E C O N O M I C S B U L L E T I N

# Information sharing in emerging credit markets

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## *Abstract*

This paper examines the lack of information flow in the credit markets of developing countries. We show that the miscoordination among financial intermediaries might explain why lenders don't share their information about the borrowers. The competition effect of more transparency in the market leads to a higher probability of default of the firm, also generating credit rationing.

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# 1 Introduction

Several recent empirical papers analyze the credit markets in developing countries. They show that one of the most prominent features of these markets is the lack of information flow between lenders. It can be explained as the result of miscoordination between financial intermediaries as shown by Ghosh and Ray (2001). If lenders have the option of privately collecting information on the credit histories of new clients, multiple equilibrium could arise. Consequently, it is possible to interpret limited client information in emerging credit markets as coordination failure among financial intermediaries. Jappelli and Pagano (1993) argue that a coordination problem can arise also in developed countries because the information sharing mechanism should be adopted first by those intermediaries that will suffer most for the increased degree of competition in the market.

Building upon the last results in the *global games* literature[1] we provide a model in which when there is imperfect knowledge of the fundamentals there exists a unique equilibrium in which the lenders share the information and fund the investment project. We modify the approach followed by Morris and Shin (2004), Hellwig (2002) and Goldstein and Pauzner (2005) among others to analyze the incentive of the banks to share their information about borrowers' quality.

This paper is motivated by two main objectives. The first is theoretical. We show conditions under which the coordination decisions about the underlyng investment financing strategy can be negatively affected by the information sharing agreement between lenders. This paper sheds new light on some implications never considered in the information sharing literature in credit markets[2]. As far as I know this paper is the first to underline the possible detrimental effect on the firm's probability of success given by the information sharing agreement of the lenders. Our second objective is to contribute to the debate on the regulation of emerging credit markets. In these markets even when information sharing is welfare enhancing, because it reduces the probability of default of the project financed, lenders don't share due to a coordination problem. This leads us to believe that a Public Credit Registry should be created by the monetary authority to increase the degree of transparency.

The plan of the paper is as follows. In Section 2 we set up the model and state basic assumptions. Section 3 lays out the two stages of the game showing the main results of the paper. Section 4 concludes while the Appendix provides proofs.

[1]For an excellent survey read Morris and Shin (2003).

[2]For a survey see Jappelli and Pagano (2000)

## 2 The Model

We consider a two stages game $\Gamma(I,\ S_i,\ v)$, where $I$ denotes the set of all players, $S = \times_{i \in I} S_i$, and $S_i$ denotes the binary set of actions for each player $i \in I$, and $v_i(\theta,\ a_i,\ a_{-i})$ denotes payoff to player $i$ of playing action $a_i$ when all other players follow action profile $a_{-i}$, for all $(a_i,\ a_{-i})$. Payoffs depend on a fundamental variable $\theta \in R$.

The timing of this infinite player game is as follows: Initially, nature draws a fundamental $\theta \in R$ from a normal distribution with mean $\widehat{\theta}$ and variance $\frac{1}{\gamma}$. Each player then receives noisy signals about $\theta$ and can decide to share his information making it public. After forming their beliefs about $\theta$, players simultaneously decide on their action.

We describe the following environment. A firm's investment project is submitted to a set of risk-neutral financial intermediaries. These have to decide to share or not their information and then about the funding of the project whose profitability is uncertain, because it depends upon the realized value of the fundamental $\theta$ and on the proportion of investors $\lambda$ that decide to grant the project. The investors have an outside option given by a risk free investment whose return is with certain $r_f$. The payoff to invest is $V > r_f$ if the proportion of banks who choose to invest exceeds $\kappa(\theta)$, and 0 if less than $\kappa(\theta)$ banks choose to invest in the project. The value of the fundamental can be interpreted as a measure of the firm's propensity to default.

We impose the following regularity conditions on expected payoffs in the infinite player incomplete information game:

**A.1** For each player $i$, posterior expectation $x_i$, and strategy profile $(a_i, a_{-i})$, $E_\theta(v_i(\theta,\ a_i,\ a_{-i})\,|x_i) \rightarrow v_i(\theta,\ a_i,\ a_{-i})$, as the noise vanishes.

This assumptions rules out the possibility that unboundedly large, but unlikely negative payoffs influence a player's choice of action. We impose the following additional restriction:

**A.2** $\kappa(\theta)$ is strictly increasing and continuously boundedly differentiable, and there exist $\overline{\theta}$ and $\underline{\theta}$ such that $\kappa(\overline{\theta}) = 1$ and $\kappa(\underline{\theta}) = 0$.

The second assumption requires the existence of dominance regions such that for all $i$, under complete information, investing in the project is a strictly dominant action whenever $\theta < \underline{\theta}$, and not investing is a strictly dominant action for player $i$ whenever $\theta > \overline{\theta}$.

Under $(A.1)$ and $(A.2)$, Theorem 1 in Milgrom and Weber (1985) establishes the existence of a perfect Bayesian equilibrium in the investment stage of the incomplete information game, provided that the noise is sufficiently small.

The investment stage of the game has multiple equilibria if $\theta$ is common knowledge and falls inside the region $[\overline{\theta}, \underline{\theta}]$. In one equilibrium, every creditor invest in the project, in a second equilibrium, not even one grant the loan and there exists also a mixed strategy equilibrium in which players randomize with probability $\kappa(\theta)$.

We introduce for the first time in a global game setting another stage, where, the investors can decide to share the information they receive about $\theta$ with the other investors, before the investment stage of the game. To set up a credit bureau the lenders have to pay a cost $c(\lambda)$ which satisfies:

**A.3** $(i)$ $c(\lambda)$ is continuously differentiable in $\lambda$ and bounded over $[0,1]$; $(ii)$ $c'(0) > 0$ but $c'(\lambda) < 0$ for some $\lambda$; $(iii)$ $c(\lambda)$ is quasi-concave.

This assumption ensures that there is a region over which banks' actions are strategic complements: that is, the payoff to each bank of choosing "Share" increases with the proportion of others who choose to share their information, when that proportion is sufficiently small. When too many intermediaries decide to share their information, banks' actions become strategic substitutes. The decision to share the information among lenders has two main effects. The first one is the *coordination effect*. The creditors are able to update their posterior about the realized value of the fundamental, affecting the coordination probability of the lenders and then indirectly the profitability of the investment. The second one is the *competition effect.* Sharing the information about the state of the fundamentals increases the possibility of all the competitors to steal profitable investment opportunities. Even if an explicit description for the loss caused by the information sharing decision is behind the purposes of this paper, I am able to analyze the interactions between these two effects on the incentives of each bank.

# 3 Summary of the main results

In the next two sections I outline the main results and the equilibrium of the incomplete information game.

## 3.1 Investment stage

Suppose that in addition to their common prior about $\theta$, banks get private noisy signals about $\theta$ :

$$x_i = \theta + \varepsilon_i, \quad \varepsilon_i \sim N\left(0, \frac{1}{\beta}\right) \tag{1}$$

where $\beta$ is the precision of private signal. The posterior belief about $\theta$ of bank $i$ is given by:

$$\theta_{NS}|x_i \sim N\left(\frac{\gamma\widehat{\theta} + \beta x_i}{\gamma + \beta}; \frac{1}{\gamma + \beta}\right) \tag{2}$$

In order to analyze the investment stage of the game when there is information sharing we suppose that there is one bank who has the same prior as all the investors and receives an additional noisy signal about the profitability of the investment:

$$y = \theta + v, \quad v \sim N\left(0, \frac{1}{\alpha}\right) \tag{3}$$

In our setting, this bank could receive better information for a previous relationship with the firm, or for a better monitoring technology. We will assume that this bank directly announces $y$ and investors update their prior accordingly. The new prior has mean

$$\theta^{IS} = \frac{\gamma\widehat{\theta} + \alpha y}{\gamma + \alpha} \tag{4}$$

and variance $1/(\gamma+\alpha)$. When the credit institutes decide to share their information the new posterior beliefs are distributed as follows:

$$\theta_{IS}|x_i, y \sim N\left(\frac{\gamma\widehat{\theta} + \alpha y + \beta x_i}{\gamma + \alpha + \beta}; \frac{1}{\gamma + \alpha + \beta}\right) \tag{5}$$

As in the global games literature, we restrict attention to symmetric "threshold" equilibria, i.e. pairs of thresholds $(x^*, \theta^*)$ such that a bank decides to invest in the project whenever its posterior expectation falls below $x^*$ and receives a payoff of $V$ whenever $\theta < \theta^*$.

I am now able to state the main result of this section:

**Proposition 1** *Given the information structure above we have that:*

*(i) The equilibrium threshold $\theta^*_{NS}$ and $\theta^*_{IS}$ are implicitly determined by*

$$\theta^*_{NS} = \widehat{\theta} + \frac{\sqrt{\beta}}{\gamma}\Phi^{-1}\left(\kappa\left(\theta^*_{NS}\right)\right) + \frac{\sqrt{\gamma+\beta}}{\gamma}\Phi^{-1}\left(\frac{r_f}{V}\right) \tag{6}$$

*and*

$$\theta^*_{IS} = \frac{\gamma}{\gamma+\alpha}\widehat{\theta} + \frac{\alpha}{\gamma+\alpha}\Upsilon + \frac{\sqrt{\gamma+\alpha+\beta}}{\gamma+\alpha}\Phi^{-1}\left(\frac{r_f}{V}\right) + \frac{\sqrt{\beta}}{\alpha+\gamma}\Phi^{-1}\left(\kappa\left(\theta^*_{IS}\right)\right) \tag{7}$$

*(ii) The information sharing decision introduces multiple equilibria, if and only if:*

$$\frac{\gamma}{\sqrt{\beta}} < \min_{\theta \in \left(\underline{\theta}, \bar{\theta}\right)} \frac{\kappa'(\theta)}{\varphi\left(\Phi^{-1}\left(\kappa(\theta)\right)\right)} < \frac{(\gamma+\alpha)}{\sqrt{\beta}} \tag{8}$$

*(iii) Suppose that* $\frac{(\gamma+\alpha)}{\sqrt{\beta}} \rightarrow d > \min_{\theta \in \left(\underline{\theta}, \bar{\theta}\right)} \frac{\kappa'(\theta)}{\varphi\left(\Phi^{-1}(\kappa(\theta))\right)}$, *as* $\sqrt{\frac{\beta}{\gamma+\alpha+\beta}} \rightarrow 1$ *and* $\sqrt{\frac{1}{\gamma+\alpha+\beta}} \rightarrow 0$. *Then there are multiple limit equilibria, all with thresholds continuous in $y$.*

Proposition 1 sheds new light upon the information sharing problem among lenders. I show that introducing a better informed bank into the market might bring back multiple equilibria, because the ability of some agents to communicate with a large proportion of other agents may be sufficient to generate common beliefs close to 1. We need a sufficiently precise private information to avoid multiple equilibria. This should be considered within the debate about the necessity of more transparency in emerging markets, as one of the possible costs. This leads us to the next issue: the influence on the other creditors that the revelation of this new information could have on the market equilibrium. The last statement of Proposition 1 deals with this issue showing that in the case of multiple equilibria the information revealed to the market would lead the investors' strategies with different results.

We are also interested in the actual probability of default, $p^*$ of the firm. This is the probability that actual $\theta$ will be above the thresholds $\theta^*_{IS}$ and $\theta^*_{NS}$, respectively:

$$p^*_{IS} = \Pr ob\left(\theta > \theta^*_{IS}\right) = 1 - \Phi\left(\gamma\left(\theta^*_{IS} - \widehat{\theta}\right)\right) \tag{9}$$

$$and$$

$$p^*_{NS} = \Pr ob\left(\theta > \theta^*_{NS}\right) = 1 - \Phi\left(\gamma\left(\theta^*_{NS} - \widehat{\theta}\right)\right) \tag{10}$$

We can state the following result about the effect of information sharing on the probability of default.

**Corollary 1** *The probability of default $p^*_{IS} < p^*_{NS}$ if and only if $y \geq \widehat{\theta} + H$, where $H \equiv \frac{\sqrt{\beta}}{\gamma}\Phi^{-1}\left(\kappa\left(\theta^*\right)\right) + \left[\frac{(\alpha+\gamma)\sqrt{\gamma+\beta} - \gamma\sqrt{\alpha+\gamma+\beta}}{\gamma\alpha}\right]\Phi^{-1}\left(\frac{r_f}{V}\right)$.*

The last Corollary underlines the role played by the coordination effect in the case of information sharing. If the condition identified above holds, information revealed by the better informed bank allows the other investors to coordinate funding the project. Hence if the banks' private information is sufficiently precise, information sharing leads to an increase of efficiency.

## 3.2 Information sharing stage

In this section we analyze the conditions under which it is optimal for the banks to share their information about the profitability of the borrower. When the agents coordinate forming a Credit Bureau, the payoff is given by:

$$u\left(\lambda\right) = \left(1 - p^*_{IS}\right)V + c\left(\lambda\right) = \left(1 - \int_{\theta^*_{IS}}^{\infty} z\varphi\left(z\right)dz\right)V + c\left(\lambda\right) \tag{11}$$

where $\varphi\left(\cdot\right)$ is the normal density. Assumption $A.3$ implies that the *competition effect* is considered by the banks together with the gain derived from the increased probability of success of the project. We consider the case in which the payoff $V$ depends upon a different market-specific parameter $\xi$ uniformly distributed on the real line. This parameter can be interpreted as a measure of the value of a Credit Bureau in the market, it depends upon the fraction of high-risky borrowers, mobility of borrowers and barriers to entry as shown by Jappelli and Pagano (1993). Each agent $i$ receives a private signal $\psi_i = \xi + \eta_i$ where $\eta_i$ is a random variable drawn uniformly from the interval $[-\varepsilon, \varepsilon]$ with $\varepsilon > 0$[3]. If the agents decide not to share their information the last term in (11) can be disregarded, and the probability of success of the project is given by $\left(1 - p^*_{NS}\right)$. Following Milgrom and Weber (1985) we suppose that agents use *distributional strategies* defined as a probability measure $y_i$ on the Cartesian product of the player's type and action space $y_i : [\xi - \varepsilon, \xi + \varepsilon] \times \{1\} \to [0, 1]$, where we have indexed the action "Invest" with 1. We use the following definitions:

**Definition 1** $(i)$ $\delta \equiv \theta^*_{IS} - \theta^*_{NS}$;
$(ii)$ $\int_{\theta^*_{IS}-\delta}^{\theta^*_{IS}} z\varphi(z)\, dz \equiv q$;
$(iii)$ $\lambda^* \equiv \arg\max_{\lambda \in [0,1]} c(\lambda)$;
$(iv)$ $v(\psi, y_i, y) = \left(\frac{1}{2\varepsilon} \int_{\psi-\varepsilon}^{\psi+\varepsilon} (qV(\xi) + c(\lambda(\xi, y)))\, d\xi\right) y_i(\psi)$.

In order to study the inefficiency derived by the miscoordination among lenders we impose the following restriction:

**A.4** $(i)$ $q > 0$; $(ii)$ $V'(\xi) > 0$ for every $\xi$.

This ensures that it would be efficient to set up a Credit Bureau because it lowers the probability of default of the firm, and the gains are increasing in the state. $v(\psi, y_i, y)$ is the expected difference in the payoffs derived from the information sharing. The following Lemma determines the unique $\psi^*$ :

**Lemma 1** *The expected payoff $v(\psi, y_i, y)$ of an agent with a signal equal to the switch point, $\psi^*$, is zero if and only if $V(\psi^*) = -\frac{1}{q}\int_0^1 c(\lambda)\, d\lambda$.*

Our main result is that the existence of a switching equilibrium requires that the value generated by the Credit Bureau is sufficiently high in order to compensate for the *competition effect*. It gives us the possibility to show that the lack of coordination among the agents leads to an important inefficiency.

**Proposition 2** $(i)$ *In the information sharing stage there exists an equilibrium in distributional strategies.*
$(ii)$ *A sufficient condition for an equilibrium in switching strategies to exist is* $\frac{c(\lambda^*) - c(1)}{q} \frac{1}{2\varepsilon} \leq V'(\psi^*)$.
$(iii)$ *If $c(1) < -qV(\psi^*)$ then there is an $\overline{\varepsilon}$ such that when $\varepsilon < \overline{\varepsilon}$, the switching strategy around $\psi^*$ is not an equilibrium.*

[3] We don't think that this assumption plays an important role, but simplifies the calculations.

The existence result follows one of the latest results in the *global games* literature given by Karp et al. (2007). They prove the existence of a switching strategy equilibrium in a global game in which the actions of the players can be strategic substitutes. We are able to identify a sufficient condition for the existence of a switching strategy equilibrium around $\psi^*$, which requires that the stealing possibilities opened by the information disclosure among the lenders are bounded above by the marginal value generated by the Credit Bureau. When this condition is not satisfied, the last statement of the proposition proves that there is no switching equilibrium. This is an important result to understand: the inefficiency generated in the emerging credit markets. We can consider $q$ a measure of the "information sharing value", hence efficiency requires that every time $q$ is positive, lenders should disclose their information about the borrowers. Our proposition shows that this might not happen if the banks believe that in this way they would sharpen the degree of competition in the market.

This has important implications for the credit rationing, in fact, if the investors don't coordinate to set up a Credit Bureau some of the banks might not fund the project, because they don't have sufficiently precise information about its profitability. Hence in our model credit rationing is not due to a moral hazard problem of the entrepreneurs, but is caused by a lack of trasparency in the market.

# 4 Concluding Remarks

We provide a completely new application for the *global game* approach, deriving some important conclusions about the necessity of transparency in emerging credit markets. We investigate the effects of an increase of communication among lenders. We find that an agreement on sharing information might lead to multiple equilibria. We show the conditions under which this disclosure of information is efficient leading to a reduction of the credit rationing in the market. We also prove that this might not happen due to a prevailing *competition effect*. This suggests the necessity for a policy interventation to enhance the sharing of data and transparency in the credit markets. One could in principle extend the analysis in the present paper to a dynamic setting in which there is strategic revelation of the information, introducing interesting issues related to the credibility of the credit intermediaries. To analyze the econometrics implications of our results could be another promising extension of the current analysis.

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# 5 Appendix

**Proof of Proposition 1.** For the moment, consider the case without information sharing. The payoff to "Invest" is $V$ if the threshold state is below $\theta^*_{NS}$ an investor will fund the project as long as the expected payoff, given his posterior belief, satisfies $r_f \leq V \Pr ob\left(\theta < \theta^*_{NS}|x_i\right)$. The unique threshold expectation $x^*$, is given by the *payoff indifference condition*:

$$r_f = V \Pr ob\left(\theta < \theta^*|x^*\right) = \Phi\left(\sqrt{\gamma+\beta}\left(\theta^* - x^*\right)\right) \tag{PI}$$

rearranging terms

$$x_{PI}\left(\theta^*\right) = \theta^* - \frac{1}{\sqrt{\gamma+\beta}}\Phi^{-1}\left(\frac{r_f}{V}\right) \tag{12}$$

Now suppose all agents follow a threshold strategy $x^*$. The fraction of banks choosing "Invest" given the state $\theta$ and $x^*$ is $\Phi\left(\left(\frac{\gamma+\beta}{\beta}\right)\sqrt{\beta}\left(x^* - \frac{\gamma}{\gamma+\beta}\widehat{\theta} - \frac{\beta}{\gamma+\beta}\theta\right)\right)$. The payoff to "Invest" is $V$ if and only if $\kappa\left(\theta\right) < \Phi\left(\left(\frac{\gamma+\beta}{\beta}\right)\sqrt{\beta}\left(x^* - \frac{\gamma}{\gamma+\beta}\widehat{\theta} - \frac{\beta}{\gamma+\beta}\theta\right)\right)$. From the monotonicity in the state and in the signal, it follows that the payoff to "Invest" is $V$ if $\theta < \theta^*_{NS}$, where $\theta^*_{NS}$ is given by the following critical mass condition:

$$\kappa\left(\theta\right) = \Phi\left(\left(\frac{\gamma+\beta}{\beta}\right)\sqrt{\beta}\left(x^* - \frac{\gamma}{\gamma+\beta}\widehat{\theta} - \frac{\beta}{\gamma+\beta}\theta^*_{NS}\right)\right) \tag{CM}$$

this gives us another equation for the threshold signal

$$\mathrm{x}^*_{CM} = \frac{\gamma}{\gamma+\beta}\widehat{\theta} + \frac{\beta}{\gamma+\beta}\theta^*_{NS} + \frac{1}{\sqrt{\beta}}\left(\frac{\beta}{\gamma+\beta}\right)\Phi^{-1}\left(\kappa\left(\theta^*_{NS}\right)\right) \tag{13}$$

The intersection of the PI with CM implicitly define the strategies in any threshold equilibrium. Substituting PI into CM and rearranging, one obtains:

$$\theta^*_{NS} = \widehat{\theta} + \frac{\sqrt{\beta}}{\gamma}\Phi^{-1}\left(\kappa\left(\theta^*_{NS}\right)\right) + \frac{\sqrt{\gamma+\beta}}{\gamma}\Phi^{-1}\left(\frac{r_f}{V}\right). \tag{14}$$

The case with information sharing follows directly with $\gamma$ replaced by $\gamma + \alpha$. This concludes the proof of $(i)$.

For the part $(ii)$ : there exist multiple equilibria if and only if $\mathrm{x}^*_{PI} = \mathrm{x}^*_{CM}$ and $\frac{dx^*_{PI}}{d\theta^*} \geq \frac{dx^*_{CM}}{d\theta^*}$ for some $\theta^* \in \left(\underline{\theta}, \overline{\theta}\right)$. For the "if part" there exists $y$ such that for some $\theta^* \in \left(\underline{\theta}, \overline{\theta}\right)$, $\mathrm{x}^*_{PI} = \mathrm{x}^*_{CM}$ whenever $\frac{dx^*_{PI}}{d\theta^*} \geq \frac{dx^*_{CM}}{d\theta^*}$. Equation 12 implies that $\frac{dx^*_{PI}}{d\theta^*} = 1$, while from equation 13 follows that $\frac{dx^*_{CM}}{d\theta^*} = \frac{\beta}{\gamma+\beta}\left(1 + \frac{1}{\sqrt{\beta}}\frac{\kappa'(\theta)}{\varphi\left(\Phi^{-1}(\kappa(\theta))\right)}\right)$. The case in which there is information sharing is analogous.

For the last statement of the Proposition fix $\frac{(\gamma+\alpha)}{\sqrt{\beta}} = d$. For sufficiently large $d$, $d = \frac{\kappa'(\theta)}{\varphi\left(\Phi^{-1}(\kappa(\theta))\right)}$ has two solutions, which we denote by $\underline{\theta}(d)$ and $\overline{\theta}(d)$ i.e. the local maximum and minimum of the r.h.s. of 7. Clearly there exist values of $y$ and $\widehat{\theta}$ such that some $\theta_1^* \in \left(\overline{\theta}(d), \overline{\theta}\right)$ and $\theta_2^* \in (\underline{\theta}, \underline{\theta}(d))$ are supported as equilibria. As $d \to \infty$ there are limit equilibria at $\underline{\theta}$ and $\overline{\theta}$ because $\underline{\theta}(d) \to \underline{\theta}$ and $\overline{\theta}(d) \to \overline{\theta}$. Equation 7 can be used to identify a critical region for the signal of the better informed creditor. When the signal falls inside this region there exists multiple equilibria in one of these, the probability of a successful project goes to 0, while in the other it goes to 1. ■

**Proof of Corollary.** Using equations 6 and 7 we can see that when $\theta_{IS}^* = \theta_{NS}^*$, $y$ must satisfy the following relation:

$$y = \widehat{\theta} + \frac{\sqrt{\beta}}{\gamma}\Phi^{-1}(\kappa(\theta^*)) + \left[\frac{(\alpha+\gamma)\sqrt{\gamma+\beta} - \gamma\sqrt{\alpha+\gamma+\beta}}{\gamma\alpha}\right]\Phi^{-1}\left(\frac{r_f}{V}\right) \equiv W \tag{15}$$

then by Proposition 1 $\frac{\partial\theta_{IS}^*}{\partial y} > 0$ while $\theta_{NS}^*$ does not depend on $y$, therefore $\theta_{IS}^* > \theta_{NS}^*$ if $y > W$. Since the probability of default $p^*$ is strictly decreasing in the equilibrium threshold we get the result. ■

**Proof of Lemma.** Conditional on receiving the signal $\psi^*$, the distribution of $\lambda$ is uniform on $[0,1]$. Therefore

$$v(\psi, y_i, y) = qV(\psi^*) + \int_0^1 c(\lambda)\, d\lambda \tag{16}$$

hence $v(\psi, y_i, y) = 0$ if and only if $V(\psi^*) = -\frac{1}{q}\int_0^1 c(\lambda)\, d\lambda$. ■

**Proof of Proposition 2.**

- For the $(i)$ part of the proposition the proof follows that of Proposition 1 in *L. Karp et al.* (2007). We refer the reader to that proof for more details.

- For the $(ii)$ part, conditional on receiving the signal $\psi^*$, the distribution of $\lambda$ is uniform on $[0,1]$. Therefore

$$v(\psi, y_i, y) = qV(\psi^*) + \int_0^1 c(\lambda)\, d\lambda \tag{17}$$

hence $v(\psi, y_i, y) = 0$ if and only if $V(\psi^*) = -\frac{1}{q}\int_0^1 c(\lambda)\, d\lambda$.

At the $\psi^*$ specified in the previous Lemma agents are indifferent between the two actions, and if the inequality

$$\frac{\partial v(\psi, y)}{\partial \psi} > 0 \tag{18}$$

holds, they strictly prefer to share (not to share) their information when $\psi > \psi^*$ ($\psi < \psi^*$). Thus it is sufficient to prove that 18 holds for arbitrary $\psi^*$. We have:

$$\frac{\partial v(\psi, y)}{\partial \psi} = \begin{cases} qV'(\psi) & \text{if } \psi < \psi^* - 2\varepsilon \\ qV'(\psi) + \frac{1}{2\varepsilon} c\left(\frac{1}{2} - \frac{1}{2\varepsilon}(\psi - \psi^* + \varepsilon)\right) & \text{if } \psi^* - 2\varepsilon \leq \psi < \psi^* \\ qV'(\psi) - \frac{1}{2\varepsilon} c\left(\frac{1}{2} - \frac{1}{2\varepsilon}(\psi - \psi^* + \varepsilon)\right) + \frac{1}{2\varepsilon} c(1) & \text{if } \psi^* \leq \psi < \psi^* + 2\varepsilon \\ qV'(\psi) & \text{if } \psi \geq \psi^* + 2\varepsilon \end{cases} \tag{19}$$

From the second line of Eq.19, $\frac{\partial v(\psi,y)}{\partial \psi} > 0$ if and only if $qV'(\psi) > -\frac{1}{2\varepsilon} c(\lambda)$ by quasi-concavity the latter holds if and only if $qV'(\psi) > -\frac{1}{2\varepsilon} c(1)$. From the third line of Eq.19 $\frac{\partial v(\psi,y)}{\partial \psi} > 0$ if and only if $qV'(\psi) > \frac{c(\lambda) - c(1)}{2\varepsilon}$ for all $\lambda \in [0, 1]$. This relation holds if and only if $\frac{c(\lambda^*) - c(1)}{q} \frac{1}{2\varepsilon} \leq V'(\psi^*)$, which is stronger than the condition $qV'(\psi) > -\frac{1}{2\varepsilon} c(1)$.

- For the part $(iii)$ consider $-\widehat{\xi} \equiv c(1) < \int_0^1 c(\lambda)\, d\lambda \equiv -qV(\psi^*)$, then $qV'(\psi^*) < \widehat{\xi}$. Let $\bar{\varepsilon} = \frac{(\widehat{\xi} - \psi^*)}{2} > 0$, and suppose that $\varepsilon < \bar{\varepsilon}$. Given such an $\varepsilon$, the bank who receives a signal of $\psi \in \left(\psi^* + 2\varepsilon, \widehat{\xi}\right)$ knows with certainty that $\lambda = 1$, since $\psi > \psi^* + 2\varepsilon$. But then the expected payoff from choosing to "share" is therefore $qV(\psi) + c(1) < 0$. Hence the switching strategy around $\psi^*$ cannot be an equilibrium.

■