/\sigma_i] - P_i, \\ \alpha_h E[\tau/\sigma_k] + (1 - \alpha_h) E[\tau/Y_h] - P_h &\geq \alpha_i E[\tau/\sigma_k] + (1 - \alpha_i) E[\tau/\sigma_i] - P_i, \\ \alpha_h E[\tau/\sigma_i] + (1 - \alpha_h) E[\tau/Y_h] - P_h &\leq E[\tau/\sigma_i] - P_i. \end{aligned}$$

Following the same argument as in Lemma 1, the only candidate for an equilibrium has $\alpha_i = 0$ $\forall i$ and the price schedule is defined by

$$\begin{aligned} P_i &= E[\tau/\sigma_i] - E[\tau/\sigma_0], \quad i \notin \{m, k\}, \\ P_h &= E[\tau/Y_h] - E[\tau/\sigma_0], \end{aligned}$$

and

$$E[\tau/Y_h] = \frac{\rho_m E[\tau/\sigma_m] + \rho_k E[\tau/\sigma_k]}{\rho_m + \rho_k}$$

So, the expected profit of the intermediary is

$$\pi = \sum_{i \notin \{m,k\}} \rho_i P_i + (\rho_m + \rho_k) P_h = E[\tau] - E[\tau/\sigma_0]$$

which corresponds to the maximum surplus that the intermediary could extract.

The proof would be exactly identical if more than two types choose the same contract. Let us show that there also exists an equilibrium where all agents choose different contracts.

Consider any successive types i and $i-1$ self-selecting on two different contracts. We have:

$$\begin{aligned} E[\tau/\sigma_i] - P_i &\geq \alpha_{i-1}E[\tau/\sigma_i] + (1-\alpha_{i-1})E[\tau/\sigma_{i-1}] - P_{i-1} \\ E[\tau/\sigma_{i-1}] - P_{i-1} &\geq \alpha_i E[\tau/\sigma_{i-1}] + (1-\alpha_i)E[\tau/\sigma_i] - P_i \end{aligned}$$

which is equivalent to

$$(1-\alpha_{i-1})(E[\tau/\sigma_i] - E[\tau/\sigma_{i-1}]) \geq P_i - P_{i-1} \geq (1-\alpha_i)(E[\tau/\sigma_i] - E[\tau/\sigma_{i-1}]).$$

The price P_i is the maximum if the downward incentive compatibility constraint is binding. that is

$$\begin{aligned} P_i &= P_{i-1} + (1-\alpha_{i-1})(E[\tau/\sigma_i] - E[\tau/\sigma_{i-1}]), \\ P_1 &= E[\tau/\sigma_1] - E[\tau/\sigma_0]. \end{aligned}$$

By induction,

$$P_i = (1-\alpha_{i-1})E[\tau/\sigma_i] + \sum_{j=2}^{i-1}(\alpha_j - \alpha_{j-1})E[\tau/\sigma_j] - E[\tau/\sigma_0],$$

and therefore the expected profit of the intermediary is

$$E(\pi) = \sum_{\iota=1}^{S}\rho_i\left[(1-\alpha_{i-1})E[\tau/\sigma_i] + \sum_{j=2}^{i-1}(\alpha_j - \alpha_{j-1})E[\tau/\sigma_j] - E[\tau/\sigma_0]\right].$$

This expression is independent of the value of α_S, so any $\alpha_S \in [0,1]$ is equally optimal. Moreover, it is straightforward to see that $\alpha_{S-1} = 0$. This implies that α_{S-2} is also equal to 0 and, by induction, that all α_i, $i < S$, are equal to 0 at the optimum. Thus,

$$P_i = E[\tau/\sigma_i] - E[\tau/\sigma_0],$$

and the missing incentive compatibility constraints are verified.

The expected profit of the intermediary is given by:

$$\begin{aligned} \sum_{i=1}^{S}\rho_i(E[\tau/\sigma_i] - E[\tau/\sigma_0]) &= E[\tau] - \rho_0 E[\tau/\sigma_0] - (1-\rho_0)E[\tau/\sigma_0] \\ &= E[\tau] - E[\tau/\sigma_0], \end{aligned}$$

which, again, is the maximum surplus that can be extracted. Therefore, offering such a menu of contract is an optimal strategy. ■

There is no equilibrium with full disclosure. By offering a contract that reveals all the information for a given type i, all types above i will choose this contract and get a positive rent. This strategy is strictly dominated by one in which only the highest types ask for certification. Indeed, if $\alpha_i = 1$ for some i, then incentive compatibility implies that the price charged by the intermediary has to be the same for all types from i to S. Therefore, all types above i choose the same contract and the intermediary leaves them a rent. The intermediary can do better by hiding the information to the buyers and no disclosure will happen at equilibrium for types below S. Moreover, any optimal menu involves the same disclosure rule $\alpha_i = 0$ for all types $i < S$ together with a price schedule P_i increasing in i. Thus, the intermediary is able to screen the different types of seller with a single instrument. This is possible because if buyers observe a seller choosing a higher category in the menu of contract, they expect a higher quality and, thus, are ready to pay more for the good. Hence, some information is indirectly transmitted through the choice of the seller of a particular category within the menu. This is analogous to the burning money effect in standard signalling models. The difference is that, in our model, this "burned money" constitutes a transfer from the seller to the intermediary. Finally, the intermediary extracts the whole possible surplus with any equilibrium menu. For all equilibria, the amount of information transmitted is very different. However, we can state the following result.

Proposition 4 *An equilibrium contract transmits the maximum amount of information if and only if the intermediary offers a menu of S different contracts.*

Proof.

The proof is rather trivial. The equilibrium is more informative if the number of contracts offered is maximal and if the highest type is not pooled with any other. Indeed in such setting, the indirect revelation of information is maximal and the intermediary is indifferent between all possible values of α_S. ■

The maximum amount of information transmitted is an increasing function of the number of signals. As an illustration, consider the limit case where the seller receives a perfectly informative signal. Applying Proposition 4 to a continuum of types, it is optimal for the intermediary to offer a continuum of prices, $P(\tau)$, such that each type of seller has incentives to choose the contract designed for him. Extending Proposition 3, the optimal price function proposed by the intermediary is $P(\tau) = \tau - \underline{\tau}$. The intermediary extracts the maximum possible rent, $E[\tau] - \underline{\tau}$, but here the signal received by the seller is perfectly revealed to the buyers through the self selection of the seller.

However, in all equilibria, the expected profit of the intermediary is exactly the same as if a unique price was implemented. Therefore, our result is not robust to the introduction of a small cost of writing contracts. Indeed, in the presence of such a cost, the intermediary would always be strictly better off by offering a single contract with no revelation of information.

Moreover, ex ante, information has no particular value since none of the agents is ready to pay for it. From an ex ante point of view, all equilibria are equivalent for all the players. The intermediary gets always $E[\tau] - E[\tau/\sigma_0]$, the seller gets $E[\tau/\sigma_0]$ and buyers get 0. Furthermore, ex ante total surplus in this economy is always equal to $E[\tau]$ and is not affected by the action of the intermediary.

In the following section we show that the intermediary might do strictly better with a menu of contracts rather than a unique price if buyers are risk averse. Intuitively, the introduction of risk aversion on the buyers' side implies that the intermediary can increase social welfare and, in particular, his own payoff, by inducing a better risk-sharing through the revelation of information.

5 Equilibrium with risk averse buyers

Consider the model of Section 4 and assume now that the utility function of a buyer is $v(\tau - \beta)$ if he buys a good of quality τ and pays a price equal to β. We assume that v is increasing and strictly concave, and we normalize $v(0) = 0$. If the intermediary commits to fully disclose the information, the buyer will be willing to pay the true quality and will get an utility of 0 whatever the quality of the good. On the other hand, if he commits not to reveal anything, the buyer will be willing to pay a price such that his expected utility is 0.

Let β_i be the price that a buyer is willing to pay for the good when he knows the seller has received signal σ_i. Formally,

$$\beta_i : E\left[v\left(\tau - \beta_i\right) / \sigma_i\right] = v\left(0\right) = 0,$$

and $\beta_i < E\left[\tau / \sigma_i\right]$ by concavity of v.

Let β_{ij} $(i > j)$ be the price that buyers are willing to pay when they believe that the seller has received some signal between σ_j and σ_i. Formally,

$$\beta_{ij} : \sum_{k=j}^{i} \frac{\rho_k}{\sum_{\ell=j}^{i} \rho_\ell} E\left[v\left(\tau - \beta_{ij}\right) / \sigma_k\right] = 0.$$

Since v is concave,

$$\beta_{ij} \leq \sum_{k=j}^{i} \frac{\rho_k}{\sum_{\ell=j}^{i} \rho_\ell} \beta_k \quad \forall i, j, \quad i > j. \tag{8}$$

We first show that the pooling equilibrium with no disclosure is no longer an equilibrium when buyers are risk averse. The intermediary can always do better by revealing some information.

Proposition 5 *For any $j < S$, any contract $(\overline{P}, 0)$ offered to all types from j to S is strictly dominated by a menu of two contracts $\left(\overline{P}, 0\right)$ for all types from j to $S-1$ and $(P_S, \alpha_S = 1)$ for type S.*

Proof.

Assume that there is an equilibrium in which the intermediary offers contract $\left(\overline{P}, 0\right)$ and all types of seller from j to S ask for certification, while all other types do not.

If the seller does not ask for certification, he reveals that his signal is lower than j and, thus, buyers will be ready to pay $\beta_{(j-1)0}$. If the seller asks for certification, buyers will infer that he is of a type between j and S and will be ready to pay β_{Nj}.

The equilibrium price, $\overline{P}$, is then the maximum price the intermediary can charge given the continuation strategies. It is defined as follows:

$$\overline{P} = \beta_{Nj} - \beta_{(j-1)0}.$$

The expected profit of the intermediary is:

$$E\left[\pi_1\right] = \sum_{i=j}^{S} \rho_i \left(\beta_{Nj} - \beta_{(j-1)0}\right). \tag{9}$$

Suppose now that the intermediary adds a new contract $(P_S, \alpha_S = 1)$ with:

$$P_S = E\left[\tau/\,\sigma_S\right] - \beta_{(j-1)0} - \varepsilon,$$

for ε small.

It is straightforward to show that there is a continuation equilibrium in which a seller of type S will choose the contract $(P_S, \alpha_S = 1)$, all types from j to $S-1$ choose the contract $\left(\overline{P}, 0\right)$ and all remaining types do not ask for certification. For that, we first show that type S prefers $(P_S, 1)$ to $\left(\overline{P}, 0\right)$. Because this new contract is not part of the equilibrium, the buyers' beliefs when a seller chooses it could be anything. However, given that the information will be fully revealed, those out of equilibrium beliefs do not play any role. A type S seller's utility when choosing contract $(P_S, \alpha_S = 1)$ is then

$$E\left[\tau/\,\sigma_S\right] - P_S = \beta_{(j-1)0} + \varepsilon > \beta_{(j-1)0}.$$

Second, we show that types from j to $S-1$ prefer contract $\left(\overline{P}, 0\right)$ to $(P_S, 1)$, $\forall i \geq j$:

$$E\left[\tau/\,\sigma_i\right] - P_S = E\left[\tau/\,\sigma_i\right] - E\left[\tau/\,\sigma_S\right] + \beta_{(j-1)0} + \varepsilon < \beta_{(j-1)0},$$

which is true for ε small enough.

The expected profit of the intermediary is then:

$$E\left[\pi_2\right] = \sum_{i=j}^{S-1} \rho_i \left(\beta_{Nj} - \beta_{(j-1)0}\right) + \rho_S \left[E\left[\tau/\,\sigma_S\right] - \beta_{(j-1)0} - \varepsilon\right]. \tag{10}$$

So using (10) and (9) we have that

$$E\left[\pi_2\right] - E\left[\pi_1\right] = \rho_S \left(E\left[\tau/\,\sigma_S\right] - \beta_{Nj} - \varepsilon\right) > 0$$

for ε small enough. Therefore offering $\left(\overline{P}, 0\right)$ was not an equilibrium. ■

The result stems from the fact that the menu of contracts (even with $\alpha_S = 0$) creates a better risk-sharing between the intermediary and the buyers and, hence, the intermediary is able to extract a higher rent. On the other hand, by directly revealing the information of type S, buyers bear even less risk and, both the total rent and the share extracted by the intermediary are larger. Finally, there is no cost for the intermediary in disclosing the information of the highest type, because there are no types above S to whom a rent should be given. In the following proposition we show that, in general, more information will be directly disclosed at equilibrium.

Proposition 6 *When there is risk aversion on the buyers' side, there is no equilibrium without direct revelation of information. When an equilibrium exists, it is such that, either there is full disclosure for all types or there exists a type* $i^* \in \{0, ..., S\}$ *such that for all types* $i < i^*$ *there is either no disclosure or no certification and for all types* $i \geq i^*$ *there is full disclosure.*

Proof.

Suppose the intermediary offers a menu of K different contracts $(P_k, \alpha_k)_{k=1}^{K}$. Define $T(k)$ as the set of types that choose contract k, so $x(\sigma_i) = Y_k$ if and only if $i \in T(k)$. We know that $T(k) \cap T(k') = \emptyset$. So, for convenience, suppose that $k < k'$ implies that $\forall i \in T(k)$ and $\forall i' \in T(k')$, $i < i'$.

We call β_k the price the buyer is willing to pay after observing Y_k if there is no disclosure of information, so

$$\beta_k : \sum_{i \in T(k)} \frac{\rho_i}{\sum_{j \in T(k)} \rho_j} Ev(\tau - \beta_k / \sigma_i) = 0.$$

Incentive compatibility requires that for all $i \in T(k)$ and for all $j \in T(k')$

$$\alpha_k E[\tau / \sigma_i] + (1 - \alpha_k)\beta_k - P_k \geq \alpha_{k'} E[\tau / \sigma_i] + (1 - \alpha_{k'})\beta_{k'} - P_{k'},$$

and

$$\alpha_{k'} E[\tau / \sigma_j] + (1 - \alpha_{k'})\beta_{k'} - P_{k'} \geq \alpha_k E[\tau / \sigma_j] + (1 - \alpha_k)\beta_k - P_k,$$

which implies that for all $i \in T(k)$ and for all $j \in T(k')$,

$$(\alpha_k - \alpha_{k'})(E[\tau / \sigma_i] - E[\tau / \sigma_j]) \geq 0.$$

In particular, if $\alpha_k = 0$ then $\alpha_{k'} = 0$ for all $k < k'$ and if $\alpha_k = 1$ then $\alpha_{k'} = 1$ for all $k > k'$.

Now, since the intermediary's profit function is linear in α_k, for all k, the optimal disclosure rule for contract k is either equal to 0 or 1.

Suppose there is an equilibrium with no disclosure: $\alpha_k = 0\ \forall k$. Using the same argument as in Lemma 1, only the lowest type will not ask for certification. Therefore, the equilibrium price schedule is given by

$$P_k = \beta_k - \beta_0.$$

So, the expected profit of the intermediary is

$$E[\pi] = \sum_{k=0}^{K} P_k \sum_{i \in T(k)} \rho_i = \sum_{k=0}^{K} \beta_k \sum_{i \in T(k)} \rho_i - (1 - \rho_0)\beta_0.$$

Suppose the intermediary offers a new contract, $(P_S, 1)$ such that

$$P_S = \beta_K - \beta_0 + \varepsilon$$

and $0 < \varepsilon < E[\tau/\sigma_S] - \beta_K$. At least type S chooses this contract:

$$E[\tau/\sigma_S] - P_S = E[\tau/\sigma_S] - \beta_K - \varepsilon + \beta_0 > \beta_0,$$

and, therefore, the profit of the intermediary is strictly higher because $P_S > \beta_K$. Therefore, there is no equilibrium with no disclosure. In equilibrium, at least, $\alpha_K = 1$.

Furthermore, because the disclosure rule is monotonic, there exists a threshold $k^* < K$ such that there is no disclosure in all contracts from 0 to k^* and full disclosure in the remaining ones.

The equilibrium is then characterized by

$$\begin{aligned} P_k &= \beta_k - \beta_0 & \alpha_k &= 0 \quad \forall k \leq k^*, \\ P_k &= E[\tau/\sigma_{i^*}] - \beta_0 = \overline{P} & \alpha_k &= 1 \quad \forall k > k^*. \end{aligned}$$

Call $i^* - 1 = \max_{i \in T(k^*)} i$. Then, k^* is defined by three conditions. First, there is no way to reduce $\overline{P}$ in order to induce types below i^* to choose the contract with full disclosure and increase the intermediary's expected profit. That is, for any $j < i^*$,

$$\sum_{i=i^*}^{S} \rho_i \left(E[\tau/\sigma_{i^*}] - E[\tau/\sigma_j]\right) \geq \sum_{i=j}^{i^*-1} \rho_i \left(E[\tau/\sigma_j] - \beta_{k_i}\right), \tag{11}$$

where $\beta_{k_i} = \beta_k$ if and only if $i \in T(k)$.

Indeed, if the intermediary wants to induce type $j < i^*$ to choose a higher category of contracts with $\alpha = 1$,

$$\overline{P}' \leq E[\tau/\sigma_j] - \beta_0,$$

so the intermediary loses $\sum_{i=i^*}^{S} \rho_i \left(E[\tau/\sigma_{i^*}] - E[\tau/\sigma_j]\right)$ because he is obliged to reduce the price for all types above i^*, but he gains $\sum_{i=j}^{i^*-1} \rho_i \left(E[\tau/\sigma_j] - \beta_{k_i}\right)$, since all types between j and $i^* - 1$ would pay a higher price.

The second condition tells that the intermediary does not want to deviate to a contract that will only disclose information for types $j > i^*$, for any j. That is, for any $j > i^*$,

$$\sum_{i=i^*}^{j-1} \rho_i \left(E[\tau/\sigma_{i^*}] - \beta_{k^*}\right) \geq \sum_{i=j}^{S} \rho_i \left(E[\tau/\sigma_j] - E[\tau/\sigma_{i^*}]\right). \tag{12}$$

It remains to check that the intermediary cannot gain by offering a contract with no disclosure for some types above i^*. With such a deviation the intermediary can charge at most a price $\beta_{Ni^*} - \beta_0$ and all types from i^* to S accept this offer. This is profitable if

$$\beta_{Ni^*} - \beta_0 > \overline{P} = E\left[\tau / \sigma_{i^*}\right] - \beta_0,$$

which gives the third condition

$$\beta_{Ni^*} \leq E\left[\tau / \sigma_{i^*}\right]. \tag{13}$$

These three conditions are jointly satisfied at least for low levels of risk aversion (since for those cases i^* is close to S) and for high levels of risk aversion, in which case β_{Ni^*} is close to $\underline{\tau}$.

It is now straightforward to show that if conditions (11) to (13) are satisfied, then there is also an equilibrium in which the intermediary offers a unique contract $\left(E\left[\tau / \sigma_{i^*}\right] - \beta_{(i^*-1)0}, 1\right)$ and all types above $i^* - 1$ accept the contract but types below $i^* - 1$ reject it. Indeed, given (11) the intermediary does not want to extend the set of types who ask for certification with full disclosure and given (12) he does not want to exclude more types. Moreover, if the intermediary proposes a new contract with no disclosure, the buyers could infer that any seller who chooses this new contract is type σ_0. Therefore, no seller would choose it. Finally, given (13) the intermediary does not want to deviate to a contract with no disclosure. ■

We have shown that it is always optimal for the intermediary to fully disclose the information of the highest type, because by doing so he increases the total rent without any cost. However, it is not always optimal to fully disclose all the information whatever the type of the seller. Indeed, even if the total rent is increased when all the information is revealed to the buyers, the intermediary is not able to extract all this extra rent because of the incentive compatibility conditions. Therefore, the intermediary's contribution to total surplus is, in general, sub-optimal. Indeed, it would be socially efficient to reveal all the information to the buyers but, as we have shown, this strategy is not always in the interest of the intermediary. Moreover, among all the equilibria for which the same set of types is fully disclosed, the one with the maximum number of categories achieves the highest level of social welfare, and it is also the one preferred by the intermediary. However, any contract k with no disclosure will be renegotiated if the true quality is above β_k. Therefore, only equilibria in which all the information is fully disclosed for all types who ask for certification are renegotiation-proof.

One illustration of a firm with a well established reputation that implements such an information transmission policy is given by JD Power in the US.[6] This company characterized as a "marketing information service firm" offers its expertise in certification to manufacturers. For the automobile industry, JD Power releases ranking for vehicles performing above industry average and simply lists below-average performers in alphabetical order. Thus, the information is revealed for all qualities above a given threshold and nothing is disclosed for lower quality cars.

6 Bertrand competition

So far we focused on the strategic revelation of information of a monopoly intermediary. However, we observe in many markets intermediaries competing among each other, but competition is far from being perfect. To reflect this situation we go back to the framework developed in Section 4 (risk-neutral buyers) and we assume that each intermediary is capacity-constrained in the sense that he cannot handle a large number of sellers. Suppose that the number of buyers is large enough so that, whatever the number of sellers, they will all be able to sell their goods. It is straightforward to show that if the capacity of the intermediaries is larger than the number of sellers, intermediaries will compete to attract sellers and there will always exist an equilibrium with full revelation of information.[7] On the contrary, when the number of sellers is weakly larger than the total capacity of the intermediaries, we obtain an exact replication of the equilibria of Section 4.[8]

Thus, to make the problem interesting, we assume that not all sellers are able to sell their

[6]We thank Alessandro Lizzeri for pointing out this example to us.

[7]This is analogous to Lizzeri (1999), who considers intermediaries competing à la Bertrand and shows that in such setting there will always be an equilibrium in which at least one intermediary fully discloses information.

[8]This is easily proved by considering that if buyers observe that the number of sellers asking for certification is smaller than the number of intermediaries, they will infer that sellers not asking for certification are the lowest type.

goods. In particular, consider the case where there are two sellers and two intermediaries, but only one buyer. We assume that intermediaries make simultaneous offers and that sellers accept or refuse the proposals simultaneously. Capacity constraints will restrain each intermediary to handle only one seller. To simplify the analysis, we will assume that each seller is perfectly informed about his quality and that types are uncorrelated. Suppose that the first seller has a good of quality τ_1 and the second one $\tau_2 < \tau_1$. If intermediaries offer a single contract with no disclosure of information and both sellers ask for certification, then the buyer's expected quality of the two goods is the same. Bertrand competition between sellers will drive the price to zero. Therefore, sellers will not be ready to pay for certification and the intermediaries will not capture any rent. On the other hand, if they offer a single contract that fully discloses information for all types, then competition will set prices at $\beta(\tau_2) = 0$ and $\beta(\tau_1) = \tau_1 - \tau_2$. Thus, sellers have an interest to differentiate themselves in order to obtain a positive price and are ready to pay for an informative certification. However, only partial revelation of information arises at symmetric equilibria.

Proposition 7 *If intermediaries are constrained to offer a unique price, there is no equilibrium in pure strategies.*

Proof.

Consider first symmetric equilibria. There are two candidates for pure strategy equilibria:

$$\begin{aligned} E^1 &: (P, \alpha = 1) \text{ and } S \text{ accepts iff } \tau \geq \widetilde{\tau}, \\ E^2 &: \left(P', \alpha' = 0\right) \text{ and } S \text{ accepts iff } \tau \geq \tau^*. \end{aligned}$$

Suppose I_i offers contract E^1 and that S_i accepts this offer if and only if his type is above $\widetilde{\tau}$, for some $\widetilde{\tau} \in [\underline{\tau}, \overline{\tau}]$. We look for the best response of I_j assuming that the equilibrium is symmetric. So, I_j should offer a contract with full disclosure of information.

The equilibrium beliefs of the buyer are

$$\Pr(\tau_i \leq \tau / Y) = \begin{cases} \frac{F(\tau) - F(\widetilde{\tau})}{1 - F(\widetilde{\tau})} & \text{if} \quad \tau \geq \widetilde{\tau} \\ 0 & \text{if} \quad \tau < \widetilde{\tau} \end{cases}$$

$$\Pr(\tau_i \leq \tau / S) = \begin{cases} 0 & \text{if} \quad \tau \geq \widetilde{\tau} \\ \frac{F(\tau)}{F(\widetilde{\tau})} & \text{if} \quad \tau < \widetilde{\tau} \end{cases}$$

Type $\widehat{\tau} \geq \widetilde{\tau}$ is indifferent between accepting the offer of I_j or not asking for certification if:

$$(1 - F(\widetilde{\tau}))(F(\widehat{\tau}) - F(\widetilde{\tau}))(\widehat{\tau} - E[\tau / \widetilde{\tau} \leq \tau \leq \widehat{\tau}]) + F(\widetilde{\tau})(\widehat{\tau} - E[\tau / \tau < \widetilde{\tau}]) - P_j = 0.$$

Indeed, with probability $(1 - F(\widetilde{\tau}))(F(\widehat{\tau}) - F(\widetilde{\tau}))$ S_i is certified by his intermediary ($\tau_i \geq \widetilde{\tau}$), but his type is lower than $\widehat{\tau}$. In such a case, S_j gets, in expectation, $\widehat{\tau} - E[\tau / \widetilde{\tau} \leq \tau \leq \widehat{\tau}]$. Similarly, with probability $F(\widetilde{\tau})$, S_i is not certified ($\tau_i < \widetilde{\tau}$), in which case S_j gets $\widehat{\tau} - E[\tau / \tau < \widetilde{\tau}]$. On the other hand, if S_j rejects the contract, his expected quality is equal to that of S_i because the equilibrium is symmetric and therefore he gets 0. So, if I_j wants to attract all types above $\widehat{\tau}$, the best strategy is to set

$$(1 - F(\widetilde{\tau}))(F(\widehat{\tau}) - F(\widetilde{\tau}))(\widehat{\tau} - E[\tau / \widetilde{\tau} \leq \tau \leq \widehat{\tau}]) + F(\widetilde{\tau})(\widehat{\tau} - E[\tau / \tau < \widetilde{\tau}]) = P_j(\widehat{\tau}).$$

The expected profit of I_j is then

$$E(\pi_j) = (1 - F(\widehat{\tau})) P_j(\widehat{\tau}).$$

I_j maximizes his profit with respect to $\widehat{\tau}$, which gives the condition

$$\begin{aligned} \frac{1 - F(\widehat{\tau})}{f(\widehat{\tau})} \left(F(\widehat{\tau})(1 - F(\widetilde{\tau})) + F(\widetilde{\tau})^2 \right) &= (1 - F(\widetilde{\tau})) \left(\widehat{\tau} F(\widehat{\tau}) - \int_{\widetilde{\tau}}^{\widehat{\tau}} \tau dF(\tau) \right) \\ &\quad + F(\widetilde{\tau})^2 \widehat{\tau} - \int_{\underline{\tau}}^{\widetilde{\tau}} \tau dF(\tau). \qquad (14) \end{aligned}$$

In the symmetric equilibrium, we have that $\widehat{\tau}(\widetilde{\tau}) = \widetilde{\tau}$. So, (14) becomes

$$\frac{1 - F(\widetilde{\tau})}{f(\widetilde{\tau})} = \widetilde{\tau} - E[\tau / \tau < \widetilde{\tau}].$$

Consider the following deviation: I_j offers a contract $(P_j(\widetilde{\tau}), \alpha = 0)$, where $P_j(\widetilde{\tau}) = F(\widetilde{\tau})(\widetilde{\tau} - E[\tau / \tau < \widetilde{\tau}])$. If this contract if offered, S_j, whatever his type, strictly prefers to accept the contract. Indeed, given the equilibrium beliefs of the buyer, if S_j accepts the contract, his ex post expected quality (as perceived by the buyer) is

$$\check{\tau} = E[\tau / \tau \geq \widetilde{\tau}] > \widetilde{\tau}.$$

Then if S_j accepts the contract he gets

$$\begin{aligned} & (1 - F(\widetilde{\tau}))(F(\check{\tau}) - F(\widetilde{\tau}))(\check{\tau} - E[\tau / \widetilde{\tau} \leq \tau \leq \check{\tau}]) + F(\widetilde{\tau})(\check{\tau} - E[\tau / \tau < \widetilde{\tau}]) - P_j(\widetilde{\tau}) \\ = \; & (1 - F(\widetilde{\tau}))(F(\check{\tau}) - F(\widetilde{\tau}))(\check{\tau} - E[\tau / \widetilde{\tau} \leq \tau \leq \check{\tau}]) + F(\widetilde{\tau})(\check{\tau} - \widetilde{\tau}) > 0. \end{aligned}$$

If the S_j rejects the contract he gets 0. So, S_j accepts this contract whatever his type.

But this implies that

$$E\left(\pi_j'\right) = P_j\left(\widetilde{\tau}\right) > \left(1 - F\left(\widetilde{\tau}\right)\right) P_j\left(\widetilde{\tau}\right),$$

so I_j does strictly better with this deviation.

Take the second equilibrium candidate. Suppose I_i offers contract E^2 and that S_i accepts this offer if and only if his type is above τ^*, for some $\tau^* \in [\underline{\tau}, \overline{\tau}]$. We look for the best response of I_j assuming that the equilibrium is symmetric. So, I_j should offer a contract with no disclosure of information.

The equilibrium beliefs of the buyer are

$$\Pr\left(\tau_i \leq \tau / Y\right) = \begin{cases} \frac{F(\tau) - F(\tau^*)}{1 - F(\tau^*)} & \text{if} \quad \tau \geq \tau^* \\ 0 & \text{if} \quad \tau < \tau^* \end{cases}$$

$$\Pr\left(\tau_i \leq \tau / N\right) = \begin{cases} 0 & \text{if} \quad \tau \geq \tau^* \\ \frac{F(\tau)}{F(\tau^*)} & \text{if} \quad \tau < \tau^* \end{cases}$$

If type $\widehat{\tau}$ accepts the offer of I_j, he gets

$$F\left(\tau^*\right)\left(E\left[\tau / \tau \geq \tau^*\right] - E\left[\tau / \tau < \tau^*\right]\right) - P_j'.$$

This is independent of $\widehat{\tau}$, so all types of S_j will accept the offer at a price P_j' smaller than or equal to

$$F\left(\tau^*\right)\left(E\left[\tau / \tau \geq \tau^*\right] - E\left[\tau / \tau < \tau^*\right]\right),$$

meaning that in the symmetric equilibrium either all types accept the offer ($\tau^* = \underline{\tau}$) or no type does ($\tau^* = \overline{\tau}$). In both cases, the expected profit of the intermediary is 0.

If instead I_j offers a contract $(\varepsilon > 0, \alpha = 1)$, a seller of type $\widehat{\tau}$ accepts the offer if

$$\widehat{\tau} - E\left[\tau\right] - \varepsilon \geq 0.$$

Therefore, all types above $\check{\tau} = E\left[\tau\right] - \varepsilon$ accept the offer and I_j gets

$$\left(1 - F\left(\check{\tau}\right)\right)\varepsilon > 0,$$

so this deviation is profitable.

Consider now asymmetric equilibria in which one intermediary offers a contract with full disclosure. Using the same argument as before, the intermediary can do better by keeping the same price with no disclosure. By doing so, he can attract all types and increase his profit. It is straightforward to show that there is no asymmetric equilibria in which both intermediaries offer contracts with no disclosure. ■

Even though sellers are willing to pay to differentiate themselves, full revelation of information cannot be part of symmetric equilibrium. It is straightforward to show that if the intermediary wants to attract all types of seller with a full disclosure contract, he will have to set the certification price to zero. Suppose now that the intermediary fully discloses information but attracts only a subset of high quality sellers. By accepting the contract, the seller signals that he offers a high quality good. Given these beliefs, the intermediary has an incentive to fool the buyer by offering a contract with no disclosure since, by doing so, he can attract all types with the same certification price. Thus, full disclosure cannot be an equilibrium strategy.

On the other hand, if there is no disclosure of information and the price of certification is unique, the intermediary cannot discriminate among different types of seller. Indeed, given that there is no revelation of information, the seller's payoff from accepting the offer only depends on the buyer's beliefs, which are independent of the true quality of the good. This implies that all types accept the offer and high quality sellers do not succeed in differentiating from low quality ones. Bertrand competition, then, brings the price to zero and no rent can be extracted from the seller.

A mixed strategy will prevent the intermediary from fooling the buyer when there is full disclosure, since no disclosure (and the associated beliefs) is part of the equilibrium.

Proposition 8 *There is a unique symmetric equilibrium in mixed strategies. The mixed strategy symmetric equilibrium is the following:*

- *At stage 1, with probability γ each intermediary offers a contract $C^1 = (P^1, \alpha^1 = 1)$ and with probability $1-\gamma$ a contract $C^2 = (P^2, \alpha^2 = 0)$, with*

$$\begin{aligned}
\gamma &= \frac{(\widetilde{\tau} - E[\tau])}{\widetilde{\tau} - E[\tau] + F(\widetilde{\tau})(E[\tau/\tau \geq \widetilde{\tau}] - \widetilde{\tau})}, \\
P^1 &= \frac{F(\widetilde{\tau})(E[\tau/\tau \geq \widetilde{\tau}] - E[\tau/\tau \leq \widetilde{\tau}])(\widetilde{\tau} - E[\tau])}{\widetilde{\tau} - E[\tau] + F(\widetilde{\tau})(E[\tau/\tau \geq \widetilde{\tau}] - \widetilde{\tau})}, \\
P^2 &= (1 - F(\widetilde{\tau}))\frac{F(\widetilde{\tau})(E[\tau/\tau \geq \widetilde{\tau}] - E[\tau/\tau \leq \widetilde{\tau}])(\widetilde{\tau} - E[\tau])}{\widetilde{\tau} - E[\tau] + F(\widetilde{\tau})(E[\tau/\tau \geq \widetilde{\tau}] - \widetilde{\tau})}, \\
\widetilde{\tau} &: \frac{F(\widetilde{\tau})(1 - F(\widetilde{\tau}))}{f(\widetilde{\tau})} = \widetilde{\tau} - E[\tau].
\end{aligned}$$

- *At stage 2, each seller accepts a contract* C^1 *if and only if its quality is larger than* $\widetilde{\tau}$ *and any type of seller accepts contract* C^2*.*

- *At stage 3, the buyer buys from the higher expected quality seller and pays a price equal to*

  $|\tau_1 - \tau_2|$ *if* S_1 *and* S_2 *ask for certification and* I_i *reveals* τ_i*,*

  $\tau_i - E[\tau / \tau \leq \widetilde{\tau}]$ *if only* S_i *asks for certification and* I_i *reveals* τ_i*,*

  $\tau_i - E[\tau]$ *if* S_1 *and* S_2 *ask for certification and* I_i *reveals* τ_i *and* I_j *reveals nothing,*

  $E[\tau] - E[\tau / \tau \leq \widetilde{\tau}]$ *if only* S_i *asks for certification and* I_i *reveals nothing,*

  0 *in any other case.*

Proof.

Suppose I play the equilibrium strategy. We first check that the continuation strategies are equilibrium strategies given the offers of the intermediaries.

Given that intermediaries and sellers play the equilibrium strategies, the ex post beliefs of the buyer are:

$$\begin{aligned} \Pr(\tau_i \leq \tau / Y, \emptyset) &= F(\tau), \\ \Pr(\tau_i \leq \tau / N) &= \begin{cases} 0 & \text{if} \quad \tau \geq \widetilde{\tau}, \\ \frac{F(\tau)}{F(\widetilde{\tau})} & \text{if} \quad \tau < \widetilde{\tau}, \end{cases} \end{aligned}$$

where $\emptyset$ means that no information is disclosed by the intermediary. Given these beliefs, the strategy of the buyer is an equilibrium.

If an intermediary offers contract C^1 a seller $\hat{\tau} \geq \widetilde{\tau}$ accepts the offer if

$$\begin{aligned} & \gamma \left[(1 - F(\widetilde{\tau})) (F(\hat{\tau}) - F(\widetilde{\tau})) (\hat{\tau} - E[\tau / \widetilde{\tau} \leq \tau \leq \hat{\tau}]) + F(\widetilde{\tau}) (\hat{\tau} - E[\tau / \tau \leq \widetilde{\tau}]) \right] \\ + \quad & (1 - \gamma)(\hat{\tau} - E[\tau]) - P^1 \geq 0. \end{aligned}$$

Replacing γ and P^1, this gives that type $\widetilde{\tau}$ is indifferent between accepting or not. The gain obtained by accepting is increasing in τ, so any type above $\widetilde{\tau}$ accepts. Moreover, types below $\widetilde{\tau}$ are strictly better off by rejecting the offer.

If an intermediary offers contract C^2 a seller $\hat{\tau}$ accepts the offer if

$$\gamma F(\widetilde{\tau}) (E[\tau] - E[\tau / \tau \leq \widetilde{\tau}]) - P^2 \geq 0.$$

Replacing by γ and P^2, this implies that all types of seller accept the offer. Therefore, given the strategies of the intermediaries, the sellers' strategies are an equilibrium.
We check now that the strategies of the intermediaries form an equilibrium. First, notice that, given that I_i is playing the equilibrium strategy, I_j is indifferent between the two contracts. Indeed, with contract C^1, he gets

$$\begin{aligned} E(\pi^m) &= (1-F(\widetilde{\tau}))P^1 \\ &= \frac{(1-F(\widetilde{\tau}))F(\widetilde{\tau})(E[\tau/\tau\geq\widetilde{\tau}]-E[\tau/\tau\leq\widetilde{\tau}])(\widetilde{\tau}-E[\tau])}{\widetilde{\tau}-E[\tau]+F(\widetilde{\tau})(E[\tau/\tau\geq\widetilde{\tau}]-\widetilde{\tau})}, \end{aligned}$$

and with contract C^2 he gets

$$P^2 = (1-F(\widetilde{\tau}))P^1.$$

Consider a deviation to a contract with no disclosure ($\alpha = 0$). Given that the intermediary cannot discriminate between different types of seller with such a disclosure rule, either all types accept or all types reject the offer. If all types reject, the profit is $0 < E(\pi^m)$. If all types accept, the maximum price is P^2. So, there is no profitable deviation with no disclosure of information.
Consider now a deviation with full disclosure ($\alpha = 1$) and price $\check{P}$. All types above $\check{\tau} \geq \widetilde{\tau}$ accept this offer, if $\forall\tau^* \geq \check{\tau}$,

$$\begin{aligned} &\gamma\left[(1-F(\widetilde{\tau}))(F(\tau^*)-F(\widetilde{\tau}))(\tau^*-E[\tau/\widetilde{\tau}\leq\tau\leq\tau^*])+F(\widetilde{\tau})(\tau-E[\tau/\tau\leq\widetilde{\tau}])\right] \\ + &\quad (1-\gamma)(\tau^*-E[\tau])-\check{P}\geq 0, \end{aligned}$$

and the intermediary gets

$$(1-F(\check{\tau}))\check{P}.$$

Moreover, the maximum price the intermediary can charge to attract all types above $\check{\tau} \geq \widetilde{\tau}$ is

$$\begin{aligned} &\gamma\left[(1-F(\widetilde{\tau}))(F(\check{\tau})-F(\widetilde{\tau}))(\check{\tau}-E[\tau/\widetilde{\tau}\leq\tau\leq\check{\tau}])+F(\widetilde{\tau})(\check{\tau}-E[\tau/\tau\leq\widetilde{\tau}])\right] \\ + &\quad (1-\gamma)(\check{\tau}-E[\tau])=\check{P}. \end{aligned}$$

Now,

$$\widetilde{\tau} = \arg\max_{\check{\tau}}(1-F(\check{\tau}))\check{P}.$$

Indeed, take the first order conditions of the problem, evaluated at $\check{\tau} = \widetilde{\tau}$:

$$\begin{aligned} &-f(\widetilde{\tau})\left[\gamma F(\widetilde{\tau})(\widetilde{\tau}-E[\tau/\tau\leq\widetilde{\tau}])+(1-\gamma)(\widetilde{\tau}-E[\tau])\right] \\ + &\quad (1-F(\widetilde{\tau}))\gamma F(\widetilde{\tau})+(1-F(\widetilde{\tau}))(1-\gamma)=0, \end{aligned}$$

using the definitions of γ and $\widetilde{\tau}$. It can be shown that the solution is unique and the second order conditions are also satisfied given the monotone hazard rate property (the proof is available upon request).

The same argument holds for a deviation towards a $\breve{\tau} < \widetilde{\tau}$. Therefore, there is no profitable deviation for the intermediary.

Uniqueness is easily proved by noting that the function $\frac{F(\tau)(1-F(\tau))}{f(\tau)}$ is single-peaked so there is a unique solution to the equation

$$\frac{F(\tau)(1-F(\tau))}{f(\tau)} = \tau - E[\tau].$$

■

The existence of this mixed strategy equilibrium is due to two different factors. First, the intermediary is unable to fool the buyers with a deviation with no disclosure. The reason is that, as no disclosure is an equilibrium strategy, acceptance of the contract does not convey any new information and therefore buyers keep their prior beliefs. Second, an intermediary can make positive profits even with a contract with no disclosure given the strategy of the other intermediary. Indeed, with some probability, the other seller will reject the offer and the buyers will infer that his expected quality is lower than the prior mean. Thus, even accepting a contract with no disclosure the seller succeeds in differentiating from the other one. Therefore, he is willing to pay a positive certification price.

At equilibrium there is only partial revelation of information. Indeed, there is revelation of information only with probability $\gamma < 1$. Moreover, there is direct information transmission only for high quality sellers, because those are the types that will be willing to accept the contract with full disclosure. There is also indirect revelation of information, since rejecting the contract is a signal of low quality.

7 Conclusions

In this paper we developed a simple model of information transmission through certification intermediaries. A seller has the possibility to be certified by an institution that owns a technology to discover the true quality and can credibly commit to a disclosure rule. The focus of the paper is the extent to which intermediaries have incentives to disclose some information to the buyers.

The first important result is that intermediaries cannot play any role when sellers have alternative efficient ways to signal themselves, since sellers will not be willing to burn money by transferring some rents to the intermediary. If such an alternative is not available, intermediaries always play a role. If ex ante nobody is willing to pay for information, no revelation occurs at equilibrium since revealing information is costly for the intermediary. However, intermediaries still play a role through their influence on the buyers' beliefs. In order to convince buyers that they are not the lowest type, sellers are ready to pay a positive certification price. Therefore, even when they do not directly disclose any information, intermediaries are able to capture at least part of the rent.

We then analyze two situations in which information is valuable for some agents. First, buyers are ready to pay for information whenever they are risk averse, because revelation of information works as an insurance against low quality goods. Second, sellers are willing to pay for information when they compete à la Bertrand because revelation of information works as a differentiation device for sellers who actually offer differentiated products. In both cases, some information is directly revealed in equilibrium. The equilibrium contract can be of two forms. Under risk aversion on buyers' side, the intermediary will only disclose information for types above a certain threshold. With Bertrand competition among sellers, intermediaries will only disclose information with a certain probability. In both cases, the intermediary rations the amount of information he discloses up to the level where the price that rationed agents are ready to pay less than compensates the cost of disclosing more information for the intermediary.

There are many aspects of the intermediation market that are not analyzed in this model. In these days, after the Enron-Arthur Andersen affaire, the first that we may think about is the possibility of collusion between the intermediary and the seller (in that case, the auditor and the audited firm). Collusion may be a real problem if reputation effects are small. For "big" cases, the bribe may offset the cost of collusion in terms of reputation. The model developed in this paper is inappropriate to analyze the possibility of collusion. Indeed, by assuming that the intermediary obtains verifiable information about the quality of the good, we make any false report simply impossible. This is actually equivalent to a case in which the maximum possible bribe cannot compensate for the loss of reputation. In a companion paper we develop a model in which the intermediary gets non-verifiable information and, therefore, collusion between the intermediary and the seller may be a real issue.

Another aspect that we are letting aside is the case of mandatory certification, since we have assumed that the seller can choose not to be certified. However, in many cases certification is mandated by law. This is typically the case of audit. When certification is mandatory, the intermediary is often obliged to make some kind of announcement, so no disclosure of information is not a feasible strategy. Both things may actually favor the possibility of collusion between the intermediary and the seller.

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