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Signalling Effects of a Large Player in a Global Game of Creditor Coordination

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Abstract

In case of multiple creditors a coordination problem can arise when the borrowing firm runs into financial distress. Even if the project's value at maturity is enough to pay all creditors in full, some creditors may be tempted to foreclose on their loans. We develop a model of creditor coordination where a large creditor moves before a continuum of small creditors, and analyze the signalling effects of the large creditor's investment decision on the subsequent behavior of the small creditors. The signalling effects crucially depend on the relative size of the large creditor and the relative precision of information. We derive conditions under which pure herding behavior is to be expected.

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1 Introduction

If multiple creditors are financing an investment project a coordination problem can arise when the borrowing firm runs into financial distress. Even if the project's value at maturity is enough to pay all the creditors in full, some creditors may be tempted to foreclose on their loans, fearing analogous behavior by other creditors. Such coordination failure among creditors has been recognized as one of the main causes of recent financial crises (see, e.g. Radelet and Sachs 1998, Fischer 1999). Despite its empirical relevance, the issue has hardly been addressed in financial market literature, since coordination problems lead to multiple equilibria if creditors are perfectly informed. By applying the equilibrium selection framework of global games, Morris and Shin (2004) have developed a basic model which uniquely determines the incidence of inefficient liquidation due to creditor coordination failure. As is well known in the theory of global games, a single large player can crucially change the equilibrium behavior of the other small players.[1] Takeda (2003) has therefore extended the global-game model of creditor coordination by introducing a large player who decides simultaneously with a continuum of small players on whether to foreclose on the loans or not.

In this paper, we modify the global-game approach of Morris and Shin (2004) and Takeda (2003) in order to analyze the signalling effects of a large player. As opposed to simultaneous decisions of creditors, we assume that a continuum of small lenders takes into account the observable decision of the large creditor who moves first. This extension enables us to analyze the large creditor's signalling effects. It turns out that the influence of the signalling ability crucially depends on the relative size of the large player and the relative precision of creditor information. Even a relatively uninformed large creditor, who has no valuable information to signal, can affect the liquidation result, but only inasmuch as his size is relevant. If size is negligible our results coincide with those derived by Morris and Shin (2004) and Takeda (2003). If the large creditor is much better informed than the small creditors, a herding effect occurs whereby the small lenders follow the large creditor's behavior blindly, regardless of their own private information.

The paper is organized as follows. In Section 2 we set up the model and solve for the equilibrium in the two limiting cases where the large creditor is infinitely better or worse informed than the small creditors. Section 3 compares our results to those derived by Takeda (2003) to emphasize the signalling effects of the large creditor. Section 4 concludes.

2 The Model

A large creditor and a continuum of ex ante identical small creditors are financing a firm's investment project. The proportion of loans financed by the large creditor is $\lambda \in [0, 1]$, while the investment of every small creditor is negligible. However, the combined mass of loans financed by small creditors amounts to $(1-\lambda)$. The project's profitability is uncertain before maturity. If the project succeeds, the firm remains in operation and is able to pay back the full face value of a loan, normalized to unity, to the creditors. Otherwise the firm is forced into bankruptcy and the creditors receive no liquidation value. Before the project matures, creditors have the right to review their investment, i.e. to decide whether

[1] Corsetti et al. (2004) have recently analyzed the role of a large player in the context of currency attacks.

to roll over their loans or to foreclose. In the event of premature foreclosure a creditor receives the collateral $\kappa \in (0,1)$ per loan. We assume that neither the collateral κ nor the value v of a loan at maturity depends on the timing of the lenders' investment decisions. Creditors who postpone their decision are able to react on the choices of the first-move lenders. Thus, a creditor can either learn from the decisions of the predecessors, or he can use the own investment decision to signal to the subsequent lenders. As usual in modern global-game theory, it is assumed that the small creditors ignore the signalling effects of their decisions.

Whether the project succeeds or fails depends on the underlying fundamental state $\theta \in \mathbb{R}$ of the firm. These fundamentals can be interpreted as a measure of the firm's ability to meet short-term claims from creditors. Let $\ell \in [0,1]$ denote the proportion of loans that are foreclosed. If the total incidence of foreclosure ℓ is greater than θ, the firm is forced into bankruptcy. Otherwise, the project proceeds successfully and the firm is able to pay back the loans to the remaining creditors. Thus, the value of each loan at maturity is given by

$$v(\theta,\ell) = \begin{cases} 1 & \text{if } \ell \leq \theta \\ 0 & \text{if } \ell > \theta \,. \end{cases}$$

For convenience, we assume that if rolling over a loan yields the same expected payoff as premature foreclosure, the risk neutral creditors prefer to stop lending.

If creditors know the fundamental state perfectly before reviewing their investment, the optimal investment strategies depending on θ can be analyzed as follows. For good fundamentals $\theta \geq 1$, the dominant strategy for any creditor is to continue lending since the project succeeds even if all other lenders prematurely foreclose on their loans. On the contrary, bad fundamentals $\theta < 0$ imply that premature foreclosure is optimal for every creditor, irrespective of the decisions of the other lenders. The interesting range is the intermediate case with $0 \leq \theta < 1$. A coordination problem among the lenders occurs since the optimal investment decision of each creditor depends on the behavior of the others. If all other creditors stop lending, the expected payoff to rolling over is 0, so that foreclosing on the loans is the optimal decision. Otherwise, if everyone else continues lending, the payoff is 1, so that rolling over the loans is the dominant strategy. Thus, under complete information there are two pure-strategy Nash equilibria, foreclose and roll over. In addition, there exists a mixed-strategy equilibrium if $\theta \in [0,1)$, such that a creditor's optimal strategy is to foreclose on the loans with probability $\ell = \theta$.

The coordination problem among creditors can be resolved by the assumption of incomplete information of fundamentals. In their seminal paper, Morris and Shin (2004) analyzed the investment decisions of small creditors possessing uncertain public and private information on the fundamentals. In the present paper, we follow Takeda (2003) and drop the assumption that information on the fundamental state θ is publicly available to creditors by assuming an improper uniform prior in $\mathbb{R}$. However, the lenders receive private signals regarding the fundamental state before reviewing their investment. The large creditor observes the realization of the noisy signal

$$y = \theta + \tau\eta \,, \tag{1}$$

where $\tau > 0$ is a scale factor indicating the amount of noise and η is a random variable with mean 0, with continuously differentiable symmetric density $g(\cdot)$, and cumulative density

$G(\cdot)$. Equivalently, a small creditor i receives the private signal

$$x_i = \theta + \sigma \varepsilon_i \;, \tag{2}$$

with the scale factor $\sigma > 0$. The random variable ε_i is distributed with mean 0, smooth symmetric density $f(\cdot)$, and cumulative density $F(\cdot)$. ε_i is i.i.d. across creditors and is independent of the disturbance η. Each creditor deduces his own estimate of θ, the distribution of signals reaching the other creditors, as well as their estimates of θ from his private information.

As argued by Corsetti et al. (2004) within a similar game-theoretic context the small players prefer delaying their decision, while the large player benefits from signalling and thus moves first. Since small creditors do not take into account the signalling effects of their decisions, they have no incentive to make their investment decision first. Instead, they might benefit from waiting, since they can observe the behavior of the large creditor and learn more about the fundamental state θ if the large lender moves first. Thus, it is a weakly dominant strategy for the small creditors to delay the decision on whether to foreclose on their loans or not. Since the large creditor anticipates the timing of the small creditors' investment decisions, he is aware that in equilibrium he can never learn from their choices. But he knows that he will send a signal to the small creditors if he decides first. Since the large creditor is concerned with coordinating his decision with those of the continuum of small lenders, he benefits from moving first and signalling his decision to these small creditors. Thus, it is a dominant strategy for the large creditor to stop lending immediately, if he is ever going to foreclose on his loans.

In this sequential-move game a unique trigger equilibrium exists which is characterized by the 5-tuple $(y^*, \underline{x}^*, \overline{x}^*, \underline{\theta}^*, \overline{\theta}^*)$. The large creditor, moving first, decides to roll over the loan if his private signal y is greater than the switching point y^*. If the small lenders observe the large creditor rolling over his loans, they will also decide to continue lending as long as their private signal x_i exceeds the threshold $\underline{x}^*$. But even if the large creditor decides to foreclose on his loans, high signals $x_i > \overline{x}^*$ make the small creditors confident of the project's success and entice them to continue lending. Since $\underline{x}^* < \overline{x}^*$ and since the private signals are correlated with the true fundamental state θ, there exist threshold values $\underline{\theta}^*$ and $\overline{\theta}^*$ corresponding to the respective switching points $\underline{x}^*$ and $\overline{x}^*$. Failure of the project can always be averted if fundamentals are sound, $\theta \geq \overline{\theta}^*$, but never if $\theta < \underline{\theta}^*$. In the intermediate range $\underline{\theta}^* \leq \theta < \overline{\theta}^*$, the project's success depends entirely on the large creditor's investment decision. Thus, in equilibrium the incidence of inefficient liquidation is uniquely determined by the interval $[0, \underline{\theta}^*)$ and $[0, \overline{\theta}^*)$, respectively, depending on whether the large creditor continues lending or not. Below, we derive conditions that jointly determine the switching points y^*, $\underline{x}^*$, $\overline{x}^*$, $\underline{\theta}^*$, $\overline{\theta}^*$.

Having received the signal y, the large creditor's expected payoff to rolling over a loan is given by

$$Pr\ (\theta \geq \underline{\theta}^* | y) = G\left(\frac{y - \underline{\theta}^*}{\tau}\right) \;.$$

Therefore, the critical signal y^* is defined by the large lender's cutoff condition

$$G\left(\frac{y^* - \underline{\theta}^*}{\tau}\right) = \kappa \;,$$

so that

$$y^* = \underline{\theta}^* + \tau G^{-1}(\kappa) \,. \tag{3}$$

A low signal $y \leq y^*$ leads the large creditor to stop lending. Then the switching point $\overline{x}^*$ of a small creditor i is implicitly given by his indifference condition

$$Pr\ (\theta \geq \overline{\theta}^* \mid y \leq y^*,\ x_i = \overline{x}^*) = \kappa \,, \tag{4}$$

if a solution to (4) exists. If the probability on the LHS is strictly larger than κ for all x_i, $\overline{x}^*$ converges to $-\infty$. Conversely, if the LHS is strictly smaller than the RHS, irrespective of the private signals x_i, the critical signal $\overline{x}^*$ tends to ∞. Since the large creditor stops lending, the proportion of loans rolled over until maturity amounts to $(1-\lambda)Pr\ (x_i > \overline{x}^*|\theta)$, so that in equilibrium the threshold $\overline{\theta}^*$ of the fundamentals solves the critical mass condition

$$\overline{\theta}^* = 1 - (1-\lambda)Pr\ (x_i > \overline{x}^*|\theta = \overline{\theta}^*) \,. \tag{5}$$

If the large creditor observes $y > y^*$, he sends an encouraging signal to the small lenders. Consequently, they prefer rolling over their loans for a larger range of signals. The private signal $\underline{x}^*$ that makes a small creditor indifferent between premature foreclosure and continued lending in this case is given by

$$Pr(\theta \geq \underline{\theta}^*|y > y^*, x_i = \underline{x}^*) = \kappa \,, \tag{6}$$

if a solution to (6) exists. Otherwise, $\underline{x}^* \to -\infty$, if the LHS is strictly larger than κ for all x_i. If κ exceeds the probability on the LHS for all x_i, $\underline{x}^* \to \infty$. The corresponding threshold value $\underline{\theta}^*$ of the fundamentals, below which stopped lending by small creditors alone is sufficient for the project to fail, solves

$$\underline{\theta}^* = 1 - \lambda - (1-\lambda)Pr(x_i > \underline{x}^*|\theta = \underline{\theta}^*) \,. \tag{7}$$

To derive the equilibrium thresholds, the equations (3) to (7) have to be solved simultaneously. From (1) and (2), the private signal of the large creditor can be rewritten as

$$y = x_i + \tau\eta - \sigma\varepsilon_i \,. \tag{8}$$

Using the equations (3) and (8), a small creditor's posterior probability assessment of the project's success conditional on the signal x_i and observing the large creditor continuing lending can be expressed as

$$\begin{aligned} &Pr\ (\theta \geq \underline{\theta}^* \mid y > y^*, x_i) = Pr(x_i - \sigma\varepsilon_i \geq \underline{\theta}^* \mid x_i + \tau\eta - \sigma\varepsilon_i > \underline{\theta}^* + \tau G^{-1}(\kappa)) \\ &= Pr\ \left(\varepsilon_i \leq \frac{x_i - \underline{\theta}^*}{\sigma} \middle| \tau\eta - \sigma\varepsilon_i > \underline{\theta}^* - x_i + \tau G^{-1}(\kappa) \right) \,. \end{aligned}$$

Thus, the critical signal $\underline{x}^*$ can be derived by solving

$$Pr\ (\theta \geq \underline{\theta}^* \mid y > y^*, x_i = \underline{x}^*) = \frac{Pr(\theta \geq \underline{\theta}^*, y > y^*, x_i = \underline{x}^*)}{Pr(y > y^*, x_i = \underline{x}^*)}$$

$$= \frac{Pr\left(\varepsilon_i \leq \frac{\underline{x}^* - \underline{\theta}^*}{\sigma},\ \tau\eta - \sigma\varepsilon_i > \underline{\theta}^* - \underline{x}^* + \tau G^{-1}(\kappa)\right)}{Pr\left(\tau\eta - \sigma\varepsilon_i > \underline{\theta}^* - \underline{x}^* + \tau G^{-1}(\kappa)\right)} = \kappa\,. \tag{9}$$

Analogously, we can derive the switching point $\overline{x}^*$ from condition (4), the case in which the large creditor has foreclosed on his loans:

$$Pr\ (\theta \geq \overline{\theta}^* \mid y \leq y^*, x_i = \overline{x}^*) = \frac{Pr(\theta \geq \overline{\theta}^*, y \leq y^*, x_i = \overline{x}^*)}{Pr(y \leq y^*, x_i = \overline{x}^*)}$$

$$= \frac{Pr\left(\varepsilon_i \leq \frac{\overline{x}^* - \overline{\theta}^*}{\sigma},\ \tau\eta - \sigma\varepsilon_i \leq \overline{\theta}^* - \overline{x}^* + \tau G^{-1}(\kappa)\right)}{Pr\left(\tau\eta - \sigma\varepsilon_i \leq \overline{\theta}^* - \overline{x}^* + \tau G^{-1}(\kappa)\right)} = \kappa\,. \tag{10}$$

Neither of these equations can be solved explicitly in the general case, without making further parametric assumptions on the distribution of the error terms η and ε_i. Therefore, we follow the procedure suggested by Corsetti et al. (2004) and confine our analysis to the limiting properties of the equilibrium to emphasize the significance of information precision. In particular, we consider the limiting cases in which the large creditor is much better and worse informed than the small lenders, respectively.

If the large creditor's private information is infinitely more volatile than the small creditors' information ($\sigma/\tau \to 0$), the equilibrium behavior of lenders can be summarized by the following proposition.

Proposition 1: *As $\sigma/\tau \to 0$, there is a unique trigger equilibrium with*

$$\begin{aligned}
y^* &= \kappa(1-\lambda) + \tau G^{-1}(\kappa) \\
\underline{x}^* &= \kappa(1-\lambda) + \sigma F^{-1}(\kappa) \\
\overline{x}^* &= \kappa(1-\lambda) + \lambda + \sigma F^{-1}(\kappa) \\
\underline{\theta}^* &= \kappa(1-\lambda) \\
\overline{\theta}^* &= \kappa(1-\lambda) + \lambda\,.
\end{aligned}$$

Proof. *See the Appendix.*

This proposition implies that even an infinitely worse informed large creditor affects the small creditors' behavior by signalling his investment decision. Since the small creditors' information is much more precise, the signal of the large lender can not reduce their uncertainty about the fundamental state θ. However, the observable action of the large creditor reduces the strategic uncertainty of small lenders, i.e. their uncertainty regarding the decisions of other creditors. Consequently, the equilibrium outcome of the game is merely affected by the size of the large lender. According to $\partial(\overline{\theta}^* - \underline{\theta}^*)/\partial\lambda > 0$, the large creditor's influence on the project's success or failure is strictly increasing in λ. As $\lambda \to 1$, the coordination failure among creditors vanishes as in the case where the project is financed by a single creditor. On the contrary, if the large creditor's investment volume becomes negligible ($\lambda \to 0$), the small creditors' strategic uncertainty does not decrease. As in the case with small lenders only, the critical thresholds $\underline{\theta}^*$ and $\overline{\theta}^*$ both converge to κ.

These results change distinctively in the opposite and more evident extreme case of a relatively better informed large creditor ($\sigma/\tau \to \infty$). The creditors' switching points and the corresponding threshold values of the fundamentals can be summarized as follows:

Proposition 2: *As $\sigma/\tau \to \infty$, there is a unique trigger equilibrium with*

$$
\begin{aligned}
& y^* = \tau G^{-1}(\kappa) \\
& \underline{x}^* \to -\infty \\
& \overline{x}^* \to \infty \\
& \underline{\theta}^* = 0 \\
& \overline{\theta}^* = 1\,.
\end{aligned}
$$

Proof. *See the Appendix.*

Proposition 2 states that an infinitely better informed large creditor can exert much more influence on the small creditor's investment decisions than in the case with $\sigma/\tau \to 0$. The large creditor does not only reduce the strategic uncertainty but also eliminates the small creditors' fundamental uncertainty by signalling his investment decision. Actually, since the switching points $\underline{x}^*$ and $\overline{x}^*$ tend to $-\infty$ and ∞, respectively, small creditors imitate the decision of the better informed large creditor irrespective of their own private signals. Since the large creditor anticipates that in equilibrium the second movers will follow him blindly, he acts as if he was the only lender. Thus, the equilibrium outcome of the sequential-move game with an arbitrarily better informed large creditor corresponds to the benchmark case with a single lender. Note that this result holds regardless of the size of the large creditor. Even the informational signalling ability of an entirely insignificant large lender ($\lambda \to 0$) generates such herding behavior among the small creditors.

3 Signalling effects of the large creditor

In order to quantify the sigalling effects of the large creditor we compare our results with those of the corresponding simultaneous-move game which describes the case of unobservable investment decisions.[2] Since it is not possible to obtain closed-form solutions in Takeda's model this analysis has to be restricted to the case where the private information of both creditor types becomes very precise ($\sigma \to 0, \tau \to 0$). The signalling effects of the large creditor are summarized in Table 1.

Table 1:
Fundamental thresholds for the project's success

	Large creditor is relatively	
Large creditor's investment decision is	informed $(\sigma/\tau \to \infty, \sigma \to 0)$	uninformed $(\sigma/\tau \to 0, \tau \to 0)$
Unobservable	$\theta^* = \kappa\,(1-\lambda)$	$\theta^* = \begin{cases} \kappa\frac{1-\lambda}{1-\kappa} & \text{if } \lambda > \kappa \\ \kappa & \text{if } \lambda \leq \kappa \end{cases}$
Observable	$\underline{\theta}^* = 0$ $\overline{\theta}^* = 1$	$\underline{\theta}^* = \kappa\,(1-\lambda)$ $\overline{\theta}^* = \kappa\,(1-\lambda) + \lambda$

[2]The fundamental thresholds of the simultaneous-move game can be derived from Proposition 2 of Takeda (2003) by taking the limit as $\sigma/\tau \to 0$ and $\sigma/\tau \to \infty$, respectively.

If the large creditor is able to signal his decision, the critical levels of the fundamentals $\underline{\theta}^*$ ($\overline{\theta}^*$) are always lower (higher) than the corresponding threshold θ^* in the case of unobservable investment decisions. In other words, the signalling effect of the large creditor is always positive, regardless of the relative precision of private information. Furthermore, allowing the large creditor to signal to small lenders dominates the outcome of the simultaneous-move game if private information is arbitrarily precise. This is due to the fact that a well informed large creditor never makes a wrong decision, i.e. he stops lending if the true state of the fundamentals is lower than $\underline{\theta}^*$. As a consequence, the project fails if $\theta < \underline{\theta}^*$ so that the upper threshold $\overline{\theta}^*$ becomes irrelevant for the analysis of coordination failure as $\tau \to 0$. Since $\underline{\theta}^* < \theta^*$, irrespective of the relative precision of information, a firm facing a very precisely informed large creditor can always reduce the incidence of inefficient liquidation by announcing the large lender's investment decision to the small creditors.

4 Concluding remarks

In their basic model, Morris and Shin (2004) have analyzed the investment decisions of small creditors obtaining public information about the fundamental state of the firm and receiving a private signal concerning this state. In our model we have neglected public information. This has enabled us to concentrate on the updated beliefs of the small creditors conditional on the large creditor's signal without taking into account the information contained in the prior distribution. Of course, the large creditor has a strong impact on the small creditor's decisions. This influence depends on three factors, the relative size of the large creditor, his signalling ability, and the relative precision of creditor information. As was shown by Takeda (2003), the incidence of inefficient liquidation is low if the size of the large creditor is considerable, and it is even lower if the large creditor is much better informed. Additionally, we have derived a strong signalling effect of the large creditor. If his decision is observable, the large creditor has an even stronger influence on the incidence of inefficient liquidation. The two thresholds of our sequential-move game indicating the investment behavior of small creditors conditional on the large creditor's signal are higher and lower, respectively, than the corresponding threshold derived by Takeda (2003) in the simultaneous-move game. Even a relatively uninformed large creditor, who has no valuable information to signal, can affect the liquidation result, but only inasmuch as his size is relevant. If size is negligible our results coincide with those derived by Takeda (2003) which in turn coincide with those derived by Morris and Shin (2004) in the version with an improper prior. If the large creditor is significantly better informed than the small creditors, a herding effect occurs. Irrespective of his size, the small creditors imitate his behavior blindly, completely ignoring their own information.

Our results imply that a single relatively well-informed large creditor like a bank can make the other small creditors either extremely aggressive or not aggressive at all, depending on the private information the large creditor receives. This reintroduces a stochastic component to the foreclosure decisions of multiple creditors. To the extend that the success of an investment project is the mitigation of a coordination problem among the creditors, the signalling ability of a precisely informed large creditor is appropriate to reduce the incidence of inefficient liquidations.

Appendix

Proof of Proposition 1

Rewrite equation (9) as

$$\frac{Pr\left(\varepsilon_i \le \frac{\underline{x}^*-\underline{\theta}^*}{\sigma}, \eta - \frac{\sigma}{\tau}\varepsilon_i > \frac{\underline{\theta}^*-\underline{x}^*}{\tau} + G^{-1}(\kappa)\right)}{Pr\left(\eta - \frac{\sigma}{\tau}\varepsilon_i > \frac{\underline{\theta}^*-\underline{x}^*}{\tau} + G^{-1}(\kappa)\right)} = \kappa\ .$$

Taking the limit as $\sigma/\tau \to 0$ yields

$$\frac{Pr\left(\varepsilon_i \le \frac{\underline{x}^*-\underline{\theta}^*}{\sigma}, \eta > \frac{\underline{\theta}^*-\underline{x}^*}{\tau} + G^{-1}(\kappa)\right)}{Pr\left(\eta > \frac{\underline{\theta}^*-\underline{x}^*}{\tau} + G^{-1}(\kappa)\right)} = \kappa\ .$$

Independence of the error terms ε_i und η implies

$$\frac{Pr\left(\varepsilon_i \le \frac{\underline{x}^*-\underline{\theta}^*}{\sigma}\right) Pr\left(\eta > \frac{\underline{\theta}^*-\underline{x}^*}{\tau} + G^{-1}(\kappa)\right)}{Pr\left(\eta > \frac{\underline{\theta}^*-\underline{x}^*}{\tau} + G^{-1}(\kappa)\right)} = \kappa \quad \Leftrightarrow$$
$$Pr\left(\varepsilon_i \le \frac{\underline{x}^*-\underline{\theta}^*}{\sigma}\right) = F\left(\frac{\underline{x}^*-\underline{\theta}^*}{\sigma}\right) = \kappa$$

and therefore

$$\underline{x}^* = \underline{\theta}^* + \sigma F^{-1}(\kappa)\ .$$

Inserting this equation into (7) yields

$$\begin{aligned}\underline{\theta}^* &= 1-\lambda-(1-\lambda)Pr(\underline{\theta}^* + \sigma\varepsilon_i > \underline{\theta}^* + \sigma F^{-1}(\kappa))\\ &= 1-\lambda-(1-\lambda)(1-F(F^{-1}(\kappa)))\\ &= 1-\lambda-(1-\lambda)(1-\kappa)\\ &= \kappa(1-\lambda)\ .\end{aligned}$$

Analogously, equation (10) can be rewritten as

$$\frac{Pr\left(\varepsilon_i \le \frac{\overline{x}^*-\overline{\theta}^*}{\sigma},\ \eta - \frac{\sigma}{\tau}\varepsilon_i \le \frac{\overline{\theta}^*-\overline{x}^*}{\tau} + G^{-1}(\kappa)\right)}{Pr\left(\eta - \frac{\sigma}{\tau}\varepsilon_i \le \frac{\overline{\theta}^*-\overline{x}^*}{\tau} + G^{-1}(\kappa)\right)} = \kappa\ .$$

Thus, in the limiting case $\sigma/\tau \to 0$ results

$$Pr\left(\varepsilon_i \le \frac{\overline{x}^*-\overline{\theta}^*}{\sigma}\right) = F\left(\frac{\overline{x}^*-\overline{\theta}^*}{\sigma}\right) = \kappa\ ,$$

so that the critical signal $\overline{x}^*$ is given by

$$\overline{x}^* = \overline{\theta}^* + \sigma F^{-1}(\kappa) \ .$$

Inserting into equation (5) yields

$$\begin{aligned}\overline{\theta}^* &= 1-(1-\lambda)Pr(\overline{\theta}^* + \sigma\varepsilon_i > \overline{\theta}^* + \sigma F^{-1}(\kappa)) \\ &= 1-(1-\lambda)(1-F(F^{-1}(\kappa))) \\ &= 1-(1-\lambda)(1-\kappa) \\ &= \kappa(1-\lambda)+\lambda \ .\end{aligned}$$

Using the above results, the creditors' switching points are given by:

$$\begin{aligned}y^* &= \kappa(1-\lambda) + \tau G^{-1}(\kappa) \\ \underline{x}^* &= \kappa(1-\lambda) + \sigma F^{-1}(\kappa) \\ \overline{x}^* &= \kappa(1-\lambda) + \lambda + \sigma F^{-1}(\kappa) \ .\end{aligned}$$

Proof of Proposition 2

Rewriting equation (9) as

$$\frac{Pr\left(\varepsilon_i \leq \frac{\underline{x}^*-\underline{\theta}^*}{\sigma}, \frac{\tau}{\sigma}\eta - \varepsilon_i > \frac{\underline{\theta}^*-\underline{x}^*}{\sigma} + \frac{\tau}{\sigma}G^{-1}(\kappa)\right)}{Pr\left(\frac{\tau}{\sigma}\eta - \varepsilon_i > \frac{\underline{\theta}^*-\underline{x}^*}{\sigma} + \frac{\tau}{\sigma}G^{-1}(\kappa)\right)} = \kappa$$

and taking the limit as $\sigma/\tau \to \infty$ yields

$$\frac{Pr\left(\varepsilon_i \leq \frac{\underline{x}^*-\underline{\theta}^*}{\sigma}, \varepsilon_i < \frac{\underline{x}^*-\underline{\theta}^*}{\sigma}\right)}{Pr\left(\varepsilon_i < \frac{\underline{x}^*-\underline{\theta}^*}{\sigma}\right)} = 1 > \kappa \ .$$

Thus, the switching point of a small creditor who has observed the large creditor rolling over the loan, tends to

$$\underline{x}^* \to -\infty \ .$$

Hence, the probability in equation (7) is equal to 1, so that

$$\underline{\theta}^* = 0 \ .$$

By the same token, equation (10) can be transformed to

$$\frac{Pr\left(\varepsilon_i \leq \frac{\overline{x}^*-\overline{\theta}^*}{\sigma}, \frac{\tau}{\sigma}\eta - \varepsilon_i \leq \frac{\overline{\theta}^*-\overline{x}^*}{\sigma} + \frac{\tau}{\sigma}G^{-1}(\kappa)\right)}{Pr\left(\frac{\tau}{\sigma}\eta - \varepsilon_i \leq \frac{\overline{\theta}^*-\overline{x}^*}{\sigma} + \frac{\tau}{\sigma}G^{-1}(\kappa)\right)} = \kappa \ ,$$

so that we get

$$\frac{Pr\left(\varepsilon_i \leq \frac{\overline{x}^*-\overline{\theta}^*}{\sigma}, \varepsilon_i \geq \frac{\overline{x}^*-\overline{\theta}^*}{\sigma}\right)}{Pr\left(\varepsilon_i \geq \frac{\underline{x}^*-\overline{\theta}^*}{\sigma}\right)} = 0 < \kappa$$

in the limiting case where $\sigma/\tau \to \infty$.

Thus, the switching point of a small creditor who has observed the large creditor foreclosing on the loan, tends to

$$\overline{x}^* \to \infty \ .$$

Hence, the probability in equation (5) is equal to 0, so that

$$\overline{\theta}^* = 1 \ .$$

Finally, we can derive the large creditor's switching point from (3):

$$y^* = \tau G^{-1}(\kappa) \ .$$

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