# Online Appendix for "Dissecting Bankruptcy Frictions"

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# Contents

This Online Appendix presents additional results, mainly extensions of the theory, complementing the results presented in the paper.

# A. Inefficient Delay in Bargaining with Complete Information

In this section, we use two-period models to illustrate the key difference between our dynamic bargaining model and the seminal framework based on Rubinstein (1982), Merlo and Wilson (1995), and Merlo and Wilson (1998). In those models with complete information, there is no inefficient delay in equilibrium even in the presence of conflict of interests. Example (i) is a simplified version of Rubinstein (1982) and Bebchuk and Chang (1992) in which there is an efficient equilibrium with no delay. Example (ii) can be viewed as a simplified version of Merlo and Wilson (1995) and Merlo and Wilson (1998) in which efficient delay occurs in equilibrium. Example (iii) is a simplified version of our model in the main text. The key feature is that the "separation principle" of Merlo and Wilson (1998) is violated, and thus inefficient delay occurs in equilibrium even when the creditors face a complete-information environment.

## A.1 Example (i): No Delay in Equilibrium

Suppose there are two periods: $t = 0, 1$. Consider senior and junior creditors who bargain over how to split the firm value. The senior and junior debt levels are denoted by $D_S$ and $D_J$, respectively. We assume that the firm value is equal to the senior debt level in period $t = 0$, that is, $V_0 = D_S$. In period $t = 1$, there are two contingent scenarios with each occurring with equal probability 1/2. In one scenario, the firm value rises to a high level $V_1 = D_S + \theta_u - \delta$; and in the other scenario, the firm value declines to a low level $V_1 = D_S - \theta_d - \delta$. The depreciation rate of firm value $\delta$ is positive. In the terminal period ($t = 1$), the judge uses the cram down provision, and distributes the outcome to creditors following the absolute priority rule (APR). The key feature is that the firm value in period $t = 1$ does not depend on who proposes the plan.

Suppose that $\theta_u = \theta_d = \theta > \delta > 0$. Thus, the size of the "cake" follows a **supermartingale**:

$$E_0[V_1] \leq V_0. \tag{1}$$

This is because $E_0[V_1] = (D_S + \theta - \delta)/2 + (D_S - \theta - \delta)/2 = D_S - \delta < D_S = V_0$.

Suppose the senior has the opportunity to propose in period $t = 0$. Before making decision, the senior needs to figure out the continuation value of both creditors if the deal moves to the next period. The continuation value is the average payoff in period $t = 1$. What are the contingent payoffs? If the world ends up in the high-level state with $V_1 = D_S + \theta - \delta$ in period $t = 1$, the senior would get $D_S$ and the junior would get $\theta - \delta > 0$; alternatively, if the world ends up in the low-level state with $V_1 = D_S - \theta - \delta$ in period $t = 1$, the senior would get $D_S - \theta - \delta$ and the junior would get 0. Thus, at the end of period $t = 0$, the continuation value of the senior creditor is $D_S/2 + (D_S - \theta - \delta)/2 = D_S - (\theta + \delta)/2$, and the continuation value of the junior creditor at the end of period $t = 0$ is $(\theta - \delta)/2 + 0/2 = (\theta - \delta)/2$. Therefore, the senior creditor would have to pay at least $(\theta - \delta)/2$ to the junior creditor if she would like to settle the deal in period $t = 0$, and the senior creditor would obtain the continuation value $D_S - (\theta + \delta)/2$ if she would like to settle the deal in period $t = 1$. The former choice (i.e. settling the deal in period $t = 0$ by paying off the junior creditor) would pay the senior creditor with $V_0 - (\theta - \delta)/2 = D_S - (\theta - \delta)/2$, and the latter choice (i.e. settling the deal in period $t = 1$) will worth $D_S - (\theta + \delta)/2$ as present value to the senior creditor. It is obvious that the former choice is preferred by the senior creditor (i.e., $D_S - (\theta - \delta)/2 > D_S - (\theta + \delta)/2$).

Fundamentally, this is a result of the supermartingale property in (1).

Therefore, there is no delay in equilibrium, and importantly, this is an efficient outcome since the firm value follows a supermartingale. This simple example illustrates the key economic insight of Rubinstein (1982).

## A.2 Example (ii): Efficient Delay in Equilibrium

Suppose there are two periods: $t = 0, 1$. Consider senior and junior creditors who bargain over how to split the firm value. The senior and junior debt levels are denoted by $D_S$ and $D_J$, respectively. We assume that the firm value is equal to the senior debt level in period $t = 0$, that is, $V_0 = D_S$. In period $t = 1$, there are two contingent scenarios with each occurring with equal probability 1/2. In one scenario, the firm value rises to a high level $V_1 = D_S + \theta_u - \delta$; and in the other scenario, the firm value declines to a low level $V_1 = D_S - \theta_d - \delta$. The depreciation rate of firm value $\delta$ is positive. In the terminal period ($t = 1$), the judge uses the cram down provision, and distributes the outcome to creditors following the absolute priority rule (APR). The key feature is that the firm value in period $t = 1$ does not depend on who proposes the plan.

So far, the setup is exactly the same as the example in Section A.1. Now, we introduce the key difference: $\theta_u$ is much larger than $\theta_d$ such that $\theta_u - \theta_d > 2\delta$. Therefore, the total size of the "cake" follows a **submartingale**:

$$E_0[V_1] \geq V_0. \tag{2}$$

This is because $E_0[V_1] = (D_S + \theta_u - \delta)/2 + (D_S - \theta_d - \delta)/2 = D_S + (\theta_u - \theta_d - 2\delta)/2 > D_S = V_0$.

Suppose the senior has the opportunity to propose in period $t = 0$. Before making decision, the senior needs to figure out the continuation value of both creditors if the deal moves to the next period. The continuation value is the average payoff in period $t = 1$. What are the contingent payoffs? If the world ends up in the high-level state with $V_1 = D_S + \theta_u - \delta$ in period $t = 1$, the senior would get $D_S$ and the junior would get $\theta_u - \delta > 0$; alternatively, if the world ends up in the low-level state with $V_1 = D_S - \theta_d - \delta$ in period $t = 1$, the senior would get $D_S - \theta_d - \delta$ and the junior would get 0. Thus, at the end of period $t = 0$, the continuation value of the senior creditor is $D_S/2 + (D_S - \theta_d - \delta)/2 = D_S - (\theta_d + \delta)/2$, and the continuation value of the junior creditor at the end of period $t = 0$ is $(\theta_u - \delta)/2 + 0/2 = (\theta_u - \delta)/2$. Therefore, the senior creditor would have to pay at least $(\theta_u - \delta)/2$ to the junior creditor if she would like to settle the deal in period $t = 0$, and the senior creditor would obtain the continuation value $D_S - (\theta_d + \delta)/2$ if she would like to settle the deal in period $t = 1$. The former choice (i.e. settling the deal in period $t = 0$ by paying off the junior creditor) would pay the senior creditor with $V_0 - (\theta_u - \delta)/2 = D_S - (\theta_u - \delta)/2$, and the latter choice (i.e. settling the deal in period $t = 1$) will worth $D_S - (\theta_d + \delta)/2$ as present value to the senior creditor. It is obvious that the latter choice is preferred by the senior creditor (i.e., $D_S - (\theta_u - \delta)/2 < D_S - (\theta_d + \delta)/2$). Fundamentally, this is a result of the submartingale property in (2).

Therefore, delay occurs in equilibrium, and importantly, this is an efficient outcome since the firm value follows a submartingale. This simple example illustrates the key economic insight discussed by Merlo and Wilson (1995) and Merlo and Wilson (1998).

## A.3 Example (iii): Inefficient Delay in Equilibrium

Based on the insight of Coase Theorem, the bargaining cost is necessary (but not sufficient) to get inefficient delay. There are several ways to generate inefficient delay in dynamic bargaining games with complete information. One example is to incorporate non-stationary strategies like trigger strategies in supergames (e.g., Fernandez and Glazer, 1991; Busch and Wen, 1995). Another example is to consider the hold-up problem in multilateral bargaining (e.g., Cai, 2000). Our model is designed to capture key features of the bankruptcy bargaining process, including the key assumption that who proposes and leads the reorganization matters for the outcome (i.e., the violation of "separation principle"). More precisely, two creditors in our model have different reorganization skills, and they cannot propose using the counterparty's plans. In other words, the size of the "cake" is proposer-dependent. The assumption is reasonable since the creditors of big bankruptcy cases are usually private equity funds and specialized distressed-asset hedge funds.

Suppose there are two periods: $t = 0, 1$. Consider senior and junior creditors who bargain over how to split the firm value. The senior and junior debt levels are denoted by $D_S$ and $D_J$, respectively. Suppose $V_{J,0}$ and $V_{S,0}$ are the size of the "cake" at $t = 0$ when junior and senior creditors propose, respectively. We assume that the firm value based on the senior creditor's reorganization plan is equal to the senior debt level in period $t = 0$, that is, $V_0 = D_S$. In period $t = 1$, there are two contingent scenarios with each occurring with equal probability 1/2. In one scenario, the firm value rises to a high level $V_{i,1} = V_{i,0} + \theta - \delta$ for each $i \in \{S, J\}$; and in the other scenario, the firm value declines to a low level $V_{i,1} = V_{i,0} - \theta - \delta$ for each $i \in \{S, J\}$. The depreciation rate of firm value $\delta$ is positive.

Assume that $V_{S,0} < V_{J,0} - \theta - \delta$. That is, the junior creditor has much higher initial reorganization skill. Suppose the senior has the opportunity to propose in period $t = 0$. Before making decision, the senior needs to figure out the continuation value of both creditors if the deal moves to the next period. The senior creditor needs to pay the junior creditor $V_{J,0} - \delta$ to settle the deal at $t = 0$. However, the senior creditor finds it not worth to do it since $V_{S,0} - (V_{J,0} - \delta) < -\theta < 0$. Therefore, the deal will be settled at $t = 1$. The social planner only cares about $V_{J,0}$ and $V_{J,1}$ since they are always the higher values (i.e., $V_{J,t} > V_{S,t}$ for $t = 0, 1$). But, $V_{J,t}$ is a supermartingale:

$$E_0 [V_{J,1}] < V_{J,0}. \tag{3}$$

This is because $E_0 [V_{J,1}] = (V_{J,0} + \theta - \delta)/2 + (V_{J,0} - \theta - \delta)/2 = V_{J,0} - \delta < V_{J,0}$. Therefore, it is efficient to settle the deal at $t = 0$, and thus, inefficient delay occurs in equilibrium. This simple example illustrates the key economic insight of our model.

In summary, there are two frictions: (i) conflict of interests, and (ii) asymmetric information. Random proposing contributes to the conflict of interests. Conflict of interests alone does not create inefficient delay in dynamic bargaining with complete information. The violation of the "separation principle" due to proposer-dependent reorganization value leads to inefficient delay. Moreover, asymmetric information interacts with conflict of interests, which leads to further delay and efficiency loss.

## B. Extended Model I: Stochastic $V_t$

In the baseline model, we assume that $V_t = \rho^{t-1}V_0$, decaying deterministically. Here, we shall assume that $V_t = \rho^{t-1}\hat{V}_t$ where $\hat{V}_t$ evolves as a two-state Markov process on $\{e^{-\nu}V_0, e^{\nu}V_0\}$ with $\nu > 0$.

At the very beginning of each period $t$ before everything else happens, there is a small probability $\pi \in (0,1)$ by which $\hat{V}_{t-1}$ will jump from $\hat{V}_{t-1}$ randomly to a value among $\{e^{-\nu}V_0, e^{\nu}V_0\}$ with equal probability 1/2. That is, $\hat{V}_{t-1}$ updates to $\hat{V}_t$ at the beginning of every period $t$ before the proposer is randomly chosen. Taking senior creditor as an example, the continuation value right before the update of $\hat{V}_{t-1}$ (i.e. the continuation value at the very end of period $t-1$) is denoted by $H_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_{t-1})$, and the continuation value right after the realization of $\hat{V}_t$ is denoted by $W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t)$. The relation between $H_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_{t-1})$ and $W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t)$ is

$$
\begin{aligned}
H_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, e^{-\nu}V_0) &= (1 - \pi + \frac{\pi}{2})W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, e^{-\nu}V_0) + \frac{\pi}{2}W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, e^{\nu}V_0), \\
H_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, e^{\nu}V_0) &= (1 - \pi + \frac{\pi}{2})W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, e^{\nu}V_0) + \frac{\pi}{2}W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, e^{-\nu}V_0).
\end{aligned}
$$

We calibrate $\nu$ and $\pi$ so that $\log \hat{V}_t$ (in the model) and the log of industry-level Tobin's Q (in the data) have the same persistence and conditional volatility. (Recall that $V_0$ in the baseline estimation equals a firm-specific constant times industry-level Tobin's Q, so $\log \hat{V}_t$ and the log of industry-level Tobin's Q should share the same persistence and conditional volatility.) Using panel data by industry and year, and using the estimator of Han and Phillips (2010), we estimate a regression of log median Tobin's Q on its lag and industry fixed effects. We choose $\nu$ and $\pi$ to match this regression's estimated slope (0.603) and residual volatility (0.211), taking into account that one model period does not correspond to one year.

Now, we explain how to solve the bargaining game with stochastic firm's potential reorganization value $V_t$. First, we describe the initial point of the dynamic programming procedure. The equilibrium, characterized by the Bellman equation, is solved recursively by backward induction. The "end period" is the first time $t$ such that $\rho^{t-1}e^{\nu}V_0 \leq L$. In equilibrium, there is certain probability that the bargaining ends before the scenario $\rho^{t-1}e^{-\nu}V_0 \leq L$ occurs. In the end period, both creditors will choose to quit the bargaining by liquidating the firm. The APR applies when splitting the liquidation value.

Next, we describe the Bellman equation for the senior creditor. Let us consider the continuation value function in period $t$ for any $t \geq 0$. The key is to establish the recursive Bellman equations for the continuation values at the beginning of the morning of period $t$, i.e., $W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t)$ and $W_{J,t}(\theta_{J,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t)$. The state variables include the endogenous state variables $(\ell_{S,t}, \ell_{J,t})$, the exogenous (private) state variable $\theta_{J,t}$ or $\theta_{S,t}$, and $\hat{V}_t$. The private information about $\theta_{S,t}$ and $\theta_{J,t}$ is learned by the senior and junior, respectively, at the very beginning of the afternoon of period $t-1$.

The continuation value of the senior creditor at the beginning of period $t$ follows the Bellman equation:

$$
\begin{aligned}
W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t) = & \underbrace{(1-\lambda_J) \max \left\{ O_{S,t},\ \max_{\xi_{S,t}} \mathbb{E}_t^S \left[ \widetilde{M}_{S,t+1}(\xi_{S,t}) \right] \right\}}_{\text{if } S \text{ proposes in the morning}} \\
& + \underbrace{\lambda_J \mathbb{E}_t^S \left[ \max_{\zeta_{S,t+1} \in \{0,1\}} \widetilde{A}_{S,t+1}(\zeta_{S,t+1}) \;\middle|\; \theta_{J,t} \geq \phi_{J,t} \right] \mathbb{P}_t^S \{\theta_{J,t} \geq \phi_{J,t}\}}_{\text{if } J \text{ proposes reorganization in the morning}} \\
& + \underbrace{\lambda_J \mathbb{E}_t^S \left[ \max\{O_{S,t}, U_{t+1}(\theta_{S,t+1}, \hat{V}_{t+1}) - O_{J,t}\} \right] \mathbb{P}_t^S \{\theta_{J,t} < \phi_{J,t}\}}_{\text{if } J \text{ decides to liquid in the morning}},
\end{aligned}
$$

where $\mathbb{E}_t^S$ is the conditional expectation of the senior creditor over $(\theta_{J,t}, \theta_{J,t+1})$, $\theta_{S,t+1}$, and $\hat{V}_{t+1}$; namely, the junior creditor's reorganization skills in the morning of periods $t$ and $t+1$, the senior's reorganization skill in the morning of period $t+1$, and the potential reorganization value in the morning of period $t+1$, conditioning on $(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t)$. Here, $\xi_{S,t}$ is the offer made by the senior in the morning of period $t$. The indicator variable $\zeta_{S,t+1} = 1$ means that the offer proposed by the junior creditor in the morning of period $t$ is accepted by the senior creditor in the afternoon of period $t$. Moreover, $\phi_{J,t}$ is the threshold for the junior creditor to choose reorganization over liquidation; that is, the junior creditor chooses to propose liquidation if and only if $\theta_{J,t} < \phi_{J,t}$.

If the senior creditor proposes in the morning of period $t$, the payoff to the senior creditor in the afternoon of period $t$, conditional on the choice $\xi_{S,t}$, is described as follows:

$$
\begin{aligned}
\widetilde{M}_{S,t+1}(\xi_{S,t}) = & \underbrace{\left[ U_{t+1}(\theta_{S,t+1}, \hat{V}_{t+1}) - \xi_{S,t} \right] \mathbf{1}\{H_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) \leq \xi_{S,t}\}}_{\text{if } J \text{ accepts the offer}} \\
& + \underbrace{H_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) \mathbf{1}\{H_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) > \xi_{S,t}\}}_{\text{if } J \text{ does not accept the offer}}.
\end{aligned}
$$

In the afternoon of period $t$, the junior creditor observes $\xi_{S,t}$ and $\theta_{J,t+1}$, and she will choose to accept the offer with payoff $\xi_{S,t}$ (i.e., the junior creditor chooses $\zeta_{J,t+1} = 1$) if and only if $H_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) \leq \xi_{S,t}$. When taking expectation over $\hat{V}_{t+1}$ conditional on $\hat{V}_t = e^{\nu} V_0$ in the Bellman equation, the transition probability are

$$
\begin{aligned}
\mathbb{P}\left( \hat{V}_{t+1} = e^{-\nu} V_0 | \hat{V}_t = e^{\nu} V_0 \right) &= \pi/2 \\
\mathbb{P}\left( \hat{V}_{t+1} = e^{\nu} V_0 | \hat{V}_t = e^{\nu} V_0 \right) &= (1-\pi) + \pi/2.
\end{aligned}
$$

How do the endogenous state variables $\ell_{S,t}$ and $\ell_{J,t}$ evolve endogenously in this case? If the senior creditor receives the proposal opportunity in the morning of period $t$, $\ell_{S,t+1} = \theta_{S,t}$ and $\ell_{J,t+1} = \max(\theta_{J,t}^*, \ell_{J,t})$ with $\theta_{J,t}^*$ being determined by $\xi_{S,t} = H_{J,t+1}(\theta_{J,t}^*, \theta_{S,t}, \theta_{J,t}^*, \hat{V}_t)$. The update of $\ell_{S,t+1}$ takes place right after the junior creditor sees the proposal $\xi_{S,t}$. The update is perfectly perceived and internalized by the senior creditor at the very beginning of period $t$, when she makes the proposal decision right after receiving the proposing opportunity.

If the junior creditor proposes in the morning of period t, the payoff to the senior creditor in the afternoon of period $t$, conditional on the junior's optimal choice $\xi_{J,t}$ (which further depends on $(\theta_{J,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t)$), is described as follows:

$$\max_{\zeta_{S,t+1}\in\{0,1\}} \widetilde{A}_{S,t+1}(\zeta_{S,t+1}) = \underbrace{\xi_{J,t}\mathbf{1}\{H_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) \leq \xi_{J,t}\}}_{\text{if } S \text{ accepts the offer: } \zeta_{S,t+1}=1}$$
$$+ \underbrace{H_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t)\mathbf{1}\{H_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) > \xi_{J,t}\}}_{\text{if } S \text{ does not accept the offer: } \zeta_{S,t+1}=0}.$$

Finally, we describe the Bellman equation for the junior creditor. The continuation value of the junior creditor at the beginning of period $t$ follows the Bellman equation:

$$W_{J,t}(\theta_{J,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t) = \underbrace{\lambda_J \max\left\{O_{J,t},\ \max_{\xi_{J,t}} \mathbb{E}_t^J\left[\widetilde{M}_{J,t+1}(\xi_{J,t})\right]\right\}}_{\text{if } J \text{ proposes in the morning}}$$
$$+ \underbrace{(1-\lambda_J)\mathbb{E}_t^J\left[\max_{\zeta_{J,t+1}\in\{0,1\}} \widetilde{A}_{J,t+1}(\zeta_{J,t+1}) \,\middle|\, \theta_{S,t} \geq \phi_{S,t}\right]\mathbb{P}_t^J\{\theta_{S,t} \geq \phi_{S,t}\}}_{\text{if } S \text{ proposes reorganization in the morning}}$$
$$+ \underbrace{(1-\lambda_J)\mathbb{E}_t^J\left[\max\{O_{J,t}, U_{t+1}(\theta_{J,t+1}, \hat{V}_{t+1}) - O_{S,t}\}\right]\mathbb{P}_t^J\{\theta_{S,t} < \phi_{S,t}\}}_{\text{if } S \text{ chooses to liquid in the morning}},$$

where $\mathbb{E}_t^J$ is the conditional expectation of the junior creditor over $(\theta_{S,t}, \theta_{S,t+1})$, $\theta_{J,t+1}$, and $\hat{V}_{t+1}$; namely, the senior creditor's reorganization skills in the morning of periods $t$ and $t+1$, the junior's reorganization skill in the morning of period $t+1$, and the potential reorganization value in period $t+1$, conditioning on $(\theta_{J,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t)$. Here, $\xi_{J,t}$ is the offer made by the junior in the morning of period $t$. The indicator variable $\zeta_{J,t+1} = 1$ means that the offer proposed by the senior in the morning of period $t$ is accepted by the junior in the afternoon of period $t$. Moreover, $\phi_{S,t}$ is the threshold for the senior creditor to choose reorganization over liquidation.

If the junior creditor proposes in the morning of period $t$, the payoff to the junior creditor in the afternoon of period $t$, conditional on the choice $\xi_{J,t}$, is described as follows:

$$\widetilde{M}_{J,t+1}(\xi_{J,t}) = \underbrace{\left[U_{t+1}(\theta_{J,t+1}, \hat{V}_{t+1}) - \xi_{J,t}\right]\mathbf{1}\{H_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) \leq \xi_{J,t}\}}_{\text{if } J \text{ accepts the offer}}$$
$$+ \underbrace{H_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t)\mathbf{1}\{H_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) > \xi_{J,t}\}}_{\text{if } J \text{ does not accept the offer}}.$$

In the afternoon of period $t$, the junior creditor observes $\xi_{J,t}$ and $\theta_{S,t+1}$, and she will choose to accept the offer with $\xi_{J,t}$ (i.e., the junior creditor chooses $\zeta_{S,t+1} = 1$) if and only if $H_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) \leq \xi_{J,t}$.

How do the endogenous state variables $\ell_{S,t}$ and $\ell_{J,t}$ evolve endogenously in this case? If the junior cred-

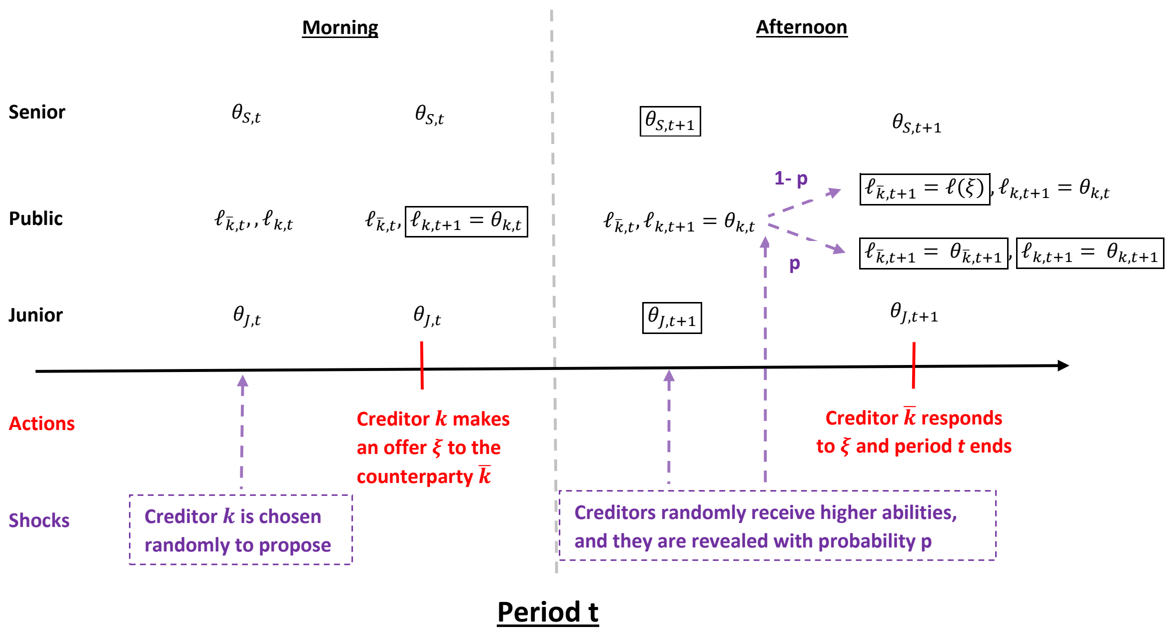



Figure OA.1: Timeline of the model with private communication.

itor receives the proposal opportunity in the morning of period $t$, $\ell_{J,t+1} = \theta_{J,t}$ and $\ell_{S,t+1} = \max(\theta^*_{S,t}, \ell_{S,t})$ with $\theta^*_{S,t}$ being determined by $\xi_{J,t} = H_{S,t+1}(\theta^*_{S,t}, \theta^*_{S,t}, \theta_{J,t}, \hat{V}_t)$. The update of $\ell_{J,t}$ takes place right after the senior creditor sees the proposal $\xi_{J,t}$. The update is perfectly perceived and internalized by the junior creditor at the very beginning of period $t$, when she makes the proposal decision right after receiving the proposing opportunity.

If the senior creditor proposes in the morning of period $t$, the payoff to the junior creditor in the afternoon of period $t$, conditional on the senior's optimal choice $\xi_{S,t}$ (which further depends on $(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \hat{V}_t)$), is described as follows:

$$\max_{\zeta_{J,t+1}\in\{0,1\}} \widetilde{A}_{J,t+1}(\zeta_{J,t+1}) = \underbrace{\xi_{S,t}\mathbf{1}\{H_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) \le \xi_{S,t}\}}_{\text{if } J \text{ accepts the offer: } \zeta_{J,t+1}=1} + \underbrace{H_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t)\mathbf{1}\{H_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, \hat{V}_t) > \xi_{S,t}\}}_{\text{if } J \text{ does not accept the offer: } \zeta_{J,t+1}=0}.$$

## C. Extended Model II: Private Communication

In this extended model, we allow the creditors to communicate privately and learn each other's type outside the court. We shall first describe the timeline of the model as follows.

Figure OA.1 illustrates how bargaining works within each period, including the pre-court period. The model setup and solution method are the same as described in Sections 2.1 and 2.3 of the main paper (Dou et al., 2020), except for the following. After skill levels change in the afternoon of period $t$, with probability

$p$ the updated skill levels are fully revealed to both creditors. Let $\omega_{t+1}$ be an indicator for whether skill levels $\theta_{J,t+1}$ and $\theta_{S,t+1}$ are revealed in the afternoon of period $t$. More precisely, the updated skills are fully revealed if $\omega_{t+1} = 1$, and they are kept private otherwise. We assume that $\omega_{t+1}$ is a random variable with an i.i.d. Bernoulli distribution with probability $p$. When $p$ is higher, the asymmetric information friction is weaker. As an extreme case, there is no asymmetric information when $p = 1$.

Now, we characterize the Bellman equations. Let's consider period $t$. The key is to establish the recursive Bellman equations for the afternoon continuation values $W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \omega_t)$ and $W_{J,t}(\theta_{J,t}, \ell_{S,t}, \ell_{J,t}, \omega_t)$ with the endogenous state variables $(\ell_{S,t}, \ell_{J,t})$ and (private) state variable $\theta_{J,t}$ or $\theta_{S,t}$. The private information about $\theta_{S,t}$ and $\theta_{J,t}$ are learned by the senior and junior, respectively, at the very beginning of the afternoon of period $t$; moreover, with probability $p$, the two private reorganization skills are fully revealed right after the creditors receive the private information.

The continuation value of the senior creditor at the end of period $t$ follows the Bellman equation:

$$
\begin{aligned}
W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t}, \omega_t) = {} & \underbrace{(1-\lambda_J) \times \max\left\{ O_{S,t},\ \max_{\xi_{S,t}} \mathbb{E}_t^S \left[ \widetilde{M}_{S,t+1}(\xi_{S,t}) \right] \right\}}_{\text{if } S \text{ proposes in the morning of period } t} \\
& + \underbrace{\lambda_J \times \mathbb{E}_t^S \left[ \max_{\zeta_{S,t+1} \in \{0,1\}} \widetilde{A}_{S,t+1}(\zeta_{S,t+1}) \;\middle|\; \theta_{J,t} \geq \phi_{J,t} \right] \times \mathbb{P}_t^S\{\theta_{J,t} \geq \phi_{J,t}\}}_{\text{if } J \text{ proposes reorganization in the morning of period } t} \\
& + \underbrace{\lambda_J \times \mathbb{E}_t^S \left[\max\{O_{S,t}, U_{t+1}(\theta_{S,t+1}) - O_{J,t}\}\right] \times \mathbb{P}_t^S\{\theta_{J,t} < \phi_{J,t}\}}_{\text{if } J \text{ decides to liquid in the morning of period } t},
\end{aligned} \tag{4}
$$

where $\mathbb{E}_t^S$ is the expectation of the senior creditor over $(\theta_{J,t}, \theta_{J,t+1})$, $\theta_{S,t+1}$, and $\omega_{t+1}$, conditional on $\theta_{S,t}$, $\ell_t = (\ell_{J,t}, \ell_{S,t})$, and $\omega_t$. The indicator variable $\zeta_{S,t+1} = 1$ means that the offer proposed by the junior creditor in the morning of period $t$ is accepted by the senior creditor in the afternoon of period $t$. Here, $\phi_{J,t}$ is the threshold for the junior creditor to choose reorganization over liquidation.

The continuation value of the junior creditor follows the Bellman equation:

$$
\begin{aligned}
W_{J,t}(\theta_{J,t}, \ell_{S,t}, \ell_{J,t}, \omega_t) = {} & \underbrace{\lambda_J \times \max\left\{ O_{J,t},\ \max_{\xi_{J,t}} \mathbb{E}_t^J \left[ \widetilde{M}_{J,t+1}(\xi_{J,t}) \right] \right\}}_{\text{if } J \text{ proposes in the morning of period } t} \\
& + \underbrace{(1-\lambda_J) \times \mathbb{E}_t^J \left[ \max_{\zeta_{J,t+1} \in \{0,1\}} \widetilde{A}_{J,t+1}(\zeta_{J,t+1}) \;\middle|\; \theta_{S,t} \geq \phi_{S,t} \right] \times \mathbb{P}_t^J\{\theta_{S,t} \geq \phi_{S,t}\}}_{\text{if } S \text{ proposes reorganization in the morning of period } t} \\
& + \underbrace{(1-\lambda_J) \times \mathbb{E}_t^J \left[\max\{O_{J,t}, U_{t+1}(\theta_{J,t+1}) - O_{S,t}\}\right] \times \mathbb{P}_t^J\{\theta_{S,t} < \phi_{S,t}\}}_{\text{if } S \text{ chooses to liquid in the morning of } t},
\end{aligned} \tag{5}
$$

where $\mathbb{E}_t^J$ is the expectation of the junior creditor over $(\theta_{S,t}, \theta_{S,t+1})$, $\theta_{J,t+1}$, and $\omega_{t+1}$, conditional on $\theta_{J,t}$, $\ell_t = \{\ell_{J,t}, \ell_{S,t}\}$, and $\omega_t$. The indicator variable $\zeta_{J,t+1} = 1$ means that the offer proposed by the junior creditor in the morning of period $t$ is accepted by the senior creditor in the afternoon of period $t$. Here,

$\phi_{S,t}$ is the threshold for the senior creditor to choose reorganization over liquidation.

Now, let's focus on the Bellman equation for the senior creditor in Eq. (4). The details about the junior creditor's Bellman equation in Eq. (5) can be explained in the same way.

We first describe the senior creditor's belief about $\theta_{J,t}$. The only reason why $\omega_t$ serves as a state variable is that the senior's belief about $\theta_{J,t}$, denoted by $\mathbb{P}_t^S(\theta_{J,t} \leq \theta)$, depends on $\omega_t$:

$$\mathbb{P}_t^S(\theta_{J,t} \leq \theta) = \begin{cases} F_\beta(\theta|\ell_{J,t}), & \text{if } \omega_t = 0 \\ F_\delta(\theta|\theta_{J,t}), & \text{if } \omega_t = 1. \end{cases} \tag{6}$$

Here $F_\beta(\theta|\ell)$ is the beta distribution, and $F_\delta(\theta|\ell)$ is the delta distribution:

$$F_\delta(\theta|\ell) \equiv \begin{cases} 0, & \theta < \ell \\ 1, & \theta \geq \ell. \end{cases} \tag{7}$$

What are the senior creditor's payoffs in the afternoon of period $t$? If the senior creditor proposes in the morning of period $t$, the payoff to the senior creditor in the afternoon of period $t$, conditional on the choice $\xi_{S,t}$, is described as follows:

$$\begin{aligned}
\widetilde{M}_{S,t+1}(\xi_{S,t}) = & \underbrace{[U_{t+1}(\theta_{S,t+1}) - \xi_{S,t}]\,\mathbf{1}\{W_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, 0) \leq \xi_{S,t}\}\mathbf{1}\{\omega_{t+1} = 0\}}_{\text{if updated skills are not revealed and } J \text{ accepts the offer}} \\
& + \underbrace{W_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, 0)\mathbf{1}\{W_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, 0) > \xi_{S,t}\}\mathbf{1}\{\omega_{t+1} = 0\}}_{\text{if updated skills are not revealed and } J \text{ does not accept the offer}} \\
& + \underbrace{[U_{t+1}(\theta_{S,t+1}) - \xi_{S,t}]\,\mathbf{1}\{W_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, 1) \leq \xi_{S,t}\}\mathbf{1}\{\omega_{t+1} = 1\}}_{\text{if updated skills are revealed and } J \text{ accepts the offer}} \\
& + \underbrace{W_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, 1)\mathbf{1}\{W_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, 1) > \xi_{S,t}\}\mathbf{1}\{\omega_{t+1} = 1\}.}_{\text{if updated skills are revealed and } J \text{ does not accept the offer}}
\end{aligned} \tag{8}$$

The continuation value functions $W_{S,t+1}(\cdot, 1)$ and $W_{S,t+1}(\cdot, 0)$ have different functional forms. At the moment right after the acceptance/rejection decision,

$$(\ell_{J,t+1}, \ell_{S,t+1}) = \begin{cases} (\theta^*_{J,t} \vee \ell_{J,t}, \theta_{S,t}), & \text{if } \omega_{t+1} = 0 \\ (\theta_{J,t+1}, \theta_{S,t+1}), & \text{if } \omega_{t+1} = 1, \end{cases} \tag{9}$$

where $\theta^*_{J,t}$ is pinned down by the following equality:

$$\xi_{S,t} = W_{J,t+1}(\theta^*_{J,t}, \theta_{S,t}, \theta^*_{J,t}, 0). \tag{10}$$

Therefore, the belief $\theta^*_{J,t}$ depends on the information up to $t$, particularly on the decision variable $\xi_{S,t}$. The effect of the proposal $\xi_{S,t}$ on the belief formation, characterized by Eqs. (9) and (10), is internalized by the senior creditor while optimally choosing $\xi_{S,t}$. The optimal offer made by the senior creditor is

$$\xi^*_{S,t} = \underset{\xi_{S,t}}{\operatorname{argmax}}\, \mathbb{E}_t^S \left[\widetilde{M}_{S,t+1}(\xi_{S,t})\right], \tag{11}$$

which is a function of the state variables $\theta_{S,t}$, $\ell_{J,t}$, and $\omega_t$.

If the junior creditor proposes in the morning of period $t$, the payoff to the senior creditor in the afternoon of period $t$, conditional on the choice $\xi^*_{J,t}$ and thus $\ell^*_{S,t+1}$, is described as follows:

$$\begin{aligned}
&\max_{\zeta_{S,t+1}\in\{0,1\}} \widetilde{A}_{S,t+1}(\zeta_{S,t+1}) = \max\left\{\xi^*_{J,t}, W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1},\omega_{t+1})\right\} \qquad (12)\\
&= \underbrace{\xi^*_{J,t}\mathbf{1}\{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1},0)\le \xi^*_{J,t}\}\mathbf{1}\{\omega_{t+1}=0\}}_{\text{if skills are not revealed and } S \text{ accepts the offer: } \zeta_{S,t+1}=1}\\
&\quad + \underbrace{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1},0)\mathbf{1}\{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1},0)> \xi^*_{J,t}\}\mathbf{1}\{\omega_{t+1}=0\}}_{\text{if skills are not revealed and } S \text{ does not accept the offer: } \zeta_{S,t+1}=0}\\
&+ \underbrace{\xi^*_{J,t}\mathbf{1}\{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1},1)\le \xi^*_{J,t}\}\mathbf{1}\{\omega_{t+1}=1\}}_{\text{if skills are revealed and } S \text{ accepts the offer: } \zeta_{S,t+1}=1}\\
&\quad + \underbrace{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1},1)\mathbf{1}\{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1},1)> \xi^*_{J,t}\}\mathbf{1}\{\omega_{t+1}=1\}}_{\text{if skills are revealed and } S \text{ does not accept the offer: } \zeta_{S,t+1}=0}. \qquad (13)
\end{aligned}$$

The lower bounds in $\ell_{t+1}$ are updated according to the following rules, which is different from Eqs. (9) and (10) since the junior creditor proposes in the morning of period $t$. The belief is updated as follows:

$$(\ell_{J,t+1},\ell_{S,t+1}) = \begin{cases} (\theta_{J,t},\theta^*_{S,t}\vee\ell_{S,t}), & \text{with } \omega_{t+1}=0\\ (\theta_{J,t+1},\theta_{S,t+1}), & \text{with } \omega_{t+1}=1\end{cases} \qquad (14)$$

where the screening cutoff point $\theta^*_{S,t}$ is pinned down by

$$\xi^*_{J,t} = W_{S,t+1}(\theta^*_{S,t},\theta^*_{S,t},\theta_{J,t},0). \qquad (15)$$

Here $\xi^*_{J,t}$ is the optimal proposal made by the junior creditor, depending on $\theta_{J,t}$, $\ell_{S,t}$, and $\omega_t$.

Let's now elaborate on the expectations in the Bellman equations. First, we consider the present value of proposing a reorganization plan $\mathbb{E}^S_t\left[\widetilde{M}_{S,t+1}(\xi_{S,t})\right]$. It equals

$$\mathbb{E}^S_t\left[\widetilde{M}_{S,t+1}(\xi_{S,t})\right] = (1-p)(E_1+E_2)+p(E_3+E_4), \qquad (16)$$

where

$$\begin{aligned}E_1 = \int [U_{t+1}(\theta_{S,t+1})-\xi_{S,t}]\,\mathbf{1}\{W_{J,t+1}(\theta_{J,t+1},\theta_{S,t},\theta^*_{J,t}\vee\ell_{J,t},0)\le\xi_{S,t}\}&\\
\times\, \mathrm{d}F_\beta(\theta_{S,t+1}|\theta_{S,t})\mathrm{d}F(\theta_{J,t}|\ell_{J,t})\otimes F_\beta(\theta_{J,t+1}|\theta_{J,t}),&\qquad (17)\end{aligned}$$

and

$$\begin{aligned}E_2 = \int W_{S,t+1}(\theta_{S,t+1},\theta_{S,t},\theta^*_{J,t}\vee\ell_{J,t},0)\mathbf{1}\{W_{J,t+1}(\theta_{J,t+1},\theta_{S,t},\theta^*_{J,t}\vee\ell_{J,t},0)>\xi_{S,t}\}&\\
\times\, \mathrm{d}F_\beta(\theta_{S,t+1}|\theta_{S,t})\mathrm{d}F(\theta_{J,t}|\ell_{J,t})\otimes F_\beta(\theta_{J,t+1}|\theta_{J,t}),&\qquad (18)\end{aligned}$$

and

$$E_3 = \int [U_{t+1}(\theta_{S,t+1}) - \xi_{S,t}]\, \mathbf{1}\{W_{J,t+1}(\theta_{J,t+1}, \theta_{S,t+1}, \theta_{J,t+1}, 1) \leq \xi_{S,t}\} \\ \times \mathrm{d}F_\beta(\theta_{S,t+1}|\theta_{S,t}) \mathrm{d}F(\theta_{J,t}|\ell_{J,t}) \otimes F_\beta(\theta_{J,t+1}|\theta_{J,t}), \tag{19}$$

and

$$E_4 = \int W_{S,t+1}(\theta_{S,t+1}, \theta_{S,t+1}, \theta_{J,t+1}, 1) \mathbf{1}\{W_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}, 1) > \xi_{S,t}\} \\ \times \mathrm{d}F_\beta(\theta_{S,t+1}|\theta_{S,t}) \mathrm{d}F(\theta_{J,t}|\ell_{J,t}) \otimes F_\beta(\theta_{J,t+1}|\theta_{J,t}), \tag{20}$$

and

$$F(\theta|\ell_{J,t}) = \begin{cases} F_\beta(\theta|\ell_{J,t}), & \text{if } \omega_t = 0 \\ F_\delta(\theta|\theta_{J,t}), & \text{if } \omega_t = 1. \end{cases} \tag{21}$$

Second, we consider $\mathbb{E}_t^S \left[\max_{\zeta_{S,t+1} \in \{0,1\}} \widetilde{A}_{S,t+1}(\zeta_{S,t+1}) \;\middle|\; \theta_{J,t} \geq \phi_{J,t}\right]$. It equals

$$\mathbb{E}_t^S \left[\max_{\zeta_{S,t+1} \in \{0,1\}} \widetilde{A}_{S,t+1}(\zeta_{S,t+1}) \;\middle|\; \theta_{J,t} \geq \phi_{J,t}\right] = (1-p)(A_1 + A_2) + p(A_3 + A_4), \tag{22}$$

where

$$A_1 = \int \xi_{J,t}^* \mathbf{1}\{W_{S,t+1}(\theta_{S,t+1}, \theta_{S,t}^* \vee \ell_{S,t}, \theta_{J,t}, 0) \leq \xi_{J,t}^*\} \\ \times \mathrm{d}F_\beta(\theta_{S,t+1}|\theta_{S,t}) \mathrm{d}G(\theta_{J,t}|\ell_{J,t}, \phi_{J,t}), \tag{23}$$

and

$$A_2 = \int W_{S,t+1}(\theta_{S,t+1}, \theta_{S,t}^* \vee \ell_{S,t}, \theta_{J,t}, 0) \mathbf{1}\{W_{S,t+1}(\theta_{S,t+1}, \theta_{S,t}^* \vee \ell_{S,t}, \theta_{J,t}, 0) > \xi_{J,t}^*\} \\ \times \mathrm{d}F_\beta(\theta_{S,t+1}|\theta_{S,t}) \mathrm{d}G(\theta_{J,t}|\ell_{J,t}, \phi_{J,t}), \tag{24}$$

and

$$A_3 = \int \xi_{J,t}^* \mathbf{1}\{W_{S,t+1}(\theta_{S,t+1}, \theta_{S,t+1}, \theta_{J,t+1}, 1) \leq \xi_{J,t}^*\} \\ \times \mathrm{d}F_\beta(\theta_{S,t+1}|\theta_{S,t}) \mathrm{d}G(\theta_{J,t}|\ell_{J,t}, \phi_{J,t}) \otimes F_\beta(\theta_{J,t+1}|\theta_{J,t}), \tag{25}$$

and

$$A_4 = \int W_{S,t+1}(\theta_{S,t+1}, \theta_{S,t+1}, \theta_{J,t+1}, 1) \mathbf{1}\{W_{S,t+1}(\theta_{S,t+1}, \theta_{S,t+1}, \theta_{J,t+1}, 1) > \xi_{J,t}^*\} \\ \times \mathrm{d}F_\beta(\theta_{S,t+1}|\theta_{S,t}) \mathrm{d}G(\theta_{J,t}|\ell_{J,t}, \phi_{J,t}) \otimes F_\beta(\theta_{J,t+1}|\theta_{J,t}), \tag{26}$$

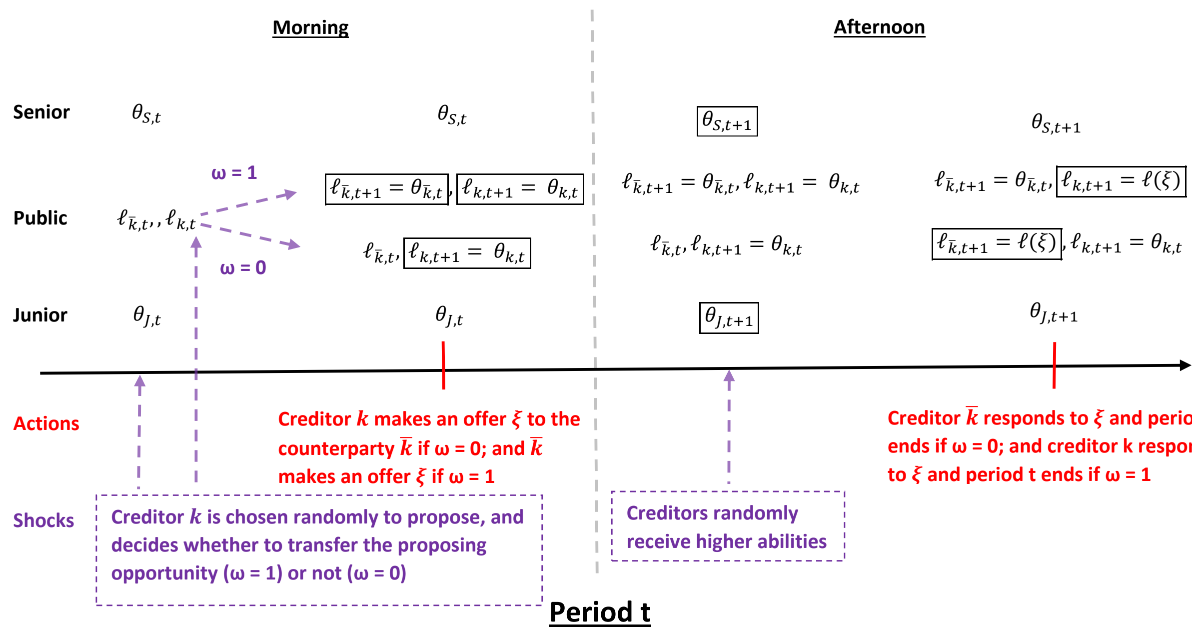



Figure OA.2: Timeline of the model with forfeiting of proposal turns.

and

$$G(\theta|\ell_{J,t}, \phi_{J,t}) = \begin{cases} F_\beta(\theta|\ell_{J,t} \vee \phi_{J,t}), & \text{if } \omega_t = 0 \\ F_\delta(\theta|\theta_{J,t})\mathbf{1}\{\theta_{J,t} \geq \phi_{J,t}\}, & \text{if } \omega_t = 1. \end{cases} \tag{27}$$

The setup for junior creditor's payoffs in period $t$ is similar to the senior creditor's payoffs, which will not be repeated here.

## D. Extended Model III: Option to Forfeit the Proposal Turn

In this extended model, we allow the creditors to forfeit their turn to make a proposal. We describe the timeline of the model as follows.

Figure OA.2 illustrates how bargaining works each period, including the pre-court period. The model's setup and solution are the same as in Sections 2.1 and 2.3 of the main paper (Dou et al., 2020), except for the following. Creditor $k$ has two choices: one is to propose her own plan, and the other is to forfeit the proposal turn, allowing the counterparty $\bar{k}$ to make a proposal in the same period. Creditor $k$ would choose whichever gives higher expected value. If creditor $k$ decides to forfeit her turn, she needs to show her original plan, thereby revealing her reorganization skill level $\theta_{k,t}$. If creditor $k$ decides to propose her own plan, she can propose reorganizing, liquidating, or waiting, which will also reveal her skill level $\theta_{k,t}$.

Now, we characterize the Bellman equations. The continuation value of the senior creditor at the beginning of period $t$ follows the Bellman equation:

$$W_{S,t}(\theta_{S,t},\ell_{S,t},\ell_{J,t}) = \underbrace{(1-\lambda_J)\times \max_{\varsigma_{S,t}\in\{0,1\}}\{(1-\varsigma_{S,t})Y_{S,t}(\theta_{S,t},\ell_{J,t})+\varsigma_{S,t}G_{S,t}(\theta_{S,t},\theta_{S,t},\ell_{J,t})\}}_{\text{if } S \text{ receives the opportunity in the morning of period } t} \tag{28}$$

$$+\underbrace{\lambda_J\times\mathbb{E}_t^S\left[Y_{S,t}(\theta_{S,t},\theta_{J,t})|\varsigma_{J,t}=1\right]\times\mathbb{P}_t^S\{\varsigma_{J,t}=1\}}_{\text{if } J \text{ receives the opportunity at } t \text{ and transfers it to } S} \tag{29}$$

$$+\underbrace{\lambda_J\times\mathbb{E}_t^S\left[\widetilde{G}_{S,t+1}|\varsigma_{J,t}=0\right]\times\mathbb{P}_t^S\{\varsigma_{J,t}=0\}}_{\text{if } J \text{ receives the opportunity at } t \text{ and proposes}}, \tag{30}$$

where $Y_{S,t}(\theta_{S,t},\ell_{J,t})$ the expected gain of the senior creditor if she proposes the liquidation/reorganization plan in the morning of period $t$:

$$Y_{S,t}(\theta_{S,t},\ell_{J,t}) = \max\left\{O_{S,t},\ \max_{\xi_{S,t}}\mathbb{E}_t^S\left[\widetilde{M}_{S,t+1}(\xi_{S,t})\right]\right\}, \tag{31}$$

and $\widetilde{G}_{S,t+1}$ is the gain of the senior creditor if the junior creditor chooses to propose a liquidation/reorganization plan:

$$\widetilde{G}_{S,t+1} = \underbrace{\mathbf{1}\{\theta_{J,t}\geq\phi_{J,t}\}\max_{\zeta_{S,t+1}\in\{0,1\}}\widetilde{A}_{S,t+1}(\zeta_{S,t+1})}_{\text{if } J \text{ proposes reorganization in the morning of period } t} \tag{32}$$

$$+\underbrace{\mathbf{1}\{\theta_{J,t}<\phi_{J,t}\}\max\{O_{S,t},U_{t+1}(\theta_{S,t+1})-O_{J,t}\}}_{\text{if } J \text{ decides to liquid in the morning of period } t}, \tag{33}$$

and

$$G_{S,t}(\theta_{S,t},\ell_{S,t},\ell_{J,t}) = \mathbb{E}_t^S\left[\widetilde{G}_{S,t+1}\right] \tag{34}$$

$$=\mathbb{E}_t^S\left[\max_{\zeta_{S,t+1}\in\{0,1\}}\widetilde{A}_{S,t+1}(\zeta_{S,t+1})\ \middle|\ \theta_{J,t}\geq\phi_{J,t}\right]\times\mathbb{P}_t^S\{\theta_{J,t}\geq\phi_{J,t}\} \tag{35}$$

$$+\mathbb{E}_t^S\left[\max\{O_{S,t},U_{t+1}(\theta_{S,t+1})-O_{J,t}\}\right]\times\mathbb{P}_t^S\{\theta_{J,t}<\phi_{J,t}\}, \tag{36}$$

where $\mathbb{E}_t^S$ is the expectation of the senior creditor over $(\theta_{J,t},\theta_{J,t+1})$ and $\theta_{S,t+1}$; namely, the junior creditor's reorganization skills in the morning of periods $t$ and $t+1$, and the senior creditor's reorganization skill in the morning of period $t+1$, conditional on $\theta_{S,t}$ and $\ell_t=(\ell_{J,t},\ell_{S,t})$. The binary choice variable $\varsigma_{S,t}$ ($\varsigma_{J,t}$) characterizes whether the senior (junior) creditor chooses to forfeit the proposal turn in the morning of period $t$ or not. The binary choice variable $\zeta_{S,t+1}=1$ means that the offer proposed by the junior creditor in the morning of period $t$ is accepted by the senior creditor in the afternoon of period $t$. Here, $\phi_{J,t}$ is the threshold for the junior creditor to choose reorganization over liquidation.

For the senior creditor, the choice between proposing and forfeiting can be characterized by

$$\varsigma_{S,t} = \begin{cases} 0, & \text{if } \; Y_{S,t}(\theta_{S,t}, \ell_{J,t}) \geq G_{S,t}(\theta_{S,t}, \theta_{S,t}, \ell_{J,t}) \\ 1, & \text{if } \; Y_{S,t}(\theta_{S,t}, \ell_{J,t}) < G_{S,t}(\theta_{S,t}, \theta_{S,t}, \ell_{J,t}). \end{cases} \tag{37}$$

The continuation value of the junior creditor follows the Bellman equation:

$$\begin{aligned} W_{J,t}(\theta_{J,t}, \ell_{S,t}, \ell_{J,t}) = & \underbrace{\lambda_J \times \max_{\varsigma_{J,t} \in \{0,1\}} \{(1-\varsigma_{J,t}) Y_{J,t}(\theta_{J,t}, \ell_{S,t}) + \varsigma_{J,t} G_{J,t}(\theta_{J,t}, \ell_{S,t}, \theta_{J,t})\}}_{\text{if } J \text{ receives the opportunity in the morning of period } t} & (38) \\ & + \underbrace{(1-\lambda_J) \times \mathbb{E}_t^J \left[ Y_{J,t}(\theta_{J,t}, \theta_{S,t}) | \varsigma_{S,t} = 1 \right] \times \mathbb{P}_t^J \{\varsigma_{S,t} = 1\}}_{\text{if } S \text{ receives the opportunity at } t \text{ and transfers it to } J} & (39) \\ & + \underbrace{(1-\lambda_J) \times \mathbb{E}_t^J \left[ \widetilde{G}_{J,t+1} | \varsigma_{S,t} = 0 \right] \times \mathbb{P}_t^J \{\varsigma_{S,t} = 0\}}_{\text{if } S \text{ receives the opportunity at } t \text{ and proposes}}, & (40) \end{aligned}$$

where $Y_{J,t}(\theta_{J,t}, \ell_{S,t})$ the expected gain of the junior creditor if she proposes the liquidation/reorganization plan in the morning of period $t$:

$$Y_{J,t}(\theta_{J,t}, \ell_{S,t}) = \max \left\{ O_{J,t}, \; \max_{\xi_{J,t}} \mathbb{E}_t^J \left[ \widetilde{M}_{J,t+1}(\xi_{J,t}) \right] \right\}, \tag{41}$$

and $\widetilde{G}_{J,t+1}$ is the gain of the junior creditor if the senior creditor chooses to propose a liquidation/reorganization plan:

$$\begin{aligned} \widetilde{G}_{J,t+1} = & \underbrace{\mathbf{1}\{\theta_{S,t} \geq \phi_{S,t}\} \max_{\zeta_{J,t+1} \in \{0,1\}} \widetilde{A}_{J,t+1}(\zeta_{J,t+1})}_{\text{if } S \text{ proposes reorganization in the morning of period } t} & (42) \\ & + \underbrace{\mathbf{1}\{\theta_{S,t} < \phi_{S,t}\} \max\{O_{J,t}, U_{t+1}(\theta_{J,t+1}) - O_{S,t}\}}_{\text{if } S \text{ decides to liquid in the morning of period } t}, & (43) \end{aligned}$$

and

$$\begin{aligned} G_{J,t}(\theta_{J,t}, \ell_{S,t}, \ell_{J,t}) & = \mathbb{E}_t^J \left[ \widetilde{G}_{S,t+1} \right] & (44) \\ & = \mathbb{E}_t^J \left[ \max_{\zeta_{J,t+1} \in \{0,1\}} \widetilde{A}_{J,t+1}(\zeta_{J,t+1}) \,\middle|\, \theta_{S,t} \geq \phi_{S,t} \right] \times \mathbb{P}_t^J \left\{ \theta_{S,t} \geq \phi_{S,t} \right\} & (45) \\ & \quad + \mathbb{E}_t^J \left[ \max\{O_{J,t}, U_{t+1}(\theta_{J,t+1}) - O_{S,t}\} \right] \times \mathbb{P}_t^J \left\{ \theta_{S,t} < \phi_{S,t} \right\}, & (46) \end{aligned}$$

where $\mathbb{E}_t^J$ is the expectation of the junior creditor over $(\theta_{S,t}, \theta_{S,t+1})$ and $\theta_{J,t+1}$; namely, the senior creditor's reorganization skills in the morning of periods $t$ and $t+1$, and the junior creditor's reorganization skill in the morning of period $t+1$, conditional on $\theta_{J,t}$ and $\ell_t = \{\ell_{J,t}, \ell_{S,t}\}$. The binary choice variable $\varsigma_{J,t}$ ($\varsigma_{S,t}$) characterizes whether the junior (senior) creditor chooses to forfeit the proposing turn in the morning of period $t$ or not. The binary choice variable $\zeta_{J,t+1} = 1$ means that the offer proposed by the junior creditor in the morning of period $t$ is accepted by the senior creditor in the afternoon of period $t$. Here, $\phi_{S,t}$ is the threshold for the senior creditor to choose reorganization over liquidation.

For the junior creditor, the choice between proposing and forfeiting can be characterized by

$$\varsigma_{J,t} = \begin{cases} 0, & \text{if } \; Y_{J,t}(\theta_{J,t}, \ell_{S,t}) \geq G_{J,t}(\theta_{J,t}, \ell_{S,t}, \theta_{J,t}) \\ 1, & \text{if } \; Y_{J,t}(\theta_{J,t}, \ell_{S,t}) < G_{J,t}(\theta_{J,t}, \ell_{S,t}, \theta_{J,t}). \end{cases} \tag{47}$$

Now, we explain the Bellman equations. Let's focus on the Bellman equation for the senior creditor in Eqs. (28) – (30). The details about the junior creditor's Bellman equation in Eqs. (38) – (40) can be explained in the same way.

The continuation value $W_{S,t}(\theta_{S,t}, \ell_{S,t}, \ell_{J,t})$ is the weighted average of payoffs under three different scenarios. First, with probability $1 - \lambda_J$, the senior creditor receives the proposing opportunity at the very beginning of period $t$. The senior creditor decides whether to propose her own plan ($\varsigma_{S,t} = 0$) or forfeit the proposal turn to the counterparty ($\varsigma_{J,t} = 1$). If proposing her own plan, the senior creditor obtains $Y_{S,t}(\theta_{S,t}, \ell_{S,t})$; and if forfeiting the proposal turn, the senior creditor obtains $G_{S,t}(\theta_{S,t}, \theta_{S,t}, \ell_{J,t})$ since she will reveal her plan details and the junior creditor will update his belief about the senior creditor's skill $\ell_{S,t} = \theta_{S,t}$. The senior creditor decides to propose her own plan if and only if $Y_{S,t}(\theta_{S,t}, \ell_{S,t}) \geq G_{S,t}(\theta_{S,t}, \theta_{S,t}, \ell_{J,t})$.

Second, with probability $\lambda_J$, the junior creditor receives the proposing opportunity at the very beginning of period $t$. Further, with probability $\mathbb{P}_t^S\{\varsigma_{J,t} = 1\}$, the junior creditor would forfeit his proposal turn to the senior creditor, and the senior creditor obtains $\mathbb{E}_t^S\left[Y_{S,t}(\theta_{S,t}, \ell_{S,t}) | \varsigma_{J,t} = 1\right]$ since the junior creditor would reveal his skill $\theta_{J,t}$ by forfeiting the proposal turn and showing his plan.

Third, given that the junior creditor receives the proposing opportunity at the very beginning of period $t$, there is a probability $\mathbb{P}_t^S\{\varsigma_{J,t} = 0\}$ by which the junior creditor would propose his own plan, and the senior creditor would get the expected gain $\mathbb{E}_t^S\left[\widetilde{G}_{S,t+1} | \varsigma_{J,t} = 0\right]$.

If the senior creditor proposes in the morning of period $t$, the payoff to the senior creditor in the afternoon of period $t$, conditional on the choice $\xi_{S,t}$, is described as follows:

$$\widetilde{M}_{S,t+1}(\xi_{S,t}) = \underbrace{\left[U_{t+1}(\theta_{S,t+1}) - \xi_{S,t}\right] \mathbf{1}\{W_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}) \leq \xi_{S,t}\}}_{\text{if } J \text{ accepts the offer}} \tag{48}$$

$$+ \underbrace{W_{S,t+1}(\theta_{S,t+1}, \ell_{S,t+1}, \ell_{J,t+1}) \mathbf{1}\{W_{J,t+1}(\theta_{J,t+1}, \ell_{S,t+1}, \ell_{J,t+1}) > \xi_{S,t}\}}_{\text{if } J \text{ does not accept the offer}} \tag{49}$$

At the moment right after the acceptance/rejection decision,

$$(\ell_{J,t+1}, \ell_{S,t+1}) = (\theta^*_{J,t} \vee \ell_{J,t}, \theta_{S,t}), \tag{50}$$

where $\theta^*_{J,t}$ is pinned down by the following equality:

$$\xi_{S,t} = W_{J,t+1}(\theta^*_{J,t}, \theta_{S,t}, \theta^*_{J,t}). \tag{51}$$

Therefore, the belief $\theta^*_{J,t}$ depends on the information up to $t$, particularly on the decision variable $\xi_{S,t}$. The effect of the proposal $\xi_{S,t}$ on the belief formation, characterized by Eqs. (50) and (51), is internalized by the senior creditor while making optimal decision on $\xi_{S,t}$. The optimal offer made by the senior creditor is

$$\xi^*_{S,t} = \underset{\xi_{S,t}}{\operatorname{argmax}}\, \mathbb{E}^S_t \left[\widetilde{M}_{S,t+1}(\xi_{S,t})\right], \tag{52}$$

which is a function of the state variables $\theta_{S,t}$ and $\ell_{J,t}$.

If the junior creditor proposes in the morning of period $t$, the payoff to the senior creditor in the afternoon of period $t$, conditional on the choice $\xi^*_{J,t}$ and thus $\ell^*_{S,t+1}$, is described as follows:

$$\max_{\zeta_{S,t+1}\in\{0,1\}} \widetilde{A}_{S,t+1}(\zeta_{S,t+1}) = \underbrace{\xi^*_{J,t}\mathbf{1}\{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1}) \le \xi^*_{J,t}\}}_{\text{if } S \text{ accepts the offer: } \zeta_{S,t+1}=1} \tag{53}$$

$$+ \underbrace{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1})\mathbf{1}\{W_{S,t+1}(\theta_{S,t+1},\ell_{S,t+1},\ell_{J,t+1}) > \xi^*_{J,t}\}}_{\text{if } S \text{ does not accept the offer: } \zeta_{S,t+1}=0} \tag{54}$$

The lower bounds in $\ell_{t+1}$ are updated according to the following rules, which is different from (9) and (51) since the junior creditor proposes in the morning of period $t$. The belief is updated as follows:

$$(\ell_{J,t+1}, \ell_{S,t+1}) = (\theta_{J,t}, \theta^*_{S,t} \vee \ell_{S,t}), \tag{55}$$

where the screening cutoff point $\theta^*_{S,t}$ is pinned down by

$$\xi^*_{J,t} = W_{S,t+1}(\theta^*_{S,t}, \theta^*_{S,t}, \theta_{J,t}). \tag{56}$$

Here $\xi^*_{J,t}$ is the optimal proposal made by the junior creditor, depending on $\theta_{J,t}$ and $\ell_{S,t}$.

We estimate the extended model's seven parameters using the same nine moments from the paper's main estimation. Estimated parameter values are in Table 7 of the main paper. Table OA.1 below compares moments from the data, baseline model, and extended model.

## E. Signaling and Judge Cramdown

In the paper's baseline model, we assume that the proposal fully reveals the proposer's true reorganization skill. Here, we relax this assumption by prohibiting direct communication and assuming that the reorganization proposal does not reveal the proposer's skill. Instead, the proposer can signal her privately known true reorganization skill through the payoff she offers to the counterparty. In this section, we show that under some assumptions such as judge's cramdown, a separating equilibrium exists, meaning proposing creditors endogenously reveal their skill levels through their choices. By definition (see Sobel, 2009), the hidden type of the signal sender is fully revealed by the signal embedded in actions in the separating equilibrium. We shall not provide a general proof for the existence of separating equilibria in our full model, because it is outside the paper's scope. Rather, we illustrate the main idea based on a special case of the paper's baseline model.

Table OA.1: Fit of the Extended Model with Forfeiting

This table is analogous to Table 3 in the main paper. The first column shows moments' estimated values from the data. The second column shows simulated moments from the estimated, extended model that gives creditors the option to forfeit their proposal turn. The last column, for comparison, shows simulated moments from the estimated baseline model. The last row shows the $J$-statistic from the test of over-identifying restrictions. *, **, and *** denote that the simulated moment differs from the data moment at the 10%, 5%, and 1% confidence levels, respectively.

| Moment | Data | Forfeiting Proposals | Baseline Model |
|---|---|---|---|
| Averages Across In-Court Cases: | | | |
| Ln Months Between Plans | 1.769 | 1.750 | 1.711 |
| Fraction Reorganized | 0.910 | 0.803*** | 0.902 |
| Ln Duration (Months) | 2.571 | 2.670* | 2.608 |
| Averages Across All Cases: | | | |
| Fraction Resolved In Court | 0.730 | 0.718 | 0.701 |
| Average Recovery Rates for Pre-Court Reorganizations: | | | |
| Junior | 0.221 | 0.212 | 0.192 |
| Senior | 0.878 | 0.829* | 0.857 |
| Averages Across In-Court Reorganizations: | | | |
| Junior's Fraction of Gain | 0.270 | 0.321*** | 0.298* |
| Slope of Ln Recovery on Duration | -0.014 | -0.053*** | -0.017 |
| Total Recovery Rate | 0.370 | 0.292*** | 0.375 |

Without loss of generality, we assume that $\lambda_J = 0$, which means that junior will not propose, and $\rho V \leq L - D_S$, which means that the bargaining will certainly be finished by the end of period $t = 1$ and the reorganization is not appealing. This simplification enables us to focus on discussing the signaling game by making strategic screening irrelevant. As a result, the strategic signaling will occur only in the first period $t = 0$. For simplicity, we further assume that $\beta = 1$, which means that the reorganization skills follow uniform distributions.

The proposed payoff is in the form of a fraction of the true reorganization skill level $\theta_{S,0}$, say $\xi_{S,0} = x\rho V \theta_{S,0}$. In other words, the proposer will propose the fraction $x$ to the counterparty. This is an equivalent way to specify the proposed payoff as in the paper's baseline model. The judge's cramdown probability $p(x)$ depends on the proposal fraction $x$. We assume that $p(x)$ satisfies the following conditions:

$$p(x) > 0 \quad \text{and} \quad p'(x) > 0.$$

We postulate the functional form $p(x) = \gamma x$ with $\gamma \in (0, 1)$, without loss of generality.

Now, we describe the value functions of the creditors. In period $t = 1$, the deal would be liquidated. According to the APR, the gain of the senior and junior creditor from liquidation is $O_{S,1} = D_S$ and $O_{J,1} = L - D_S$, respectively. Then, it must hold that

$$W_{S,1}(\theta_{S,1}, \ell_{S,1}, \ell_{J,1}) \equiv O_{S,1} = D_S \quad \text{and} \quad W_{J,1}(\theta_{J,1}, \ell_{S,1}, \ell_{J,1}) \equiv O_{J,1} = L - D_S. \tag{57}$$

In period $t = 0$, it holds that

$$\begin{aligned} W_{S,0}(\theta_{S,0}, \ell_{S,0}, \ell_{J,0}) = \max_{x \in [0,1]} \{ & p(x)\rho V \left(\mathbb{E}_0 \left[\theta_{S,1}\right] - x\theta_{S,0}\right) \\ & + [1 - p(x)]\rho V \mathbb{E}_0 \left[\left(\theta_{S,1} - x\theta_{S,0}\right) \mathbf{1}\{O_{J,1} \leq x\rho V \theta_{S,0}\}\right] \\ & + [1 - p(x)] O_{S,1} \mathbb{E}_0 \left[\mathbf{1}\{O_{J,1} > x\rho V \theta_{S,0}\}\right] \} . \end{aligned}$$

The term $p(x)\rho V \{\mathbb{E}_0 [\theta_{S,1}] - x\theta_{S,0}\}$ is the expected payoff to the senior creditor if the judge cramdown occurs. The term $[1 - p(x)]\rho V \mathbb{E}_0 [(\theta_{S,1} - x\theta_{S,0}) \mathbf{1}\{O_{J,1} \leq x\rho V \theta_{S,0}\}]$ is the expected payoff to the senior creditor if the judge cramdown does not occur and the junior creditor accepts the proposal. The term $[1 - p(x)] O_{S,1} \mathbb{E}_0 [\mathbf{1}\{O_{J,1} > x\rho V \theta_{S,0}\}]$ is the expected payoff to the senior creditor if the judge cramdown does not occur and the junior creditor declines the proposal.

Because $O_{J,1} = L - D_S \geq \rho V$, the Bellman equation above can be rewritten as follows:

$$W_{S,0}(\theta_{S,0}, \ell_{S,0}, \ell_{J,0}) = \max_{x \in [0,1]} \left\{ p(x)\rho V \left(1/2 + \theta_{S,0}/2 - x\theta_{S,0}\right) + [1 - p(x)] O_{S,1} \right\} . \tag{58}$$

The first-order condition is

$$\gamma \left[\rho V (1/2 + \theta_{S,0}/2 - x\theta_{S,0}) - O_{S,1}\right] = \gamma x \rho V \theta_{S,0}. \tag{59}$$

Thus, after rearranging terms and plugging in $O_{S,1} = D_S$, the optimal proposal can be characterized by

$$x = \frac{\gamma(\rho V/2 - D_S) + \gamma \rho V \theta_{S,0}/2}{2\gamma \rho V \theta_{S,0}}, \tag{60}$$

which is strictly monotonic in $\theta_{S,0}$. Therefore, the signaling using $x$ would fully reveal the private type $\theta_{S,0}$.

# F. Additional Empirical Robustness Exercises

This section contains details on additional robustness exercises discussed in Section 6 in the main paper:

(i) We re-estimate the model after replacing confirmation date with sale date for cases with a Section 363 sale outcome, which changes the duration measure for roughly 20% of cases. Re-estimation results are in Table OA.2, column “Alternative Duration Measure.” Parameter estimates are similar to those in our main analysis, and the estimated inefficiency is almost identical (0.079, compared to 0.078 in our main analysis).

(ii) We address concerns about potential underestimation of liquidation values, $L$. There is no evidence on the degree to which liquidation values are underestimated. To check whether underestimation of $L$ would affect our conclusions, we re-estimate the model after inflating all $L$ values by 20%. Results are in Table OA.2, column "Inflated Liquidation Value." When $L$ is higher, there is a stronger incentive to liquidate. To offset this force and continue fitting the unchanged frequencies of liquidation and reorganization observed in the data, the model needs a faster learning speed (i.e., lower $\beta$). A higher liquidation value also disproportionately increases payoffs to the junior creditor. To offset this effect and continue fitting the unchanged payoff data, the model needs a lower estimated probability that the junior proposes ($\lambda_J$). The estimated inefficiency increases to 0.097, compared to 0.078 in the main analysis. This result suggests that our conclusion would be even stronger if liquidation values were underestimated.

(iii) We compare results in cases with and without DIP financing. Results from estimating in these two subsamples are in the last columns of Table OA.2. Consistent with DIP financing reducing junior creditors' relative bargaining power, we find that cases with DIP financing feature a lower estimated value of $\lambda_J$, the junior's probability of proposing. The estimated inefficiency, however, is quite similar across the two subsamples (0.077 and 0.070).

(iv) We remove 22 cases (roughly 7% of the sample) in which the reported filing reason is tort or fraud. Removing these cases has virtually no effect on the data moments, so parameter estimates and the implied inefficiency would be almost identical to our main results.

(v) We remove 13 cases (roughly 4% of the sample) in which the equity holders are not fully wiped out. Removing these cases has virtually no effect on the data moments, so parameter estimates and the implied inefficiency would be almost identical to our main results.

Table OA.2: Additional Empirical Robustness Exercises

This table contains results from estimating the model with alternative measures or subsamples. Details are in the text above.

| | Alternative Duration Measure | Inflated Liquidation Value | Cases Without DIP Financing | Cases With DIP Financing |
|---|---|---|---|---|
| **Panel A: Parameter Estimates** | | | | |
| Months per Period ($\mu$) | 4.381 | 4.189 | 4.474 | 4.969 |
| Senior's Initial Skill ($\theta_{S,0}$) | 0.281 | 0.249 | 0.270 | 0.340 |
| Junior's Initial Skill ($\theta_{J,0}$) | 0.364 | 0.391 | 0.360 | 0.408 |
| Inverse Speed of Creditor Learning ($\beta$) | 9.801 | 7.993 | 9.526 | 12.187 |
| Persistence of Reorganization Value ($\rho$) | 0.884 | 0.879 | 0.882 | 0.873 |
| Fixed Cost of Going to Court ($c_0$, %) | 4.669 | 3.883 | 4.161 | 2.648 |
| Junior's Probability of Proposing ($\lambda_J$) | 0.346 | 0.168 | 0.441 | 0.240 |
| **Panel B: Model Implications (Social Planner Model Minus Estimated Model)** | | | | |
| Avg. Total Recovery Rate | 0.079 | 0.097 | 0.077 | 0.07 |
| Avg. Reorganization Value | 0.081 | 0.089 | 0.07 | 0.033 |
| Fraction Resolved Pre-Court | 0.136 | 0.172 | 0.092 | 0.666 |
| Avg. Duration of Court Cases (Months) | -11.8 | -13.0 | -10.5 | -12.6 |

## G. Additional Identification Analysis

Andrews, Gentzkow and Shapiro (2017, 2020) proposed a local measure of the relationship between parameter estimates and moments for enhancing the transparency of structural identification and estimation. In this spirit, we present the Jacobian matrix of moments with respect to parameter values in the main text. Here, we show that similar identification results are obtained using the sensitivity matrix proposed by Andrews, Gentzkow and Shapiro (2017).

Table OA.3 shows the sensitivity matrix of seven parameters to nine simulated moments. It shows a transparent identification of our model, which is consistent with the Jacobian matrix of moments with respect to parameter values in the main text.

To be more precise, the first moment is helpful for identifying $\mu$, the number of months per period. The second moment is informative about $\beta$, which governs the speed of learning. The third moment is important to identify $\rho$, capturing the decay speed of reorganization value. The toughest identification challenge is to disentangle $\beta$ and $\rho$ since both affect the costs and benefits of waiting in the bargaining. Moments (1) – (3) together provide clear identification for $\beta$ and $\rho$ since they all move in different directions when perturbing $\beta$ and $\rho$. Intuitively, the fourth moment strongly identifies $c_0$, the fixed cost of entering the court. The fifth and sixth moments significantly and positively affect the parameter estimates $\theta_{S,0}$ and $\theta_{J,0}$, respectively. As a result, $\theta_{S,0}$ and $\theta_{J,0}$ are clearly identified by these two moments. The seventh moment is chosen to identify the ex-ante bargaining power of the junior creditor, captured by $\lambda_J$. The eighth and ninth moments are over-identification moment restrictions. Each of them is highly informative about several parameters.

Table OA.3: Sensitivity of Parameters to Moments

This table shows the sensitivity of model parameters (in columns) with respect to model-implied moments (in rows) proposed by Andrews, Gentzkow and Shapiro (2017). Moments are defined in detail in the main text. Parameter $\mu$ is the months per model period, $\beta$ is the (inverse) speed of creditor learning, $\rho$ is the persistence of reorganization value, $c_0$ is the fixed cost of going to court, $\theta_{S,0}$ and $\theta_{J,0}$ are the initial skill levels of the senior and junior creditor, respectively, and $\lambda_J$ is the probability that the junior proposes in a given period.

Panel A. Sensitivity of Moments to Parameters

| | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| Moments | $\mu$ | $\beta$ | $\rho$ | $c_0$ | $\theta_{S,0}$ | $\theta_{J,0}$ | $\lambda_J$ |
| (1) | **0.5633** | -0.2794 | -0.9548 | 0.0253 | -0.0045 | 0.0532 | 0.0964 |
| (2) | -0.3506 | **-0.6398** | 0.3424 | 0.4961 | 0.0727 | 0.6454 | -0.3258 |
| (3) | -0.0700 | 0.1723 | **1.0098** | 0.0533 | 0.0167 | 0.0850 | -0.1507 |
| (4) | -0.1107 | 0.0294 | 0.2758 | **-0.0845** | -0.1509 | -0.3265 | 0.2769 |
| (5) | 0.2588 | 0.0904 | -0.2076 | -0.0572 | **0.4658** | 0.1481 | 0.1746 |
| (6) | -0.3787 | -0.0839 | 0.5236 | 0.1623 | -0.5813 | **0.1137** | -0.0465 |
| (7) | -0.2118 | 0.3329 | 0.7017 | -0.2676 | -0.7919 | 0.2014 | **0.5074** |
| (8) | 0.3250 | -0.0360 | -0.2595 | -0.3169 | 0.9651 | 0.5290 | 0.1955 |
| (9) | 0.5029 | 0.5246 | -0.3748 | -0.4024 | -0.0637 | -0.7065 | 0.2888 |

Panel B: Description of Moments

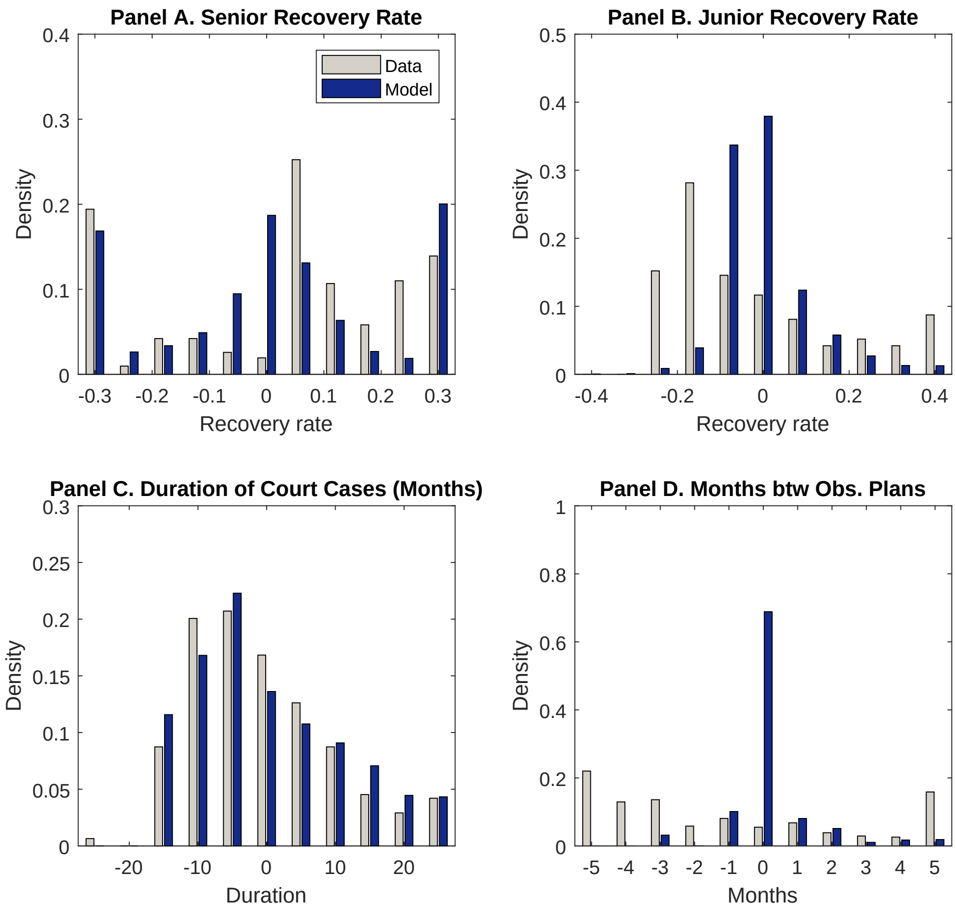
| | |
|---|---|
| (1) | Average log number of months between observed proposals for in-court cases. |
| (2) | Fraction of cases that result in a reorganization, conditional on resolving in court. |
| (3) | Average log duration of in-court cases, in months. |
| (4) | Fraction of cases resolved in court. |
| (5) | Senior creditor's average recovery rate in pre-court reorganizations. |
| (6) | Junior creditor's average recovery rate in pre-court reorganizations. |
| (7) | Junior creditor's average fraction of gain, conditional on an in-court reorganization. |
| (8) | Total recovery rate averaged across all in-court reorganizations. |
| (9) | Regression slope coefficient of log total recovery rate on case duration across all in-court reorganizations. |

## H. Additional Analysis of Model Fit

Figure 7 in the paper contains histograms of four variables, comparing the predicted and empirical distributions. When creating that figure, we pool data across ten clusters with different values of $\{D_J, V_0, L\}$. This section decomposes Figure 7's pooled variation into within- and across-cluster variation. In the model, within-cluster variation comes from shocks to creditors' skill and to randomness in which creditor is chosen to propose in each period. First we analyze within-cluster variation, then we analyze cross-cluster variation.

To show within-cluster variation, Figure OA.3 plots histograms of variables that have been de-meaned at the cluster level in both the actual and the simulated data. The variables therefore mechanically have a mean of zero. The senior creditors' recovery rate has a tri-modal distribution that looks quite similar in the

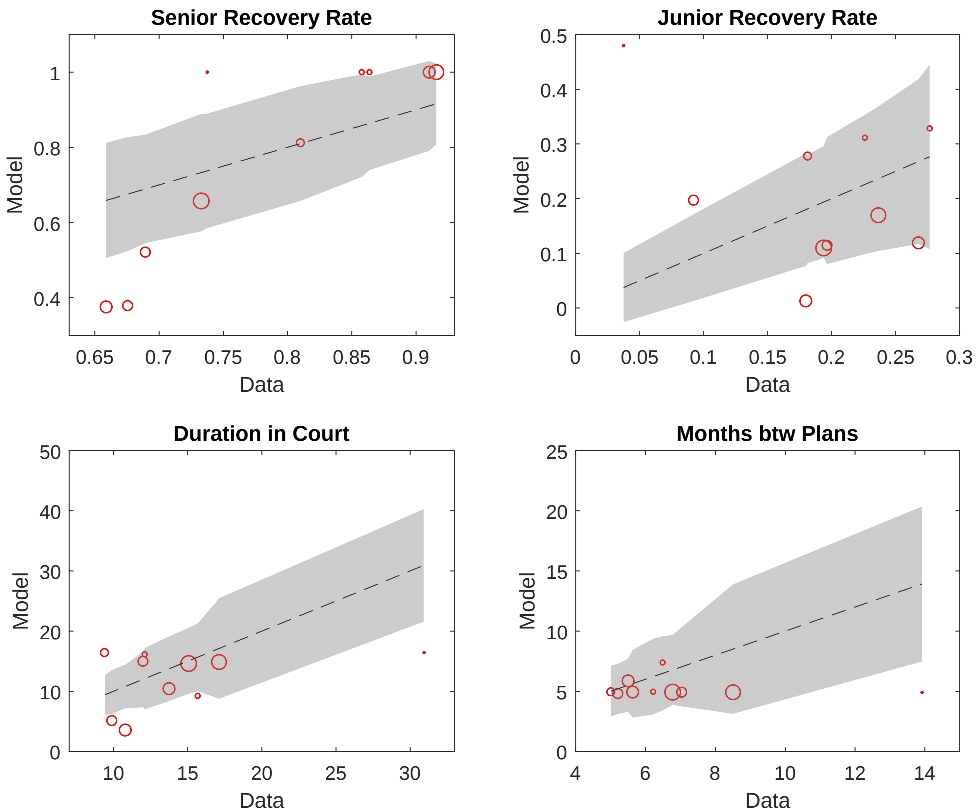
Figure OA.3: Comparing within-cluster distributions of simulated and actual data.
This figure matches Figure 7 in the main paper, except we de-mean each variable at the cluster level before plotting the histograms. The ten clusters have different values of $\{D_J, V_0, L\}$ and are described in detail in Section 3.2 and Appendix C of the main paper.




simulated and actual data (Panel A). As in Figure 7's Panel B, the within-cluster version of Panel B shows more dispersion in the actual data compared to the model. In Panel C, the model fits court case duration strikingly well. Model fit is worse, however, for months between observed proposals (Panel D), which is much more dispersed in the actual data than in the model. It makes sense that we see more dispersion in the actual data than the simulated data in Panels B and D, for two reasons. First, in the actual data but not in the model, there is within-cluster variation in $\{D_J, V_0, L\}$, which produces more variation in outcome variables than the model can produce. Second, the model omits features of reality that make the actual data more dispersed than the simulated data. For both these reasons, we target averages rather than variances in our simulated minimum distance estimation.

Figure OA.4 shows how well the model can explain variation across clusters. For each variable, the ten clusters' means are plotted as ten red circles. The size of the circle indicates the number of data observations in the cluster. If the circle falls exactly on the dashed 45-degree line, the cluster's simulated

Figure OA.4: Comparing cross-cluster variation between the model and data.
This figure compares variables' cluster-level averages between the simulated and actual data. The four panels correspond to the four panels in Figure 7 in the paper. Each red circle corresponds to one of the ten clusters, each with its own value of $\{D_S, V_0, L\}$ in the model. The size of the circle indicates the number of actual observations belonging to each cluster. The horizontal axis indicates the cluster's average in the actual data, and the vertical axis indicates the cluster's average in the simulated data. The dashed line is the 45-degree line indicating perfect model fit. The gray area indicates the 95% confidence interval for the cluster's mean. We compute these confidence intervals off the actual data, and we center them at the null hypothesis indicating perfect model fit.

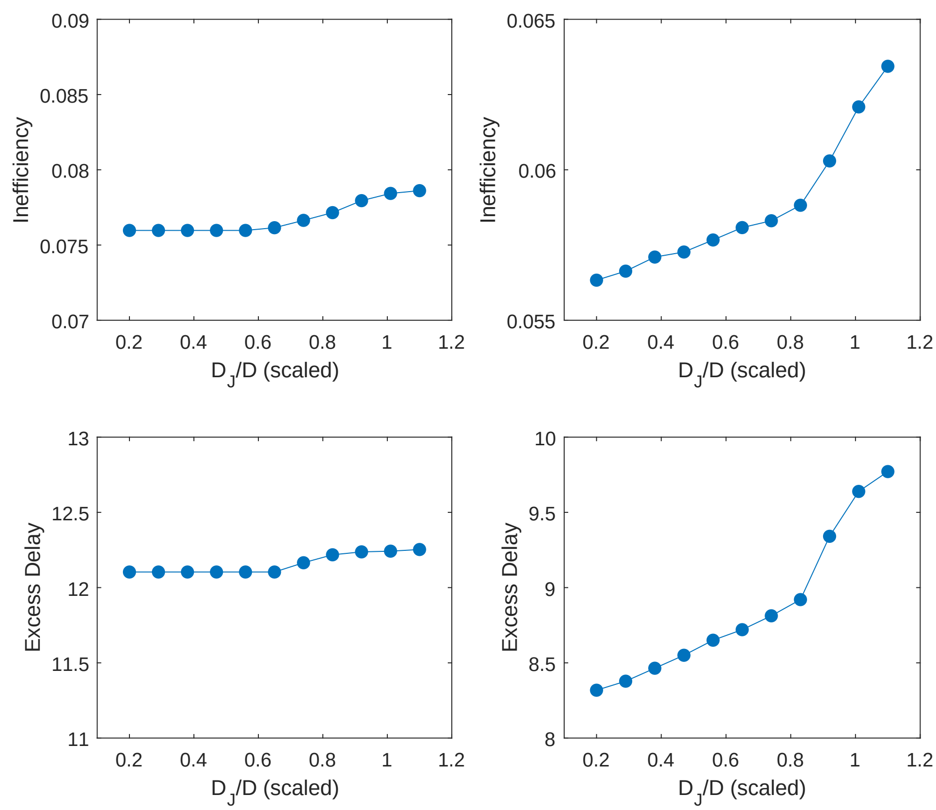



average exactly equals the average from the actual data, meaning model fit is perfect. The farther the circles are from the dashed line, the worse is model fit. Of course, each cluster's average is measured with error in the actual data, so we also plot gray 95% confidence intervals around the perfect-fit null hypothesis.

In both the model and the actual data, all variables' means vary considerably across clusters. In other words, the red circles vary both along the x-axis and y-axis. The model helps to explain the cross-cluster variation that we see in the actual data: the red dots slope upwards, meaning clusters with higher average values in the actual data also have higher averages in the simulated data. While the circles do not fall exactly on the dashed 45-degree line, a large majority of circles fall within the gray 95% confidence region around the dashed line. For the senior recovery rate, the circles slope up too steeply, while the opposite is true for months between plans. The figure provides a powerful out-of-sample test of model fit. We did not ask the model to fit variation across the ten clusters, and yet the model does fit that variation reasonably

Figure OA.5: Inefficiencies, excess delay, and debt structure.

This figure is analogous to Figure 8 in the main paper, except we vary $D_J/D$ along the horizontal axis. In the left column we assume that liquidation values $L$ are at their empirical estimates. In the right column we multiply clusters' estimated values of $L$ by 1.5 before computing comparative statics with respect to $D_J/D$. We do not center the horizontal axis at 1, because for scaled values of $D_J/D$ much greater than one some clusters would have $D_J/D > 1$, which is not allowed. Remaining details are the same as in Figure 8 in the main paper.




well (although not perfectly).

# I. Comparative Statics for $D_J/D$

This section extends the analysis of Section 5 in the main paper. Figure OA.5 shows how the predicted levels of inefficiency and excess delay vary with $D_J/D$, the amount of junior debt as a fraction of total debt.

We find that inefficiencies and excess delay increase only slightly in $D_J/D$ when we use empirically relevant parameter values. This result is in the left column of Figure OA.5. We expect inefficiencies and excess delay to increase in $D_J/D$, because the level of junior creditor bargaining power approaches the level of senior creditor bargaining power as junior creditors make up a larger fraction of the capital structure, and equal bargaining power leads to more inefficiency (see discussion in Section 2.3 of the main paper). The increase is only slight, however, because estimated liquidation values $L$ are considerably smaller than

$D_S$ and $D_L$ in our data. The junior creditor's bargaining power depends in part on its payout in a liquidation, because this payout represents the junior's outside option. The junior's payout in a liquidation is $\max(L - C_t - D_S, 0)$. Since estimated values of $L$ are typically less than $D_S$ in our sample (Panel B of Table 1), the junior's liquidation payout is typically zero, making the junior creditor's bargaining power fairly insensitive to $D_J/D$. As a result, changing $D_J/D$ has little effect on inefficiencies or excess delay.

If liquidation values were counterfactually larger, we would see a stronger effect of $D_J/D$ on inefficiencies. We illustrate this result in the right column of Figure OA.5, which re-computes the comparative statics for $D_J/D$ using counterfactually large values of $L$. Specifically, we scale up each cluster's estimated $L$ by a factor of 1.5 before computing the comparative statics. We now see that the levels of inefficiency and excess delay strongly increase in $D_J/D$, consistent with the prediction above. The reason is that as $D_J/D$ increases, the junior's payout in liquidation increases, since $D_S/D$ decreases in $D_J/D$. As the junior's outside option in liquidation improves, the junior's bargaining power approaches the senior's bargaining power, which in turn produces more excess delay.

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