Accepted Manuscript

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PII: S0304-405X(19)30022-4
DOI: https://doi.org/10.1016/j.jfineco.2018.05.012
Reference: FINEC 3018

To appear in: *Journal of Financial Economics*

Received date: 30 January 2018
Revised date: 9 May 2018
Accepted date: 31 May 2018

Please cite this article as: Samuel Antill, Steven R. Grenadier, Optimal capital structure and bankruptcy choice: Dynamic bargaining versus liquidation, *Journal of Financial Economics* (2019), doi: https://doi.org/10.1016/j.jfineco.2018.05.012

Optimal capital structure and bankruptcy choice: Dynamic bargaining versus liquidation[☆]

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Abstract

We model a firm's optimal capital structure decision in a framework in which it may later choose to enter either Chapter 11 reorganization or Chapter 7 liquidation. Creditors anticipate equityholders' ex-post reorganization incentives and price them into the ex-ante credit spreads. Using a realistic dynamic bargaining model of reorganization, we show that the off-equilibrium threat of costly renegotiation can lead to lower leverage, even with liquidation in equilibrium. If reorganization is less efficient than liquidation, the added option of reorganization can actually make equityholders worse off ex-ante, even when they liquidate on the equilibrium path.

Keywords: capital structure, bankruptcy, default, dynamic bargaining
JEL classification: C73, C78, G32, G33

1. Introduction

In 2016, the US bankruptcy court system received nearly 38,000 commercial bankruptcy filings.[1] For publicly traded firms, 80% of bankruptcies are handled under Chapter 11, while only 20% are Chapter 7 liquidations (Corbae and D'Erasmo, 2017). Given the significance of Chapter 11 filings among reasonably sized firms, the possible contingency of a future reorganization must be priced into the debt issued by such firms. We propose a model in which equityholders can choose both their timing of default and the chapter of bankruptcy,[2] and then we examine how this flexibility alters capital structure decisions. In addition to providing novel mechanisms for explaining debt conservatism and the "credit spread puzzle," this model allows us to answer other important questions: how do the characteristics of the Chapter 11 process impact the capital structure of firms? Conversely, can the capital structure of firms impact their choice of bankruptcy chapter?

In this work, we develop and solve a realistic continuous-time dynamic bargaining model of Chapter 11. For tractability, we must make some simplifying assumptions, but we make every effort to ensure our model accords with the US Bankruptcy Code and its implementation. We include many features of the Chapter 11 process such as automatic stay, suspension of dividends, the exclusivity period, postexclusivity proposals by creditors, forced conversion to Chapter 7, absolute priority rule (APR) in liquidation, and the unanimity rule (by creditor class) in approval of a reorganization plan. The reorganized firm may issue new debt and continue operating. Chapter 11 entails inefficiencies that are distinct from Chapter 7 such as professional fees and a decline in the cash flows that accumulate during reorganization. Moreover, both debtors and creditors face uncertainty over future asset values as they debate reorganization plans. In our model, creditors and equityholders are fully strategic in proposing and accepting plans, and we solve for a unique Markov perfect equilibrium outcome in closed form. This outcome turns out

[☆]The authors would like to thank Erwan Morellec (the referee), Shai Bernstein, Will Cong, Peter DeMarzo, Darrell Duffie, Nicolae Gârleanu, Ben Hébert, Andrey Malenko, David Scharfstein, Amit Seru, Victoria Vanasco, Neng Wang, Zhe Wang, Toni Whited (the editor), and Jeff Zwiebel for helpful comments. We are also grateful for discussions by Juliana Salomao at the 2018 Western Finance Association Meeting and Barney Hartman-Glaser at the University of Washington 4th Summer Finance Conference and for comments from participants at the Stanford Berkeley joint student seminar. This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under grant no. DGE-114747. All remaining errors are our own.

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[1]American Bankruptcy Institute, January 2017 bankruptcy statistics on commercial filings.

[2]Iverson (2017) reports that fewer than 2% of Chapter 11 filings are involuntary.

to be Pareto optimal, despite potential delays in agreement.

Using this equilibrium bargaining outcome, we extend the classic Leland (1994) model of endogenous default by allowing firms to choose between Chapter 7 or Chapter 11 when they default. As is standard in these models (see Strebulaev and Whited, 2012 or Sundaresan, 2013), equityholders receive nothing in liquidation. It follows that at the moment of default, equityholders choose Chapter 11 if and only if the expected bargaining outcome exceeds the fixed cost they must pay to enter Chapter 11. Intuitively, in the subgame following debt issuance (ex-post), Chapter 11 is optimal for equityholders when the firm is sufficiently profitable at the moment of default. Taking into account the ex-post, strategic behavior of equityholders, the firm issues rationally priced debt at time zero (ex-ante) to exploit tax benefits.

The time zero capital structure decision depends on the relative efficiencies of Chapter 7 and Chapter 11 (traded off against the tax benefits of leverage). Specifically, depending on model parameters, there are three possible scenarios. The first two cases are rather stark and straight-forward. In the first case, Chapter 11 is significantly more efficient than Chapter 7, so equityholders naturally find the former more attractive ex-post upon default. Thus, at time zero, debtholders demand a higher credit spread to compensate them for the rents equityholders extract in the event of a future reorganization. Notably, equityholders are willing to pay this higher spread since it is the rational expectation of their contingent Chapter 11 proceeds. The net effect is an increase in ex-ante firm value from the added option of a Chapter 11, due to the lower default costs of Chapter 11. Alternately, in the second case, Chapter 11 is extremely wasteful relative to Chapter 7. It follows that equityholders are not willing to incur the fixed cost of entering reorganization. Thus at time zero, equityholders optimally issue the same coupon as in the Leland (1994) model (which neglects Chapter 11), and ex-post liquidate at the same stopping time as well. In this case, the added option of Chapter 11 has no effect on ex-ante firm value.

The third case, in which Chapter 11 is slightly less efficient than Chapter 7, is the most interesting. In this case, if equityholders issue the optimal coupon from Leland (1994), they will ex-post find it optimal to enter Chapter 11. This is because large coupons imply the firm defaults in profitable states of the world, where the prospects of Chapter 11 for equityholders justify the fixed cost of entry. Debtholders thus demand a higher credit spread at time zero for such a coupon. Equityholders are hesitant to pay this spread since reorganization destroys more value than Chapter 7. For such parameters, equityholders have two choices. They can issue a large coupon to reap tax benefits and accept that they will pay for the ex-post Chapter 11 inefficiencies with a higher credit spread at time zero. We call this the "optimal inefficient Chapter 11" strategy. Alternately, equityholders can issue a smaller coupon consistent with ex-post optimal Chapter 7. In this case, they sacrifice the tax benefits of a larger coupon, but they enjoy a lower cost of debt due to the rational expectation of a future, more efficient liquidation. We call this the "constrained debt Chapter 7" strategy. Counterintuitively, regardless of which of these two strategies is optimal, the added option of Chapter 11 actually reduces ex-ante firm value.

Graham (2000) points out that "paradoxically, large, liquid, profitable firms with low expected distress costs use debt conservatively" and "the typical firm could double tax benefits by issuing debt until the marginal tax benefit begins to decline." Many existing dynamic models can produce low leverage (for example, Hennessy and Whited, 2005; DeAngelo, DeAngelo, and Whited, 2011; Strebulaev, 2007 and others). However, our model generates a new mechanism for explaining low leverage, even when the firm's environment on the equilibrium path is identical to Leland (1994). If the relative inefficiencies of Chapter 11 are large compared to the tax benefits of debt, equityholders optimally use the constrained debt Chapter 7 strategy and issue a modest coupon. For such a coupon, they will find Chapter 7 optimal ex-post, which lowers the cost of debt ex-ante. Since this entails forgoing tax benefits, equityholders issue the largest coupon consistent with future Chapter 7. In this case, for reasonable parameters, our model predicts a leverage ratio of 40%. For the same parameters, the Leland (1994) model predicts a 70% leverage ratio. To an econometrician, our model looks identical to the Leland model for such parameters: a firm issues debt then eventually liquidates. However, the off-equilibrium considerations introduced by our bargaining model lead the firm to issue a much smaller coupon than in the standard Leland model. In this case, our model predicts lower leverage than the Leland model, even for the 65% of (public and private) firms that liquidate in Chapter 7 (Bernstein, Colonnelli, and Iverson, 2017, henceforth BCI).

Endogenous default models of capital structure tend to underestimate credit spreads (Huang and Huang, 2012). Under the optimal inefficient Chapter 11 strategy, our model suggests that high credit spreads could be due to the rational expectation of future rents extracted by equityholders in Chapter 11. For these parameter ranges, firms are unwilling to sacrifice tax benefits to get a lower cost of debt from issuing a low coupon consistent with ex-post Chapter 7. Instead, they accept the higher cost of debt and issue a large coupon for the tax shield. Since the higher default costs are internalized by equityholders when they issue debt, the overall coupon is still lower than in the Leland model. For reasonable parameter values, credit spreads can be 17 basis points higher than in the Leland model, even with an optimal leverage ratio that is 7 percentage points lower. While many other models can produce higher credit spreads than Leland (1994), ours does so simply by adding a realistic choice of bankruptcy chapter.

Finally, our model generates many other testable implications about the relation between Chapter 11 and capital structure. Consider the following list. Creditor rights might be interpreted as the relative bargaining power of creditors in bankruptcy. Under this interpretation, stronger creditor rights lead to higher optimal leverage and firm value, consistent with empirical evidence. Firms with higher growth rates should be more likely to choose Chapter 11, so comparing Chapter 11 and Chapter 7 by the value of assets at the end of bankruptcy might overstate the efficiency of Chapter 11. Firms with more volatile cash flows or lower growth rates should have longer bankruptcies. Firms that choose Chapter 11 should have both more valuable assets and higher leverage ratios at the time of default than firms that choose Chapter 7. When the constrained debt Chapter 7 strategy is optimal, anything that makes Chapter 11 less appealing (for example, higher legal costs) will actually improve firm value. Changes in parameter values can have surprising comparative statics when they cause the firm to shift from Chapter 11 to Chapter 7 or vice versa.

Our paper contributes to the literature on dynamic contingent claims models of capital structure. Relative to Leland (1994), we contribute by allowing equityholders to choose to file for Chapter 11 bankruptcy or Chapter 7 liquidation. Papers such as Fan and Sundaresan (2000) have extended the Leland (1994) framework to allow for costless renegotiation in private workouts.[3] Articles such as Hackbarth, Hennessy, and Leland (2007) and Hackbarth and Mauer (2012) study the optimal mixture of bank and public debt, where bank debt may be renegotiated in a private workout. These works document important links between private workouts and optimal capital structure decisions, but the details of the Chapter 11 procedure are not modeled.

François and Morellec (2004) and Broadie, Chernov, and Sundaresan (2007) are more similar to our work. François and Morellec (2004) extend the model of Fan and Sundaresan (2000) to study the Chapter 11 bankruptcy procedure. In their model, equityholders choose a threshold at which to enter Chapter 11. While the asset value is below this threshold, equityholders and debtholders split the cash flow according to Nash bargaining. If asset values do not rise back above the same threshold before an exogenous window of time expires, then the firm liquidates. Moraux (2002) and Galai, Raviv, and Wiener (2007) use a similar formulation. Broadie, Chernov, and Sundaresan (2007) numerically extend this by keeping track of accumulated earnings and accumulated arrears during the bankruptcy. In their framework, the firm emerges from bankruptcy when accumulated earnings are sufficient to pay off the accumulated arrears, where an exogenous fraction of the debt is forgiven. They study equity and debt values when creditors pick the bankruptcy threshold compared to the same values when equityholders choose the thresholds. Both François and Morellec (2004) and Broadie, Chernov, and Sundaresan (2007) also consider a time zero capital structure decision. These papers capture the impact of bankruptcy procedure on time zero capital structure but only allow for liquidation after the firm has already entered Chapter 11. In reality, the majority of firms go straight to Chapter 7 without ever entering Chapter 11 (BCI, 2017). By allowing equityholders to choose either Chapter 7 or Chapter 11, our model produces implications for the choice of bankruptcy procedure. This also has important implications for the time zero capital structure decision that are impossible to produce in either of the previously mentioned models. To our knowledge, the only models that allow firms to enter Chapter 7 or Chapter 11 are Bernardo, Schwartz, and Welch (2016) and Corbae and D'Erasmo (2017). Both models are extremely different from ours (for example, bankruptcies always last one period, and all debt matures in one period), so our analysis complements theirs while providing novel insights.

A novel methodological contribution of our paper rel-

[3]See also Anderson and Sundaresan (1996) and Mella-Barral and Perraudin (1997). More recent papers that jointly consider renegotiation and investment include Sundaresan and Wang (2007) and Shibata and Nishihara (2015). Christensen et al. (2014) have a similar model with dynamic capital structure. Earlier structural models of debt pricing include Merton (1974), Brennan and Schwartz (1984), Kane, Marcus, and McDonald (1984), Black and Cox (1976), and Fischer, Heinkel, and Zechner (1989). More recent models of dynamic capital structure with endogenous default (solely through Chapter 7) include Leland (1998), Goldstein, Ju, and Leland (2001), Titman and Tsyplakov (2007), and Strebulaev (2007).

ative to all previous work is our bargaining model of Chapter 11. We use a new continuous-time formulation of the stochastic bargaining model from Merlo and Wilson (1995). This captures two important features of the bankruptcy process. First, all impaired classes of creditors (including equity) must unanimously agree to a reorganization plan to exit bankruptcy (see Section 3.1). The models mentioned previously assume that equity or debt unilaterally decide the timing of the exit. Second, Chapter 11 bankruptcies can take as long as ten years, and all parties face significant uncertainty over how the value of the firm's assets will change in this time. The previously mentioned models, such as Corbae and D'Erasmo (2017), assume that the split between equity and debt is either determined exogenously or by Nash bargaining at the moment of entering Chapter 11. Our stochastic bargaining framework allows parties to change their bargaining strategies as they observe the resolution of uncertainty.[4]

Our stochastic bargaining model produces results that cannot be replicated by a standard Nash bargaining model of Chapter 11. For example, Chapter 11 outcomes like APR violations or postreorganization capital structure and firm value are unpredictable until the moment of reorganization. Additionally, we find that equity's expected bargaining outcome is increasing in the size of the firm, consistent with empirical evidence. This relation is used by Garlappi, Shu, and Yan (2008) and Garlappi and Yan (2011) to explain a number of empirical facts about distress and expected equity returns, even though their models use Nash bargaining that does not endogenously produce this relation. Our stochastic bargaining model thus provides a theoretical foundation for proxying equity bargaining power with firm size. The realistic nature of the bargaining could help improve the already strong fit of other structural contingent claims models with renegotiation (for example, Favara et al., 2017 or Morellec, Nikolov, and Schuerhoff, 2018).

The article proceeds as follows. Section 2 describes the model and reviews the Leland (1994) setup. Section 3 provides institutional details then describes and solves for the equilibrium of the Chapter 11 reorganization timing game. Section 4 derives the optimal decision to enter Chapter 11 or Chapter 7. Section 5 describes the time zero capital structure choice, provides our results on capital structure, and gives additional empirical implications. Section 6 discusses possible generalizations of the model, and Section 7 concludes.

2. Model setup

In this section, we begin by describing the setup of our model of the leveraged firm. In particular, we focus on the timing of the decision to enter Chapter 11 reorganization or Chapter 7 liquidation, the continuous-time bargaining game that occurs during reorganization, and the endogenous emergence from reorganization. This model is solved in Sections 3 and 4, working backward through time. As a useful benchmark, and for our own model prior to and following reorganization, in Section 2.2, we provide a brief derivation of the standard solution where Chapter 11 reorganization is not considered.

2.1. Outline and assumptions of the baseline model

We consider a continuous-time infinite-horizon model of a firm, whose manager maximizes shareholder value. At all times at which the firm is operating, its assets in place produce earnings before interest and taxes (EBIT) δ_t. We assume the existence of a risk-neutral measure with risk-free rate r under which δ_t follows a geometric Brownian motion

$$d\delta_t = \delta_t \mu dt + \delta_t \sigma dB_t, \tag{1}$$

where $\mu < r$ and $\sigma > 0$ are constants representing the risk-neutral growth rate and volatility of δ_t, respectively, and B_t is a standard Brownian motion under the risk-neutral measure. The cash flow δ_t is subject to effective corporate tax rate τ.

The model comprises a sequence of optimizations that are separated by four distinct times, $\mathbb{T} = 0, 1, 2, 3$. Fig. 1 presents a graphical timeline of the model. Time 0 represents the initial determination of the capital structure of the firm. Specifically, at Time 0, the firm can issue consol debt with total perpetual coupon C_0. Debt entails a tax shield, and we follow the literature in assuming a full loss offset provision, so the firm subsequently pays taxes $\tau(\delta_t - C_0)dt$ per unit time. The firm

[4] A few earlier papers have bargaining models of Chapter 11 that are more strategic than Nash bargaining. For example, Paseka (2003) considers a dynamic bargaining game in Chapter 11, but only equityholders can make take it or leave it offers, there is no accumulation of cash flows, and the firm cannot relever after Chapter 11. Eraslan (2008) structurally estimates a dynamic, but deterministic, bargaining model of Chapter 11 similar to Rubinstein (1982), and Annabi, Breton, and François (2012) numerically solve a bargaining model of Chapter 11 with exogenously many rounds of fixed exogenous length. Earlier theoretical papers studying Chapter 11 include Franks and Torous (1989) and Longstaff (1990) who model Chapter 11 as a right to extend the maturity date of debt. Lambrecht and Perraudin (1996) study a creditor race in bankruptcy where multiple creditors might preempt one another in seizing assets (Bruche, 2011 examines a similar setup). Importantly, none of these consider the decision of whether to enter Chapter 7 or Chapter 11, and none of these papers have any capital structure decision.

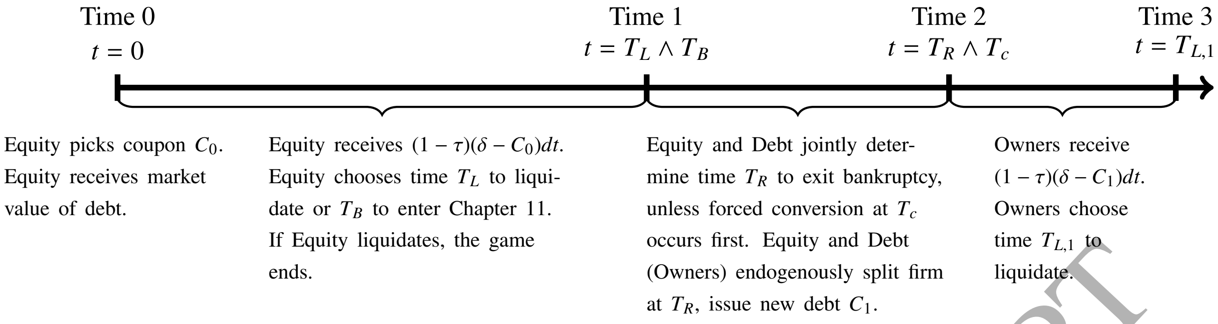


Fig. 1. Timeline of the model.

chooses C_0 to maximize firm value, the determination of which will depend on expectations of future strategic decisions.

Once the firm has issued debt with coupon C_0, they progress to the period between Time 0 and Time 1. During this period, the firm is operating and equityholders receive after-tax cash flow $(1 - \tau)(\delta_t - C_0)dt$ per unit time. Equityholders choose Time 1, the moment of default and the end of the period, and this can be either of two potential stopping times that the owners must contemplate. One is the standard liquidation decision that is common in the literature. At any stopping time T_L, the equityholders may choose to liquidate, at which point equityholders receive 0, and debtholders receive the liquidation value

$$\zeta\delta_{T_L} = \frac{(1-\tau)(1-\alpha)\delta_{T_L}}{r-\mu}. \qquad (2)$$

The liquidation value $\zeta\delta_{T_L}$ is the expected discounted value of receiving $(1 - \tau)\delta_t$ in perpetuity given the current value of δ_{T_L}, multiplied by a constant $(1 - \alpha)$. As is standard in the literature, we assume a fraction $\alpha \in (0, 1)$ of the firm value is lost in liquidation. If the firm chooses to liquidate, the game ends.

Our novel contribution is the additional option for the firm to enter a Chapter 11 reorganization. At any time T_B, the firm may declare bankruptcy and enter into a Chapter 11 reorganization. In this case, they pay a fixed cost $B > 0$ and enter the next period.

If the firm enters Chapter 11, then the period between Time 1 and Time 2 represents the time spent in Chapter 11 reorganization. In this period, debtholders and equityholders play a continuous-time bargaining game to determine when to emerge from bankruptcy. During the Chapter 11 process, which Section 3.1 describes in greater detail, the automatic stay provision prevents creditors from demanding payments. At the same time, dividend suspension prevents debtors (equityholders) from paying themselves dividends. We assume that the firm continues to receive cash flows $(1 - \tau)h\delta dt$ per unit time, where $h \in [0, 1]$ is a multiplier representing the inefficiency of operations during bankruptcy, and these cash flows accumulate. At any stopping time T_R, the debtholders and equityholders may agree to a reorganization plan. At this time, the equityholders and debtholders split the firm value $V(\delta_{T_R})$ minus a fixed reorganization cost $R_0 > 0$. They also receive the accumulated earnings, for a total payment of

$$P_{T_R} \equiv V(\delta_{T_R}) - R_0 + (1-\tau)h\int_{T_B}^{T_R} \delta_s ds. \qquad (3)$$

In Broadie, Chernov, and Sundaresan (2007), the authors provide a model of Chapter 11 that assumes equityholders receive the residual firm value after paying arrears at a time chosen by equityholders. We depart from this by modeling the reorganization as a bargaining process. Consistent with the laws of Chapter 11, equityholders and debtholders alternate filing plans for how to split the total P_t, and the process ends at the first time T_R when one party makes a proposal the other party accepts.

The period ends at Time 2 by either the debtholders and equityholders agreeing to a reorganization plan at stopping time T_R or by a judge-mandated liquidation. With probability ιdt per unit time, the judge converts the Chapter 11 reorganization into a Chapter 7 liquidation. In the event of liquidation, debtholders receive the liquidation value $\zeta\delta$ plus the accumulated earnings net of fees, equityholders receive nothing consistent with APR, and the game ends. While this occurs exogenously, agents anticipate the possibility of liquidation and may endogenously increase the likelihood of liquidation by stalling. If equityholders and debtholders agree to a reorganization prior to liquidation, the game proceeds to the final period.

If the firm reorganizes, the period between Time 2 and Time 3 represents the operation of the reorganized firm. Just as at Time 0, the new equityholders of the reorganized firm issue new debt C_1 to maximize firm value at Time 2. For the remainder of the period, equityholders receive a payment $(1-\tau)(\delta_t - C_1)dt$ per unit time. For simplicity, we assume that the option to reorganize no longer exists and the firm may only exit through liquidation (Section 6.1 discusses relaxing this assumption). Thus, at any stopping time $T_{L,1}$, equityholders may choose to liquidate the firm. As described previously, at the time of liquidation (Time 3), equityholders receive 0, the new debtholders receive $\zeta\delta_{T_{L,1}}$, and the game ends.

2.2. Benchmark model: the Leland model with only Chapter 7 liquidation

In the standard Leland model, a levered firm with coupon C chooses a liquidation time T_L to maximize equity value:

$$E^L(\delta) \equiv \sup_{T_L \in F^\delta} \mathbb{E}^\delta \Big[\int_0^{T_L} e^{-rt}(1-\tau)(\delta_t - C)dt \Big], \tag{4}$$

where throughout the paper, $\mathbb{E}^\delta$ represents expectation with respect to the probability law of the process δ_t starting at $\delta_0 = \delta$. We require that T_L is a stopping time with respect to the filtration F^δ generated by δ_t. It is worth noting that there could be a time $t < T_L$ such that the cash flow to equity is negative. Consistent with the prior literature, we assume in this case that equityholders issue new shares and dilute their equity to pay the coupon to debtholders. For the optimal T_L, the value of equity will always be positive for $t < T_L$, consistent with limited liability, so such dilution is possible.

In the region where liquidation is not optimal, standard dynamic programming arguments show the value of equity $E^L(\delta)$ satisfies the following ordinary differential equation (ODE):

$$rE^L(\delta) = \mathcal{D}E^L(\delta) + (1-\tau)(\delta - C), \tag{5}$$

where, defining "smooth" to mean continuously differentiable and twice continuously differentiable almost everywhere, $\mathcal{D}$ is the differential operator from Ito's lemma for smooth functions of δ_t:

$$\mathcal{D}f(\delta) \equiv f'(\delta)\mu\delta + f''(\delta)\frac{\sigma^2}{2}\delta^2. \tag{6}$$

As $\delta \to \infty$, the value of the option to liquidate should become worthless. This implies the value of equity $E^L(\delta)$ should approach the value of receiving the after-tax cash flows less the debt payments in perpetuity, which is $(1-\tau)[\delta/(r-\mu) - C/r]$. Imposing this condition, the relevant solution of Eq. (5) is

$$E^L(\delta) = A_1\delta^\psi + (1-\tau)[\frac{\delta}{r-\mu} - \frac{C}{r}],$$

where A_1 is an arbitrary constant, and ψ is the negative root of the characteristic polynomial

$$r - \mu z - \frac{\sigma^2}{2}z(z-1) = 0.$$

It can be verified that the optimal liquidation time T_L is a hitting time $T_L \equiv \inf\{t : \delta_t \le \delta_L\}$ for some barrier δ_L. The constant A_1 and the liquidation threshold δ_L are determined by value matching and smooth pasting at δ_L. Since equity receives nothing in liquidation, the value matching and smooth pasting conditions are

$$A_1\delta_L^\psi + (1-\tau)[\frac{\delta_L}{r-\mu} - \frac{C}{r}] = 0 \tag{7}$$

$$A_1\psi\delta_L^{\psi-1} + \frac{(1-\tau)}{r-\mu} = 0. \tag{8}$$

This system of equations has the usual unique solution

$$\delta_L = \frac{\psi}{\psi-1}\frac{r-\mu}{r}C \tag{9}$$

$$A_1 = \delta_L^{-\psi}(1-\tau)[\frac{C}{r} - \frac{\delta_L}{r-\mu}]. \tag{10}$$

Taking the liquidation threshold δ_L as given, the value of the debt $D^L(\delta)$ satisfies an ODE similar to Eq. (5) prior to liquidation:

$$rD^L(\delta) = \mathcal{D}D^L(\delta) + C, \tag{11}$$

and similar logic shows the relevant solution of this ODE is

$$D^L(\delta) = \frac{C}{r} + A_2\delta^\psi \tag{12}$$

for an arbitrary constant A_2. As discussed in the previous section, at the time of liquidation T_L a fraction of firm value α is lost, leaving value $\zeta\delta_L$ for the debtholders. Imposing that $D^L(\delta_L) = \zeta\delta_L$ uniquely determines the constant A_2, which gives the rational expectations value of consol debt with coupon C:

$$D^L(\delta) = \frac{C}{r} + \delta^{\psi}\delta_L^{-\psi}[-\frac{C}{r} + \zeta\delta_L]. \quad (13)$$

The standard Leland model features a Time 0 capital structure decision. Specifically, at Time 0, equityholders choose the coupon C for their consol debt to maximize the total firm value $E^L(\delta_0) + D^L(\delta_0)$. As in the standard trade off theory, the firm weighs the tax benefits of debt with the loss of firm value in liquidation. For any arbitrary δ_0, we can plug in Eq. (9) for δ_L, and the resulting expression for $E^L(\delta_0) + D^L(\delta_0)$ is concave in C. Solving the first order condition gives the unique optimal C^*:

$$C^* = \delta_0 \frac{r}{r-\mu}\frac{\psi-1}{\psi}[\frac{-\tau}{\psi(1-\tau)\alpha + (\psi-1)\tau}]^{\frac{-1}{\psi}}. \quad (14)$$

Note that the optimal coupon C^* is linear in the starting cash flow δ_0. Since the liquidation barrier δ_L is linear in C, it can be seen from Eq. (9, 10, 13, 14) that at the optimal coupon,

$$E^L(\delta_0) + D^L(\delta_0) = \theta\delta_0 \quad (15)$$

for a constant θ that is a known function of the model primitives given in the Online Appendix.

3. Chapter 11 as a stochastic bargaining game

Recall that our model is divided by four distinct times. Since we rule out a second reorganization, in the period between Time 2 and Time 3 the equityholders solve the standard liquidation problem described in Section 2.2. Likewise, at Time 2, they issue an optimal level of debt as described above. In this section, we describe and solve the period between Time 1 and Time 2, the Chapter 11 process.

We first discuss some features of the Chapter 11 process that are important for our model in Section 3.1. We then set up our model of bargaining in reorganization in Section 3.2. Notably, the payoff is simplified by our Leland model benchmark from above. In Section 3.3, we determine the socially efficient timing of reorganization, which coincides with the equilibrium timing due to a Pareto-optimality result. Then, conditional on this efficient timing, we solve for the equilibrium bargaining split in Section 3.4. Section 3.5 discusses implications of our dynamic bargaining model, and Section 3.6 compares our dynamic bargaining model to Nash bargaining.

3.1. Relevant features of Chapter 11

To be tractable, our model makes some simplifying assumptions regarding the Chapter 11 process. However, we make every attempt to ensure that our model is broadly consistent with some of the most salient features of the actual Bankruptcy Code. In this section, we summarize some of the most important aspects of the Chapter 11 process that inform much of our modeling assumptions. A comprehensive description of Chapter 11 is far beyond the scope of this paper.

First, over 98% of Chapter 11 cases begin with a voluntary filing (Iverson, 2017). In a voluntary filing, the debtor (management on behalf of equityholders) chooses the bankruptcy chapter. In some cases, creditors can file for an involuntary bankruptcy in their chosen chapter under 11 USC § 303. However, courts only enforce a controverted filing if "the debtor is generally not paying such debtors debts as such debts become due," and in this case, the debtor still "may file an answer to a petition under this section" to choose the chapter (11 USC § 303(d,h)).

Second, the automatic stay provision of Chapter 11 (11 USC § 362) prohibits all entities from "any act to obtain possession of property of the estate." In particular, debtholders stop receiving coupons and equityholders stop receiving dividends.

Third, to confirm a reorganization plan and exit Chapter 11, every impaired class of creditors must accept the plan by 11 USC § 1129(a) (we ignore 11 USC § 1129(b) cram downs). This gives equityholders, who constitute a class of claims, some power to hold up the reorganization process and potentially extract rents. The APR refers to the idea, in Chapter 7 or 11, that each creditor should only be compensated once all senior creditors are paid in full. However, equityholders are often able to use their bargaining power to violate this in Chapter 11. Bris, Welch, and Zhu (BWZ, 2006) find in their sample that APR is always followed in Chapter 7, while it is violated in 12% of Chapter 11 cases. Weiss (1990) finds violations in 29 of the 37 Chapter 11 cases he studies.

Fourth, at the start of the Chapter 11 process, equityholders enjoy an "exclusivity period." Specifically, the debtor-in-possession (DIP) enjoys the exclusive right to propose reorganization plans for 120 days under 11 USC § 1121(a). Small businesses have 180 days. The debtors then have another 60 days to get the plan approved by creditors. After this window, any party in interest may file a plan. Under 11 USC § 1121(d), the court may reduce or increase this window. Since this is at the judge's discretion, both equityholders and creditors face uncertainty as to the length of the exclusivity period, although it cannot exceed 18 months (20 months for small businesses).

Fifth, it is common for bankruptcy cases that begin as Chapter 11 reorganizations to be converted to Chapter 7 liquidations. In the sample analyzed in BWZ (2006), 14% of the cases that began in Chapter 11 were converted, while as many as 40% of cases were converted in the sample of BCI (2017). While debtors may in principle choose to convert to Chapter 7, and creditors may petition for such a conversion, the ultimate decision lies with the judge. This suggests that modeling the conversion as exogenous and random is a reasonable approximation of reality. Indeed, BCI (2017) use the random assignment of judges to bankruptcy cases as exogenous variation in the probability of conversion: "US bankruptcy courts use a blind rotation system to assign cases to judges, effectively randomizing filers to judges within each court division. While there are uniform criteria by which a judge may convert a case from Chapter 11 to Chapter 7, there is significant variation in the interpretation of these criteria across judges."

Finally, Chapter 11 entails significant costs, some of which are fixed and invariant to the size of the firm or length of the bankruptcy. Further, some nontrivial amount of these costs are borne by the equityholders and may not be reimbursed from the estate. We discuss this in greater detail in the Online Appendix.

3.2. The dynamic reorganization game

At Time 1, the firm enters Chapter 11, and the period ends at Time 2 with a reorganization or a forced liquidation. Based on the analysis of Section 2.2, the total firm value available to be split among debtholders and equityholders if a reorganization occurs at time T_R is $\theta\delta_{T_R}$. This expression takes into account the value of the debt the new equityholders will issue.

As discussed previously, there are no payments during the Chapter 11 process. We assume that after-tax earnings accumulate into an account, and that the accumulated earnings $\int_{T_B}^{T_R}(1-\tau)h\delta_t dt$ are split among equityholders and debtholders. We allow for the possibility that the firm operates less efficiently during bankruptcy by including a multiplier $h \in [0, 1]$, so $h < 1$ implies a haircut. This can also include a flow of professional fees.

We assume that with probability ιdt per unit time, exogenous to the decisions of any agent, the bankruptcy case is converted and the firm is liquidated. The parameter ι can be positive or zero. While debtors may in principle choose to convert to Chapter 7, and creditors may petition for such a conversion, the ultimate decision lies with the judge. If a conversion occurs at time T_c, we assume APR is upheld so equityholders receive zero and debtholders receive the liquidation value $\zeta\delta_{T_c}$ plus the accumulated earnings net of fees described below. While this occurs exogenously, agents anticipate the possibility of liquidation and may endogenously increase the likelihood of liquidation by stalling. However the firm emerges from bankruptcy, they must pay a fixed cost $R_0 > 0$, where R_0 is a parameter. This represents the costs discussed in detail in the Online Appendix.

In summary, if the reorganization occurs at a time $T_R < T_c$, then equityholders and debtholders split P_{T_R}, where P_t is as defined in Eq. (3):

$$P_t = \theta\delta_t - R_0 + (1-\tau)\int_{T_B}^{t} h\delta_s ds.$$

The accumulated earnings complicate the problem since now the current value δ_t is not sufficient to determine the potential payoff. To handle this, we introduce a second state variable R_t that measures the fixed cost of emerging net of the accumulated earnings:

$$R_t \equiv R_0 - (1-\tau)\int_{T_B}^{t} h\delta_s ds. \tag{16}$$

Introducing this "net exercise price" allows us to write the reorganization payoff as $P_t = \theta\delta_t - R_t$ and the liquidation payoff as $\zeta\delta_t - R_t$.

One of our primary contributions relative to the literature is modeling Chapter 11 reorganization as a bargaining process. As discussed in Section 3.1, both the debtors and creditors have opportunities to propose reorganization plans, and approval must be unanimous. Further, the bargaining process is inherently dynamic. The average Chapter 11 case lasts two-and-a-half years (BWZ, 2006), so it is inevitable that the value of underlying assets fluctuates stochastically during this period. In light of this, we model the Chapter 11 process as a dynamic, stochastic bargaining game between debtholders and equityholders. Section 3.6 discusses the benefits of this dynamic bargaining model relative to a static model like Nash bargaining.

The bargaining procedure is the continuous-time equivalent of the bargaining game in Merlo and Wilson (1995, 1998). The two players bargain over a time T_R to emerge from bankruptcy, which must be agreed upon unanimously, and a split of the firm value $\theta\delta_{T_R} - R_{T_R}$. If a forced conversion occurs, the game ends and debtholders receive the entire liquidation payoff $\zeta\delta_{T_c} - R_{T_c}$. At any moment in the game, exactly one player (equity or debt) is the proposer. The proposer may make offers to the other player in any second, and the receiving player instantaneously decides to accept or reject their proposed share of the payoff. The game ends when a proposed split is accepted. The proposer in any instant is given exogenously by a time-homogeneous Markov chain s_t taking values in two states that we label $\{e, d\}$. When $s_t = e$, equityholders get to propose splits, and when $s_t = d$, debtholders get to propose splits. For simplicity, we assume the Markov chain has constant transition intensities, so the probability of transitioning from state i to state j per unit time is $\lambda_i dt$, $i = e, d$.

The stochastic proposer bargaining protocol is standard in the literature (see Merlo and Wilson 1995, 1998; Baron and Ferejohn, 1989; Yildiz, 2003; Hart and Mas-Colell, 1996; Rubinstein and Wolinsky, 1985; Binmore and Dasgupta, 1987). The rates of transitions are a tractable representation of bargaining power. In this setting, equityholders have a strong bargaining position if λ_e, the rate of transition away from state e, is low and if the rate of transition λ_d into state e is high. Likewise, equityholders have a weak bargaining position if s_t leaves state e quickly and transitions into state e infrequently. Virtually all bargaining models (including continuous-time models like Perry and Reny, 1993 and Admati and Perry, 1987) assume there is some discrete length of time during which one player cannot make offers. In our model, that length is stochastic, but for any fixed dt, there exist transition probabilities such that all players have the chance to make offers within the interval $[t, t + dt]$ with arbitrarily high probability. Merlo (1997) uses a structural estimation to show the stochastic proposer model fits empirical data on government negotiations well.

The main advantage of the stochastic proposer model is that it facilitates the analysis of time-homogeneous strategies and equilibria. However, giving equityholders a window of exogenously stochastic length during which they have the exclusive right to propose splits is actually a highly realistic model of the exclusivity period. After the exclusivity period, creditors may file a competing plan, and equityholders may file additional plans. If the reader would prefer a model in which equityholders and debtholders may both make offers in any instant, letting λ_e, λ_d approach infinity accomplishes this.

Given this bargaining protocol and the model primitives, equityholders (player e) and debtholders (player d) form strategies. We will focus on equilibria in stationary strategies that only depend on the current state (δ, R, s). A stationary strategy for player i consists of

1. A region $O_i \subset \mathbb{R}^2$ of (δ, R) values for which they make an offer when they are the proposer.

2. An offer function $\omega_i : O_i \to \mathbb{R}$ such that they offer $\omega_i(\delta_t, R_t)$ to player j when $(\delta_t, R_t) \in O_i$.

3. A correspondence $A_i : \mathbb{R}^2 \to \mathbb{R}$ mapping current (δ, R) values to the set of offers that they will accept when they are the receiver.

Stationary strategies allow for a great deal of flexibility. Each player chooses a triple of infinite dimensional objects. However, restricting attention to stationary strategies does rule out some possibilities. For example, players may not condition their actions on previous offers. They also may not make decisions as explicit functions of the elapsed time since the start of the bargaining, so without loss of generality we may take the starting time as $t = 0$ rather than $t = T_B$.

The benefit of focusing on stationary strategies is that they clearly induce outcomes. If we fix a stationary strategy (O_i, A_i, ω_i) for each player, we can define

$$\mathcal{T}_i \equiv \inf\{t : s_t = i, (\delta_t, R_t) \in O_i, \omega_i(\delta_t, R_t) \in A_j(\delta_t, R_t)\}$$

as the first time that player i is proposer and the value of (δ_t, R_t) is such that player i makes a proposal that is accepted by player j. It follows that $\mathcal{T} \equiv \mathcal{T}_e \wedge \mathcal{T}_d$ is the time at which the game ends (unless liquidation occurs first), according to the fixed strategies. When the game ends in reorganization, the payoff to player i depends on whose proposal is accepted. It will be convenient to define the terminal payoff for player i, given fixed strategies, as

$$J_i(\delta, R, s) \equiv \mathbf{1}(s = i)[\theta\delta - R - \omega_i(\delta, R)] + \mathbf{1}(s = j)\omega_j(\delta, R).$$

Intuitively, $J_i(\delta, R, s)$ equals the offer that player j makes to player i if $s = j$, while if the game ends with a proposal from player i, then it equals the stochastic payoff minus the offer made by player i. Finally, given these definitions of $\mathcal{T}$, J_i, we can define the outcome induced by the fixed strategies. The expected payoff to equityholders, conditional on a starting state (δ, R, s) and following the fixed stationary strategies, can be written as

$$E(\delta, R, s) = \mathbb{E}^{(\delta,R,s)}\Big[\mathbf{1}(\mathcal{T} < T_c)e^{-r\mathcal{T}} J_e(\delta_{\mathcal{T}}, R_{\mathcal{T}}, s_{\mathcal{T}})\Big], \tag{17}$$

while the expected payoff to creditors is

$$D(\delta, R, s) = \mathbb{E}^{(\delta,R,s)}\Big[\mathbf{1}(\mathcal{T} < T_c)e^{-r\mathcal{T}} J_d(\delta_{\mathcal{T}}, R_{\mathcal{T}}, s_{\mathcal{T}}) + \mathbf{1}(\mathcal{T} \geq T_c)e^{-rT_c}(\zeta\delta_{T_c} - R_{T_c})\Big]. \tag{18}$$

The expected payoffs take into account the possibility of a forced conversion, in which case equityholders receive zero and debtholders receive $\zeta\delta_{T_c} - R_{T_c}$. Given the expected payoffs $E(\delta, R, s), D(\delta, R, s)$ induced by stationary strategies, we can define our equilibrium concept.

Definition. A Markov perfect equilibrium (MPE) consists of a stationary strategy (O_i, A_i, ω_i) for each player such that

1. Taking the opponents' strategies as given, for every (δ, R, s), player e's strategy maximizes $E(\delta, R, s)$, and player d's strategy maximizes $D(\delta, R, s)$.

2. Player e finds it optimal to set an acceptance policy $A_e(\delta, R) = [E(\delta, R, d), \infty)$, and player d finds it optimal to set an acceptance policy $A_d(\delta, R) = [D(\delta, R, e), \infty)$.

Our definition of a MPE is highly intuitive. Condition 1 ensures that the equilibrium strategies correspond to a Nash equilibrium in stationary strategies for any starting values. Condition 2 is our notion of subgame perfection in continuous time: players must optimally accept offers if and only if the offer exceeds their continuation value in the equilibrium.

The value functions $E(\delta, R, s), D(\delta, R, s)$ corresponding to a MPE solve a fixed point problem. Given the strategies, the expected equilibrium payoffs are $E(\delta, R, s), D(\delta, R, s)$, and given the opponent's strategy, each player finds it optimal to set an acceptance cutoff equal to their value function. Nonetheless, the fixed point problem simplifies the calculation of such equilibria, since now we only need to search for value functions, offer regions O_i, and offer functions ω_i. The following lemma simplifies analysis further:

Lemma 1. In any MPE, $\omega_e(\delta, R) \leq D(\delta, R, e)$ and $\omega_d(\delta, R) \leq E(\delta, R, d)$ for all δ, R. For any MPE, there exists another MPE with identical value functions in which all equilibrium offers are accepted and the above inequalities hold with equality for all δ, R.

The lemma is sufficiently obvious that we do not provide a proof. As a consequence of this lemma and the definition of MPE, it is without loss of generality to characterize a MPE by a collection of value functions $E(\delta, R, s), D(\delta, R, s)$ and offer regions O_i with the interpretation that the game ends the first time $(\delta, R, s) \in O_i \times \{i\}$ for any i (unless liquidation occurs first). The outcome is player i proposing an offer equal to player j's value function and player j accepting. Given this lemma, we can prove the bargaining outcome must be Pareto optimal:

Proposition 1. In any MPE, $E(\delta, R, s) + D(\delta, R, s) = V(\delta, R)$, where $V(\delta, R)$ is the value function of a social planner who picks the efficient reorganization time:

$$V(\delta, R) \equiv \sup_{T_R \in F^{\delta, R}} \mathbb{E}^{(\delta, R)}\Big[\boldsymbol{1}(T_R < T_c)e^{-rT_R}(\theta\delta_{T_R} - R_{T_R}) + \boldsymbol{1}(T_c \leq T_R)e^{-rT_c}(\zeta\delta_{T_c} - R_{T_c})\Big]. \tag{19}$$

The proof is given in the Online Appendix, but it follows from three simple observations. First, the sum of the value functions cannot exceed V. Second, letting T_R denote the efficient reorganization time solving (19), any player can deviate to force the game to end at the maximum of T_R and the equilibrium time $\mathcal{T}$ (unless liquidation occurs first). For this to not be profitable, each player must weakly prefer to receive their terminal payoff at $\mathcal{T}$ rather than $\mathcal{T} \vee T_R$. The final observation is that in any cases where $\mathcal{T} > T_R$, it must be that waiting until $\mathcal{T}$ is just as good as waiting until T_R or else the proposer at time T_R has a profitable deviation.

3.3. The efficient timing of reorganization

In light of Proposition 1, the first step in calculating the equilibrium is to find the social planner's value function defined by the optimal stopping problem in Eq. (19). By standard dynamic programming arguments, in the region where continuation is optimal, the continuation value $V(\delta, R)$ solves a partial differential equation (PDE):

$$rV(\delta, R) = \mathcal{L}V(\delta, R) + \iota[\zeta\delta - R - V(\delta, R)], \tag{20}$$

where, letting subscripts denote partial derivatives, $\mathcal{L}$ is a differential operator defined on smooth functions of δ, R by

$$\mathcal{L}f \equiv \delta\mu f_\delta + \frac{\sigma^2}{2}\delta^2 f_{\delta\delta} - (1-\tau)h\delta f_R. \tag{21}$$

The first two terms are familiar from Ito's lemma and represent the sensitivity of the value function to changes in EBIT. The third term represents the fluctuations in the continuation value due to the accumulation of earnings. The final term in Eq. (20) captures the compensation for the risk of a forced conversion to Chapter 7 liquidation.

Following Bartolini and Dixit (1991), we solve the PDE by making a change of variables. In the Online Appendix, we solve for the general solutions of Eq. (20). We impose the intuitive boundary condition that for fixed $R > 0$, the value function stays bounded by the liquidation value as $\delta \to 0$ since reorganization could never be optimal if $\delta = 0$ and $R > 0$. The unique solution of Eq. (20) satisfying this is $V(\delta, R) = \delta v(R/\delta)$, where the function $v : \mathbb{R} \to \mathbb{R}$ is defined by

$$v(x) \equiv A_3 x^\gamma M\left(-\gamma, -2(\gamma-1) + \frac{2\mu}{\sigma^2}, \frac{-2h(1-\tau)}{\sigma^2 x}\right) + \frac{\iota\zeta + \frac{h(1-\tau)\iota}{r+\iota}}{r+\iota-\mu} - \frac{\iota x}{r+\iota}. \tag{22}$$

In this definition, A_3 is an arbitrary constant, γ is the negative root of the polynomial

$$0 = [-(r+\iota-\mu) - \mu z + \frac{\sigma^2}{2} z(z-1)],$$

and $M(a, b, z)$ is the confluent hypergeometric function

$$M(a,b,z) \equiv 1 + \frac{a}{b}z + \frac{1}{2!}\frac{a(a+1)}{b(b+1)}z^2 + \frac{1}{3!}\frac{a(a+1)(a+2)}{b(b+1)(b+2)}z^3 + ...$$

The confluent hypergeometric function can be thought of as a generalization of the exponential function.

In the region where the social planner finds it optimal to immediately reorganize, we have $V(\delta, R) = \theta\delta - R$. Given the form of the value function in the continuation region, we conjecture there exists a threshold $\bar{x}$ such that immediate reorganization is optimal if and only if $x \equiv R/\delta \leq \bar{x}$. In this case, $\delta v(R/\delta)$ should value match and smooth paste with $\theta\delta - R = \delta(\theta - R/\delta)$ on the curve $R/\delta = \bar{x}$. This is equivalent to the following system:

$$A_3 \bar{x}^\gamma M(-\gamma, -2(\gamma-1) + \frac{2\mu}{\sigma^2}, \frac{-2h(1-\tau)}{\sigma^2 \bar{x}}) + \frac{\iota\zeta + \frac{h(1-\tau)\iota}{r+\iota}}{r+\iota-\mu} - \frac{\iota\bar{x}}{r+\iota} = \theta - \bar{x} \tag{23}$$

$$\frac{d}{dx}\left(A_3 x^\gamma M(-\gamma, -2(\gamma-1) + \frac{2\mu}{\sigma^2}, \frac{-2h(1-\tau)}{\sigma^2 x})\right)\Big|_{x=\bar{x}} = \frac{\iota}{r+\iota} - 1. \tag{24}$$

This system of algebraic equations is simple to solve numerically. However, we still must verify that the optimal policy is in fact a barrier policy as conjectured. We prove the following proposition in the Online Appendix:

Proposition 2. Suppose $A_3, \bar{x}$ solve Eq. (23, 24), and the following two conditions are met:

$$\bar{x} \leq -\frac{h(1-\tau) + \mu\theta + \iota(\zeta-\theta) - r\theta}{r} \tag{25}$$

$$v(x) \geq \theta - x, \tag{26}$$

where $v(x)$ is the function given in Eq. (22). Then the stopping time $T_R \equiv \inf\{t : R_t < \bar{x}\delta_t\}$ solves Eq. (19) with associated value function

$$V(\delta, R) = \begin{cases} \delta v(\frac{R}{\delta}), & R \geq \bar{x}\delta \\ \theta\delta - R, & R \leq \bar{x}\delta. \end{cases} \tag{27}$$

The conditions of Proposition 2 are intuitive: Eq. (25) ensures that reorganization does not happen too early according to the barrier strategy, while Eq. (26) ensures it does not occur too late. The conditions are easy to check numerically for a candidate $A_3, \bar{x}$, and we have yet to find a case where they are not satisfied.

In summary, a social planner would watch the movement of the EBIT and the net exercise price and emerge from bankruptcy when the current EBIT is large or the net exercise price is low (i.e., when the accumulated earnings have offset enough of the fixed cost of emerging from bankruptcy). To be clear, the fixed cost of exiting bankruptcy makes this analogous to a real option. For some firms, this option is "in the money" at default so the reorganization is instantaneous, while for other firms, the option value of reorganizing in the future leads to efficient delay and lengthy reorganizations.

3.4. Calculating the split

From Proposition 2, the social planner chooses to emerge from bankruptcy when $(\delta, R) \in O^* \equiv \{(\delta, R) : R \leq \bar{x}\delta\}$. Proposition 1 then implies that the game cannot end when $(\delta, R) \notin O^*$ (except by forced liquidation). Intuitively, in the region where a single agent would optimally choose to wait, in equilibrium the proposer chooses to wait. Then the value function of each player in this region must equal the discounted expectation of receiving their value function a second later. If we conjecture that both value functions are smooth, then by a standard dynamic programming argument, this implies the following system of linked PDEs:

$$rE(\delta, R, e) = \mathcal{L}E(\delta, R, e) + \lambda_e[E(\delta, R, d) - E(\delta, R, e)] + \iota[0 - E(\delta, R, e)], \quad (28)$$

$$rE(\delta, R, d) = \mathcal{L}E(\delta, R, d) + \lambda_d[E(\delta, R, e) - E(\delta, R, d)] + \iota[0 - E(\delta, R, d)], \quad (29)$$

$$rD(\delta, R, e) = \mathcal{L}D(\delta, R, e) + \lambda_e[D(\delta, R, d) - D(\delta, R, e)] + \iota[\zeta\delta - R - D(\delta, R, e)], \quad (30)$$

and

$$rD(\delta, R, d) = \mathcal{L}D(\delta, R, d) + \lambda_d[D(\delta, R, e) - D(\delta, R, d)] + \iota[\zeta\delta - R - D(\delta, R, d)], \quad (31)$$

which must hold for all $(\delta, R) \notin O^*$. Next, recall that in the definition of a MPE, each player i must find it optimal in every instant where $s_t \neq i$ to accept an offer equal to their value function. Player i's outside option, should they reject, would be to wait a second and receive their value function. This suggests that for the players receiving offers, their value functions should always equal the discounted expectation of receiving their value function a moment later, even in the region where offers are made. If player i's value function in state $s \neq i$ were ever strictly less than the expected discounted value of waiting a second, it is suboptimal for player i to follow their equilibrium strategy of accepting offers equal to their value function. Likewise, if player i's value function in state $s \neq i$ were ever strictly greater than the expected discounted value of waiting a second, then player i should be willing to accept an offer just below their value function. This suggests that in an MPE with smooth value functions, the value functions should satisfy Eq. (28)-(31) for all $(\delta, R) \notin O^*$, and the receiving value functions $E(\delta, R, d), D(\delta, R, e)$ should satisfy Eq. (29, 30) everywhere. The following proposition, which is proved in the Online Appendix, shows this constitutes a MPE.

Proposition 3. Assume the conditions of Proposition 2 hold. Let $E(\delta, R, s), D(\delta, R, s)$ be smooth functions such that $E(\delta, R, s) + D(\delta, R, s) = V(\delta, R)$. Assume Eq. (28)-(31) are satisfied for all $(\delta, R) \notin O^*$, and Eq. (29, 30) hold everywhere. Then the following strategy for each player i constitutes a MPE, with value functions $E(\delta, R, s), D(\delta, R, s)$:

1. Offer player j their value function if and only if $(\delta, R) \in O^*$.

2. Accept an offer equal to or greater than player i's value function at any time, for any (δ, R).

Proposition 3 allows us to calculate the MPE for our bargaining game. In the Online Appendix, we prove Proposition 3 and calculate the unique smooth MPE value functions $E(\delta, R, s), D(\delta, R, s)$ in closed form. The solution, which requires solving a linked system of PDEs, combines the methods of Proposition 2 with Markov chain techniques appearing in Guo, Miao, Morellec (2005), among other papers.

3.5. Dynamic bargaining outcomes

In this section, we provide intuition for the outcome of our dynamic bargaining game. First, we briefly motivate our baseline parameters. Our model shares parameters $\mu, \sigma, \tau, r, \alpha$ with the standard Leland model. For these parameters, we follow the literature (see Strebulaev and Whited, 2012, Table 3). For the bargaining power parameters, we choose λ_e to correspond to the exclusivity period in Chapter 11. Specifically, since equityholders begin with a 120-day window (or longer) to exclusively make offers, we choose $\lambda_e = 3$ so that in expectation, the equityholders' first offer window lasts 120 days. All parameters are annualized. To start the analysis, we set $\lambda_d = \lambda_e$. For the rate of forced conversion to Chapter 7, we set a baseline value of $\iota = 0.06$, which corresponds to the 14% of Chapter 11 cases converted to liquidations in the sample of BWZ (2006), given the average length of 2.5 years for a Chapter 11 case. For ease of interpretation, we use $\delta_0 = 1$ for all our numerical analysis. Firm values may then be interpreted as years of earnings. These baseline parameters are listed in Table 1, and unless otherwise stated, all analysis uses these values.

The inefficiencies of Chapter 11, captured by h and R_0, are difficult to quantify, so we consider different values for these. For now we use $h = 0.95$ and $R_0 = 3.3$, which correspond to Table 1(b). Finally, it will be helpful at times to keep the EBIT in the moment of default fixed while we vary other parameters. When we do this, we set δ to the exogenous value $\delta_{def} = .3674$, which is the ratio of average firm assets for firms entering Chapter 11 to average firm assets of healthy firms in Corbae and D'Erasmo (2017). In the next section, we allow equityholders to endogenously choose the EBIT at which the firm defaults, but using this exogenous value can be helpful for intuition.

Fig. 2(a) shows how the firm value in Chapter 11, evaluated at δ_{def} and R_0, changes with each parameter. Specifically, we calculate $V(\delta_{def}, R_0)$, then for each parameter, we increase the parameter by 5% of its baseline value and calculate $V(\delta_{def}, R_0)$ again. Fig. 2(a) plots the elasticity of firm value with respect to each parameter, calculated as the percent change in $V(\delta_{def}, R_0)$ from a 5% increase in each parameter. An increase in the cost

Table 1
Baseline parameter values
This table shows the baseline parameters we use throughout the paper. When we reference Table 1(a), we are using the h, R_0, B values corresponding to panel (a), for which the firm liquidates on the equilibrium path. When we reference Table 1(b), we are using the h, R_0, B values corresponding to panel (b), for which the firm enters Chapter 11 on the equilibrium path.

Common parameters	
μ	0.02
σ	0.25
r	0.05
τ	0.2
α	0.1
ι	0.06
λ_d	3
λ_e	3
δ_0	1
(a) Constrained debt Chapter 7	
R_0	4
h	0.9
B	0.3
(b) Optimal inefficient Chapter 11	
R_0	3.3
h	0.95
B	0.12

of reorganizing (R_0) decreases firm value, while an increase in the multiplier on cash flows in bankruptcy (h) increases firm value. Once the costs of entering Chapter 11 B have been paid, the firm is always better off reorganizing than liquidating, so firm value is decreasing in the rate of liquidation ι. Since the Chapter 11 outcome is Pareto efficient, the bargaining power parameters λ_e, λ_d have no impact on firm value. The other comparative statics are similar to the Leland model and thus omitted.

Fig. 2(b) shows how the underlying parameters of the model affect the bargaining split in Chapter 11. We calculate the expected fraction of firm value accruing to equity as

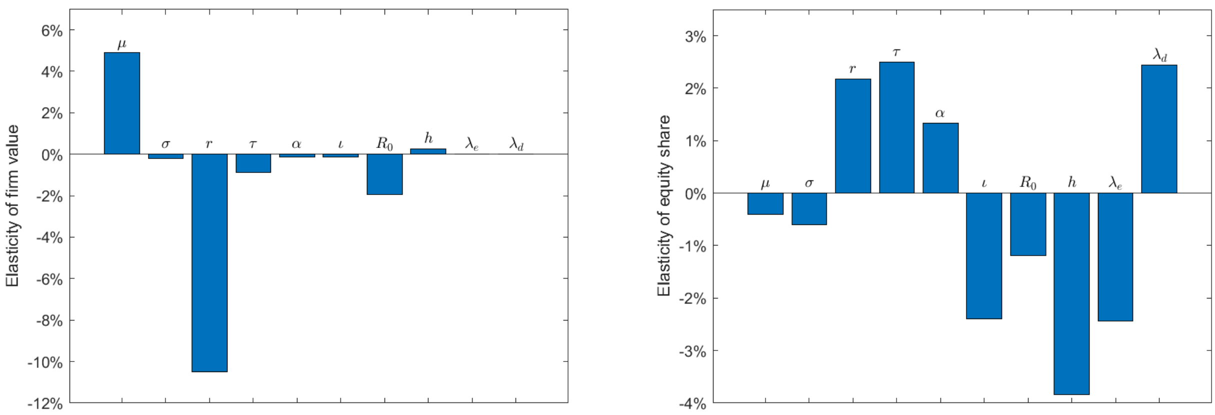
$$E^{share}(\delta_{def}, R_0, e) \equiv \frac{E(\delta_{def}, R_0, e)}{E(\delta_{def}, R_0, e) + D(\delta_{def}, R_0, e)}.$$

Just as above, we increase each parameter one at a time by 5% of its baseline value and recalculate the same quantity. Fig. 2(b) plots the percentage change in $E^{share}(\delta_{def}, R_0, e)$ from a 5% increase in each parameter. The typical intuition in dynamic bargaining models is that the more patient party extracts more of the surplus (Rubinstein, 1982). Because of the exclusivity window, equityholders have the first opportunity to make offers. Intuitively, then, anything that makes reorganization during the exclusivity window more attractive should improve equity's bargaining outcome. Accordingly, increasing r improves equity's expected outcome since it makes everyone more impatient. Conversely, increasing μ reduces the fraction of value that equity can extract, despite improving firm value, since it speeds up reorganization. Increasing R_0 (the cost of exiting bankruptcy) or h (the profitability of the firm during Chapter 11) makes it optimal to wait longer to exit bankruptcy, which in turn reduces equity's share of the firm value.

Any improvement in the outside option of creditors (waiting for Chapter 7) helps the creditors in the bargaining game. An increase in ι thus leads to a worse outcome for equity since, in the event of forced conversion to Chapter 7, creditors receive everything. Conversely, an increase in α or τ helps equityholders since the tax benefits of debt and the liquidation costs α are lost in Chapter 7. It is well known that the ex-ante firm value in Leland (1994) decreases in σ, while the liquidation value does not depend upon σ, so an increase in volatility makes Chapter 7 relatively more attractive and harms equity's outcome. Finally, higher λ_e means equity's offer window is shorter, while lower λ_d means the creditors' offer window is longer, so both of these reduce equity's expected share of the firm value.

3.6. Benefits of the dynamic bargaining framework

The remainder of this section provides three arguments for the benefits of our dynamic bargaining model relative to Nash bargaining. First, in many existing models that rely on Nash bargaining, all outcomes of the reorganization are known with certainty. For example, in Fan and Sundaresan (2000), the bargaining occurs when the asset value hits a lower threshold and is instantaneous. It follows that the firm value upon exiting bargaining, and the respective fractions of the firm value that go to equity and creditors, is known with certainty even before the bargaining begins. Later models featuring bargaining, like that in François and Morellec (2004), allow for the possibility that the firm is liquidated prior to reorganizing. However, conditional on emerging, the value of the firm and the split are both known with certainty. In contrast, the empirical evidence suggests nothing about bankruptcy is predictable. Gilson, Hotchkiss, and Ruback (2000) find that the post-reorganization market value of bankrupt firms is diffi-



(a) Bankrupt firm value

(b) Equity's share

Fig. 2. Chapter 11 equilibrium comparative statics. Using the baseline parameters of Table 1(b), we calculate the value of the firm at the moment of entering bankruptcy at $\delta = \delta_{def}$, $V(\delta_{def}, R_0)$, as in the text. We also compute the corresponding expected fraction of value that equity will receive, $E^{share}(\delta_{def}, R_0, e)$, as in the text. Then, for each parameter individually, we increase that parameter by 5% of its baseline value and recalculate both of these quantities. Panel (a) plots the percentage change in the bankrupt firm value from increasing each parameter, one at a time, by 5%. Panel (b) plots the corresponding changes for the expected fraction of value that equity will receive.

cult to forecast. Using management's cash flow projections and a methodology employed by practitioners, they find that value estimates are unbiased but with a very large variance. The estimated values range from 20% to over 250% of the realized market value.

The outcomes of Chapter 11 bargaining are similarly difficult to predict. Eberhart and Sweeney (1992) look at whether postbankruptcy-announcement bond prices are unbiased estimates of the final settlement prices. They fail to reject the null hypothesis that the postannouncement bond prices are unbiased estimates. However, in their Table 2, expected bond returns can only explain 42%-76% of realized bond returns over the bankruptcy. Wong et al. (2007) try to predict cases in which shareholders receive a nonzero payout at the end of Chapter 11 with little success—they obtain a psuedo R^2 of less than 0.18 with their Cox's proportional hazards model (Table 6). BWZ (2006) examine the determinants of creditor recovery rates (Table 15). The R^2 in their regressions ranges between 0.21 and 0.46. Their regressions that seek to predict APR violations have R^2 values between 0.18 and 0.6. All their regressions include prebankruptcy variables like assets and leverage, which simpler Nash bargaining models predict should be sufficient to exactly determine these quantities. Our model predicts that these Chapter 11 outcomes cannot be perfectly forecast, consistent with the empirical evidence. Likewise, BWZ (2006) show regressions that seek to predict time in bankruptcy have R^2 values between 0.07 and 0.26. In their sample, the days in bankruptcy vary from 56 to 2,215 days, while Fan and Sundaresan (2000) model an instantaneous bargaining process, and the models of François and Morellec (2004) and Broadie, Chernov, and Sundaresan (2007) assume an exogenous upper limit on the length of Chapter 11. Our model allows for any length Chapter 11 to occur with positive probability, and this length is uncertain. Additionally, all earlier models of Chapter 11 bargaining we are aware of assume that the capital structure upon emerging from bankruptcy is known with certainty. Gilson (1997) finds adjusted R^2 values between 0.14 and 0.24 when trying to predict post-Chapter 11 leverage ratios (Table 2) with a variety of explanatory variables (including pre-Chapter 11 leverage ratios). In our model of Chapter 11, the accumulation of cash flows introduces path dependence such that, in equilibrium, the EBIT upon emerging from Chapter 11 is not known with certainty until the firm exits Chapter 11. Since this EBIT determines the postreorganization capital structure, this means the postreorganization capital structure cannot be perfectly predicted, consistent with empirical evidence.

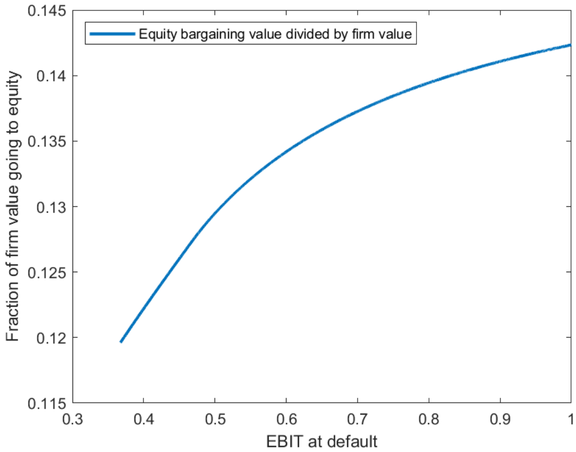


Fig. 3. Equity's share of firm value. This figure shows $E^{share}(\delta, R_0, e)$, the ratio of equity's Chapter 11 value function to the total firm value in bankruptcy if they default at a value δ and choose Chapter 11, as a function of δ. The parameters correspond to Table 1(b).

Second, our dynamic bargaining model produces an endogenous link between firm size and equity's bargaining outcome. In a standard Nash bargaining model like Fan and Sundaresan (2000), equityholders rationally expect to receive a constant fraction (equal to their bargaining power parameter) of the firm value, no matter when they begin the bargaining. However, the empirical literature suggests that equityholders enjoy larger APR violations when the bankrupt firm is larger. In Table 7 of Franks and Torous (1994), the authors find that a 1% increase in the size (liabilities) of a firm at the time of default is associated with an approximate one percentage point increase in the absolute priority deviation going to equityholders. Table 6 of Betker (1995) shows that equity receives much larger APR violations when the firm is closer to solvency. Eberhart, Moore, and Roenfeldt (1990) find a positive correlation between APR violations received by equity and the market capitalization of the firm at the announcement of bankruptcy. Consistent with this empirical fact, our model predicts that when the firm is larger (closer to the reorganization threshold) at the time of default, equityholders receive a better outcome in bargaining. Fig. 3 plots the expected fraction of firm value accruing to equity $E^{share}(\delta, R_0, e)$ as a function of δ. It can be clearly seen that equity's expected share of firm value is increasing in the EBIT. The intuition for why dynamic bargaining produces this endogenous link between solvency and bargaining outcome is the same one that explains Fig. 2. If the firm's condition improves to the point that exiting Chapter 11 is efficient before the exclusivity period expires, then creditors are less willing to wait for their turn in the bargaining game. Anything that makes reorganization more likely during the exclusivity period (like a higher starting EBIT) will thus improve equity's outcome.

It is interesting in itself that our dynamic bargaining matches this empirical link between size and shareholder bargaining outcome. However, by providing a strategic foundation for this result, our model also lends theoretical support to other papers that rely on this fact. Garlappi, Shu, and Yan (2008) and Garlappi and Yan (2011) use a modified version of Fan and Sundaresan (2000) to produce testable implications on equity returns, default probability, and shareholder bargaining power. In their empirical evidence, they show that if size is a proxy for expected shareholder recovery, then debt renegotiation can explain the concentration of momentum profits among low credit quality firms, as well as the lower expected returns and stronger book-to-market effects exhibited by distressed firms. While the model they use has a constant bargaining outcome for shareholders, our dynamic bargaining model endogenously produces exactly the link between size and shareholder recovery that they need to explain all of these phenomena. A recent literature has shown that the possibility for debt renegotiation can help explain empirical patterns in leverage (Morellec, Nikolov, and Schuerhoff, 2018), investment (Favara et al., 2017), and equity returns (Hackbarth, Haselman, and Schoenherr, 2015; Favara, Schroth, and Valta, 2012). Since our dynamic bargaining adds this additional realism to the negotiation process, it is conceivable that variations of our dynamic bargaining model could match the data even better.

Third, stochastic dynamic bargaining is inherently a more realistic description of Chapter 11. The Nash bargaining model itself is an axiomatic, not strategic, model of bargaining that does not describe noncooperative agents. It is well known that the Nash solution coincides with the outcome of the strategic Rubinstein bargaining model. However, when the object of the bargaining evolves stochastically, this is an unsatisfying answer. The Nash outcome is the one that would occur if equity and debt could, off the equilibrium path, exchange infinitely many offers while the rest of reality remains frozen in time. Our dynamic bargaining model allows participants to watch uncertainty resolve while considering proposals, as in reality.

4. Analysis of the decision to reorganize or liquidate and capital structure

In this section, we work backward in time and solve for the firm's optimal strategy prior to defaulting. We first consider the firm's optimal stopping problem for when to default and whether to file for Chapter 11 or Chapter 7. When the firm defaults, equityholders prefer to enter Chapter 11 if and only if their prospects in the bargaining equilibrium of the previous section justify the fixed cost they must pay to enter Chapter 11. Section 4.1 studies the problem of when to default when only Chapter 11 is available. Section 4.2 solves the full problem in which equityholders may choose either chapter, and Section 4.3 describes the Time 0 capital structure decision.

4.1. The levered firm with the option to reorganize

In this section, we consider the decision of the equityholders between Time 0 and Time 1 to enter Chapter 11. Ultimately, equityholders will have the option to reorganize or liquidate, but the first step to solve this problem is to ignore the option to liquidate. We assume the bargaining game starts with equityholders making proposals in the exclusivity period (i.e., in state $s_0 = e$). Thus, if equityholders choose to enter Chapter 11, they receive $E(\delta, R_0, e) - B$, where $E(\delta, R, s)$ is the unique smooth MPE value function for equityholders, and B is a fixed cost of entering bankruptcy.[5] The function $E(\delta, R, e)$ is calculated in closed form in the Online Appendix; for simplicity of notation we define $\mathcal{E}(\delta) \equiv E(\delta, R_0, e)$.

Prior to bankruptcy, equityholders receive cash flow $(1-\tau)(\delta - C_0)dt$ per unit time, where C_0 is the optimally chosen coupon at Time 0. In this section, we assume the firm only has the option to enter Chapter 11. In this case, equityholders choose a stopping time T_B at which point the firm enters Chapter 11 to solve

$$E^B(\delta) \equiv \sup_{T_B \in F^\delta} \mathbb{E}^\delta \Big[\int_0^{T_B} e^{-rt}(1-\tau)(\delta_t - C_0)dt + e^{-rT_B}(\mathcal{E}(\delta_{T_B}) - B) \Big]. \tag{32}$$

To solve for the optimal time to enter Chapter 11, we conjecture a lower barrier δ_B such that equityholders declare bankruptcy the first time $\delta_t \le \delta_B$. Following the logic of Section 2.2, the value of equity prior to entering bankruptcy must be

$$E^B(\delta) = A_4\delta^\psi + (1-\tau)[\frac{\delta}{r-\mu} - \frac{C_0}{r}],$$

where A_4 is an arbitrary constant, and ψ is again the negative root of

$$0 = -r + \mu z + \frac{\sigma^2}{2}z(z-1).$$

The constant A_4 is determined by value matching and smooth pasting on the bargaining value at the point of bankruptcy. Using the closed form for $\mathcal{E}(\delta)$, we solve the nonlinear system

$$A_4\delta_B^\psi + (1-\tau)[\frac{\delta_B}{r-\mu} - \frac{C_0}{r}] = \mathcal{E}(\delta_B) - B \tag{33}$$

and

$$A_4\psi\delta_B^{\psi-1} + (1-\tau)[\frac{1}{r-\mu}] = \mathcal{E}'(\delta_B). \tag{34}$$

Proposition 4 provides conditions analogous to those in Proposition 2 under which the barrier strategy is optimal:

Proposition 4. Assume the conditions of Propositions 2 and 3 hold. Suppose A_4, δ_B solve Eq. (33, 34), and the following two conditions are met:

1. *On the set $[0, \delta_B]$, the function $\mathcal{E}(\delta)$ satisfies*

$$-r(\mathcal{E}(\delta) - B) + \mu\delta\mathcal{E}'(\delta) + \frac{\sigma^2\delta^2}{2}\mathcal{E}''(\delta) \le -(1-\tau)(\delta - C_0). \tag{35}$$

2. *On the set $[\delta_B, \infty)$, the function $\mathcal{E}(\delta)$ satisfies*

$$A_4\delta^\psi + (1-\tau)[\frac{\delta}{r-\mu} - \frac{C_0}{r}] \ge \mathcal{E}(\delta) - B. \tag{36}$$

[5] In Chapter 11, both debtors and creditors hire professionals. Professional fees incurred during bankruptcy are typically reimbursed from the firm's assets through §330(a) awards. Weiss (1990) estimates that such fees average 3.1% of firm value, but LoPucki and Doherty (2011) give many reasons why this is an underestimate. In extreme cases like the bankruptcy of Allied Holdings, fees can reach 22% of firm assets (LoPucki and Doherty, 2011, Appendix A).

Firms also hire professionals prior to entering bankruptcy, and these prepetition fees are not reimbursed. It is thus reasonable to think of these prepetition fees, which average 43% of total fees, as being incurred by equityholders (LoPucki and Doherty, 2011).

Finally, there is empirical evidence that a substantial component of these fees are fixed costs, which do not vary with the size of the firm or length of bankruptcy (Warner, 1977; Guffey and Moore, 1991; LoPucki and Doherty, 2004; LoPucki and Doherty, 2011; BWZ, 2006). In the sample of BWZ (2006), firms with less than \$100,000 in prebankruptcy assets incur expenses that average 31.5% of assets, while for firms with more than \$10 million in assets, fees average 1.3% of assets. See the Online Appendix for more details and evidence.

Then the stopping time $T_B \equiv \inf\{t : \delta_t < \delta_B\}$ solves Eq. (32) with associated value function

$$E^B(\delta) = \begin{cases} A_4\delta^{\psi} + (1-\tau)[\frac{\delta}{r-\mu} - \frac{C_0}{r}], & \delta \geq \delta_B \\ \mathcal{E}(\delta) - B, & \delta \leq \delta_B. \end{cases} \quad (37)$$

The proof appears in the Online Appendix. Finally, once we have solved for δ_B, the calculation for the value of debt is straightforward. Debt has value

$$D^B(\delta) = A_5\delta^{\psi} + \frac{C_0}{r}, \quad (38)$$

and A_5 is calculated by value matching at δ_B:

$$A_5\delta_B^{\psi} + \frac{C_0}{r} = D(\delta_B, R_0, e). \quad (39)$$

Once we plug in the closed form solutions for $D(\delta, R_0, e), \mathcal{E}(\delta), \mathcal{E}'(\delta)$, Eq. (33-39) represent a system of algebraic equations that are easily solved numerically. Likewise, the second derivative in Eq. (35) is available in closed form, allowing us to numerically check the conditions for the verification.

4.2. The levered firm with the option to reorganize or liquidate

In this section, we consider the decision of the equityholders prior to Time 1 to enter Chapter 11 or enter Chapter 7. In the previous subsection, we solved for the equity value E^B when equityholders may only choose Chapter 11 and showed the corresponding optimal stopping time T_B is a first hitting time with threshold δ_B. In Section 2.2, we derived the equity value E^L when equityholders could only liquidate, with corresponding optimal liquidation time T_L and associated threshold δ_L. In this section, we study the decision of how to optimally choose a time of liquidation T_L and time of bankruptcy T_B to maximize

$$E_0(\delta) \equiv \sup_{T_L, T_B \in F^{\delta}} \mathbb{E}^{\delta}\Big[\int_0^{T_B \wedge T_L} e^{-rt}(1-\tau)(\delta_t - C_0)dt + \mathbf{1}(T_B < T_L)e^{-rT_B}[\mathcal{E}(\delta_{T_B}) - B]\Big]. \quad (40)$$

This decision is equivalent to picking a time of default $T_D \equiv T_L \wedge T_B$ and whether to enter Chapter 7 or Chapter 11 at that time. Using our results from Section 3, the latter decision is trivial: either the bargaining value net of fixed costs $\mathcal{E}(\delta_{T_D}) - B$ is larger than zero, so Chapter 11 is optimal, or it is less than zero, so liquidation is optimal. Define

$$g(\delta) \equiv \max(\mathcal{E}(\delta) - B, 0). \quad (41)$$

Then the decision of when to enter Chapter 7 or Chapter 11 is equivalent to

$$E_0(\delta) = \sup_{T_D \in F^{\delta}} \mathbb{E}^{\delta}\Big[\int_0^{T_D} e^{-rt}(1-\tau)(\delta_t - C_0)dt + e^{-rT_D}g(\delta_{T_B})\Big]. \quad (42)$$

Since g is continuous and nonnegative, standard results (Øksendal, 2003, chapter 10) show that $E_0(\delta)$ exists, with associated exercise region $S \equiv \{\delta : E_0(\delta) = g(\delta)\}$.

In reality, firms default in bad states of the world. However, if creditors have no rights in Chapter 11, then equityholders might use Chapter 11 in good states of the world as an opportunity to default on their existing debt, issuing more debt afterward to take advantage of the tax shield. Since Chapter 11 is an opportunity to reduce, not increase, a firm's debt, we rule out this unrealistic case with the following assumption:

Assumption 1. The bargaining power of debtholders is high enough that

$$\lim_{\delta \to \infty} \mathcal{E}(\delta) - \frac{(1-\tau)\delta}{r-\mu} = -\infty.$$

This intuitive assumption says that as firms become infinitely profitable, the unlevered firm value exceeds the value to equity of defaulting and entering Chapter 11. We give a specific condition on underlying parameters that is sufficient for this in the Online Appendix. When this assumption holds, we can obtain a clean characterization for the equityholders' optimal policy in Eq. (40).

Proposition 5. Suppose the conditions of Propositions 2, 3, and 4 are met, and in addition, Assumption 1 holds. For any fixed C, let $S(C) \equiv \{\delta : E_0(\delta) = g(\delta)\}$ denote the set of δ values where the firm defaults immediately, and let δ_L, δ_B be the optimal liquidation and reorganization thresholds from Sections 2.2 and 4.1. Then $\bar{\delta}(C) \equiv \sup S(C)$ is finite. Further, $\bar{\delta}(C)$ equals the liquidation trigger δ_L if and only if $\mathcal{E}(\bar{\delta}(C)) \leq B$, and it equals the bankruptcy threshold δ_B if and only if $\mathcal{E}(\bar{\delta}(C)) \geq B$.

This proposition says that for any fixed C, at a large enough δ the firm knows with certainty which of Chapter 11 or Chapter 7 they will eventually enter, and it will occur at a lower threshold. We next show that which of these occurs will depend on C:

Proposition 6. Suppose the conditions of Propositions 2, 3, and 4 are met, and in addition, Assumption 1 holds. The default threshold $\bar{\delta}(C)$ is a weakly increasing and continuous function of C, and $\lim_{C\to\infty}\bar{\delta}(C) = \infty$. There exists $\bar{C}$ such that $\mathcal{E}(\bar{\delta}(\bar{C})) = B$ and $C > \bar{C}$ implies $\mathcal{E}(\bar{\delta}(C)) > B$.

Proposition 6 delivers the central intuition of the choice between Chapter 7 and Chapter 11 in our model. When the firm has a larger coupon, they default at higher δ values. We see from Fig. 4 that equity's value in Chapter 11 $\mathcal{E}(\delta)$ is strictly increasing in δ, so equity's prospects in Chapter 11 are more likely to justify the fixed cost B of entering Chapter 11 when δ is high. Proposition 6 shows the existence of a $\bar{C}$ such that when the firm has issued more debt than $\bar{C}$, they will default at a sufficiently profitable δ that Chapter 11 is preferable to Chapter 7 at that δ. Given the strict monotonicity of $\mathcal{E}$ and $\bar{\delta}(C)$ we observe numerically, equityholders will strictly prefer liquidation for $C < \bar{C}$, by the same logic.

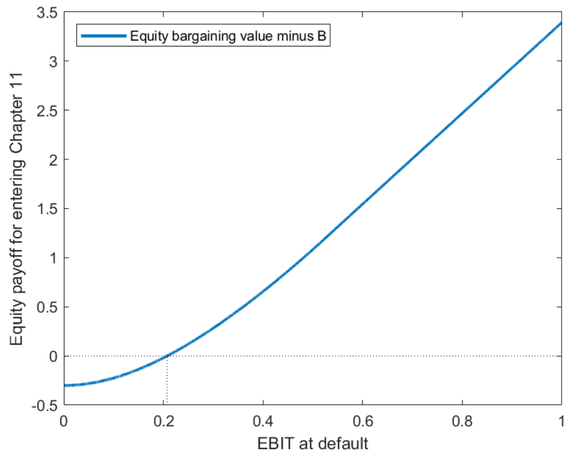


Fig. 4. Equity's payoff for entering Chapter 11. This figure shows $\mathcal{E}(\delta) - B$, the payoff to equity if they default at a value δ and choose Chapter 11, as a function of δ. The parameters correspond to Table 1(a).

4.3. Analysis of the capital structure with Chapter 11 reorganization

In this section, we consider the decision of equityholders at Time 0 of how much debt to issue. Let

$$F^j(\delta_0, C_0) \equiv E^j(\delta_0, C_0) + D^j(\delta_0, C_0), \quad j = L, B$$

denote firm value for a given coupon C_0, assuming either a future Chapter 7 ($j = L$) or Chapter 11 ($j = B$) bankruptcy. Since equityholders receive the proceeds of the initial debt issue, at Time 0 equity chooses the optimal coupon C_0 to maximize the sum of the values of equity and debt, subject to the constraint that equity will subsequently decide between Chapter 7 and Chapter 11 to maximize equity value. Under Assumption 1, as long as δ_0 is large relative to C_0, equity will know immediately after they issue debt whether they will eventually enter Chapter 7 or Chapter 11 (Proposition 5), so the Time 0 value of equity equals the maximum of $E^B(\delta_0, C_0)$ and $E^L(\delta_0, C_0)$. Under rational expectations, the Time 0 value of the firm for a given coupon C_0 is then

$$F_0(\delta_0, C_0) \equiv \begin{cases} F^B(\delta_0, C_0), & E^B(\delta_0, C_0) > E^L(\delta_0, C_0) \\ F^L(\delta_0, C_0), & E^B(\delta_0, C_0) < E^L(\delta_0, C_0) \\ F^{B\vee L}(\delta_0, C_0), & E^B(\delta_0, C_0) = E^L(\delta_0, C_0), \end{cases} \tag{43}$$

where $F^{B\vee L}(\delta, C) \equiv \max(F^L(\delta, C), F^B(\delta, C))$. In words, the value of the firm for a given coupon is either the value of the firm conditional on eventual liquidation or the value of the firm conditional on eventual Chapter 11. Which of these cases occurs is determined by which is better ex-post for equityholders. As is standard in dynamic models of capital structure, equityholders lack commitment power. For a given coupon C_0, equityholders might be able to get a better price on debt (and higher overall Time 0 value) if they could commit to a future Chapter 7. However, if that C_0 implies equity will prefer Chapter 11, the debt will be priced at Time 0 under the rational expectation of a future Chapter 11. From Proposition 6, and the observation that in all numerical examples $\mathcal{E}(\delta)$ is strictly increasing, we can obtain a cleaner characterization of how debt will be priced at a given coupon: there will always exist $\bar{C}$ such that for large δ_0,

$$F_0(\delta_0, C_0) = \begin{cases} F^B(\delta_0, C_0), & C_0 > \bar{C} \\ F^L(\delta_0, C_0), & C_0 < \bar{C} \\ F^{B\vee L}(\delta_0, C_0), & C_0 = \bar{C}. \end{cases}$$

It follows that at Time 0, the firm has two options. They may choose any coupon larger than $\bar{C}$ and receive the firm value $F^B(\delta_0, \cdot)$ under the rational expectation of a future Chapter 11 reorganization. Alternately, they may choose a coupon weakly less than $\bar{C}$ and receive the firm value $F^L(\delta_0, \cdot)$ under the rational expectation of a future Chapter 7 liquidation.

Using the solutions derived in the last two sections (and Section 2.2), we calculate $F_0(\delta_0, \cdot)$ according to Eq. (43). We then numerically maximize $F_0(\delta_0, \cdot)$ on a grid of possible coupons to find the optimal coupon C^*. In the cases we consider in the following section, C^* is equal to one of the following three coupons:

$$\bar{C} = \max\{C_0 : E^B(\delta_0, C_0) \leq E^L(\delta_0, C_0)\}, \qquad (44)$$

$$C_L = argmax_{C_0 \in [0,\infty)} F^L(\delta_0, C_0), \qquad (45)$$

or

$$C_B = argmax_{C_0 \in [0,\infty)} F^B(\delta_0, C_0). \qquad (46)$$

In these equations, $\bar{C}$ is the threshold coupon from Proposition 6. C_L and C_B are the optimal coupons equity would choose if they were constrained to only use Chapter 7 or only use Chapter 11, respectively.

5. Capital structure and empirical predictions

5.1. Capital structure decisions and the relative efficiency of Chapter 11

In this section, we analyze the optimal capital structure of the firm with the option to reorganize or liquidate. As is standard in capital structure models, the equityholders internalize the inefficiency of their ex-post optimal bankruptcy procedure when they issue debt. Put differently, the price equityholders can charge for their debt will exactly reflect the inefficiency of their future preferred bankruptcy procedure. When one form of bankruptcy (Chapter 11 or Chapter 7) is so inefficient relative to the other that equityholders would never find it optimal ex-post, equityholders can credibly ignore that option. In these cases, equityholders are unconstrained by their lack of commitment when choosing the coupon to maximize the tax benefits given their preferred future bankruptcy form. Debtholders will correctly infer the future strategy of equityholders when they price the debt.

However, when Chapter 11 is slightly less efficient than Chapter 7, our model predicts a more nuanced capital structure decision. In this region of the parameter space, debtholders prefer Chapter 7 liquidation since Chapter 11 reorganization only allows them to capture a fraction of a slightly smaller pie. Equityholders would like to issue a large coupon to take advantage of tax benefits and commit to future liquidation to obtain a low cost of debt. However, for these parameters, the result of Proposition 6 implies that these two goals conflict with each other: large coupons imply equityholders will ex-post find Chapter 11 optimal. Debtholders recognize this and pay less for debt with such a coupon at Time 0. Since equityholders cannot formally commit to Chapter 7, they have two choices. They can issue a large coupon to maximize tax benefits and accept that debtholders will charge extra for the future Chapter 11 inefficiencies. Alternately, equityholders can issue the largest coupon $\bar{C}$ consistent with Chapter 7 being optimal for equity ex-post. This allows equityholders to get a better price for the debt they issue, but they forgo tax benefits since for these parameters, $\bar{C}$ is smaller than the coupon they would otherwise issue.

To an econometrician, in this latter case, our model looks identical to the Leland model: a firm issues debt then eventually liquidates. However, the off-equilibrium considerations introduced by our bargaining model lead the firm to issue a much smaller coupon than in the standard Leland model. In this case, our model predicts lower leverage than the Leland model, even for the 65% of firms that liquidate in Chapter 7 (BCI, 2017).

To illustrate the capital structure decision in more detail, we now present examples of each case. The parameters h, R_0, B capture the inefficiencies of Chapter 11. To succinctly describe regions of the (h, R_0, B) parameter space, we introduce two measures of efficiency. The first measure is RelEff, which is the ratio of total firm value upon entering Chapter 11 to the total firm value at the moment of liquidation:

$$\text{RelEff} \equiv \frac{V(\delta_{def}, R_0) - B}{\zeta \delta_{def}}. \qquad (47)$$

Recall the numerator is the total firm value in Chapter 11 reorganization, which incorporates a partial loss of earnings during Chapter 11 and a fixed cost of exiting Chapter 11, minus the fixed cost B of entering Chapter 11. The denominator is the liquidation value debtholders receive by selling the assets for their perpetuity value minus proportional liquidation costs. Since Chapter 11 entails fixed costs in our model, while Chapter 7 does not, the value of this ratio is sensitive to the δ at which it is evaluated. Intuitively, spending several years in court over a firm worth one dollar would be extraordinarily wasteful relative to liquidating such a firm, regardless of the overall efficiency of each procedure. This is why both are evaluated at the exogenous value δ_{def}.

RelEff has no direct significance in the solution of our model but is helpful for concisely summarizing the inefficiencies of Chapter 11 and Chapter 7 without delving into the optimal strategy of equityholders. The extent to which these inefficiencies impact firm value is of course endogenous. It will be helpful to define a second mea-

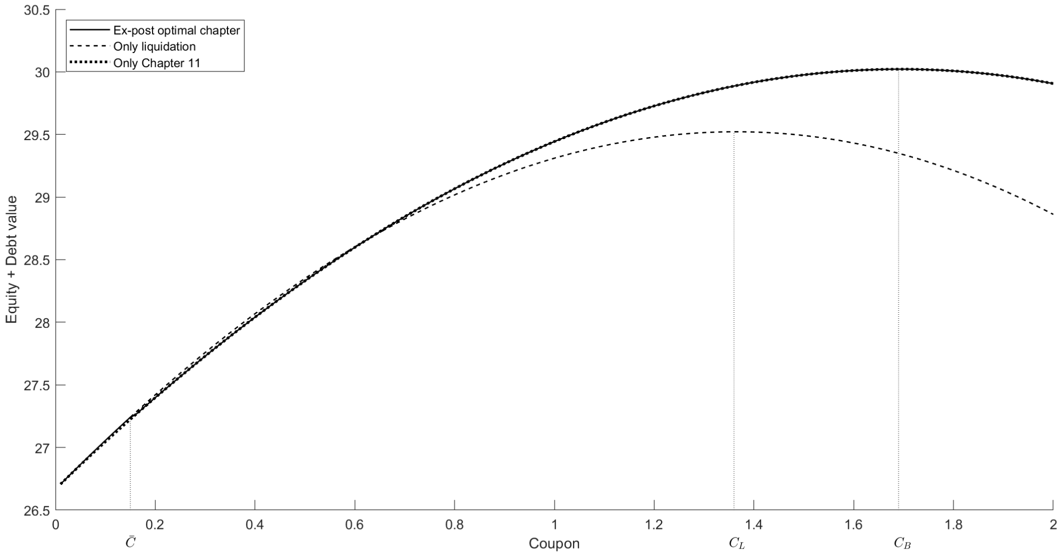


Fig. 5. Capital structure choice: RelEff= 115%. This figure shows ex-ante firm value (Equity + Debt) as a function of the coupon C_0. The dashed curve plots $F^L(\delta_0, C_0)$, the firm value under the assumption of future liquidation. The vertical dotted line descending from the peak of the dashed curve marks C_L, the optimal coupon under future liquidation, on the x-axis. The dotted curve plots $F^B(\delta_0, C_0)$, the firm value under the assumption of future Chapter 11. The vertical dotted line descending from the peak of the dotted curve marks C_B, the optimal coupon under future Chapter 11 reorganization, on the x-axis. The solid curve plots the actual firm value $F_0(\delta_0, C_0)$ as a function of the coupon C_0. Finally, the vertical dotted line ending in $\bar{C}$ on the x-axis marks the largest coupon for which equity finds liquidation optimal ex-post. The parameters corresponding to this figure are the baseline parameters from Table 1, with $R_0 = 0.6, h = 1, B = 0.1$.

sure that measures how much firm value is changed by the added option of Chapter 11:

$$\text{Choicevalue} \equiv \frac{F_0(\delta_0, C^*)}{F_L(\delta_0, C_L)}. \tag{48}$$

The numerator is the Time 0 value of the firm with the option to liquidate or enter Chapter 11, evaluated at the optimal coupon. The denominator is the Time 0 firm value in the Leland model with only Chapter 7, evaluated at the corresponding optimal coupon. This measure provides clearer intuition on how the optimal strategy changes with the Chapter 11 parameters. We use Choicevalue to partition the space of (h, R_0, B) values into cases corresponding to distinct optimal strategies, and then we reference RelEff to describe the exogenous inefficiencies that induce each case.

Case 1: Choicevalue > 1. Suppose that Chapter 7 liquidation is less efficient than Chapter 11 reorganization. Since the tax benefits of debt are large empirically, equityholders like to issue large coupons. Such coupons imply equityholders will default in profitable states of the world (Proposition 6), and these are the states of the world where equity's prospects in Chapter 11 justify the fixed costs of entering Chapter 11 (Proposition 5). Debtholders might dislike sharing the firm with equityholders in Chapter 11, but since Chapter 11 is more efficient, the overall pie is bigger. Equityholders are thus willing to pay a higher cost of debt associated with Chapter 11 being ex-post optimal since they are compensated by the rents they eventually extract in Chapter 11, and they issue a large coupon to take full advantage of the tax shield.

Fig. 5 plots firm value as a function of C_0, the Time 0 perpetual coupon on the consol debt. We use the parameters of Table 1, except we use different (h, R_0, B) values such that Chapter 11 is 15% more efficient than Chapter 7 by our metric RelEff. The dashed curve plots $F^L(\delta_0, C_0)$, the firm value under the assumption of future liquidation, as a function of the coupon C_0. As usual, the trade off between the tax shield of debt and the efficiency loss in liquidation leads to an inverted U shape for firm value as a function of the coupon. The vertical dotted line descending from the peak of the dashed curve marks C_L, the optimal coupon under fu-

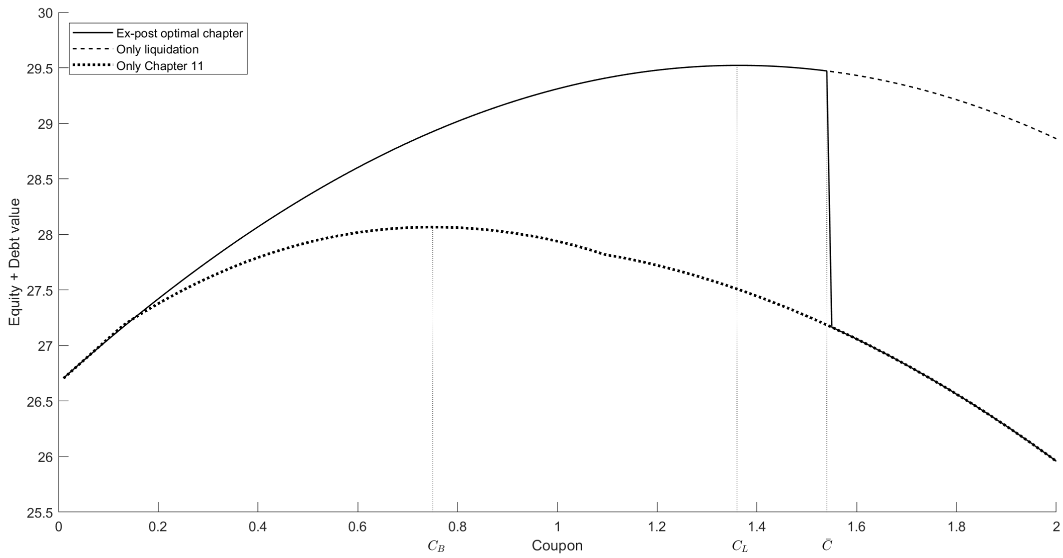


Fig. 6. Capital structure choice: RelEff= 50%. This figure shows ex-ante firm value (Equity + Debt) as a function of the coupon C_0. The dashed curve plots $F^L(\delta_0, C_0)$, the firm value under the assumption of future liquidation. The vertical dotted line descending from the peak of the dashed curve marks C_L, the optimal coupon under future liquidation, on the x-axis. The dotted curve plots $F^B(\delta_0, C_0)$, the firm value under the assumption of future Chapter 11. The vertical dotted line descending from the peak of the dotted curve marks C_B, the optimal coupon under future Chapter 11 reorganization, on the x-axis. The solid curve plots the actual firm value $F_0(\delta_0, C_0)$ as a function of the coupon C_0. Finally, the vertical dotted line ending in $\bar{C}$ on the x-axis marks the largest coupon for which equity finds liquidation optimal ex-post. The parameters corresponding to this figure are the baseline parameters from Table 1, with $R_0 = 4.4, h = 0.4, B = 2$.

ture liquidation, on the x-axis. The dotted curve plots $F^B(\delta_0, C_0)$, the firm value under the assumption of future Chapter 11. Again, there is a trade off between the tax shield of debt and the inefficiency of Chapter 11. The vertical dotted line descending from the peak of the dotted curve marks C_B, the optimal coupon under future Chapter 11 reorganization, on the x-axis. Since we have assumed here that the bankruptcy costs in Chapter 11 are less extreme than those in Chapter 7, the optimal coupon C_B is larger than C_L as expected.

The solid curve plots the actual firm value $F_0(\delta_0, C_0)$ as a function of the coupon C_0. Since equityholders lack commitment power, F_0 is either equal to F^B or F^L, depending upon whether equityholders will subsequently find it optimal to enter Chapter 11 or liquidate. The first vertical dotted line marks $\bar{C}$, the threshold coupon for Chapter 11 versus Chapter 7, on the x-axis. For $C \leq \bar{C}$, the solid curve F_0 follows the liquidation value F^L since the firm will subsequently find it optimal to liquidate. For $C > \bar{C}$, the solid curve follows F^B since equityholders will subsequently enter Chapter 11. In particular, if equityholders want to sell debt for the value under liquidation D^L, the largest coupon they may issue is $\bar{C}$. Since Chapter 11 is good for firm value in this instance, equityholders find it optimal to issue C_B and credibly signal a future Chapter 11 reorganization since this is the maximal point on the solid curve. Equityholders are thus unconstrained by their lack of commitment when they decide to maximize the firm value under future Chapter 11.

Case 2: Choicevalue = 1. Another possible case is that Chapter 7 liquidation is much more efficient than Chapter 11 reorganization. In this case, if equity had commitment power, they would get the greatest Time 0 value by committing to a future Chapter 7 and issuing debt with the coupon C_L that maximizes the firm value conditional on future Chapter 7. However, if Chapter 11 reorganization is very inefficient, there will be no commitment problem. Specifically, with an inefficient Chapter 11 process, equityholders would have to default in a very profitable state of the world in order for their bargaining prospects to justify the fixed costs of Chapter 11. They will only default in such a state of the world if they have issued debt with a coupon $\bar{C}$ much larger than

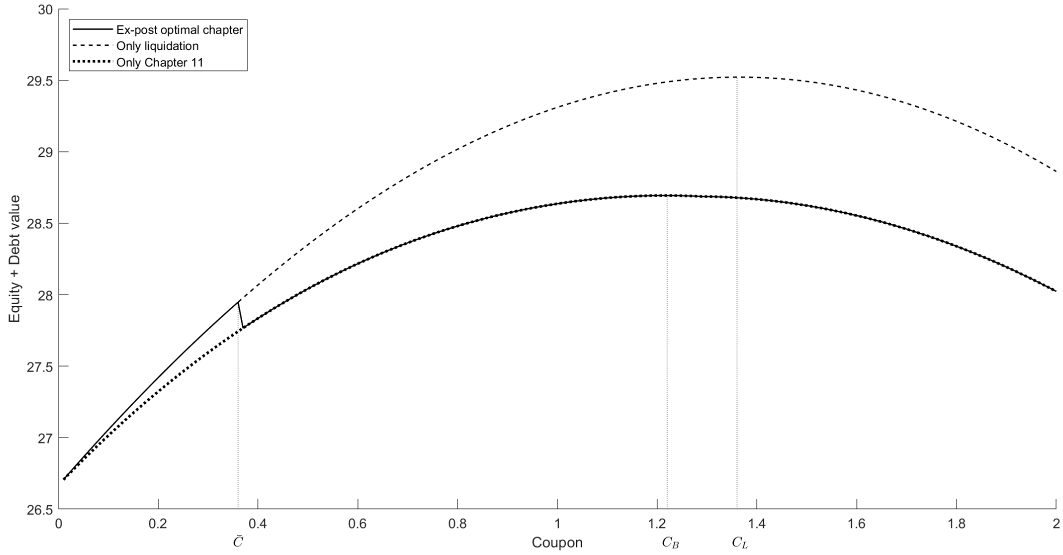


Fig. 7. Capital structure choice: RelEff=85%. This figure shows ex-ante firm value (Equity + Debt) as a function of the coupon C_0. The dashed curve plots $F^L(\delta_0, C_0)$, the firm value under the assumption of future liquidation. The vertical dotted line descending from the peak of the dashed curve marks C_L, the optimal coupon under future liquidation, on the x-axis. The dotted curve plots $F^B(\delta_0, C_0)$, the firm value under the assumption of future Chapter 11. The vertical dotted line descending from the peak of the dotted curve marks C_B, the optimal coupon under future Chapter 11 reorganization, on the x-axis. The solid curve plots the actual firm value $F_0(\delta_0, C_0)$ as a function of the coupon C_0. Finally, the vertical dotted line ending in $\bar{C}$ on the x-axis marks the largest coupon for which equity finds liquidation optimal ex-post. The parameters corresponding to this figure are the baseline parameters from Table 1(b).

C_L. So even without formal commitment power, equity can issue their favorite coupon C_L and credibly promise a future Chapter 7 liquidation. This is depicted graphically in Fig. 6, with (h, R_0, B) values that correspond to a Chapter 11 process that is 50% less efficient than Chapter 7.

The interpretation of Fig. 6 is exactly the same as Fig. 5. The point on the x-axis where the solid curve F^0 drops down from the dashed curve F^L to the dotted curve F^B corresponds to the threshold coupon $\bar{C}$. In this figure, we see that the solid curve F_0 is maximized at the point where F^L is maximized, with corresponding coupon C_L. Since $C_L < \bar{C}$, equityholders are able to issue C_L, credibly promise a future liquidation, and receive F^L. In this sense, equityholders are unconstrained in their decision to maximize the firm value under future liquidation.

Case 3: Choicevalue < 1. Perhaps the most interesting case is when the Chapter 11 procedure is less efficient than Chapter 7 but efficient enough that equityholders still find it attractive ex-post for reasonable levels of debt. The inefficiency of Chapter 11, combined with equity's lack of commitment power, will actually reduce firm value in this region, relative to the value if Chapter 11 were not an option. To see this intuitively, suppose that Chapter 7 is slightly more efficient than Chapter 11. In such a situation, equityholders might be able to get a much lower cost of debt by committing to a future Chapter 7 liquidation. If equityholders had commitment power, in this case, they would promise a future Chapter 7 liquidation and issue the coupon C_L that optimally trades off tax benefits with the liquidation costs. However, such a coupon C_L would imply that equityholders default in a profitable state of the world, where the reasonably efficient Chapter 11 is appealing to equityholders. Since equityholders lack commitment power, debtholders recognize that the coupon C_L will correspond to a future Chapter 11 and charge a higher cost of debt.

This leaves the equityholders with two choices. If the higher cost of debt associated with Chapter 11 is small in magnitude relative to the tax benefits of debt, equityholders will optimally issue the coupon C_B that maximizes tax benefits relative to Chapter 11 inefficien-

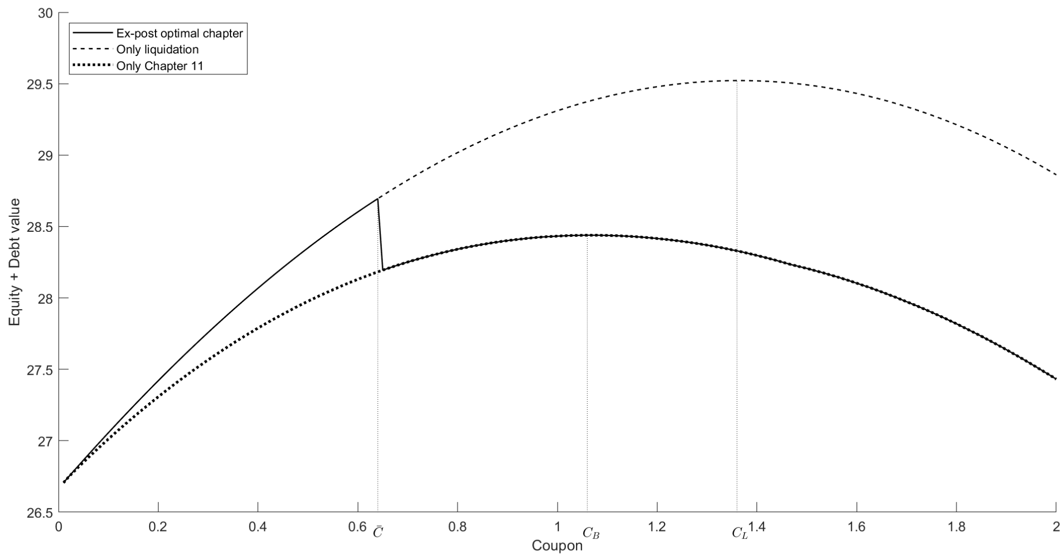


Fig. 8. Capital structure choice: RelEff=75%. This figure shows ex-ante firm value (Equity + Debt) as a function of the coupon C_0. The dashed curve plots $F^L(\delta_0, C_0)$, the firm value under the assumption of future liquidation. The vertical dotted line descending from the peak of the dashed curve marks C_L, the optimal coupon under future liquidation, on the x-axis. The dotted curve plots $F^B(\delta_0, C_0)$, the firm value under the assumption of future Chapter 11. The vertical dotted line descending from the peak of the dotted curve marks C_B, the optimal coupon under future Chapter 11 reorganization, on the x-axis. The solid curve plots the actual firm value $F_0(\delta_0, C_0)$ as a function of the coupon C_0. Finally, the vertical dotted line ending in $\bar{C}$ on the x-axis marks the largest coupon for which equity finds liquidation optimal ex-post. The parameters corresponding to this figure are the baseline parameters from Table 1(a).

cies. In this case, equityholders are optimally choosing an inefficient Chapter 11 process and a high cost of debt because it allows them to capture tax benefits. An example of this case is shown in Fig. 7, which plots firm value as a function of the coupon C_0, for the parameters in Table 1(b) that induce RelEff= 0.85.

Fig. 7 has the same interpretation as Fig. 5 and 6. The highest firm value, corresponding to the coupon C_L, is on the dashed curve depicting firm value under future liquidation. However, Chapter 11 is sufficiently attractive that $\bar{C} < C_L$, so equity's lack of commitment power prevents them from obtaining this firm value. The highest attainable value on the solid curve corresponds to C_B, the optimal coupon given a future Chapter 11. Thus, even though Chapter 11 is less efficient than Chapter 7, the tax benefits of a large coupon outweigh the increased cost of debt, so equity optimally chooses Chapter 11. We call this the optimal inefficient Chapter 11 strategy.

The other choice that equity can make in Case 3 is to issue $\bar{C}$. If the higher cost of debt associated with Chapter 11 is large relative to the tax benefits of a larger coupon, equityholders will sacrifice some tax benefits to issue a coupon that credibly commits them to a future Chapter 7. Specifically, equityholders will optimally issue $\bar{C}$, the largest coupon such that they will subsequently find Chapter 7 optimal.

Fig. 8 plots firm value as a function of the initial coupon C_0, with a parameter set, Table 1(a), corresponding to RelEff = 75%. Once again, the highest point on the graph occurs on the dashed curve, at $F^L(\delta_0, C_L)$, which corresponds to the firm value if equity could issue C_L and commit to Chapter 7. However, this value is unattainable for equityholders. If they issue debt with a coupon larger than $\bar{C}$, which is the point on the x-axis where the solid curve drops from the dashed curve to the dotted curve, then the value they receive is F^B. As a result, the best equityholders can do is to issue $\bar{C}$ and receive $F^L(\delta_0, \bar{C})$. We refer to this as the constrained debt Chapter 7 strategy.

We reiterate that the equityholders optimally issue a lower coupon than in the Leland (1994) model, even though they subsequently face the exact same liquidation costs. This is because we have found a novel agency cost of debt: it encourages equityholders to destroy firm value in Chapter 11 bankruptcy. The coupon that optimally trades off tax benefits with liquidation costs and this novel agency cost is lower than the one predicted by the Leland model.

5.2. Results on capital structure

In Graham (2000), he finds that "paradoxically, large, liquid, profitable firms with low expected distress costs use debt conservatively," and "the typical firm could double tax benefits by issuing debt until the marginal tax benefit begins to decline." Contingent claims models like that in Leland (1994) have historically had a difficult time matching the 20%-25% quasi-market leverage ratios typical of Compustat firms (Strebulaev and Whited, 2012) without assuming extreme liquidation costs or adding much more complicated assumptions.

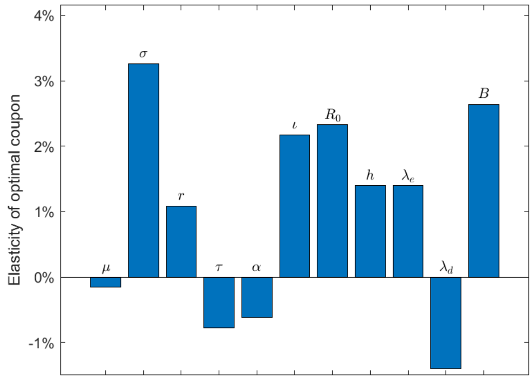
We solve our model for the parameters of Table 1(a), which correspond to the constrained debt Chapter 7 case of our model, with a RelEff value of 75%. In this case, equityholders optimally issue $\bar{C}$, which is 0.64 for these parameters, to credibly commit to a future liquidation. The optimal coupon with just liquidation (C_L) is 1.36, roughly twice as large as $\bar{C}$. We follow the literature in evaluating leverage as $D_0(\delta_0, C^*)/F_0(\delta_0, C^*)$, the value of debt at issuance divided by the sum of equity and debt values at issuance, all evaluated at the optimal coupon. For these exact parameters, the Leland model (see Section 2.2) predicts a leverage ratio of 70%, while in our equilibrium, the leverage ratio is just 40%. To be clear, many models predict lower leverage ratios than the Leland model. However, by simply adding a realistic choice between Chapter 11 and Chapter 7, our model can lead to a leverage ratio 30 percentage points lower than Leland (1994), even though the equilibrium behavior is indistinguishable.

We calculate the unlevered firm value as $U = (1 - \tau)\delta_0/(r - \mu)$, the perpetuity value of the cash flows. The ratio of the levered firm value to the unlevered firm value, calculated as $F_0(\delta_0, C^*)/U$, captures the value of debt in our model. Without the Chapter 11 option, the tax benefits of debt (net the liquidation inefficiencies) would add 11% to the unlevered firm value. However, to credibly commit to Chapter 7, in our model, firms can only add 8% to their unlevered firm value. For these parameters, our model thus suggests the option to reorganize costs firms 3% of their unlevered firm value.

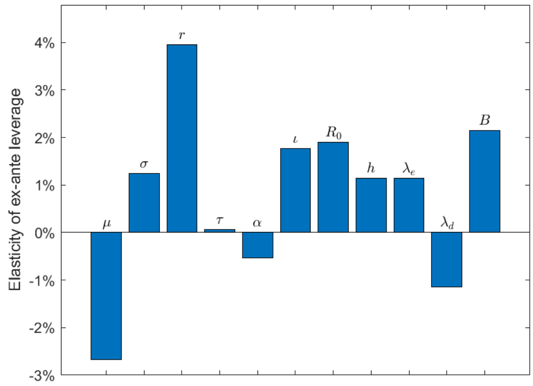
Chapter 11 efficiency and capital structure: Fig. 9 shows comparative statics for the capital structure implied by our model. Starting with the parameter values in Table 1(a), we compute the optimal coupon, leverage, and ratio of levered firm value to unlevered firm value as above. Then, one parameter at a time, we increase the parameter by 5% of its value and recalculate these quantities. The figure plots elasticities (the percent change resulting from a 5% change in each parameter) for each of these quantities. In this constrained debt Chapter 7 case, anything that makes Chapter 11 less appealing will increase $\bar{C}$. Intuitively, when Chapter 11 gets worse for equityholders, it is easier for them to promise not to file for Chapter 11, which lets them issue a higher coupon while receiving the lower cost of debt corresponding to Chapter 7. When we increase R_0 by 5%, panels (a) and (b) of Fig. 9 show that the optimal coupon and leverage increase. Since the marginal benefit of debt is positive, panel (c) shows this increases the levered firm value as well. Counterintuitively, a less efficient Chapter 11 process is actually increasing firm value. This general effect can be observed in many parameters that affect the relative attractiveness of Chapter 11 for equityholders. Increasing the rate of conversion ι to Chapter 7 or increasing the cost to equity B of entering Chapter 11 both lead to higher leverage and firm value. Increasing h, which improves the efficiency of Chapter 11, actually increases leverage and firm value, but this is because it makes equityholders worse off in the bargaining (Fig. 2), which loosens their constraint.

Of course, all of these results depend upon the firm finding the constrained debt Chapter 7 strategy optimal. In Fig. 10, we present the same comparative statics exercise for the parameters of Table 1(b), for which the optimal inefficient Chapter 11 strategy is optimal (RelEff=85%). Here the firm is optimally choosing Chapter 11, so for small declines in the efficiency of Chapter 11 (for example, higher R_0, B or lower h), the firm optimally reduces debt. This is the standard trade off theory logic, and this decline in efficiency is accompanied by a decline in firm value. However, an increase in ι, the rate of conversion to Chapter 7, can still increase leverage. While such an increase makes Chapter 11 slightly less efficient, it also makes Chapter 11 much better for debtholders since it endogenously increases their outside option and thus their bargaining position. As a result, equityholders take advantage of the lower cost of debt by issuing more debt, increasing firm value.

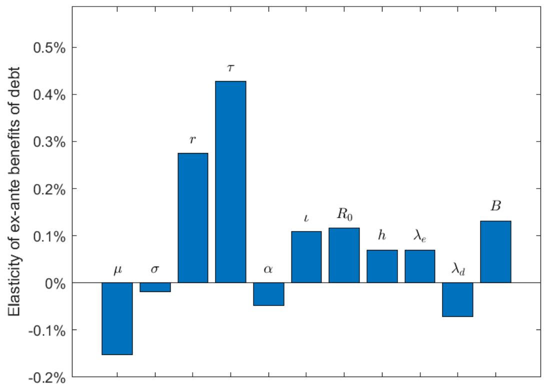
Creditor rights and capital structure: There is a growing empirical literature examining the real effects of creditor rights. Li, Whited, and Wu (2016) study the enactment of antirecharacterization laws in seven states in the late 1990s and early 2000s. These laws protected the rights of creditors who used special purpose vehicles to conduct secured borrowing, and several papers argue these represent an exogenous increase in creditor rights. Li, Whited, and Wu (2016) find this led to an increase in leverage. Mann (2018) studies the same laws and also finds an increase in long-term debt over assets.



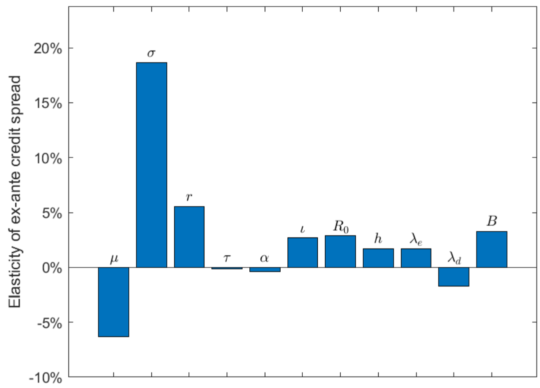
(a) Optimal coupon



(b) Ex-ante leverage



(c) $\frac{\text{Levered firm value}}{\text{Unlevered firm value}}$



(d) Ex-ante credit spread

Fig. 9. Capital structure comparative statics, constrained debt Chapter 7 case. Using the baseline parameters of Table 1(a), we calculate the optimal coupon and the corresponding ex-ante leverage, ex-ante credit spread, and the ratio of the firm value to the unlevered firm value U as in the text. Then, for each parameter individually, we increase that parameter by 5% of its baseline value and recalculate each of the four quantities. Panel (a) plots the percentage change in the optimal coupon from increasing each parameter, one at a time, by 5%. Panels (b), (c), and (d) plot the corresponding changes for optimal ex-ante leverage, the ratio of the Time 0 levered firm value to the perpetuity value of the cash flows, and the ex-ante credit spread, respectively.

In our model, creditor rights might reasonably be interpreted as the relative bargaining power of debtholders. Laws like the antirecharacterization laws certainly reduce the relative bargaining power of equityholders since they may no longer hold up creditors with the threat of recharacterizing assets held in special purpose vehicles. As noted in Section 3, the timing in the dynamic bargaining game is not affected by the relative bargaining power of creditors and debtors. However, the bargaining power of creditors affects the fraction of firm value that can be captured by equityholders in Chapter 11, which factors into the capital structure decision of equityholders. Recall that higher λ_e values correspond to shorter offer windows for equityholders and stronger creditor rights. In the constrained debt Chapter 7 strategy considered in Fig. 9, an increase in creditor rights (increasing λ_e by 5%) increases leverage by approximately 1%. Similarly, increasing λ_d lowers leverage. This is the same mechanism discussed above: when creditor rights improve, Chapter 11 becomes less attractive to equityholders, so they may issue a larger coupon $\bar{C}$ while still credibly committing to Chapter 7. In Fig. 10, where Chapter 11 is optimal, better creditor rights still lead to an increase in leverage because it makes Chapter 11 more appealing to debtholders and lowers the cost of debt. Thus, our model generally predicts that stronger creditor rights lead to higher leverage, consistent with the empirical evidence. The only exception to this is when an increase in creditor rights pushes equityholders from Chapter 11 to Chapter 7. In unreported results, we have found that a decline in λ_d can make equityholders prefer the lower cost of debt associated with Chapter 7 to the rents they can extract in Chapter 11. They then drastically reduce their coupon from C_B to $\bar{C}$ and choose liquidation instead of Chapter 11.

In most cases, when creditor rights improve, the resulting increase in leverage leads to an improvement in firm value. Under the constrained debt Chapter 7 strategy, this is because the marginal benefits of debt for the firm are positive at the optimum, and equity's constraint becomes looser with stronger creditor rights. Thus, the increase in debt has a net positive effect on firm value. Under the optimal inefficient Chapter 11 strategy, when creditor rights improve, the expected costs of default endogenously decline. This is because creditors get a better Chapter 11 outcome, so equity waits longer to default for any given coupon. As a result, our model predicts that stronger creditor rights should improve firm value. There is empirical evidence for this comparative static. Ponticelli and Alencar (2016) find an increase in value after an increase in the enforceability of creditor rights, and Ersahin (2017) finds greater productivity after the antirecharacterization laws discussed previously. However, these empirical results have different mechanisms than the tax benefits of debt that drives the result in our model.

Other model primitives: We briefly summarize the other predictions of our model for capital structure. All our results vary depending on the cases described above, but we focus on the results that do not appear in the standard Leland model. For example, it is possible for an increase in μ to lead to lower optimal leverage (Fig. 9). This is because higher expected tax benefits make Chapter 11 more attractive. This forces equityholders to issue a lower coupon with lower leverage to credibly commit to Chapter 7, which is in some cases optimal.

Unlike in the Leland model, higher volatility can lead to higher leverage. With only liquidation, higher volatility lowers optimal leverage and the overall levered firm value. The last effect means that the reorganized firm value is lower when volatility is higher. This tends to lower the relative efficiency of Chapter 11, so for the constrained debt Chapter 7 strategy, this can lead to higher leverage in our model.

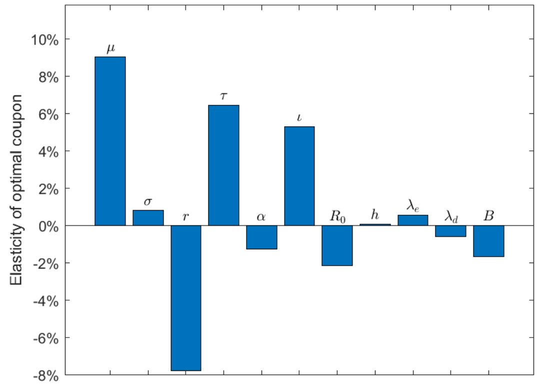
In any trade-off model, higher taxes imply greater tax benefits of debt and thus more debt. However, Chapter 11 includes an embedded option to relever upon reorganizing, making it more appealing to equityholders when taxes are high. Fig. 9 presents an example where, when taxes increase by 5%, the commitment effect outweighs the Time 0 increase in tax benefits, and the firm optimally lowers its coupon to commit to Chapter 7. Finally, even when liquidation inefficiencies are tiny ($\alpha = 0.005$), the commitment problem in our model can lead to leverage as low as 44%, compared to 78% in the Leland model.

Credit spreads: Our model produces credit spreads by the formula

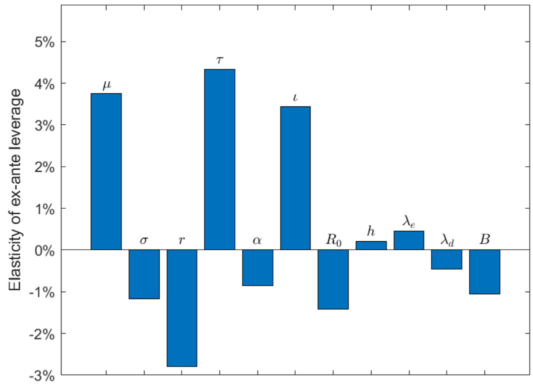
$$\mathrm{CS} = \frac{C^*}{D_0(\delta_0, C^*)} - r, \tag{49}$$

where $D_0(\delta_0, C^*)$ is the value of debt at the optimal coupon at issuance. Panel (d) of Fig. 9 and 10 suggest that changes in Chapter 11 costs and the bargaining parameters have similar effects on credit spreads as they do on leverage and the optimal coupon. This is intuitive since higher coupons always lead to earlier default and thus riskier debt.

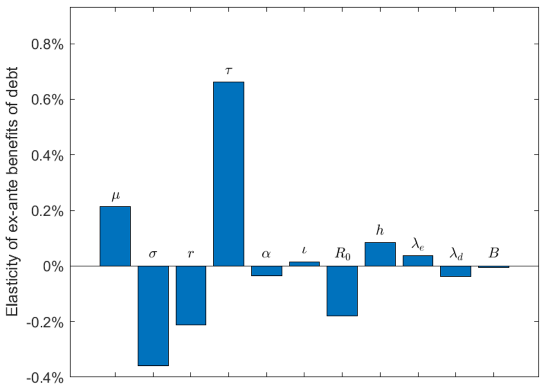
What is perhaps most interesting in our model is not the comparative statics of credit spreads but the levels. In cases where equityholders find Chapter 11 to be ex-post optimal, debtholders demand a higher cost of debt to compensate them for the rents that equityholders will



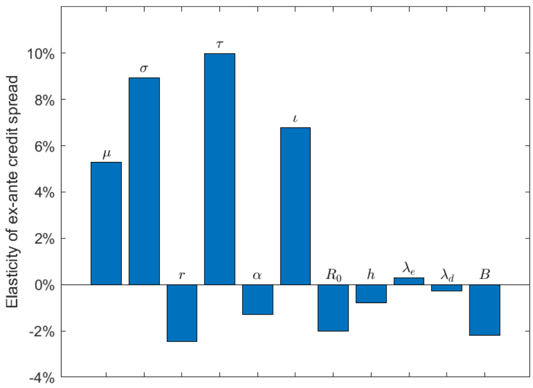
(a) Optimal coupon



(b) Ex-ante leverage



(c) $\frac{\text{Levered firm value}}{\text{Unlevered firm value}}$



(d) Ex-ante credit spread

Fig. 10. Capital structure comparative statics, optimal inefficient Chapter 11 case. Using the baseline parameters of Table 1(b), we calculate the optimal coupon and the corresponding ex-ante leverage, ex-ante credit spread, and the ratio of the firm value to the unlevered firm value U as in the text. Then, for each parameter individually, we increase that parameter by 5% of its baseline value and recalculate each of the four quantities. Panel (a) plots the percentage change in the optimal coupon from increasing each parameter, one at a time, by 5%. Panels (b), (c), and (d) plot the corresponding changes for optimal ex-ante leverage, the ratio of the Time 0 levered firm value to the perpetuity value of the cash flows, and the ex-ante credit spread, respectively.

extract in Chapter 11. The credit spread puzzle suggests that models like Leland (1994) tend to underestimate credit spreads on risky debt. By adding the option of Chapter 11, we can produce credit spreads higher than those in the Leland model. In the optimal inefficient Chapter 11 strategy, the higher default costs lead equityholders to issue less debt than if they only were able to liquidate. This is because they internalize the default costs when they issue debt at Time 0. However, the debtholders still demand compensation for the future Chapter 11 reorganization. As a result, for the parameters in Table 1(b), the model can simultaneously generate a credit spread 17 basis points higher than the Leland model while producing an optimal leverage ratio that is 7 percentage points lower.

5.3. The decision to enter Chapter 7 or Chapter 11

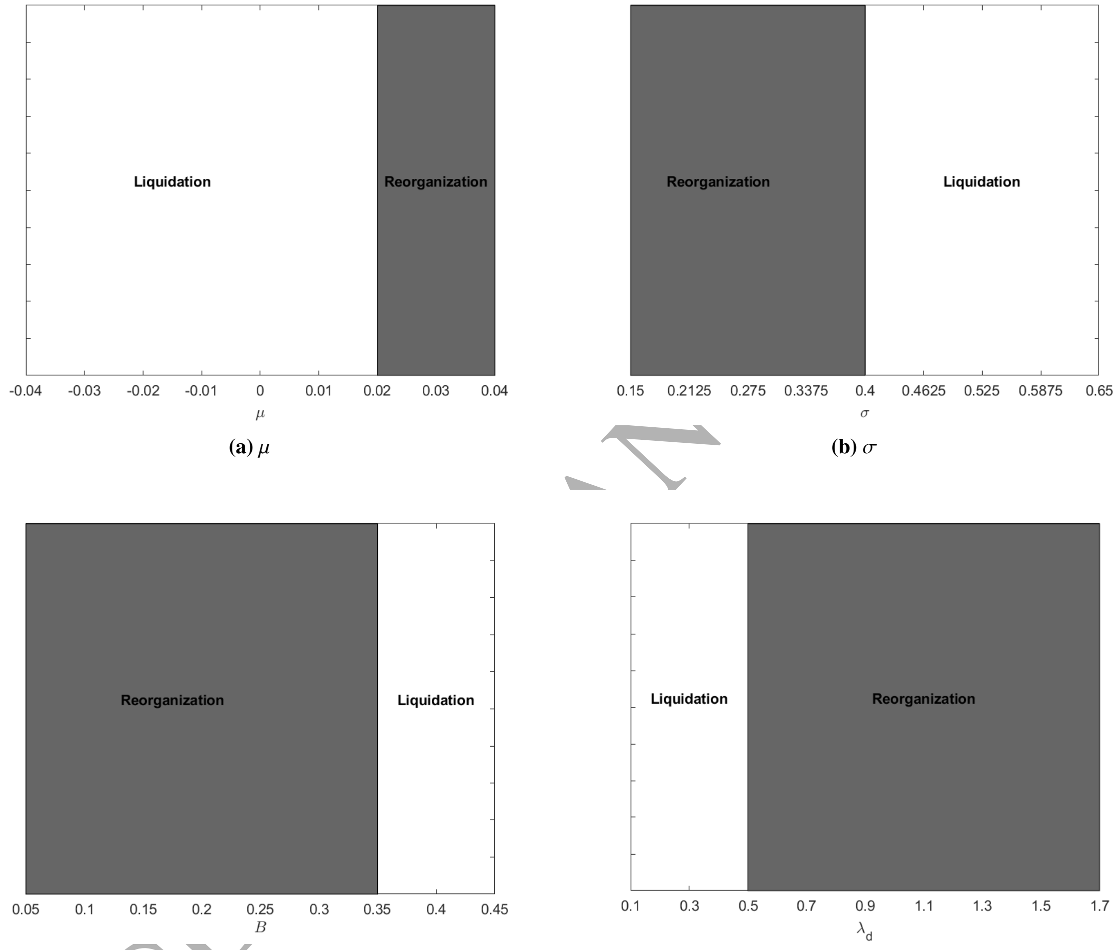
There is recent interest in empirical research about the causal effect of bankruptcy procedure on future firm asset performance. The main challenge in such work is overcoming the selection bias, that firms choosing Chapter 11 are inherently different from those choosing Chapter 7. Any statements our model might generate about the causal effect of Chapter 11 versus Chapter 7 would be dependent on the parameter values we assume. However, our model generates much more general predictions about what types of firms choose Chapter 11 or Chapter 7.

Profitability, asset value, and choice of bankruptcy procedure: In our model, when equityholders default, they choose Chapter 11 if and only if their value function in the subsequent bargaining justifies their fixed cost of entering Chapter 11 (Proposition 5). Since the value function is increasing in the current EBIT (δ), this implies that firms that are more profitable at default will choose Chapter 11. It is standard in the Leland model to define the firm asset value as the unlevered firm value U, which is linear in δ, so this also implies firms with more valuable assets at default should choose Chapter 11. These predictions of our model are supported by BWZ (2006), BCI (2017), and Corbae and D'Erasmo (2017). Specifically, in Table 1 of BWZ (2006), they find that the average asset value of firms entering Chapter 11 is nearly four times as large as the average asset value of firms entering Chapter 7. Their Table 2 shows in a Probit model that conditional on being a reasonable size, firms with more valuable assets are more likely to choose Chapter 11. Table 1 of Corbae and D'Erasmo (2017) similarly shows that firms entering Chapter 11 are roughly four times as large as those entering Chapter 7, and Table 1 of BCI (2017) shows firms in Chapter 11 have four times as many plants as firms entering Chapter 7. While none of these tables show statistics on unnormalized EBIT, firms entering Chapter 11 have higher earnings before interest, tax, depreciation and amortization (EBITDA), normalized by assets, than firms entering Chapter 7 (Corbae and D'Erasmo, 2017, Table 1). Also, multiplying the median firm's EBITDA over assets by the median firm's assets in the same table suggests a higher unnormalized EBITDA for firms entering Chapter 11.

Debt and Chapter 11: In Proposition 6, we show that firms with higher coupons tend to choose Chapter 11 (specifically, those with a coupon above some threshold $\bar{C}$). This implies the prediction that defaulting firms should be more likely to choose Chapter 11 when they have a lot of debt. Table 1 of BWZ (2006) shows that firms entering Chapter 11 have a higher debt/assets ratio, and combining this with the higher denominator for firms in Chapter 11 mentioned previously, firms entering Chapter 11 have more debt. This is also a significant predictor of Chapter 11 in their Probit regressions. Table 1 of Corbae and D'Erasmo (2017) confirms these findings, consistent with our model. In summary, Propositions 5 and 6 characterize the decision between Chapter 7 and Chapter 11 in our model, and both of the mechanisms enjoy empirical support.

Other comparative statics: Fig. 11 plots how equity's decision to choose Chapter 11 versus Chapter 7 varies with four parameters. We start with the baseline parameters of Table 1(b). Then, one parameter at a time for each of $\mu, B, \sigma, \lambda_d$, we change the parameter to nine different values and record the corresponding equilibrium chapter choice. Higher growth firms value the tax shield of debt more, which makes them want to issue a large coupon. Higher μ also increases the relative efficiency of Chapter 11 since it allows the firm to relever. This means that ceteris paribus, firms with higher μ tend to prefer Chapter 11 since larger coupons encourage Chapter 11 ex-post, as shown in panel (a). To our knowledge, this is a novel empirical prediction. It also suggests that estimates of the benefits of Chapter 11 might be overstated since the firms that chose to enter Chapter 11 might have had higher growth rates on average.

Panel (b) shows that higher volatility has the opposite effect as it decreases the relative efficiency of Chapter 11. Intuitively, when it is more costly for equityholders to enter Chapter 11 (B increases), equityholders are more likely to choose Chapter 7, as shown in panel (c). Stronger creditor rights (lower λ_d) make Chapter 11 less appealing to equityholders, and panel (d) shows this tends to encourage Chapter 7. Similarly, in unreported results, we find a higher rate of conversion to



(a) μ **(b)** σ **(c)** B **(d)** λ_d

Fig. 11. Chapter choice. We start with the baseline parameters of Table 1(b), for which the firm optimally chooses Chapter 11. In each subpanel, we change the pictured parameter to each of the nine values depicted on the x-axis. For each value, we evaluate the bankruptcy chapter chosen on the equilibrium path. The shaded area covers parameter values on the x-axis for which the firm chooses Chapter 11, while the white region covers parameter values for which the firm chooses Chapter 7. In all cases, shading is "right continuous" in that the firm chooses the chapter corresponding to the region immediately to the right of the x-axis value.

Chapter 7 tends to discourage equityholders from paying for Chapter 11.

5.4. Length of Chapter 11

As we discussed in Section 3.6, our model of Chapter 11 produces the realistic result that Chapter 11 cases of any length can occur with positive probability on the equilibrium path. Our model also produces a comparative static for the length of bankruptcy that is consistent with empirical evidence. Bandopadhyaya (1994) finds that firms with a greater interest burden have a significantly higher instantaneous probability of exiting Chapter 11. In our model, firms with a larger interest burden endogenously default in more profitable states, which leads them to reach their upper reorganization threshold faster.

Our model also produces novel predictions for the length of Chapter 11 cases. The length of Chapter 11 is stochastic since it depends upon the path of the EBIT δ_t during bankruptcy. Rather than simulate the average length, we use the metric $R_0/(\bar{x}\delta_B)$. Recall that δ_B is the endogenous threshold at which equity defaults and enters Chapter 11, while the firm emerges from Chapter 11 the first time t that $\delta_t \geq R_t/\bar{x}$, where $\bar{x}$ is endogenous. When $h = 0$, we have $R_t = R_0$ for all t, so $R_0/(\bar{x}\delta_B)$ reflects the factor by which cash flows must improve to exit Chapter 11.

Fig. 12 plots elasticities of this metric $R_0/(\bar{x}\delta_B)$ with respect to a 5% change in various parameters from their baseline values, Table 1(b). Based on Fig. 12, we find that lower growth firms, higher volatility firms, and firms with greater shareholder bargaining power all have longer bankruptcy procedures. We are unaware of any empirical papers that test these findings.

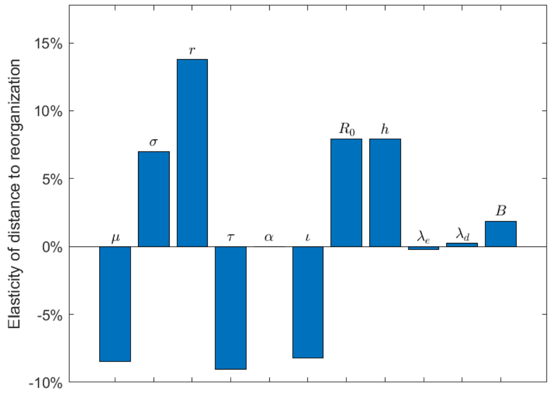


Fig. 12. Comparative statics for equilibrium length of Chapter 11. Using the baseline parameters of Table 1(b), we calculate the optimal reorganization threshold $\bar{x}$ and the optimal threshold δ_B for entering Chapter 11 and use them to calculate the ratio $R_0/(\bar{x}\delta_B)$. Then, for each parameter individually, we increase that parameter by 5% of its baseline value and recalculate $R_0/(\bar{x}\delta_B)$. This figure plots the percentage change in $R_0/(\bar{x}\delta_B)$ from increasing each parameter, one at a time, by 5%.

6. Extensions

In this section, we informally consider how two assumptions in our model might impact our results. First, since in reality some firms enter Chapter 11 multiple times, in Section 6.1, we discuss what might happen if we allowed firms to enter Chapter 11 more than once. Second, since empirically firms adjust their leverage, while our model allows for just one capital structure decision, Section 6.2 discusses how leverage adjustments might impact our results. Section 7 concludes.

6.1. Multiple Chapter 11 opportunities

For tractability, we assume that firms can only enter Chapter 11 once, so after reorganizing, equityholders must liquidate if they subsequently default. If we were to extend the model to allow for two Chapter 11 opportunities, we believe this would not significantly change the results. Suppose we allow two Chapter 11 opportunities and consider a history in which the firm chose to default, entered Chapter 11, and has just emerged. When this reorganized firm is choosing its new capital structure, it looks exactly like a firm at Time 0 in our model and makes the exact capital structure decision we described in the previous section. If Choicevalue > 1, then this relevered firm value is more attractive than the corresponding reorganized firm value with only Chapter 7 available in the future. Then, considering a history where the firm has not yet defaulted, Chapter 11 looks more appealing since the reorganized firm value is even higher. Since Choicevalue > 1, the firm was likely already going to choose Chapter 11, and now with two Chapter 11 opportunities, this is even more appealing, so the firm chooses Chapter 11 at the first default. Thus, in this case, the choice of Chapter 7 versus Chapter 11 is unchanged, and the firm likely issues slightly more debt at Time 0 since the first Chapter 11 is now less costly. It is unlikely that this increase in debt is significant since the reduction in the cost of Chapter 11 only occurs in an unlikely state of the world (where the firm defaults and reemerges before a forced conversion) that is heavily discounted.

If Choicevalue = 1, then when the firm emerges from the first Chapter 11, they ignore the option to enter a second Chapter 11 and issue a coupon consistent with future Chapter 7. But then in a history where the firm has not yet defaulted the first time, the first Chapter 11 looks exactly as attractive as it would if there were no second Chapter 11 opportunity. In this case, the firm still chooses Chapter 7 at the first default, and the Time 0 coupon is unchanged.

If Choicevalue < 1, it is possible the second Chapter 11 might change behavior. In particular, the firm value upon emerging from the first Chapter 11 will now be lower than in the current model, which makes the first Chapter 11 less appealing. This could slightly increase debt in the constrained debt Chapter 7 strategy since it is easier for equity to promise ex-post not to enter Chapter 11. However, it could also shift the strategy from optimal inefficient Chapter 11 to the constrained debt Chapter 7 strategy since now the inefficiency of the first Chapter 11 could outweigh the tax benefits of the larger coupon $C_B > \bar{C}$.

In summary, adding a second Chapter 11 might lead to slightly higher debt in some cases, while it could also drastically reduce debt if it causes a firm to shift from the optimal inefficient Chapter 11 strategy to the constrained debt Chapter 7 strategy. There is no change in the intuition if we were to add a third, fourth, or general *n*th Chapter 11 opportunity.

6.2. *Leverage adjustments and dynamic capital structure*

In our model, we assume the firm can only issue debt once (as in Leland, 1994). There is empirical evidence suggesting that some firms adjust their leverage ratios infrequently (Fama and French, 2002; Leary and Roberts, 2005; Korteweg, Schwert, and Strebulaev, 2014). Further, debt covenants are often written with tight interest coverage ratios such that further issuance is restricted even at the inception of the loan (Chava and Roberts, 2008). However, in reality, many firms adjust their book leverage over time: the within-firm standard deviation of book leverage in Compustat is approximately 12% (see Korteweg, Schwert, and Strebulaev, 2014; DeAngelo, DeAngelo, and Whited, 2011; DeAngelo and Roll, 2015; DeAngelo, Goncalves, and Stulz, 2018). Our assumption that firms issue debt once is an abstraction from reality we make for tractability, which has the added benefit that it makes our results simpler to interpret.

One potential means of relaxing this assumption would be to let firms issue callable debt with an indenture restricting further issuance prior to calling existing debt. This is the assumption made in the dynamic capital structure literature (Leland, 1998; Goldstein, Leland, and Ju, 2001; Strebulaev, 2007). The nonlinearity of equity's Chapter 11 bargaining value function would violate the scaling property needed to solve such models. However, we imagine this would not change the implications of our model too drastically. In general, the tax benefits of any particular debt issue are lower in these models since the firm may always refinance with a larger coupon if profitability improves. Thus, at Time 0, firms would generally issue less debt, and in our Case 3, it is more likely that firms would find the constrained debt Chapter 7 strategy optimal than the optimal inefficient Chapter 11 strategy since large coupons are less valuable.

Importantly, the ability to refinance and issue more debt in such a setting would not change the ability of equityholders to credibly commit to Chapter 7. Should equityholders issue a coupon $\bar{C}$ consistent with future Chapter 7, the creditors purchasing this debt would recognize that if equityholders want to issue more debt, the firm would first need to call the outstanding debt at par, defending the existing creditors from devaluation by the shift to an ex-post optimal Chapter 11. This informal logic suggests our constrained debt Chapter 7 strategy would be robust to allowing multiple debt issuances.

7. Conclusion

This paper studies the choice of bankruptcy chapter and its relation to capital structure decisions. We provide a model of an equity value-maximizing firm that decides how much debt to issue then subsequently chooses when and under which bankruptcy chapter to default. We model Chapter 11 reorganization with a novel continuous-time stochastic bargaining model in the style of Merlo and Wilson (1995). Specifically, equityholders and debtholders observe the firm's assets and accumulated cash flows evolve stochastically, and they must unanimously agree when to emerge from Chapter 11 and how to split the firm. The reorganized firm can then issue new debt and continue operating.

There may often be a conflict between the desires of equityholders and creditors in terms of their relative treatment in the two chapters of bankruptcy. Equityholders with larger debt obligations endogenously default in more profitable states in which they prefer the prospect of reorganization. Creditors might enjoy higher recovery rates in Chapter 7 liquidation due to APR. Thus, when the firm issues debt, creditors take these incentives into account and demand higher credit spreads for large coupons that imply a subsequent Chapter 11. In some cases, the model predicts equityholders will optimally issue a coupon that implies a future inefficient Chapter 11, leading to lower leverage and higher credit spreads than the Leland (1994) model. In other cases, equityholders optimally issue a small coupon, such that they will find Chapter 7 optimal ex-post, to obtain a lower credit spread. For a reasonable parameterization of this case, our model predicts an optimal leverage ratio of 40%, while the Leland (1994) model predicts 70%, even though the firm liquidates on the equilibrium path in both models. Stated another way, while in our model the observed bankruptcy behavior may be identical to that of the Leland model in which only liquidation may be undertaken, the off-equilibrium threat of reorganization delivers a much lower optimal leverage ratio. The added option of Chapter 11 actually reduces ex-ante firm value in these cases since equityholders cannot commit to a future Chapter 7 liquidation.

Several extensions of our model may prove illuminating. The model could be generalized to incorporate asymmetric information between equityholders and debtholders given the rich tradition in the corporate finance literature exploiting the implications of hidden information. In addition, the model could be extended to a multiple-firm industry equilibrium (similar to Lambrecht, 2001; Grenadier, 2002; Miao, 2005). The latter extension could produce interesting interactions wherein firms might push rivals toward Chapter 7, rather than Chapter 11, to reduce competition. Finally, the model's framework might prove useful for empirical work aimed at estimating the relative inefficiencies of Chapter 7 and Chapter 11.

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