# The Real Effects of Credit Default Swaps

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**ABSTRACT**

We examine the effect of introducing Credit Default Swaps (CDSs) on firms' investment and financing policies. Our model allows for dynamic investment and dynamic financing using equity and debt, and credit risk can be hedged using CDSs. A calibrated version of the model allows us to do a counterfactual analysis, in which we compare an economy with to an economy without a CDS market. Both the negative effect of CDSs of increasing the probability of bankruptcy and the positive effect of reducing the risk of strategic default are present in the model. The effect of reducing the cost of debt dominates, allowing the firm to gain from a source of financing less costly than equity, which leads to higher investment and firm value. Our model is able to reconcile seemingly conflicting empirical evidence regarding the effect of CDSs in reducing the cost of debt capital and in increasing the default probability. Finally, we show that the real effect on investment and firm value is largest for firms that are small and have high growth opportunities.



*Keywords:* credit default swaps, CDS, empty creditor, restructuring, bankruptcy
*JEL classification:* G33, G34

What is the welfare effect of Credit Default Swaps? Did the introduction of a market for credit risk in the 1990s increase the ability of firms to access financing and therefore improve the broad economy? These questions are fundamentally important, and we argue that we need a more thorough economic analysis to guide the current policy debate on CDS contracts. In this paper we take a first step to look at the positive and negative effects of CDSs simultaneously and to estimate their net effect. From the perspective of a firm we show that while the net effect of credit derivatives on firm value and firm investment can be positive or negative, the net effect is likely to be positive. After calibrating our dynamic model to empirical data we find that for the average public corporation in the U.S. the introduction of a CDS market increases firm value by 4.7%.

The public debate on the welfare effects of CDSs, ignited by the financial crisis, together with CDS related regulatory changes are evidence for the importance of these results. Several investors and market commentators argue that credit derivatives reduce social welfare and should be regulated. Some articles even call for a ban on CDSs.[1] Around the same time and in support of the view that CDSs are useful, financial regulators in the U.S. and Europe have started introducing new rules for the CDS market. On November 1, 2012, the European Union banned trading in the sovereign CDS market without holding the underlying bonds. By 2014, regulators in the U.S. and Europe have implemented rules so that most trading in the CDS market is cleared by central counterparties.[2] The analysis of the costs and benefits of CDS markets presented in our paper could be useful for the current policy discussion.

In order to estimate the net effect of CDSs on firms, we construct a dynamic economy with stock, bond and CDS markets, and calibrate the model to the data. In the model the firm optimally chooses investment and financing each period, allowing for equity and debt issues. Debtholders can trade in the CDS market and purchase or sell CDS protection from a dealer who sets actuarially fair prices. Each period, the firm optimally decides whether to repay the debt, renegotiate with debtholders, or to file for bankruptcy. The model features several well-known frictions, such as equity issuance costs, bankruptcy costs, and renegotiation frictions, which allow us to match several important data moments. The calibrated model allows us to do a counterfactual analysis of what the firm's value, investment and financing would be exactly in the same conditions except for access to credit risk insurance. We show

[1] George Soros wrote in *The Wall Street Journal* on March 24, 2009, that "CDS are toxic instruments whose use ought to be strictly regulated". *Fortune* published an article on June 18, 2012, entitled "Why it's time to outlaw credit default swaps". Similar articles were published by *Financial Times*, March 6, 2009, *The Atlantic*, March 30, 2009, and *The New York Times*, February 27, 2010.

[2] *Financial Times*, October 19, 2011, "EU ban on naked CDS to become permanent", and "New Rules for Credit Default Swap Trading: Can We Now Follow the Risk?", June 24, 2014, Federal Reserve Bank of Cleveland.

how the sign and size of this effect depends on parameters such as bankruptcy costs, debt renegotiation frictions, and bargaining power between equity and debt. Also, we show how the effect changes in relation to firm characteristics such as size, growth opportunities, and financing constraints.

Even though we are ultimately interested in the net effect of CDSs, the model is designed to capture both positive and negative effects. A trade-off between the costs and benefits of CDS contracts has been analyzed by Bolton and Oehmke (2011). On the positive side, CDS contracts allow debtholders to demand better terms in an ex post debt renegotiation, which deters strategic default. Debtholders anticipate this, leading to lower ex ante spreads when the debt is issued and increasing debt capacity. On the negative side, debtholders who are hedged with CDSs demand such a high payoff in renegotiation that equity holders sometimes find it optimal to file for bankruptcy, even though it would be cheaper to renegotiate. This is the so called empty creditor problem first suggested by Hu and Black (2008). The higher probability of bankruptcy is priced in ex ante yielding higher credit spreads.

To the setup described above, we add a tradeoff between debt and equity, whereby equity is a more costly form of financing than debt, and we endogenize the firm's capital structure. In the context of a single-period model, in which the state variable has continuous values and the firm has a flexible production function with continuous investment levels, we analyze the effect of CDS on firm value.

However, in a single-period model the equity holders' incentives to debt renegotiation are distorted because the long-term consequences of renegotiation are not accounted for. Also, while the effect of CDSs depends on the current state, in a static model the analysis is necessarily based on an arbitrary initial point. Therefore, we extend the model to a dynamic setup, in which the firm can invest in long-term real assets and exogenous shocks to firm productivity follow a stochastic process. With a dynamic model we endogenize the current state of the firm and the debt holders' hedging policy, thus excluding off-equilibrium state points that would otherwise distort the quantitative results. More importantly, the long-term consequences of debt renegotiation are properly accounted for, giving a more realistic dynamic of strategic default. Because the analytic results of the single-period model cannot be easily extended to the more general dynamic model, we rely on a numerical simulation analysis to illustrate the effect of CDSs.

We argue that a structural approach is better suited to address the research question on the effect of CDSs on firm value than reduced form estimation techniques. In a perfect experiment, CDS contracts would be randomly assigned to firms, ideally staggered over time.

Unfortunately, that is not the case, and unobservable firm characteristics might be correlated with the assignment of CDSs to firms. Also, it is not easy to find a good source of exogenous variation, like a natural experiment or a strong instrumental variable, in place of a random assignment. Therefore, we propose an analysis based on a calibrated structural model as an alternative technique. This method is used increasingly in corporate finance to answer questions about capital structure (as in Hennessy and Whited (2007)), corporate governance (see Albuquerque and Schroth (2010)), executive compensation (Taylor (2010)), and agency conflicts (see Nikolov and Whited (2014)).

Our dynamic model can explain several recent empirical findings. Ashcraft and Santos (2009) report that CDS contracts increase the cost of debt for high risk firms, while there is no significant effect on the average borrower. Saretto and Tookes (2013) find that firms with CDSs can borrow more and can maintain higher leverage ratios. Subrahmanyam, Tang, and Wang (2014) report that the introduction of CDS markets increases the probability of bankruptcy, although this need not imply that the firm value is reduced by CDSs. Using a sample of out-of-court debt restructurings, Danis (2014) shows that if bondholders are more likely to hold CDSs, it is more difficult for a firm to reduce its debt through a restructuring. Also, he finds that after a change in the standard CDS restructuring clause that makes it more likely that a protection buyer is an empty creditor, there are fewer out-of-court debt restructurings for firms with CDSs, but there is no such decrease for firms without CDSs. All these contributions try to estimate the causal effect of CDS contracts on firm outcomes. They use instrumental variables and natural experiments as plausible sources of exogenous variation. In our model, however, we can easily compare an economy with and without a CDS market to estimate its purely causal effect on firm outcomes.

In addition to our findings on the net effect for the average public corporation in the U.S., we look at how the effect of CDSs depends on different firm characteristics. We find that small firms and firms with high growth opportunities benefit the most from the introduction of credit derivatives. For other types of firms the net effect is smaller. This does not imply that CDS contracts have no effect at all. Our model predicts that higher hedge ratios for debtholders lead to fewer strategic defaults and more bankruptcies. It is rather that the two offset each other in their effect on investment and firm value. Finally, we do not find a type of firm with negative effects on firm value.

Our paper is contributes to several strands in the literature. First, the literature on the costs and benefits of introducing CDS markets. From the perspective of the firm, we have mentioned the empirical findings of Ashcraft and Santos (2009), Saretto and Tookes (2013), Subrahmanyam, Tang, and Wang (2014), and Danis (2014). On the theoretical side, Bolton and Oehmke (2011) provide a stylized model that predicts both positive and negative effects on firms. Outside of corporate finance there are several other contributions. Duffee and Zhou (2001) and Morrison (2005) examine the effect of CDS contracts on bank loans. Fostel and Geanakoplos (2012) show how the CDS market may have contributed to the crash of 2007-2009. Oehmke and Zawadowski (2014) explore the effect of CDS markets on the liquidity in the corporate bond market, and Chernov, Gorbenko, and Makarov (2013) show that CDS auctions can be biased. Among these theoretical contributions, our paper is most closely related to Bolton and Oehmke (2011), as the channels through which CDSs affect firm value are very similar. While the other papers are important contributions for our understanding of CDS markets, they do not model the effect of CDSs on the interaction of equity holders and debtholders. In this sense, we focus on the corporate finance aspect of credit derivatives. However, the breadth of this literature suggests that for a full welfare analysis it might be necessary to include other aspects of the CDS market as well.

Second, the literature on credit risk and strategic default. On the theoretical side, Anderson and Sundaresan (1996), Mella-Barral and Perraudin (1997), Mella-Barral (1999), Fan and Sundaresan (2000), Hege and Mella-Barral (2005), and Acharya, Huang, Subrahmanyam, and Sundaram (2006) examine the effect of strategic default on credit risk. On the empirical side, Davydenko and Strebulaev (2007) find that the risk of strategic default is reflected in credit spreads. Favara, Schroth, and Valta (2012) use a cross-country sample to show that strategic default risk affects equity beta and volatility. Our model differs from the existing theories in several ways. First, we endogenize the firm's investment policy, whereas most authors assume an exogenous cash flow process. Second, we expand the strategic interaction between equity holders and debtholders. In the game at the beginning of each period, the equity holders choose their investment and financing policies and strategically decide whether to repay the debt, to renegotiate the debt, or to file for bankruptcy. The debtholders, on the other hand, strategically trade in the CDS market in order to deter the firm from strategic default. In the second game at the end of the period, played when debt is renegotiated, the two claimholders engage in Nash bargaining which determines the renegotiated debt level. Our strategic analysis shows how CDS markets can mitigate the strategic default problem identified in this literature.

# I. A dynamic model with investment and debt renegotiation

We make the usual assumptions about the economy for a partial equilibrium dynamic capital structure model. The horizon is infinite and time is discrete. All agents in the model are risk–neutral and the discount factor is $\beta \in ]0,1[$. Following Cooley and Quadrini (2001), we will model a representative firm owned by an entrepreneur, who makes investment and financing decisions to maximize her own value.

The main driver of the model is the firm's profit shock, $z$, a continuous-state Markov process with compact support and whose transition probability $\Gamma(z, dz') = \Pr\{dz'|z\}$ satisfies the Feller property. For definiteness, we will assume that the evolution of $\log z$ is an AR(1) process, $\log z' = \rho \log z + \sigma\varepsilon'$, where $\varepsilon$ are i.i.d. draws from a truncated standard Normal distribution, and $\rho \in ]0,1[$ and $\sigma > 0$ are parameters that will be calibrated later on.

The firm's production function determines the cash flow from operations: $\pi(z,k) = zk^\alpha - f$, where $k$ is the capital stock, $\alpha \in ]0,1[$ is the return to scale parameter, and $f$ is a fixed production cost. Capital depreciates over time at a rate $\delta \in ]0,1[$. The contract issued by the firm to raise debt financing is an unsecured zero coupon bond, with face value $b$ decided by the firm's owner at issuance. Both $k$ and $b$ are assumed non–negative.

The state of a firm at a given date is described by $(z,k,b)$, where $k$ and $b$ have been decided upon at the prior date, and $z$ is observed at the current date. For convenience, we define the *ex post book value of the asset*

$$a(z,k) = (1-\delta)k + \pi(z,k), \tag{1}$$

and we denote $w$ the firm's current *net worth*,

$$w = w(z,k,b) = a(z,k) - b. \tag{2}$$

Based on $(z,k,b)$, or equivalently, given equation (2), on $(z,w)$, the owner decides whether to pay the debt in full and continue with the operations, to renegotiate the debt, or to file for bankruptcy and liquidate the firm. In what follows we will characterize these different decisions and the consequences for the credit risk of the debt.

We denote $V(z,w)$ the *cum-dividend equity value* at the current state $(z,w)$, which results from the owner's optimal choice of dividend payment, $d$,

$$V(z,w) = \max_d \left\{ d^+ + (1+\lambda)d^- + v(z, w-d) \right\}, \tag{3}$$

where $d$ can have either sign and if it is negative it corresponds to the injected equity capital. In this case, we assume that the firm incurs a transaction cost $\lambda$ per unit of equity capital. In (3), $v(z, w-d)$ denotes the market value of the firm's equity, to be determined later, at the *revised net worth*, $e = w - d$, determined by the payout decision.

At $(z,k,b)$, the decision of paying back the debt is optimal when the value of equity, $V(z,w)$, is sufficiently high. However, there are states in which instead of repaying the debt, the owner maximizes her value by renegotiating the debt obligation, or by liquidating the firm. Given the liquidation/bankruptcy cost $\xi \geq 0$, if the liquidation value of the firm's asset, $(1-\xi)a(z,k)$, is not lower than $b$, then the threat to liquidate posed by the owner is not credible, and therefore she will repay the par value. It is only if $(1-\xi)a(z,k) < b$, or equivalently $w < \xi a(z,k)$, that renegotiation can take place because the threat is credible, as debt holders can get a payoff lower than $b$ if renegotiation fails. While $w < \xi a(z,k)$ is necessary, it is not a sufficient condition for debt renegotiation, as in this case the owner can still optimally choose to repay the debt.

We denote $b_r$ the debt payment resulting from a Nash sharing rule between the owner and debt holders. In this case the owner gets $V(z, w_r)$, where $w_r = w(z,k,b_r)$, and the ensuing revised net worth is $e = w_r - d$, where $d$ is the argmax of the program in (3) solved at $w_r$. In what follows, we will assume a given bargaining power of the debt holders, gauged by $q \in [0,1]$. The solution to the bargaining game is

$$b_r(z,k,b) = \arg\max_p \left[V(z, w(z,k,p))\right]^{1-q} \times \left[p - (1-\xi)a(z,k)\right]^q, \tag{4}$$

with constraints

$$p \geq (1-\xi)a(z,k), \text{ and } p \leq a(z,k) - w_d(z),$$

where $w_d(z) \leq 0$ is defined as the unique zero of $V(z,\cdot)$: $V(z, w_d(z)) = 0$.[3] Alternatively, renegotiation is not feasible if $a(z,k) - w_d(z) < (1-\xi)a(z,k)$, or equivalently if $w_d(z) >$

[3] The second constraint derives from the assuption that the outcome of renegotiation is acceptable to the owner if $V(z, w(z,k,p)) \geq 0$, or equivalently $V(z, w(z,k,p)) \geq V(z, w_d(z))$ by definition of $w_d(z)$. Therefore, from $w(z,k,p) \geq w_d(z)$, using equation (2), we have $a(z,k) - p \geq w_d(z)$. It results that $w_d(z) \leq 0$ , because the continuation value of the firm is non-negative. As a consequence of this, if $w_d(z) < 0$, the bargaining space for problem (4) would be non-empty even if we assumed $\xi = 0$.

$\xi a(z, k)$. Clearly, the latter condition is never satisfied, because $a(z, k) \geq 0$ and $w_d(z) \leq 0$. So renegotiation is always feasible and liquidation would never occur in a model without CDS.[4]

To match the empirically observed occurrence of bankruptcy/liquidation also in a model with strategic debt service, following Davydenko and Strebulaev (2007), we assume that renegotiation may fail for exogenous reasons with probability $\gamma \in [0, 1[$, in which case the firm is liquidated, the debt holders receive $(1 - \xi)a(z, k)$ and the owner nothing. The liquidated firm exits the economy and is replaced by a new firm with initial net worth $e = w_d(z)$. A timeline describing the above options is offered in Figure 1.

We denote $\mathcal{V}(z, w)$ the *revised equity value*, as resulting from the owner's decision on debt repayment. In states $(z, w)$ where $w \geq \xi a(z, k)$, the owner will repay the debt and $\mathcal{V}(z, w) = V(z, w)$. Otherwise, for $w < \xi a(z, k)$ with $b > 0$, she will renegotiate if this is better than repaying the debt. With probability $(1 - \gamma)$, renegotiation will be successful, the debt payment is $b_r = b_r(z, k, b)$ and the revised equity value is $\mathcal{V}(z, w) = V(z, w_r)$, with $w_r = w(z, k, b_r)$. With probability $\gamma$ renegotiation will fail, in which case the debt payment is $(1 - \xi)a(z, k)$ and $\mathcal{V}(z, w) = 0$. Therefore, the expected value from renegotiation is $(1 - \gamma)V(z, w_r)$. Finally, when $w < \xi a(z, k)$ with $b = 0$, the firm will be liquidated. To summarize

$$\mathcal{V}(z, w) = \begin{cases} V(z, w) & \text{if } w \geq \xi a(z, k) \\ \max\{V(z, w), (1 - \gamma)V(z, w_r)\} & \text{if } w < \xi a(z, k), b > 0. \\ 0 & \text{if } w < \xi a(z, k), b = 0. \end{cases} \tag{7}$$

[4] The problem in (4) cannot be solved analytically, because also $V$ must be found numerically. Therefore, we will determine $b_r(z, k, b)$ by solving the first order condition of the problem, which is

$$(q - 1)\frac{\partial V(z, w)}{\partial w}\left[b_r - (1 - \xi)a(z, k)\right] + qV(z, w(z, k, b_r)) = 0. \tag{5}$$

However, a convenient approximation of the solution can be obtained by observing that $V$ is a smooth function and generally

$$V(z, w_2) - V(z, w_1) \approx \left.\frac{\partial V(z, w)}{\partial w}\right|_{w=w_1}(w_2 - w_1), \tag{6}$$

if $w_2$ and $w_1$ are sufficiently close to each other. Putting $w_1 = w(z, k, b_r)$ and $w_2 = w_d(z)$, then the second addend in (5) is replaced, and we can find a convenient approximation of the renegotiated debt payment:

$$b_r(z, k, b) \approx (1 - q)(1 - \xi)a(z, k) + q\left[a(z, k) - w_d(z)\right].$$

In equilibrium $b_r \leq b$. To show this, if $b_r$ were higher than $b$, then in equation (7) $V(z, w)$ would be higher than $(1-\gamma)V(z, w_r)$, and repayment would be optimal instead of renegotiation, which results in a contradiction.

Given the revised net worth $e$ as per the above discussion, the owner makes an optimal decision for next period capital stock, $k'$, and debt, $b'$, from which $v$ is determined:

$$v(z, e) = \max_{(k', b')} \beta \int \mathcal{V}(z', w')\Gamma(z, dz'), \tag{8}$$

where the optimal decision is restricted by condition

$$k' - m(z, k', b') = e, \tag{9}$$

$w' = w(z', k', b')$, from equation (2), and $k' \geq 0$ and $b' \geq 0$. In (9), $m(z, k', b')$ is the market value of newly issued debt, with face value $b'$, when the new capital stock for the next period is $k'$. The price $m$, derived in equilibrium, is derived here below as a function of the firm's optimal policy and the stochastic evolution of $z$.

Given the optimal renegotiation policy, the ex-ante equilibrium price of the debt contract at $(z, k, b)$ is

$$\begin{aligned} m(z, k', b') = \frac{1}{1+r} \Bigg\{ & \int \Phi_c(z', k', b')b' \ \Gamma(z, dz') \\ & + \int \Phi_r(z', k', b') \left[(1-\gamma)b_r(z', k', b') + \gamma(1-\xi)a(z', k')\right] \ \Gamma(z, dz') \Bigg\}, \end{aligned} \tag{10}$$

where $(k', b')$ are from the optimal investment/financing policy of the firm at $(z, k, b)$ and $\Phi_r$, and $\Phi_c$ are the indicator functions for the states in which the owner renegotiates and repays the debt, respectively. In the second addent on the right-hand side of (10) we have the payoff if renegotiation is successful with probability $(1-\gamma)$, or the liquidation value if renegotiation is unsuccessful with probability $\gamma$. In equation (10), similarly to Cooley and Quadrini (2001), we assume that $0 < r < 1/\beta - 1$.

The algorithm to numerically find $v$ and the optimal policy is based on value iteration on a discretized state space and comprises the following stages. At each step of the iteration, based on a guess for $v$, we solve equation (3) for all $(z, w)$ to determine $V$ and the payout policy. Then, we find $w_d(z)$ as the zero of $V(z, \cdot)$ using linear interpolation. If the current state is $w < \xi a(z, k)$, we determine $V(z, w(z, k, b_r))$ using linear interpolation, where the current net worth is redefined through equation (2) and $b_r(z, k, b)$ is from (4). At this point, given $\mathcal{V}(z,w)$ from (7) we solve problem (8) with condition (9), where $m(z,k',b')$ is found in (10). To keep the model stationary, we assume that if a firm is liquidated, it is replaced by a new firm, which is started at the value $V(z,w_d(z))=0$, and therefore it immediately makes an optimal investment and financing decision based on $e=w_d(z)$ as per program (8).

# II. Debt renegotiation with a CDS market

There is a competitive market for insuring against credit risk. In particular, debt holders can purchase a credit default swap (CDS) from a dealer (protection seller) at the time the debt contract is issued. The CDS dealer and the debt holders (credit protection buyer) agree on the fraction $h$ of the debt exposure covered by the CDS contract and on the CDS spread (the insurance premium), which accounts for the probability of default on the debt contract, as per the firm's optimal decisions, and for the default severity. In the model, the credit event that triggers the CDS payment is bankruptcy/liquidation. An out-of-court debt restructuring does not trigger a CDS payment, in line with the Standard North American Contract (SNAC) of the International Swaps and Derivatives Association (see, for example, Bolton and Oehmke (2011)). The debt holders choose the hedge ratio to maximize their value. Because we assumed that the credit risk market is competitive, the CDS spread is fair (and the transaction has zero–NPV for the protection seller). In the first part of this section, $h$ will be an arbitrary hedge ratio. We will discuss later how the optimal hedge ratio is determined by solving the debt holders' optimal program.

With respect to the case presented in the previous section, when a CDS market is introduced, the firm's program depends not only on $(z,w)$, but also on the hedge ratio, $h$, chosen by the debt holders in the prior period. As before, we denote the revised equity value that accounts for the owner's default decision with $\mathcal{V}(z,w,h)$. If $w\geq \xi a(z,k)$, the threat of renegotiation is not credible and debt is repaid in full. The payoff to equity holders is $\mathcal{V}(z,w,h)=V(z,w)$, where $V(z,w)$ is calculated in (3).

In the case where $w<\xi a(z,k)$ and $b>0$, the threat of renegotiation is credible, and the Nash bargaining game is

$$b_r(z,k,b,h)=\arg\max_p \left[V(z,w(z,k,p))\right]^{1-q}\times\left[p-hb-(1-h)(1-\xi)a(z,k)\right]^q, \qquad (11)$$

with constraints

$$p \geq hb + (1-h)(1-\xi)a(z,k), \text{ and } p \leq a(z,k) - w_d(z), \tag{12}$$

where $hb$ is the payoff associated with the hedged fraction of the debt, and $(1-h)(1-\xi)a(z,k)$ is the payoff for the uninsured part of the debt. Renegotiation is not feasible if $a(z,k) - w_d(z) < hb + (1-h)(1-\xi)a(z,k)$, or equivalently, if

$$h > \frac{\xi a(z,k) - w_d(z)}{\xi a(z,k) - w} = H(z,w), \tag{13}$$

where the $H(z,w)$ is positive, as $w_d(z) \leq 0$. When (13) is satisfied, then the debt is repaid if $V(z,w) \geq 0$, and the firm is liquidated if $V(z,w) < 0$. The owner's payoff is $\mathcal{V}(z,w,h) = V(z,w)$ in the case of repayment and $\mathcal{V}(z,w,h) = 0$ in the case of liquidation.

If renegotiation is feasible, $h < H(z,w)$, the owner prefers debt repayment to renegotiation if $V(z,w) \geq (1-\gamma)V(z,w_r)$, where $w_r = w(z,k,b_r)$, and her payoff is $\mathcal{V}(z,w,h) = V(z,w)$; otherwise, she prefers renegotiation with expected payoff $\mathcal{V}(z,w,h) = (1-\gamma)V(z,w_r)$. Figure 2 depicts the owner's optimal default decision and the corresponding payoffs with $b > 0$.[5] Finally, if $w < \xi a(z,k)$ and $b = 0$, the firm is liquidated. Therefore, the owner's payoffs is

$$\mathcal{V}(z,w,h) = \begin{cases} V(z,w) & \text{if } w \geq \xi a(z,k), \\ \max\{V(z,w), 0\} & \text{if } w < \xi a(z,k), b > 0, h > H(z,w), \\ \max\{V(z,w), (1-\gamma)V(z,w_r)\} & \text{if } w < \xi a(z,k), b > 0, h \leq H(z,w) \\ 0 & \text{if } w < \xi a(z,k), b = 0 \end{cases} \tag{15}$$

The dependence of $\mathcal{V}$ on $h$ is set through $b_r(z,k,b,h)$ and through the dependence of the payoff on the relation between $h$ and $H(z,w)$.

[5] As before, when renegotiation occurs, the first order condition to find $b_r(z,k,b,h)$ is solved numerically:

$$(q-1)\frac{\partial V(z,w)}{\partial w}\left[b_r - hb - (1-h)(1-\xi)a(z,k)\right] + qV(z,w(z,k,b_r)) = 0. \tag{14}$$

Using the same linearization as in (6), a convenient approximation of the renegotiated value is

$$b_r(z,k,b,h) \approx (1-q)\left[hb + (1-h)(1-\xi)a(z,k)\right] + q\left[a(z,k) - w_d(z)\right].$$

Accordingly, we define the indicator function $\Phi_c$ for the states where the owner repays debt and continues operations, $\Phi_r$ for the states where she renegotiates the debt, and $\Phi_\ell$ for liquidation.

So far, the firm's optimal program in (3), (8) with condition (9), has been solved assuming that there is a schedule of equilibrium debt prices, $m$, and the corresponding optimal hedging policy, $h'$, for each possible $(z, k', b')$. However, $m$ and $h'$ must be found simultaneously, as they are interdependent through the debt holder's optimal decision. In what follows we will assume that the owner's optimal policy, characterized by the indicator functions $(\Phi_c, \Phi_r, \Phi_\ell)$, has been already determined for all possible state points $(z, k, b)$ and arbitrary $h$'s, as seen above.

Under the assumption of a competitive market for credit risk, the current price of credit protection for a given $h'$, to be paid at the end of the period, is the expectation of the net payment from the protection seller:

$$C(z, k', b', h') = \int (h'b' - h'(1-\xi)a(z', k'))\,[\gamma\Phi_r(z', k', b', h') + \Phi_\ell(z', k', b', h')]\;\Gamma(z, dz').$$

From the right-hand side of this expression, credit insurance only covers the loss in case of firm's liquidation, whether this follows from failed renegotiation or because renegotiation is made infeasible by a high hedge ratio $h$. This latter case is exactly the empty creditor problem, as in Hu and Black (2008) or in Bolton and Oehmke (2011).

For all possible $h'$, the end–of–period payoff to debt holders for given capital $k'$ and face value $b'$ is

$$\begin{aligned}\varphi(z', k', b', h') = b\;\Phi_c(z', k', b', h') + b_r(z', k', b', h')\;(1-\gamma)\Phi_r(z', k', b', h')\\ + [h'b' + (1-h')(1-\xi)a(z', k')]\;\,[\gamma\Phi_r(z', k', b', h') + \Phi_\ell(z', k', b', h')]\,. \quad (16)\end{aligned}$$

In this expression, the first term is the payment when the firm is solvent, the second term is the payoff from renegotiation, and the third term is the payoff when the firm is liquidated. The expected value of the debt for a given hedge ratio, $h'$, net of the cost of the CDS is therefore

$$M(z, k', b', h') = -C(z, k', b', h') + \int \varphi(z', k', b', h')\;\Gamma(z, dz'),$$

and using the definition of $C(z,k',b',h')$, the expression can be simplified to

$$M(z,k',b',h') = \int \{b'\ \Phi_c(z',k',b',h') + b_r(z',k',b',h')\ (1-\gamma)\Phi_r(z',k',b',h') \\ +(1-\xi)a(z',k')\left[\gamma\Phi_r(z',k',b',h') + \Phi_\ell(z',k',b',h')\right]\}\ \Gamma(z,dz').$$

Then the debt holders' program is to maximize the value of their claim by choosing the hedge ratio,

$$m(z,k',b') = \max_{h'} \frac{1}{1+r} M(z,k',b',h'), \tag{17}$$

and the argmax of the above program, $h' = h(z,k',b')$, is the state–contingent optimal hedge ratio that is considered in the owner's program

$$v(z,e) = \max_{(k',b')} \beta \int \mathcal{V}(z',w',h')\Gamma(z,dz'), \tag{18}$$

where the optimal decision is also in this case restricted by condition (9). This closes the problem for the case of an economy with CDS market.

The algorithm to solve this program is similar to the one in the previous section, with the differences that $h$ and $m$ are found using equation (17), in place of (10), and solving program (11) in place of (4).

# III. The single–period model

In order to derive some preliminary intuitions on the effect of CDSs on investment, financing, and default policy, we simplify the setup developed in the previous sections by considering a single-period version of our model. The resulting model can be compared to Bolton and Oehmke (2011) model, with respect to which we allow the firm to tap also external equity to finance investment, as opposed to use only debt. This difference has important consequences as per the overall real effect of CDSs.

Given the current $z$ and the initial net worth $e$, the firm chooses $k'$ and $b'$ by solving the program in (18) subject to the constraint in (9). The debt holders' program is to maximize the value of their claim by choosing the optimal hedge ratio in program (17), and the argmax is $h' = h(z,k',b')$, the state–contingent optimal hedge ratio that is considered in the owner's program. $M(z,k',b',h')$ is the expected payoff to debt holders, which we will derive below for the single period model.

The payoff to equity at the end of the period, $\mathcal{V}$ defined in (15), depends on the ex post value net worth, $w' = a(z', k') - b' = a' - b'$, and on the owner decision regarding debt repayment. Therefore,

$$\mathcal{V}(z', w', h') = \begin{cases} a' - b' & \text{if debt is repaid} \\ a' - b_r & \text{if debt is succesfully renegotiated} \\ \max\{(1-\xi)a' - b', 0\} & \text{if the firm is liquidated.} \end{cases}$$

The corresponding payoff to debt is respectively $b'$, and $b_r$, the renegotiated value derive later on, in the first two cases. In the case of liquidation, the payoff to debt is $h'b' + (1-h')(1-\xi)a'$ if $(1-\xi)a' \leq b'$, or equivalently $w' \leq \xi a'$, or $b'$ otherwise. We will derive the optimal default decision for the two cases $w' > \xi a'$ and $w' \leq \xi a'$ separately here below.

## A. The optimal default policy

When the owner's liquidation payoff is positive, $w' > \xi a'$, the threat of renegotiation is not credible because the debtholders can recover the full face value of debt in liquidation. The owner herself prefers repayment to liquidation, because the repayment payoff, $a' - b'$, is higher than the liquidation payoff, $(1-\xi)a' - b'$. Therefore, debt is always repaid if $w' > \xi a'$. The payoffs are $a' - b'$ for equity and $b'$ for debt.

If the liquidation payoff to equity is zero, $w' \leq \xi a'$, then debt renegotiation leads to the Nash bargaining problem

$$b_r(z', k', b', h') = \arg\max_p \left[a' - p\right]^{1-q} \times \left[p - h'b' - (1-h')(1-\xi)a'\right]^q,$$

with constraints $a' \geq p$ and $p \geq h'b' + (1-h')(1-\xi)a'$. Renegotiation is feasible if

$$h'b' + (1-h')(1-\xi)a' \leq a'. \tag{19}$$

If renegotiation is feasible, the solution is

$$b_r(z', k', b', h') = h'b' + (1-h')(1-\xi)a' + q[a' - h'b' - (1-h')(1-\xi)a']. \tag{20}$$

Debt repayment is preferred to renegotiation when $a' - b' \geq (1-\gamma)(a' - b_r)$, or

$$a'\left[1 - (1-\gamma)(1-q)s(h')\right] \geq b'\left[1 - (1-\gamma)(1-q)h'\right], \tag{21}$$

where $s(h') = \xi + h'(1-\xi)$. Renegotiation feasibility depends on the sign of $s(h') = \xi + h'(1-\xi)$, whose only zero is

$$h_0 = -\frac{\xi}{1-\xi} < 0.$$

When $h' > h_0$ (i.e., $s(h') > 0$), renegotiation is feasible if

$$a' \geq \frac{h'b'}{1-(1-h')(1-\xi)} = a_R. \tag{22}$$

Because the numerator of the last term in the right–hand side is negative when $h' \in ]h_0, 0]$, then renegotiation is feasible for all $a' > 0$. Otherwise, for $h' > 0$, renegotiation is feasible for $a' \geq a_R > 0$. When $h' = h_0$ (i.e., $s(h') = 0$), then (19) is always satisfied, and so renegotiation is feasible for all $a' > 0$. Finally, if $h' < h_0$ (i.e., $s(h') < 0$), renegotiation is feasible if $a' \leq a_R$, and in this case $a_R > 0$. Therefore, renegotiation is feasible for $a' \in ]0, a_R]$ when $h' < h_0$.

The choice between repayment and renegotiation depends on the sign of $1-(1-\gamma)(1-q)s(h')$, and the only zero of this function is

$$h_1 = \frac{1-\xi(1-q)(1-\gamma)}{(1-q)(1-\xi)(1-\gamma)}, \tag{23}$$

with $h_1 > h_0$, and $h_1 > 1$. When $h' < h_1$ (i.e., $1-(1-\gamma)(1-q)s(h') > 0$), repayment is optimal for

$$a' \geq \frac{b'\left[1-h'(1-\gamma)(1-q)\right]}{1-(1-\gamma)(1-q)s(h')} = a_P. \tag{24}$$

Because the numerator in the second term defining $a_P$ is negative for $1/[(1-\gamma)(1-q)] \leq h'$, and because $1/[(1-\gamma)(1-q)] < h_1$ (this is equivalent to $(1-\gamma)(1-q) < 1$, which is consistent with our assumptions), then for $h' \in [1/[(1-\gamma)(1-q)], h_1[$, $a_P \leq 0$, and repayment is optimal for all $a' > 0$. Otherwise, for $h' \leq 1/[(1-\gamma)(1-q)]$, repayment is optimal for $a' \geq a_P$.

If $h' = h_1$ (i.e., $1-(1-\gamma)(1-q)s(h') = 0$), the left–hand side of (21) vanishes, and in the right–hand side, from $1-(1-\gamma)(1-q)h_1$, after rearranging, we have $-\xi[\gamma + q(1-\gamma)]/(1-\xi)$, which is negative. Because the left–hand side is zero and the right–hand side is negative, then (21) is true and repayment is preferred to renegotiation for all $a' > 0$.

When $h' > h_1$ (i.e., $1-(1-\gamma)(1-q)s(h') < 0$), repayment is optimal for $a' \leq a_P$. However, for $h' > h_1$, we have that also $[1-h'(1-q)] < 0$ in (24). Therefore $a_P > 0$, and repayment is optimal for $a' \in ]0, a_P]$.

When renegotiation is not feasible, the equity payoff is $a' - b'$ under repayment and zero under liquidation. Therefore, if $a' \geq b'$, the owner prefers repayment, and if $a' < b'$, she prefers liquidation.

**Proposition 1.** *Given the choices $k'$ and $b'$:*

1. *at $t$, the equilibrium hedge ratio is $h' \in [0, 1]$;*

2. *at $t+1$, it is optimal for the owner to repay the debt for $a' \geq a_P$, to attempt renegotiation for $a_R \leq a' < a_P$, and to liquidate the firm for $a' < a_R$, where $a_R < b' < a_P$, and $a_P$ is defined in equation (24), and $a_R$ in equation (22).*

The proof of the proposition is in Appendix. Figure 3 shows the optimal default decision for different $h'$. If $h'$ is negative (Case (a)), renegotiation is always feasible, and the firm is never liquidated deliberately. If the asset value $a'$ is higher than $a_P$, the debt is repaid in full. If it is lower than $a_P$, the debt is renegotiated. For intermediate values of $h'$ (Case (b)), liquidation, renegotiation, and repayment are all possible in equilibrium. Low asset values lead to liquidation, intermediate asset values trigger renegotiation, and values of $a'$ lead to repayment of debt. Finally, if the hedge ratio $h'$ is higher than one (Case (c)), renegotiation is never feasible. In this case, the firm is liquidated if $a' < b'$, and debt is repaid if $a' \geq b'$. Proposition 1 states that in equilibrium Case (b) prevails.

The general model and the above solution nests also the model and solution without a CDS market. More details about this case are in Appendix. Figure 3, in the case where $h' \leq 0$, shows that if the bondholders have no CDS protection; i.e. $h' = 0$, the debt is renegotiated if $a' < a_P$, and debt is repaid if $a' \geq a_P$.

## B. Valuation of corporate securities

Given Proposition 1, we can focus on Case (b) in Figure 3. Therefore, we will derive the value of equity and debt for this case only. While $a_P$ and $a_R$ are functions of $(b', h')$, and $b_r$ is a function of $(a(z', k'), b', h')$, we suppress these dependences for notational convenience.

The value of equity is

$$v(z,e) = \max_{(k',b')} \beta \left[ \int_{a^{-1}(a_R)\vee 0}^{a^{-1}(a_P)\vee 0} (1-\gamma)(a(z',k') - b_r)\Gamma(z,dz') \right.$$
$$\left. + \int_{a^{-1}(a_P)\vee 0}^{\infty} (a(z',k') - b')\Gamma(z,dz') \right], \quad (25)$$

with constraint $e = k' - m(z,k',b')$. In (25), $b_r = b_r(z',k',b',h')$ is from equation (20), based on the optimal $h'$, $a^{-1}$ is the inverse of the function $a(z',k')$ defined in (1) with respect to its first argument while $k'$ is kept constant, and $x \vee y = \max\{x,y\}$.

The price of credit protection for a given $h' \in [0,1]$, to be paid at the end of the period, is the expectation of the net compensation from the protection seller:

$$C(z,k',b',h') = \int_0^{a^{-1}(a_R)\vee 0} [h'b' - h'(1-\xi)a(z',k')]\ \Gamma(z,dz')$$
$$+ \int_{a^{-1}(a_R)\vee 0}^{a^{-1}(a_P)\vee 0} \gamma[h'b' - h'(1-\xi)a(z',k')]\ \Gamma(z,dz')\ \Gamma(z,dz'). \quad (26)$$

For $h' \in [0,1]$, the expected payoff to debt holders, including the payment from the protection seller in case of a credit event, but excluding the insurance premium $C(z,k',b',h')$, is

$$\psi(z,k',b',h') = \int_0^{a^{-1}(a_R)\vee 0} [h'b' + (1-h')(1-\xi)a(z',k')]\ \Gamma(z,dz')$$
$$+ \int_{a^{-1}(a_R)\vee 0}^{a^{-1}(a_P)\vee 0} \Big[(1-\gamma)b_r + \gamma[h'b' + (1-h')(1-\xi)a(z',k')]\Big]\ \Gamma(z,dz') + \int_{a^{-1}(a_P)\vee 0}^{\infty} b'\ \Gamma(z,dz'). \quad (27)$$

The expected value of the debt for a given hedge ratio, $h'$, net of the cost of the CDS is

$$M(z,k',b',h') = -C(z,k',b',h') + \psi(z,k',b',h').$$

Therefore, the price of debt and the optimal $h'$ are found as solution of the program

$$m(z,k',b') = \max_{h'} \frac{1}{1+r} \left[ \int_0^{a^{-1}(a_R)\vee 0} (1-\xi)a(z',k')\ \Gamma(z,dz') \right.$$
$$\left. + \int_{a^{-1}(a_R)\vee 0}^{a^{-1}(a_P)\vee 0} [(1-\gamma)b_r + \gamma(1-\xi)a(z',k')]\ \Gamma(z,dz') + \int_{a^{-1}(a_P)\vee 0}^{\infty} b'\ \Gamma(z,dz') \right]. \quad (28)$$

The total firm value is then $v(z,e)+m(z,k^*,b^*)$, where $(k^*,b^*)$ are the argmax of (25).

## C. Comparative statics

To illustrate the impact of the costs and benefits associated with renegotiation and therefore of CDSs, we solve the single-period model, meaning we solve equation (25) and (28) simultaneously, and report the optimal value of several metrics that characterize either the current status or the policy of the firm. Because of the assumption that $\log z'$ is conditionally distributed as a truncated normal (between $\pm 3$ times the unconditional standard deviation), we must solve the problem numerically.[6]

The metrics we focus on are the value of equity, $v(z,e)$, the value of debt, $m(z,k^*,b^*)$, the total firm value $v(z,e)+m(z,k^*,b^*)$, the optimal capital stock, $k^*$, the optimal face value of debt $b^*$, quasi-market leverage, $b^*/(b^*+v(z,e))$, the optimal hedge ratio, $h^*$, the credit spread on newly issued debt, the probability of renegotiation, and the probability of liquidation at the end of the period.

Figures 4, 5, and 6 present sensitivity analysis of the above metrics for the model based on the parameters in Table I. These plots are necessarily based on a specific starting point $(z,k,b)$. We choose $z=1$, the intermediate value of $z$, $k=49$, and $b=46$, so that the current state is representative of the steady state of the dynamic model summarized in Table III, which will be clarified later on. Also, this is a point in which the firm is repaying the current debt, so to avoid the issue of sorting the current optimal default strategy for the firm.

Across all three plots, we see that firm value is higher with a CDS market compared to an economy without CDSs. Equity value is uniformly lower with CDS contracts. Since firm value is defined as the sum of equity and debt, the loss in equity value is more than offset

[6] However, in this case, the numerical approach is more accurate than the one we use for the dynamic model, because here it is based on global adaptive quadrature.

by the gain in debt value. The intuition for the increase in debt value, which is also the cause of the increase in firm value, is the following. A CDS market allows debtholders to commit to a stronger bargaining position in case of ex post debt renegotiation. Debtholders make heavy use of this commitment device, as can be seen in the subplots for the hedge ratio. This reduces the equity holders' incentive to engage in unnecessary renegotiation, or strategic default, ex post. Bondholders anticipate this positive effect, which reduces credit spreads ex ante. Firms then make use of the lower cost of debt financing, they invest more (see subplots for capital stock), and they financing that investment with debt instead of equity financing (see subplots for debt).

The subplots for the probability of renegotiation show an increase after the introduction of CDS markets, which seems counterintuitive. The reason is that the reduction in the cost of debt is so large that firms want to issue more debt, which actually increases the likelihood of renegotiation in equilibrium. On of the consequences of using more debt is an increase in the leverage ratio, which can be seen in the subplots for quasi-market leverage.

The effect of CDSs on the cost of debt is remarkable. The subplots for the credit spread show that the cost of debt decreases after the introduction of a CDS market. However, this reduction is observable even though the firm issues significantly more debt with CDSs. These findings suggest that if the face value of debt was held constant, the reduction in credit spreads would be even larger.

Looking only at Figure 4 allows us to understand the effect of debtholders' bargaining power. We see that the amount of value created by CDS markets is highest for low values of $q$, and is monotonically decreasing for higher values of $q$. The intuition for this is that with a low $q$, equity holders can reduce the debt a lot more in renegotiation. This is an outcome that debtholders want to avoid, so they buy more CDS protection, as can be seen in the subfigure for the hedge ratio. In the limit, as $q$ moves closer to 1, debtholders have all the bargaining power. Equity holders cannot extract any rents from debtholders, which alleviates the agency conflict between the two parties. As a result, the cases with and without CDSs are identical, making CDSs *redundant*.

Figure 5 shows that the amount of value created is an increasing function of the liquidation cost $\xi$. The intuition is that a higher liquidation cost reduces the outside option of debtholders in bargaining, which allows the equity holders to extract higher rents. Bondholders are aware of this, so they purchase more CDS contracts to improve their outside option. This can be seen in the subplots for the hedge ratio.

Figure 6 depicts comparative statics with respect to $\gamma$, the exogenous probability of renegotiation failure. The increase in firm value is higher for large values of $\gamma$. To understand this, we start with the effects of $\gamma$ without CDS markets. On the one hand, a higher $\gamma$ reduces $a_P$, which decreases the likelihood of (attempted) renegotiation and increases the probability of debt repayment. On the other hand, it increases the probability of liquidation and decreases the probability of (successful) renegotiation. The second effect outweighs the first one, so the cost of debt increases with $\gamma$. The subfigure for debt shows that the firm reacts to this by issuing less debt. Now let's turn to the case with CDS markets. The two effects described before are still present. However, the first one is stronger now, because increased hedging by debtholders reduces the probability of renegotiation even further, while increasing the likelihood of repayment. Now the two effects approximately offset each other, so the firm does not issue less debt for higher $\gamma$.

# IV. Calibration

While our aim is to have a realistic model to perform the numerical analysis of the efficiency of CDSs, we cannot avoid the limitations in trying to match our structural model to empirical data. The purpose of the model is to focus on the effect of CDSs and the mechanisms by which they result in higher or lower firm value, rather than to provide an accurate model of corporate leverage and investment. However, it is still useful to calibrate our model to empirical data to ensure that it is sufficiently representative of a typical firm.

The base case parameters for our analysis are shown in Table I. Some are set directly to match commonly used empirical estimates, while others are based on calibrating the model, such that simulated moments of key firm level metrics approximate empirical moments. A comparison of simulated and empirical moments will be provided after briefly describing each parameter value.

We use a risk-free discount factor for equity holders of $\beta = .9434$ and a risk-free discount rate for debtholders of $r = 5\%$, so that $r < 1/\beta - 1$. Equity financing is more expensive than debt financing, as in Cooley and Quadrini (2001), which creates and incentive for the firm to issue debt.

The value of $\rho = 0.65$ is close those chosen by Gomes (2001) (0.62), or estimated by Hennessy and Whited (2007) (0.66) or DeAngelo, DeAngelo, and Whited (2011) (0.728). Our value of $\sigma = 0.35$ is slightly higher than Gomes (2001) (0.15), Hennessy and Whited

(2007) (0.12), or DeAngelo, DeAngelo, and Whited (2011) (0.28). These two parameters directly impact metrics such as EBITDA/Asset and leverage, and indirectly affect default rates and credit spreads.

The production return-to-scale parameter $\alpha = 0.55$ is set at the upper end of the range of values used by Moyen (2004) (0.25) and Zhang (2005) (0.30), and Hennessy and Whited (2005) (0.55). The fixed production cost of $f = 2.5$ is set (Moyen (2004) sets it at 0.76) to calibrate the Q–Ratio. We use an annual depreciation rate of $\delta = 0.06$, which is lower than the 1% monthly rate in Livdan, Sapriza, and Zhang (2009) and Schmid (2008), and closer to the 10% estimated by Hennessy and Whited (2005).

The equity issuance cost is $\lambda = 5\%$, not far from direct cost estimates in Altinkilic and Hansen (2000) (5.38%) and indirect structural estimates in Hennessy and Whited (2005) (5.9%). The cost associated with liquidation ($\xi$) is assumed to be 0.10 of the ex post value of the firm's asset. This compares with the value estimated by Hennessy and Whited (2007) (10.4%) and used also by Gomes and Schmid (2010).

Finally, we specify the probability of renegotiation failure $\gamma$ and the bargaining power $q$ to be 0.05 and 0.1, respectively. It is difficult to find parameter values in the existing literature, since both parameters are unobservable empirically. Our value of $\gamma$ essentially assumes that there is a small but positive probability that debt renegotiations fail. Empirically, Asquith, Gertner, and Scharfstein (1994) and Gilson, John, and Lang (1990) find that roughly a half of firms that attempt an out-of-court debt restructuring end up in bankruptcy. However, since bankruptcy filings are observable public events, whereas private debt restructurings often are not, the true probability might be significantly lower. For the debtholders' bargaining power, Anderson and Sundaresan (1996) assume that equity holders have all the bargaining power, so that $q = 0$. Since empirical proxies are difficult to find, Morellec, Nikolov, and Schurhoff (2012) indirectly estimate the parameter using structural estimation, and report that $q = 0.57$. However, their model is very different from ours, as they assume exogenous cash flows and focus on agency conflicts between management and shareholders. Our value of $q = 0.1$ essentially assumes that equity holders have a low of bargaining power, which allows them to extract rents in case of debt renegotiation.

We solve the dynamic program using a discrete-state discrete control version of the model and employing a value iteration approach. In detail, we discretize the exogenous variable $\log z$ in the range of $\pm$ 3 times the unconditional standard deviation of the AR(1) process using Gaussian quadrature with 11 points. We also discretize the interval $[0, \overline{k}]$ for $k$ and the interval $[0, \overline{b}]$ for $b$ with 45 points each, and the interval $[0, 1]$ for $h$ with 61 points.

The bounds $\bar{k}$ and $\bar{b}$ are set so that they are never binding in the simulated economy. The numerical solution of the Bellman problem gives us the optimal policies and the optimal security values. We then simulate an economy comprising 10,000 firms at their steady state for 100 years, for a total of 1 million firm/year observations.

Simulated values of common firm level metrics from our model are compared to corresponding empirical values in Table II, and in more detail in Tables III and IV. The first two columns of Table II show sample means in the dynamic economies without and with CDS markets, respectively. For all the metrics except the liquidation, the means are calculated by finding the cross-sectional mean for a particular economy at a particular point in time, then taking the time-series average of these cross-sectional means in the economy. To calculate the liquidation rate, we first measure the number of liquidated firms as a percentage of the number of active firms in the previous period, for each point in time and then take the time-series mean of this rate.

The empirical moments are taken from various sources. We use an average investment rate of 15%, based on the 14.5% reported in Gomes (2001), and 15% in Zhang (2005). As for the measure of firm's profitability as a fraction of capital, EBITDA/Assets, we take 15% reported in Hennessy and Whited (2005). Equity distribution is measured as a percentage of assets, and it is negative when equity is issued. We take the empirical mean of -4% reported in Hennessy and Whited (2005). For the Q–Ratio (equal to firm value divided by capital, $(v + b')/k'$), we use 1.93 as reported in Nikolov and Schmid (2012). Finally, with regards to financing measures, we take the average quasi-market leverage ratio of 35% from Nikolov and Schmid (2012). We use a 0.55% annual default rate based on Chava and Jarrow (2004), who collect a comprehensive sample of 404 bankruptcies and 72,682 firm/year observations. Our average credit spread is based on Giesecke, Longstaff, Schaefer, and Strebulaev (2011), who show that the average credit spread over the past 150 years is roughly 60 basis points.

# V. Results from numerical simulation

Tables III and IV present simulation results for the economy without and with CDSs, respectively. These are unconditional results, using all firm/year observations, and allow us to draw some general conclusions about the effect of CDSs on the firm's policy and the value of securities. By comparing the two tables, we see that the mean firm value is higher in the economy with CDSs. The increase from 83.28 to 87.22, or 4.7%, is economically significant. This magnitude is roughly half of the effect of optimal capital structure on firm value in

Graham (2000). There are two sources for this value creation. First, the firm uses more debt and less equity financing. Average market value of debt increases from 44.17 to 68.08 after introducing a CDS market, while equity falls from 39.11 to 19.14. This debt-for-equity swap creates value because debt is a cheaper source of financing than equity. Second, to a smaller extent, the firm is able to invest more in the economy with CDSs: the average investment rate grows from 0.21 to 0.24. Since we model an economy with several financial frictions, firms cannot invest to the amount they would in a frictionless world. The increase in investment allows the firm to move closer to the point where it would be in a first-best world without frictions.

The firm uses more debt because the probability of renegotiation is lower in the economy with CDS markets (0.30% to 0.04%), which makes debt cheaper. The reason why the average credit spread does not decrease is that the firm issues so much more debt that the equilibrium credit spread with CDSs increases slightly from 1.68 to 10.89 basis points. As Bolton and Oehmke (2011) predicted, CDSs not only reduce the probability of renegotiation, but also increase the likelihood of liquidation (0.02% to 0.03%). However, the reduction in the cost of debt due to fewer renegotiations outweighs the higher cost of debt due to more liquidations.

Our model can explain several findings of the empirical literature. First, the increase in the probability of liquidation is consistent with Subrahmanyam, Tang, and Wang (2014), who show that firms are more likely to file for bankruptcy if CDS contracts are introduced on their debt. Second, the decrease in the probability of renegotiation is consistent with Danis (2014), who examines a change in the definition of the standard restructuring clause in the CDS market which makes it more likely that a CDS protection buyer is an empty creditor. He finds that there are fewer out-of-court debt restructurings for firms with CDS contracts, but there is no such decrease for firms without CDSs. Third, our model predicts an increase in market leverage from 0.50 to 0.79, which is consistent with the findings of Saretto and Tookes (2013). Finally, Ashcraft and Santos (2009) report that CDSs decrease the cost of debt for high quality borrowers, while increasing it for low quality borrowers. Our model predicts that for a fixed amount of debt, introducing CDSs reduces the credit spread. However, allowing for endogenous debt issuance increases the firm's leverage so much that credit spreads increase.

Figure 7 depicts the effect of CDSs on firm value and on firm policies. In contrast to the unconditional results in Tables III and IV,it shows the firm at a specific point in the state space, where capital is $k = 41$ and the face value of debt is $b = 61$. The horizontal axis represents different values of current productivity $z$. The blue curves (with circles) show a firm without CDSs, while the red curves (with diamonds) represent a firm in the economy with CDS markets. Solid circles indicate that the firm optimally renegotiates its debt at this point, before choosing the optimal $k'$ and $b'$. We see that firm value increases with the introduction of CDSs. Equity value is lower and the book value of debt is higher, which results in a higher leverage ratio. The firm with CDSs chooses a slightly higher level of capital. The probability of renegotiation decreases substantially, even though the firm is using more debt. Differently from the unconditional results, the probability of liquidation does not increase with the introduction of CDSs. The reason is that there are two ways a firm can end up in liquidation. The first on is the empty creditor problem, where a higher hedge ratio makes renegotiation infeasible. The second is that every renegotiation may fail with probability $\gamma$. Since in this state the probability of renegotiation is very high for the firm without CDSs, the probability of liquidation is high as well. Finally, the hedge ratio is a decreasing function of current productivity $z$. The intuition is that a higher $z$ implies that next period's cash flow will likely be high, which reduces the risk of renegotiation. As a result, bondholders do not need to purchase as much protection.

In Tables V and VI we look at the effect of CDSs on small firms and large firms, respectively. We perform a $2 \times 3$ double sort on all simulated firm/year observations in the no-CDS economy, where the sorting variables are $k$ and $z$. Small firms are defined as the observations with low $k$ and intermediate $z$, while large firms have high $k$ and intermediate $z$. We perform the same sorting in the with-CDS economy. The two tables show that small firms have a high investment rate, and finance that investment by issuing debt and equity. The average investment rate for small firms in the no-CDS economy is 0.41, the change in debt relative to assets is 0.35, and the equity payout ratio is $-0.02$. Large firms do the opposite, by disinvesting assets, reducing debt, and paying dividends. Small firms seem to benefit substantially from CDSs, as their investment and financing policies suggest. The average investment rate increases to 0.71, change in debt to 0.69, and equity payouts changes to $-0.06$. The effect of CDSs on firm policies seems to be a little weaker for large firms, but the changes go in the same direction. Finally, average firm value is higher with CDS markets, both for small and large firms. This suggests that the introduction of CDSs creates value for both types of firms. As a caveat, the no-CDS and with-CDS firms in Table V are not exactly identical. While we do sort based on size, the firms in the two economies have slightly different average sizes. The same is true for Table VI.

Tables VII and VIII provide summary statistics for firms with low and high equity payout ratios, respectively. A low payout ratio has been used as a measure of financial constraints in the empirical literature (Farre-Mensa and Ljungqvist (2014) provide a recent review). Using all observations in the no-CDS economy, we use the median payout ratio to classify firms in low and high payout groups. We repeat this sorting for the with-CDS economy. The two tables show that firms with a low payout ratio invest less on average than firms with a high payout ratio. However, the median investment rates are not different, which suggests that some of the difference between the means might be driven by outliers. Curiously, average change in debt decreases for CDS firms compared to no-CDS firms in Table VII, which is at odds with the intuition that CDS contracts reduce the cost of debt and foster debt issuance. We would expect to observe this especially for low payout firms, which are supposed to be constrained, but Table VII shows the opposite. Finally, if we compare average firm value of no-CDS and with-CDS firms, we see in both tables that CDSs create value on average. However, the median firm value actually drops for low payout firms, whereas it increases for high payout firms. We conclude that in our model a low payout ratio need not be the best measure for financial constraints.

To alleviate the shortcomings of the previous two tables, we develop a more accurate measure of financial constraints in the context of our model. In Tables IX and X, we perform a $2 \times 3$ double sort on the firm's cashflow available for investment and on $z$. The available cashflow is defined as $\pi(z, k) - b$. We define constrained firms as having low available cashflow and high $z$. Unconstrained firms have high available cashflow and high $z$. The high productivity shock $z$ guarantees that the firm has good investment opportunities. Comparing the two tables, we find that average investment is significantly higher for unconstrained firms than constrained firms. In the no-CDS economy, average investment is 0.14 for constrained firms and 1.18 for unconstrained firms. Similarly large gains are observable in the with-CDS economy. The increase in median investment rates is approximately as large as the increase in the averages. These findings suggest that our measure of financial constraints captures the problem of firms with good investment opportunities but not enough internal resources to fund investment. However, our unconstrained firms are smaller than the constrained firms, which is in contrast with the intuition that unconstrained firms are large. The smaller size of unconstrained firms might cause a stronger desire for investment, in addition to being unconstrained.

Interestingly, the introduction of CDSs does not have positive effect on investment. For constrained firms, average investment drops slightly with CDSs, with no change in the medians. For unconstrained firms, mean investment increases slightly, with no effect on the medians. However, we observe a positive effect of CDSs on average firm value, both for constrained and unconstrained firms. The sources of this increase in value are different for the two types of firms. For constrained firms, CDSs do not lead to more debt issuance, nor is there a large drop in credit spreads. Instead, firms in the with-CDS economy are endogenously larger, with an average size of 90.07 compared to 88.65 without CDSs. This larger size, achieved by higher growth over several periods, seems to cause the higher valuation. Unconstrained firms are different because their higher investment is partly funded by higher debt issuance for CDS firms than no-CDS firms. Cheaper access to debt financing increases firm value for these firms. Finally, it is interesting to compare the payout ratios between Tables IX and X. Constrained firms actually have slightly higher payout ratios than unconstrained firms. This suggests that one has to be careful with using payout ratios as a proxy for financial constraints in our model.

In Tables XI and XII we compare firms with low and high growth opportunities, respectively. We perform a $2 \times 3$ double sort on $k$ and $z$, and classify observations with high $k$ and low $z$ as firms with low growth opportunities. Analogously, high growth opportunities are defined as having low $k$ and high $z$. Firms with few growth opportunities disinvest significantly, and reduce their debt by approximately the same amount. Firms with more attractive growth options, do the opposite, as they invest heavily and increase debt to roughly the same degree.

Interestingly, the effect of CDS contracts on low growth firms is slightly negative, as average firm value with CDSs is lower. This is the only type of firm in our analysis that exhibits a loss in value from CDSs, although a small one. We have to be careful with the interpretation of this decrease, as it might be explained by the slightly different average assets of 50.56 and 49.05, respectively. Put differently, if we compared two low growth firms at the same $(z, k, b)$, with and without CDS markets, we might not see a drop in firm value. In the case with high growth opportunities, CDSs allow to invest more and to increase debt more, without having to issue costly equity. All three of these effects create value. A higher investment rate allows the firm to move closer to the capital stock of a firm in a frictionless economy, the issuance of debt instead of equity creates value because the discount rate of debt is lower, and avoiding equity issuance economizes on issuance costs.

# VI. Conclusions

We examine the effect of CDSs from the perspective of corporate finance in a single-period debt renegotiation model of a firm whose financing is subject to frictions, in particular with equity being a more expensive source of financing than debt. While CDSs have both the effect of increasing costly liquidation and reducing the likelihood of renegotiation, as predicted by previous contributions, we show that the dominating effect of CDSs is to reduce the cost of debt financing and to increase the leverage and investment of the firm. There is a positive overall effect on firm value when compared to an otherwise identical firm without a market for CDSs.

In order to make quantitative predictions on the value contribution of CDSs, we then endogenize the initial state of the firm, a first order determinant of the effect of CDSs, and the continuation value on which equity holders base the debt renegotiation decision, by developing a dynamic model of the firm. In this model, at the beginning of each period the equity holders decide the investment in real assets and the amount of debt financing, and simultaenously the debt holders decide their hedging policy using CDSs. The equilibrium price of both debt and CDSs reflect the expectation of end-of-period debt renegotiation strategy.

Using a calibrated version of the dynamic model, we then simulate an economy with CDS markets and contrast it with the corresponding economy without CDSs. Our unconditional results show that the effect of CDSs on firm value is positive and economically significant, as they boost investment and debt financing and reduce the occurrence of debt renegotiation. We show that the effect of CDSs is generally positive, and that in the cross-section they have a stronger impact on the investment policy of smaller firms and on firms with more growth opportunities, which both are characterized by higher investment, because of their relative higher needs of external financing.

While the empirical literature has recently focused on specific aspects of the introduction of CDSs on corporate finance, like their effect on firm leverage and debt maturity, on the frequency of liquidation and renegotiation, and on credit spreads on corporate debt, with our model we provide a unifying theory of the firm that can explain these facts altogether.

A natural extension of our current research is to structurally estimate some deep parameters of the model, like the bargaining power of the parties, the probability of renegotiation failure, and the liquidation costs. We defer this to future research.

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# A. Proof of Proposition 1

## The relation between $b'/(1-\xi)$, $a_P$, $a_R$, and $b'$

**Lemma 1** (Compare $a_P$ and $b'$). *If $1-(1-\gamma)(1-q)s(h')>0$ (i.e. $h'<h_1$), and $h'>1$, then $a_P<b'$.*
*If $h'<1$ then $b'<a_P$.*
*If $1-(1-\gamma)(1-q)s(h')<0$ (i.e. $h'>h_1$), then $b'<a_P$.*

This can be shown by rearranging the inequality

$$\frac{b'\left[1-h'(1-\gamma)(1-q)\right]}{1-(1-\gamma)(1-q)s(h')}<b'$$

and using the different conditions on $h'$.

**Lemma 2** (Compare $a_R$ and $b'$). *If $s(h')>0$ (i.e. $h'>h_0$), and $h'<1$, then $a_R<b'$.*
*If $s(h')>0$ (i.e. $h'>h_0$), and $h'>1$, then $a_R>b'$.*
*If $s(h')<0$ (i.e. $h'<h_0$), and $h'<1$, then $a_R>b'$.*

To show this, assume $s(h')>0$ and $h'<1$. Then, from $h'/s(h')<1$, after rearranging using the different conditions, it follows that the inequality holds. The other two cases are analogous.

**Lemma 3** (Compare $a_P$ and $b'/(1-\xi)$). *If $1-(1-\gamma)(1-q)s(h')>0$ (i.e. $h'<h_1$), then $a_P<b'/(1-\xi)$.*
*If $1-(1-\gamma)(1-q)s(h')<0$ (i.e. $h'>h_1$), then $b'/(1-\xi)<a_P$.*

This can be shown by rearranging the inequality

$$\frac{b'\left[1-h'(1-\gamma)(1-q)\right]}{1-(1-\gamma)(1-q)s(h')}<\frac{b'}{1-\xi}$$

and using the different conditions on $h'$.

**Lemma 4** (Compare $a_R$ and $b'/(1-\xi)$). *If $s(h')>0$ (i.e. $h'>h_0$), then $a_R<b'/(1-\xi)$.*
*If $s(h')<0$ (i.e. $h'<h_0$), then $a_R>b'/(1-\xi)$.*

To show this, assume $s(h')>0$ and $h'<1$. Then, from $h'/s(h')<1/(1-\xi)$, after rearranging using the conditions, it follows that the inequality holds. The other two cases are analogous.

**Lemma 5** (Compare $a_P$ and $a_R$). *$a_P \geq a_R$ if and only if*

$$\frac{1 - h'(1-\gamma)(1-q)}{1 - (1-\gamma)(1-q)s(h')} \geq \frac{h'}{s(h')}.$$

This is proved as follows. Since the denominator can be either positive or negative, we have the following four subcases:

1. Assume $s(h') > 0$ and $1 - (1-\gamma)(1-q)s(h') > 0$, which is the same as $h' > h_0$ and $h' < h_1$. In this subcase, it can be shown that

   - If $h_0 < h' < 1$, then $a_P > a_R$.
   - If $1 < h' < h_1$, then $a_P < a_R$.

   This follows from rearranging the inequality above using the conditions, and using the fact that $h_0 < 1 < h_1$.

2. Assume $s(h') > 0$ and $1 - (1-\gamma)(1-q)s(h') < 0$, which is the same as $h' > h_0$ and $h' > h_1$. Because $h_0 < h_1$, these assumptions are equivalent to $h' > h_1$. In this case, it can be shown that the inequality above always holds strictly, because $h_1 > 1$. Therefore, $a_P > a_R$ for all $h' > h_1$.

3. Assume $s(h') < 0$ and $1 - (1-\gamma)(1-q)s(h') > 0$, which is the same as $h' < h_0$ and $h' < h_1$. Because $h_0 < h_1$, these assumptions reduce to $h' < h_0$. In this case, it can be shown that the inequality above never holds. Therefore, $a_P < a_R$ for all $h' < h_0$.

4. Assume $s(h') < 0$ and $1 - (1-\gamma)(1-q)s(h') < 0$, which is equivalent to $h' < h_0$ and $h' > h_1$. This is impossible, so this subcase can be dropped.

**Lemma 6** (Compare 0 and $a_R$). *If $h' > 0$ and $h' > h_0$ then $a_R > 0$.*
*If $h_0 < h' < 0$ then $a_R < 0$.*
*If $h' < 0$ and $h' < h_0$ then $a_R > 0$.*

This follows from the definition

$$a_R = \frac{h'b'}{1 - (1-h')(1-\xi)}.$$

**Lemma 7** (Compare 0 and $a_P$). *If $h' < 1/[(1-\gamma)(1-q)]$ and $h' < h_1$ then $0 < a_P$.*
*If $1/[(1-\gamma)(1-q)] < h' < h_1$ then $0 > a_P$.*
*If $h' > 1/[(1-\gamma)(1-q)]$ and $h' > h_1$ then $0 < a_P$.*

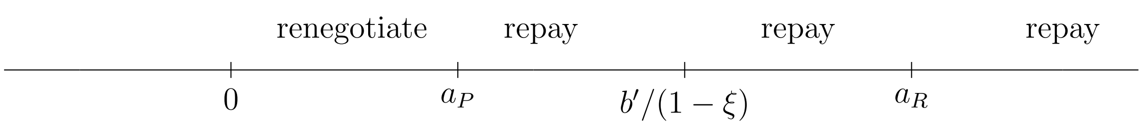
This follows from the definition

$$a_P = \frac{b'\left[1 - h'(1-\gamma)(1-q)\right]}{1-(1-\gamma)(1-q)s(h')}.$$

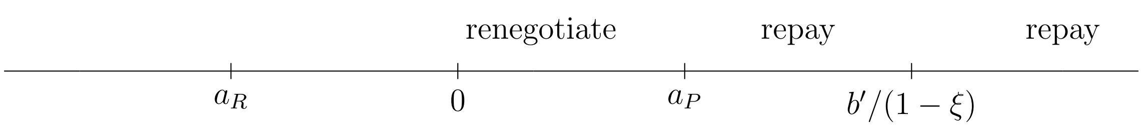
## The optimal default policy

Because $h_0 < 0 < 1 < 1/[(1-\gamma)(1-q)] < h_1$, there are six regions for $h'$. We will describe the default policy in these regions, from lowest to highest $h'$, and in each of the six cases, for the different $a'$. Initially we will consider only the interior of these intervals. We will deal with the boundaries (i.e., $h' = h_0$, $h' = 0$, etc.) later on.

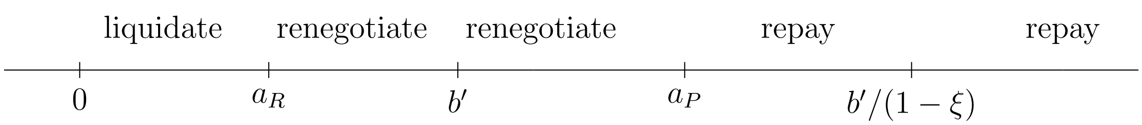
1. If $h' < h_0$, because in Lemmas 3, 4, and 7 we have determined that $0 < a_P < b'/(1-\xi) < a_R$, then the following diagram summarizes the optimal actions:




2. If $h_0 < h' < 0$, because $a_R < 0 < a_P < b'/(1-\xi)$ from Lemmas 3, 6, and 7, we can derive the following diagram:



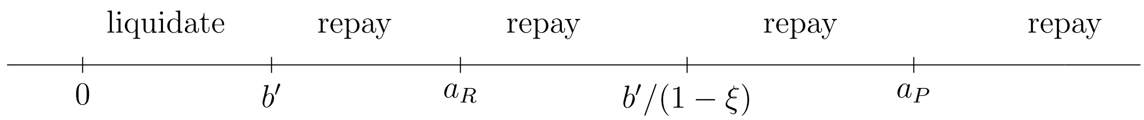

3. If $0 < h' < 1$, we know from Lemmas 1, 2, 3, and 6 that $0 < a_R < b' < a_P < b'/(1-\xi)$.




4. If $1 < h' < 1/[(1-\gamma)(1-q)]$, we have determined in Lemmas 1, 2, 4, and 7 that $0 < a_P < b' < a_R < b'/(1-\xi)$.


5. If $1/[(1-\gamma)(1-q)] < h' < h_1$, we know from Lemmas 2, 4, and 7 that $a_P < 0 < b' < a_R < b'/(1-\xi)$. Then the optimal actions are


6. Finally, if $h_1 < h'$, because from Lemmas 2, 3, and 4 we have $0 < b' < a_R < b'/(1-\xi) < a_P$, then we can derive the diagram




The six diagrams above can be summarized into three main cases. This is done in Figure 3.

We now analyze the optimal decision at the boundaries $h' = 0$ and $h' = 1$.[7] At $h' = 0$, from Lemmas 1 and 2 we have $0 = a_R < b' < a_P$. From this, a graph similar to the above Cases 1 or 2 can be derived, whereby renegotiation is optimal below $a_P$, and repayment is optimal above $a_P$. At $h' = 1$, from the previous section that $0 < b' = a_P = a_R$. From this, a graph similar to Cases 4, 5, or 6 can be derived, whereby liquidation is optimal below $b'$, and repayment is optimal above $b'$, and renegotiation never occurs.

## Proof that the equilibrium hedge ratio is in $[0, 1]$

The proof consists of two parts. In the first part, we show that $h' < 0$ is not optimal. Then we show that $h' > 1$ never occurs.

For the first part, assume that $h' < 0$, which corresponds to Case (a). Note that $\partial a_P / \partial h' < 0$, for any $h'$. This is because

$$\frac{\partial}{\partial h'} \frac{b' \left[1 - h'(1-\gamma)(1-q)\right]}{1 - (1-\gamma)(1-q)s(h')} < 0$$

can be shown to be equivalent to $(1-\gamma)(1-q) < 1$, which is always true, given our assumptions. Also, we know that the payoff to bondholders is higher for $a > a_P$ than for $a < a_P$. It follows that bondholders can always increase their expected payoff by increasing the hedge ratio $h'$. Therefore, $h' < 0$ cannot be optimal.

[7]The other boundaries, $h_0$, $1/[(1-\gamma)(1-q)]$, and $h_1$ are not relevant, as they are interior points of intervals in which the same action is optimal.

For the second part, assume that $h' > 1$, which corresponds to Case (c). As the figure shows, bondholders receive the liquidation payoff if $a < b'$, and the repayment payoff if $a > b'$. Neither of the two payoffs, nor the threshold $b'$ separating them, depends on $h'$. Therefore, the bondholders cannot be made better off (or worse off) by increasing their hedge ratio above the point $h' = 1$.

## The model without a CDS market

The solution of the model without a CDS market is very similar to the solution of the model with a CDS market. Let's derive the solution following the same logic as before. The case $w' > \xi a'$, is simple, as it does not depend on $h'$, with repayment being always optimal.

If $w' \leq \xi a'$, renegotiation is feasible if $(1-\xi)a' \leq a'$, so renegotiation is feasible for all $a' \leq b'/(1-\xi)$. If renegotiation is feasible, the solution can be written as

$$b_r = (1-\xi)a' + q[a' - (1-\xi)a']. \tag{29}$$

Repayment is preferred to renegotiation when $a' - b' \geq (1-\gamma)(a' - b_r)$, or,

$$a'\,[1 - (1-\gamma)(1-q)\xi] \geq b'. \tag{30}$$

We can define $a_P = b'/[1-(1-q)(1-\gamma)\xi]$, where $a_P \geq 0$ under our parameter assumptions. Then, repayment is optimal for $a' \geq a_P$ and renegotiation is optimal for $a' \in [0, a_P[$.

It is easy to show that $a_P < b'/(1-\xi)$. Therefore, the final solution is that renegotiation is optimal for $a' \in [0, a_P[$, and repayment is optimal for $a' \geq a_P$.

Figure 1: Timeline of the dynamic model. The figure shows how the decisions in period $t+1$ are made.

Three possible outcomes:

- debt is repaid: $d_t$ is the argmax of (3), $e_t = w_t - d_t$.
- debt is successfully renegotiated: net worth is reset to $w_{rt} = a(z_t, k_t) - b_{rt}$, with $b_{rt}$ from (11); $d_t$ is the argmax of (3) at $(z_t, w_{rt})$; $e_t = w_{rt} - d_t$.
- the firm is liquidated. It is replaced by a new firm with $e_t = w_d$.

Firm has $(k_t, b_t, h_t)$ from $t-1$

Nature draws $z_t$. Net worth $w_t = a(z_t, k_t) - b_t$

Given $e_t$, the owner decides $k_{t+1}$ and $b_{t+1}$ as argmax of (18).

Given $(z_t, k_{t+1}, b_{t+1})$, debtholders decide $h_{t+1}$ as argmax of (17).

Firm has $(k_{t+1}, b_{t+1}, h_{t+1})$ from $t$

Nature draws $z_{t+1}$. Net worth $w_{t+1} = a(z_{t+1}, k_{t+1}) - b_{t+1}$, etc.

Figure 2: Default decision tree (i.e., for $b > 0$) in the dynamic model

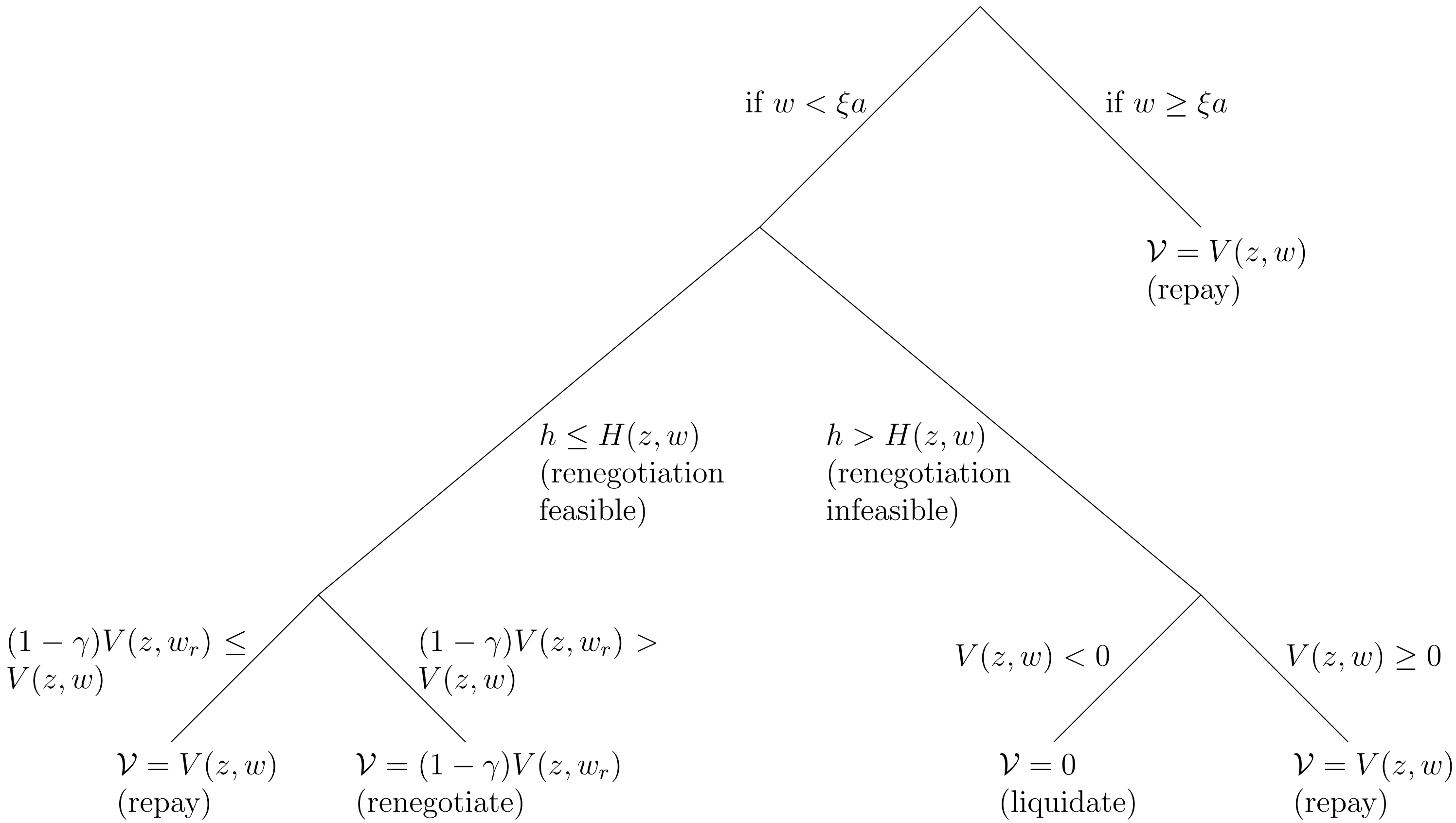


Figure 3: Single–period model, optimal default decision

The figure presents three scenarios for $h'$ of the optimal shareholder's decisions, as a function of $a'$, in the single–period model. "Liquidity default" denotes the region where the firm would default even in a world where debt cannot be renegotiated. "Strategic default" denotes the region where the firm would not default if debt could not be renegotiated.

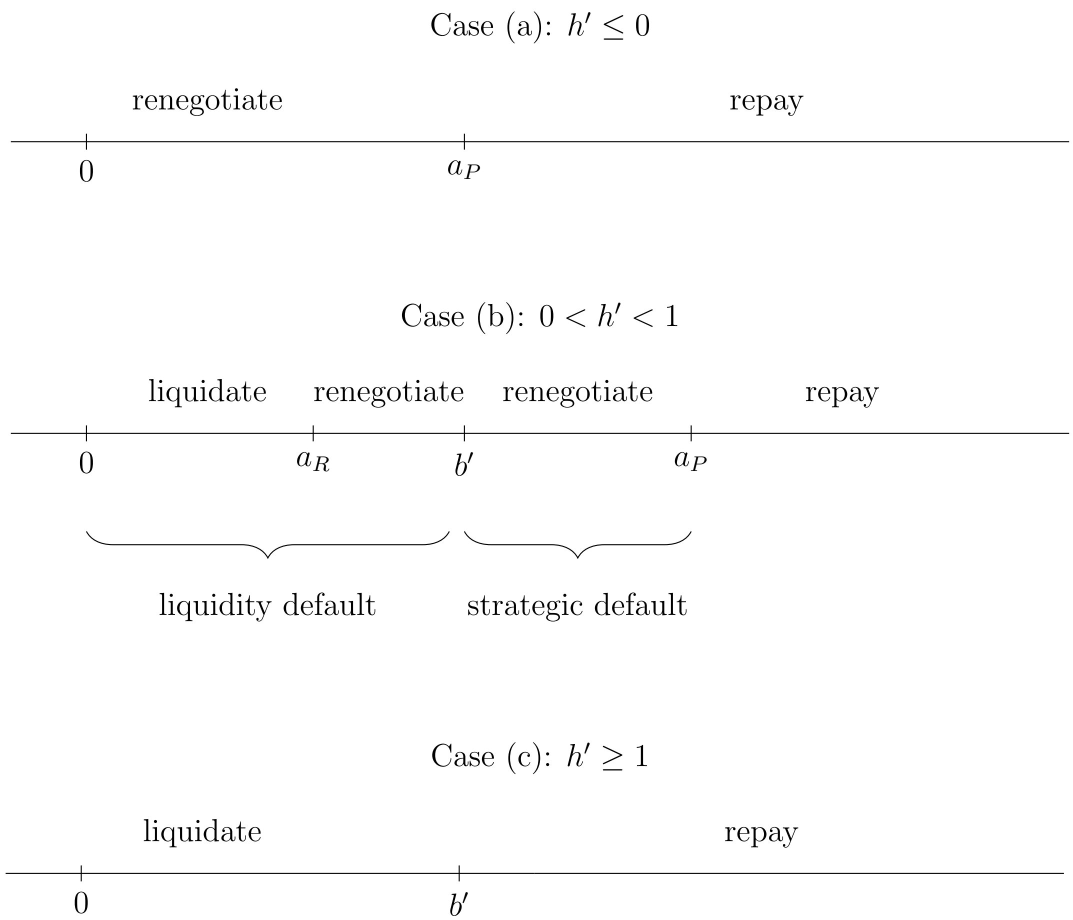


Figure 4: Single-period model. Sensitivity to different levels of debt bargaining power $q$.

This figure is based on the solution of the single-period model, and the base case parameters in Table I, for a specific point of the state space, $(z, k, b)$.

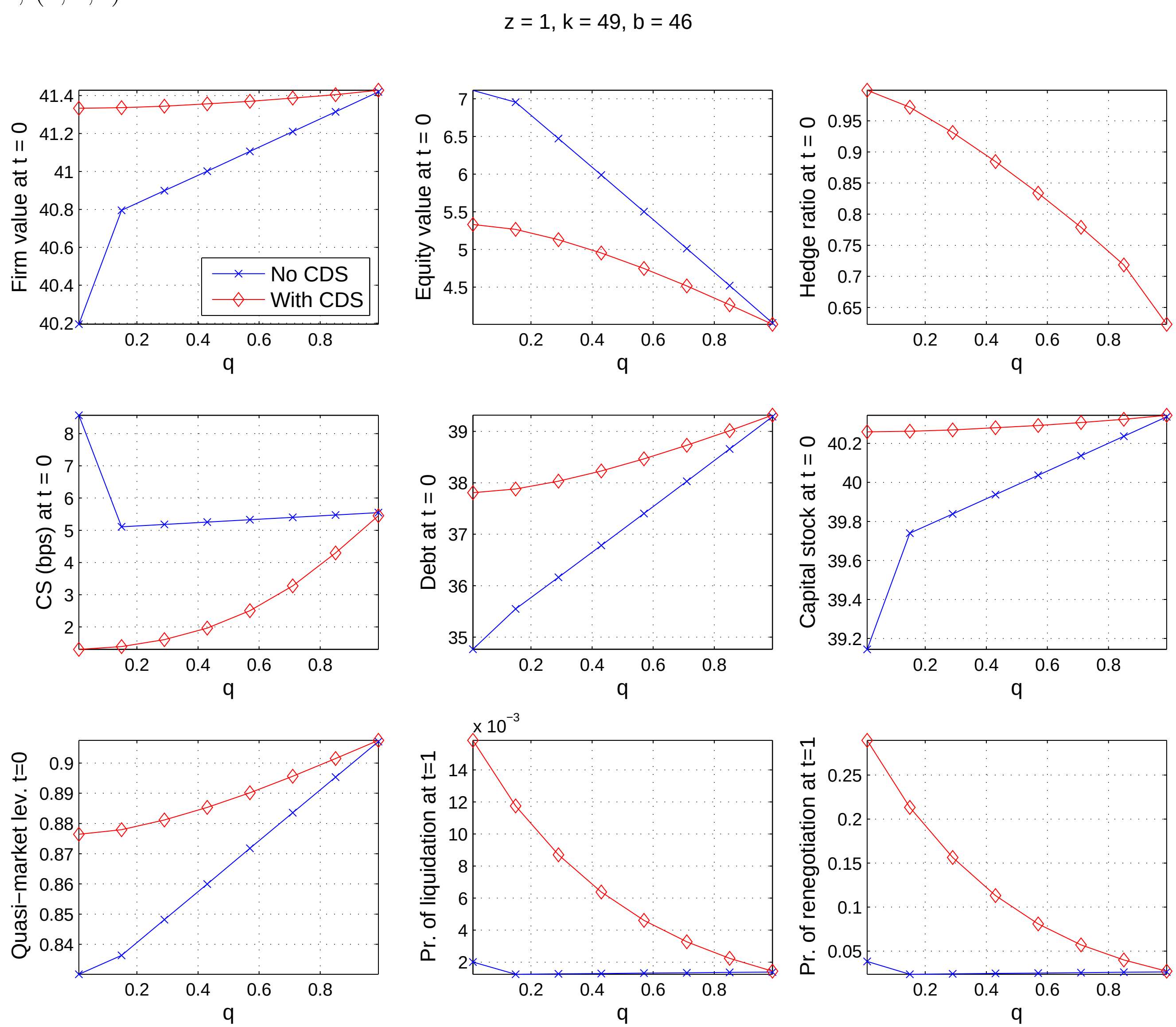


Figure 5: Single-period model. Sensitivity to different levels of liquidation cost $\xi$.

This figure is based on the solution of the single-period model, and the base case parameters in Table I, for a specific point of the state space, $(z, k, b)$.

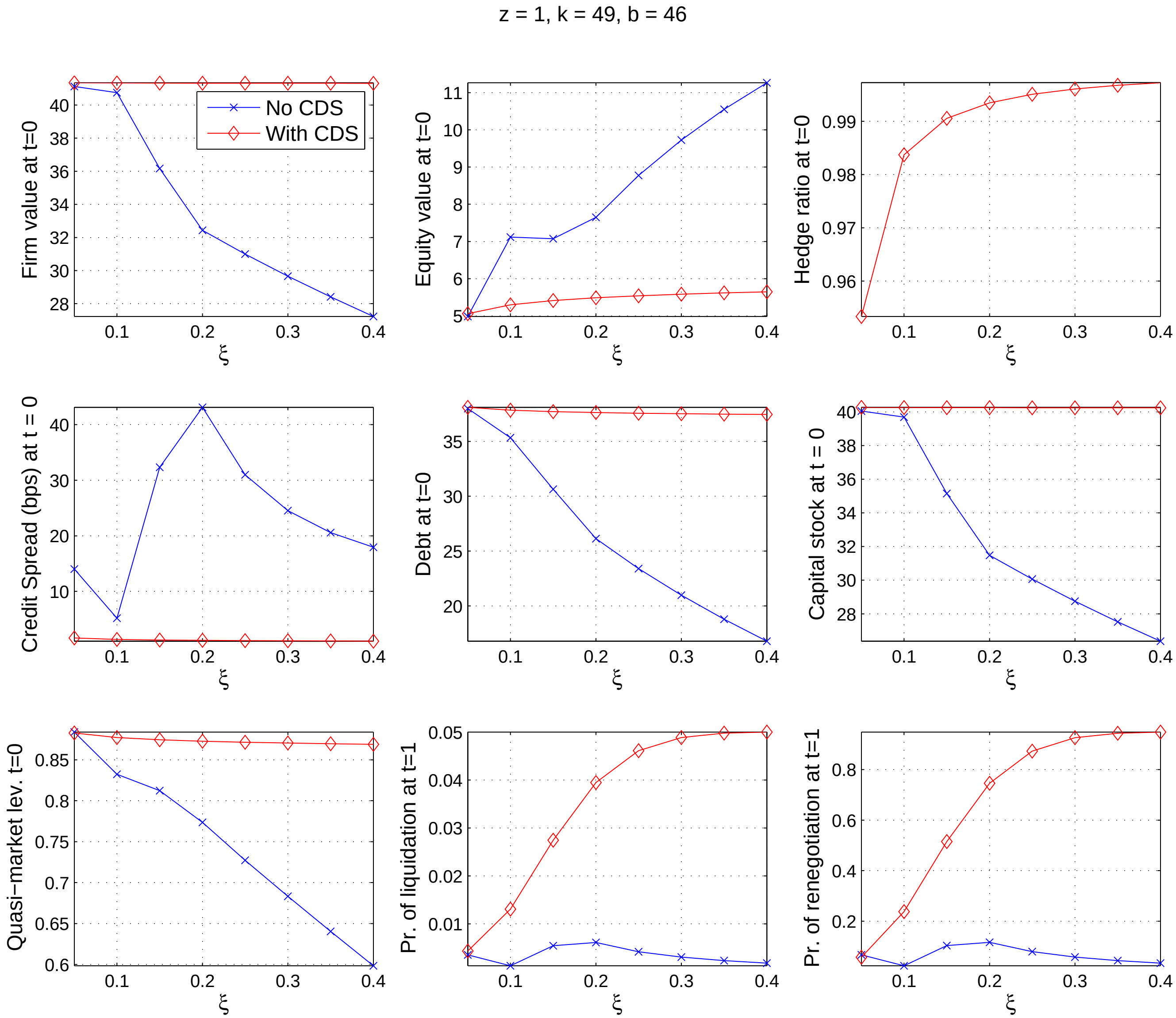


Figure 6: Single-period model. Sensitivity to different levels of renegotiation cost $\gamma$.

This figure is based on the solution of the single-period model, and the base case parameters in Table I, for a specific point of the state space, $(z, k, b)$.

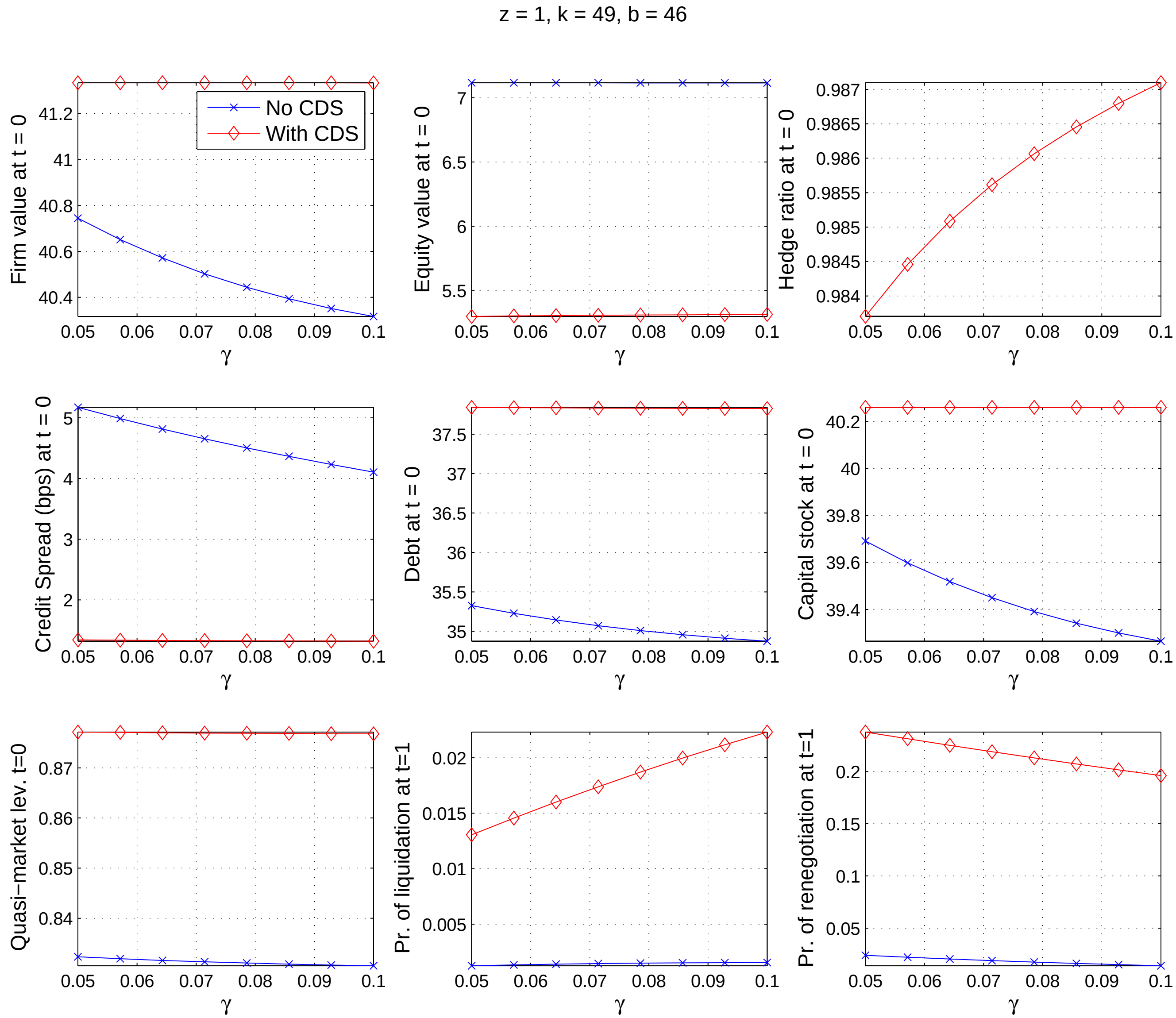
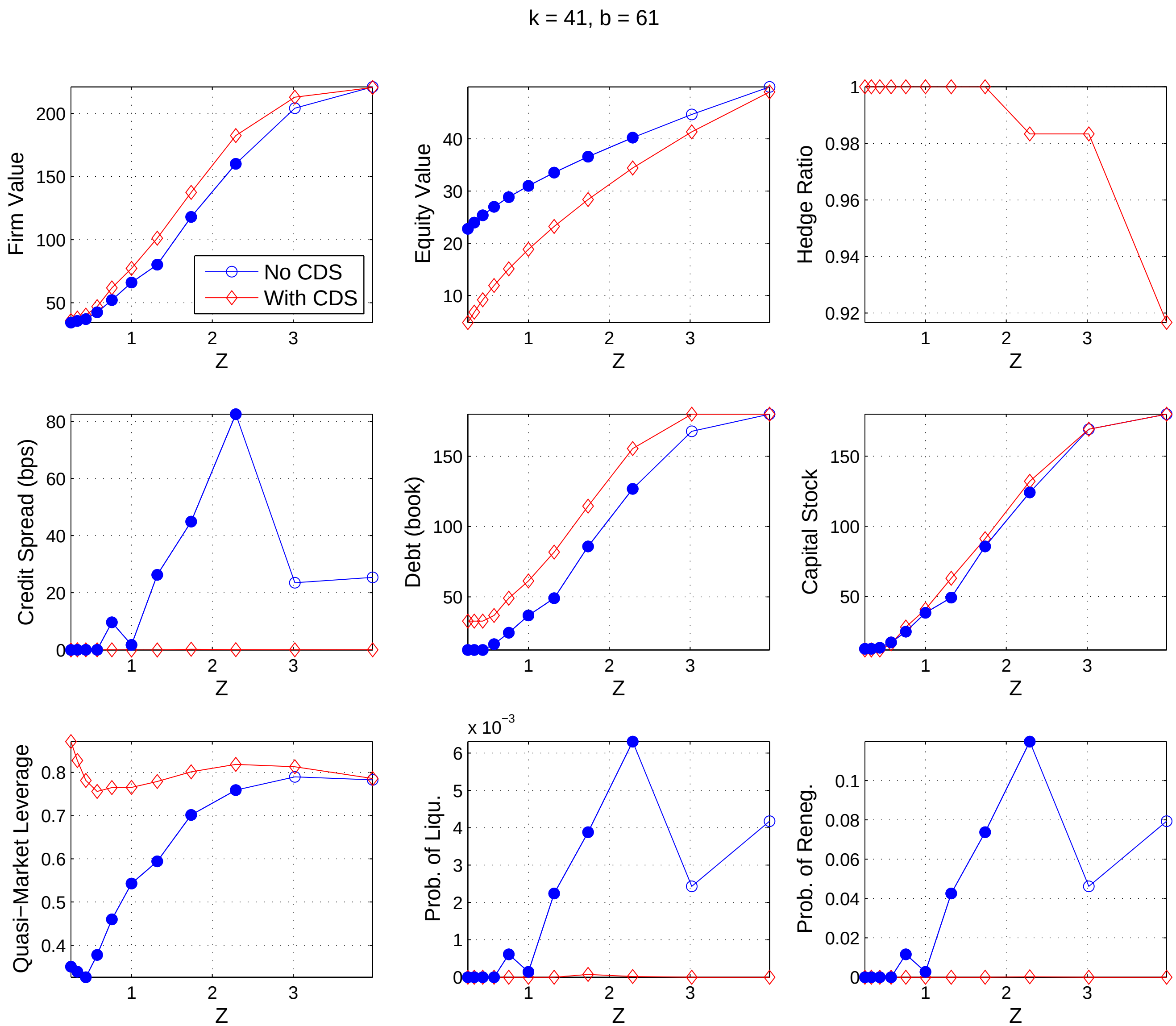


Figure 7: Dynamic model.

This figure is based on the solution of the dynamic model, and the base case parameters in Table I, and plots the different metrics against current productivity $z$ for a specific pair $(k, b)$ of current capital and current debt, respectively. Solid circles indicate that the firm optimally renegotiates its debt at this point, before choosing the optimal $k'$ and $b'$.



| | | |
|---|---|---|
| $\beta$ | time discount factor for equity holders | 0.9434 |
| $r$ | risk free rate | 0.05 |
| $\rho$ | persistence of productivity shock | 0.65 |
| $\sigma$ | conditional volatility of productivity shock | 0.35 |
| $\alpha$ | return to scale | 0.55 |
| $f$ | fixed production cost | 2.5 |
| $\delta$ | annual depreciation rate | 0.06 |
| $\lambda$ | flotation cost for equity | 0.05 |
| $\xi$ | proportional liquidation costs | 0.10 |
| $\gamma$ | probability of renegotiation failure | 0.05 |
| $q$ | bargaining power of debt holders | 0.1 |

Table I: **Base Case Parameter Values**. This table provides the base case parameters used in simulations.

| | No CDS | With CDS | Empirical |
|---|---|---|---|
| Investment Rate | 0.21 | 0.24 | 0.15 |
| EBITDA/Assets | 0.13 | 0.12 | 0.15 |
| Payouts/Assets | 0.01 | -0.02 | -0.04 |
| Q–Ratio | 1.95 | 2.05 | 1.93 |
| Leverage | 0.50 | 0.79 | 0.35 |
| Credit Spread (bps) | 1.68 | 10.89 | 60.00 |
| Liquidation (pct) | 0.02 | 0.03 | 0.55 |

Table II: **Simulated Means of Key Metrics.** This table provides unconditional sample means for the following variables: investment rate $((k' - k(1 - \delta))/k)$; EBITDA/Assets $(\pi/k)$; Payouts/Assets $((\pi + k(1 - \delta) - k' - b + m')/k)$; Q–ratio $((v + b')/k')$; Leverage $(b'/(b' + v))$; Credit Spread $(b'/m - (1 + r)$, in basis points); and Liquidation (the annual frequency of liquidation). The sources of the empirical estimates are provided in the paper. The columns represent the case of an economy without CDSs and with CDSs, based on the simulation described in the text using the base parameters shown in Table I. All means are reported on an annual basis.

Table III: **Economy without CDSs: Simulated Moments of Key Metrics.** This table provides unconditional sample moments for the following variables: firm value ($v+m'$); assets ($k$); face value of debt ($b$); ex dividend equity value ($v$); debt value ($m'$); investment rate ($(k'-k(1-\delta))/k$); EBITDA/Assets ($\pi/k$); Payouts/Assets ($(\pi+k(1-\delta)-k'-b+m')/k$); Q–ratio ($(v+b')/k'$); Leverage ($b'/(b'+v)$); Credit Spread ($b'/m-(1+r)$, in basis points); Liquidation (the annual frequency of liquidation); and Death (the percentage of times the firm ceases to exists because the asset is negative while there is no debt). The columns report several unconditional moments ('sd' is the standard deviation, 'ac' is the autocorrelation, 'sk' is the skewness, 'kur' is the kurtosis) and unconditional percentiles based on the simulation described in the text using the base parameters shown in Table I. All moments are reported on an annual basis.

| | mean | sd | ac | sk | kur | 1th | 25th | median | 75th | 99th |
|---|---|---|---|---|---|---|---|---|---|---|
| Firm Value | 83.28 | 40.97 | 0.63 | 1.55 | 5.70 | 35.00 | 55.15 | 74.02 | 93.31 | 237.84 |
| Assets | 49.01 | 34.72 | 0.57 | 1.65 | 5.84 | 12.58 | 25.79 | 40.64 | 55.55 | 180.00 |
| Debt (book) | 46.38 | 32.79 | 0.57 | 1.67 | 6.02 | 12.27 | 24.55 | 36.82 | 53.18 | 171.82 |
| Debt (market) | 44.17 | 31.22 | 0.57 | 1.67 | 6.02 | 11.69 | 23.37 | 35.06 | 50.64 | 163.60 |
| Equity | 39.11 | 10.18 | 0.75 | 1.25 | 5.13 | 23.33 | 32.26 | 37.54 | 42.80 | 74.02 |
| Hedge Ratio | 0.00 | 0.00 | – | – | – | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Investment/Assets | 0.21 | 0.66 | -0.14 | 1.82 | 9.00 | -0.63 | -0.25 | 0.06 | 0.51 | 2.30 |
| EBITDA/Assets | 0.13 | 0.09 | 0.47 | 0.44 | 4.05 | -0.08 | 0.08 | 0.13 | 0.18 | 0.37 |
| Payouts/Assets | 0.01 | 0.07 | 0.67 | -0.37 | 4.60 | -0.19 | -0.02 | 0.02 | 0.06 | 0.19 |
| Q–Ratio | 1.95 | 0.44 | 0.54 | 0.74 | 2.80 | 1.30 | 1.67 | 1.81 | 2.17 | 3.08 |
| Market Leverage | 0.50 | 0.10 | 0.50 | 0.04 | 2.21 | 0.31 | 0.42 | 0.51 | 0.56 | 0.71 |
| Chg. Debt/Assets | 0.15 | 0.64 | -0.15 | 1.85 | 9.40 | -0.67 | -0.30 | 0.00 | 0.46 | 2.17 |
| Credit Spread (bps) | 1.68 | 2.61 | 0.14 | 3.34 | 24.33 | -0.00 | -0.00 | 0.56 | 2.85 | 9.66 |
| Renegotiation (pct) | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Liquidation (pct) | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table IV: **Economy with CDSs: Simulated Moments of Key Metrics.** This table provides unconditional sample moments for the following variables: firm value ($v+m'$); assets ($k$); face value of debt ($b$); hedge ratio ($h$); ex dividend equity value ($v$); debt value ($m'$); investment rate ($(k'-k(1-\delta))/k$); EBITDA/Assets ($\pi/k$); Payouts/Assets ($(\pi+k(1-\delta)-k'-b+m')/k$); Q–ratio ($(v+b')/k'$); Leverage ($b'/(b'+v)$); Credit Spread ($b'/m-(1+r)$, in basis points); Liquidation (the annual frequency of liquidation); and Death (the percentage of times the firm ceases to exists because the asset is negative while there is no debt). The columns report several unconditional moments ('sd' is the standard deviation, 'ac' is the autocorrelation, 'sk' is the skewness, 'kur' is the kurtosis) and unconditional percentiles based on the simulation described in the text using the base parameters shown in Table I. All moments are reported on an annual basis.

| | mean | sd | ac | sk | kur | 1th | 25th | median | 75th | 99th |
|---|---|---|---|---|---|---|---|---|---|---|
| Firm Value | 87.22 | 41.22 | 0.60 | 1.33 | 4.64 | 37.45 | 59.78 | 79.84 | 96.84 | 219.22 |
| Assets | 49.66 | 34.29 | 0.57 | 1.47 | 5.12 | 11.83 | 26.44 | 43.37 | 55.55 | 169.20 |
| Debt (book) | 71.52 | 34.02 | 0.57 | 1.31 | 4.37 | 32.73 | 49.09 | 65.45 | 77.73 | 180.00 |
| Debt (market) | 68.08 | 32.39 | 0.57 | 1.31 | 4.37 | 31.17 | 46.72 | 62.33 | 74.03 | 171.43 |
| Equity | 19.14 | 9.25 | 0.67 | 1.79 | 8.73 | 6.28 | 13.15 | 17.50 | 22.63 | 52.25 |
| Hedge Ratio | 1.00 | 0.01 | 0.18 | -39.96 | 2208.70 | 0.98 | 1.00 | 1.00 | 1.00 | 1.00 |
| Investment/Assets | 0.24 | 0.73 | -0.16 | 2.01 | 10.37 | -0.67 | -0.33 | 0.06 | 0.65 | 2.67 |
| EBITDA/Assets | 0.12 | 0.09 | 0.48 | 0.36 | 4.02 | -0.09 | 0.08 | 0.13 | 0.18 | 0.37 |
| Payouts/Assets | -0.02 | 0.18 | 0.60 | -33.30 | 1771.96 | -0.29 | -0.07 | -0.01 | 0.04 | 0.18 |
| Q–Ratio | 2.05 | 0.53 | 0.56 | 0.93 | 2.91 | 1.30 | 1.73 | 1.84 | 2.29 | 3.36 |
| Market Leverage | 0.79 | 0.02 | 0.21 | -0.59 | 12.28 | 0.72 | 0.78 | 0.79 | 0.80 | 0.84 |
| Chg. Debt/Assets | 0.18 | 0.77 | -0.16 | 1.44 | 15.06 | -0.75 | -0.38 | 0.00 | 0.59 | 2.70 |
| Credit Spread (bps) | 10.89 | 533.99 | 0.16 | 61.17 | 4330.73 | -0.00 | 0.05 | 0.25 | 0.89 | 7.00 |
| Renegotiation (pct) | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Liquidation (pct) | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table V: **Small Firms.** We perform a $2 \times 3$ double sort on $k$ and $z$, and select observations with low $k$ and intermediate $z$. This table provides sample moments for the following variables: firm value $(v+m')$; assets $(k)$; face value of debt $(b)$; debt value $(m')$; ex dividend equity value $(v)$; hedge ratio $(h)$; investment rate $((k'-k(1-\delta))/k)$; EBITDA/assets $(\pi/k)$; payouts/assets $((\pi+k(1-\delta)-k'-b+m')/k)$; Q–ratio $((v+b')/k')$; market leverage $(b'/(b'+v))$; book leverage $(b'/k')$; change in debt / assets $((b'-b)/k)$; credit spread $(b'/m-(1+r)$, in basis points); renegotiation (annual frequency of renegotiation); liquidation (annual frequency of liquidation). All moments are reported on an annual basis.

| | No CDS | | | | With CDS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Obs. | Mean | Median | SD | Obs. | p-Value |
| Firm Value | 62.43 | 56.15 | 7.88 | 244656 | 67.85 | 60.49 | 9.32 | 192623 | 0.00 |
| Assets | 25.85 | 26.44 | 8.24 | 244656 | 22.22 | 26.44 | 6.31 | 192623 | 0.00 |
| Debt (book) | 24.53 | 24.55 | 7.95 | 244656 | 43.97 | 49.09 | 7.01 | 192623 | 0.00 |
| Debt (market) | 28.85 | 23.38 | 5.96 | 244656 | 53.27 | 46.72 | 7.70 | 192623 | 0.00 |
| Equity | 33.58 | 32.77 | 2.14 | 244656 | 14.58 | 13.77 | 1.89 | 192623 | 0.00 |
| Hedge Ratio | 0.00 | 0.00 | 0.00 | 244656 | 1.00 | 1.00 | 0.00 | 192623 | 0.00 |
| Investment/Assets | 0.41 | 0.51 | 0.50 | 244656 | 0.71 | 0.70 | 0.64 | 192623 | 0.00 |
| EBITDA/Assets | 0.10 | 0.08 | 0.03 | 244656 | 0.10 | 0.08 | 0.03 | 192623 | 0.00 |
| Payouts/Assets | -0.02 | -0.02 | 0.04 | 244656 | -0.06 | -0.07 | 0.12 | 192623 | 0.00 |
| Q-Ratio | 2.01 | 2.12 | 0.16 | 244656 | 2.07 | 2.24 | 0.22 | 192623 | 0.00 |
| Market Leverage | 0.47 | 0.45 | 0.04 | 244656 | 0.79 | 0.80 | 0.01 | 192623 | 0.00 |
| Book Leverage | 0.96 | 0.96 | 0.02 | 244656 | 1.70 | 1.86 | 0.17 | 192623 | 0.00 |
| Chg. Debt/Assets | 0.35 | 0.46 | 0.49 | 244656 | 0.69 | 0.62 | 0.68 | 192623 | 0.00 |
| Credit Spread (bps) | 3.20 | 1.73 | 3.80 | 244656 | 4.20 | 7.00 | 3.08 | 192623 | 0.00 |
| Renegotiation (pct) | 0.00 | | | | 0.01 | | | | |
| Liquidation (pct) | 0.00 | | | | 0.00 | | | | |

Table VI: **Large Firms.** We perform a $2 \times 3$ double sort on $k$ and $z$, and select observations with high $k$ and intermediate $z$. This table provides sample moments for the following variables: firm value ($v + m'$); assets ($k$); face value of debt ($b$); debt value ($m'$); ex dividend equity value ($v$); hedge ratio ($h$); investment rate ($(k' - k(1-\delta))/k$); EBITDA/assets ($\pi/k$); payouts/assets ($(\pi + k(1-\delta) - k' - b + m')/k$); Q–ratio ($(v+b')/k'$); market leverage ($b'/(b'+v)$); book leverage ($b'/k'$); change in debt / assets ($(b'-b)/k$); credit spread ($b'/m - (1+r)$, in basis points); renegotiation (annual frequency of renegotiation); liquidation (annual frequency of liquidation). All moments are reported on an annual basis.

| | No CDS | | | | With CDS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Obs. | Mean | Median | SD | Obs. | p-Value |
| Firm Value | 70.08 | 76.54 | 8.97 | 180641 | 72.68 | 79.84 | 9.39 | 233375 | 0.00 |
| Assets | 59.04 | 55.55 | 21.14 | 180641 | 56.67 | 43.37 | 20.67 | 233375 | 0.00 |
| Debt (book) | 55.80 | 53.18 | 19.89 | 180641 | 78.84 | 65.45 | 20.88 | 233375 | 0.00 |
| Debt (market) | 32.64 | 35.06 | 6.98 | 180641 | 56.31 | 62.33 | 7.55 | 233375 | 0.00 |
| Equity | 37.44 | 37.99 | 2.73 | 180641 | 16.37 | 17.50 | 2.17 | 233375 | 0.00 |
| Hedge Ratio | 0.00 | 0.00 | 0.00 | 180641 | 1.00 | 1.00 | 0.00 | 233375 | 0.00 |
| Investment/Assets | -0.26 | -0.16 | 0.22 | 180641 | -0.23 | -0.33 | 0.22 | 233375 | 0.00 |
| EBITDA/Assets | 0.10 | 0.12 | 0.02 | 180641 | 0.10 | 0.12 | 0.02 | 233375 | 0.00 |
| Payouts/Assets | 0.02 | 0.02 | 0.01 | 180641 | -0.01 | -0.01 | 0.01 | 233375 | 0.00 |
| Q-Ratio | 1.93 | 1.81 | 0.18 | 180641 | 2.01 | 1.85 | 0.21 | 233375 | 0.00 |
| Market Leverage | 0.47 | 0.49 | 0.05 | 180641 | 0.78 | 0.79 | 0.01 | 233375 | 0.00 |
| Book Leverage | 0.92 | 0.93 | 0.02 | 180641 | 1.64 | 1.51 | 0.17 | 233375 | 0.00 |
| Chg. Debt/Assets | -0.31 | -0.25 | 0.21 | 180641 | -0.29 | -0.38 | 0.22 | 233375 | 0.00 |
| Credit Spread (bps) | 0.56 | -0.00 | 0.68 | 180641 | 3.01 | 0.89 | 2.95 | 233375 | 0.00 |
| Renegotiation (pct) | 0.04 | | | | 0.00 | | | | |
| Liquidation (pct) | 0.00 | | | | 0.00 | | | | |

Table VII: **Low Payout Ratio.** We select observations with a payout ratio below the median. This table provides sample moments for the following variables: firm value ($v + m'$); assets ($k$); face value of debt ($b$); debt value ($m'$); ex dividend equity value ($v$); hedge ratio ($h$); investment rate ($(k' - k(1-\delta))/k$); EBITDA/assets ($\pi/k$); payouts/assets ($(\pi + k(1-\delta) - k' - b + m')/k$); Q–ratio ($(v + b')/k'$); market leverage ($b'/(b' + v)$); book leverage ($b'/k'$); change in debt / assets ($(b' - b)/k$); credit spread ($b'/m - (1 + r)$, in basis points); renegotiation (annual frequency of renegotiation); liquidation (annual frequency of liquidation). All moments are reported on an annual basis.

| | No CDS | | | With CDS | | | |
|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Mean | Median | SD | p-Value |
| Firm Value | 52.19 | 54.34 | 13.11 | 53.11 | 46.07 | 13.90 | 0.00 |
| Assets | 22.22 | 17.14 | 8.96 | 24.10 | 26.44 | 11.40 | 0.00 |
| Debt (book) | 21.27 | 16.36 | 8.57 | 46.07 | 49.09 | 12.29 | 0.00 |
| Debt (market) | 21.88 | 23.36 | 9.83 | 41.84 | 35.06 | 11.12 | 0.00 |
| Equity | 30.31 | 30.99 | 3.53 | 11.27 | 11.00 | 2.93 | 0.00 |
| Hedge Ratio | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 0.02 | 0.00 |
| Investment/Assets | 0.27 | 0.06 | 0.64 | 0.13 | 0.06 | 0.60 | 0.00 |
| EBITDA/Assets | 0.05 | 0.07 | 0.07 | 0.04 | 0.04 | 0.06 | 0.00 |
| Payouts/Assets | -0.07 | -0.04 | 0.05 | -0.14 | -0.10 | 0.28 | 0.00 |
| Q-Ratio | 2.34 | 2.19 | 0.40 | 2.60 | 2.77 | 0.51 | 0.00 |
| Market Leverage | 0.41 | 0.43 | 0.07 | 0.80 | 0.80 | 0.02 | 0.00 |
| Book Leverage | 0.96 | 0.96 | 0.03 | 2.16 | 2.28 | 0.52 | 0.00 |
| Chg. Debt/Assets | 0.20 | 0.00 | 0.62 | 0.06 | 0.00 | 0.69 | 0.00 |
| Credit Spread (bps) | 2.18 | 0.00 | 3.78 | 31.28 | -0.00 | 1018.23 | 0.00 |
| Renegotiation (pct) | 0.83 | | | 0.14 | | | |
| Liquidation (pct) | 0.04 | | | 0.18 | | | |

Table VIII: **High Payout Ratio.** We select observations with a payout ratio above the median. This table provides sample moments for the following variables: firm value ($v+m'$); assets ($k$); face value of debt ($b$); debt value ($m'$); ex dividend equity value ($v$); hedge ratio ($h$); investment rate ($(k'-k(1-\delta))/k$); EBITDA/assets ($\pi/k$); payouts/assets ($(\pi+k(1-\delta)-k'-b+m')/k$); Q–ratio ($(v+b')/k'$); market leverage ($b'/(b'+v)$); book leverage ($b'/k'$); change in debt / assets ($(b'-b)/k$); credit spread ($b'/m-(1+r)$, in basis points); renegotiation (annual frequency of renegotiation); liquidation (annual frequency of liquidation). All moments are reported on an annual basis.

| | No CDS | | | With CDS | | | |
|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Mean | Median | SD | p-Value |
| Firm Value | 124.59 | 102.23 | 40.47 | 131.76 | 136.28 | 38.52 | 0.00 |
| Assets | 78.66 | 55.55 | 39.01 | 74.87 | 55.55 | 36.31 | 0.00 |
| Debt (book) | 74.33 | 53.18 | 36.80 | 96.61 | 77.73 | 34.87 | 0.00 |
| Debt (market) | 74.67 | 50.64 | 32.16 | 102.82 | 109.09 | 30.73 | 0.00 |
| Equity | 49.93 | 48.06 | 9.07 | 28.94 | 27.19 | 8.93 | 0.00 |
| Hedge Ratio | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 0.01 | 0.00 |
| Investment/Assets | 0.28 | 0.06 | 0.59 | 0.40 | 0.06 | 0.76 | 0.00 |
| EBITDA/Assets | 0.21 | 0.19 | 0.07 | 0.22 | 0.18 | 0.07 | 0.00 |
| Payouts/Assets | 0.08 | 0.07 | 0.04 | 0.08 | 0.07 | 0.05 | 0.00 |
| Q-Ratio | 1.57 | 1.64 | 0.17 | 1.59 | 1.53 | 0.15 | 0.00 |
| Market Leverage | 0.59 | 0.57 | 0.06 | 0.79 | 0.78 | 0.02 | 0.00 |
| Book Leverage | 0.95 | 0.96 | 0.01 | 1.29 | 1.26 | 0.10 | 0.00 |
| Chg. Debt/Assets | 0.21 | 0.00 | 0.56 | 0.35 | 0.00 | 0.77 | 0.00 |
| Credit Spread (bps) | 1.82 | 2.85 | 1.43 | 0.14 | 0.10 | 0.09 | 0.00 |
| Renegotiation (pct) | 0.00 | | | 0.00 | | | |
| Liquidation (pct) | 0.00 | | | 0.00 | | | |

Table IX: **Financially Constrained Firms.** We perform a $2 \times 3$ double sort on cashflow available for investment and $z$, and select observations with low available cashflow and high $z$. Available cashflow is defined as $\pi - b$. This table provides sample moments for the following variables: firm value ($v + m'$); assets ($k$); face value of debt ($b$); debt value ($m'$); ex dividend equity value ($v$); hedge ratio ($h$); investment rate ($(k' - k(1-\delta))/k$); EBITDA/assets ($\pi/k$); payouts/assets ($(\pi + k(1-\delta) - k' - b + m')/k$); Q–ratio ($(v + b')/k'$); market leverage ($b'/(b'+v)$); book leverage ($b'/k'$); change in debt / assets ($(b'-b)/k$); credit spread ($b'/m - (1+r)$, in basis points); renegotiation (annual frequency of renegotiation); liquidation (annual frequency of liquidation). All moments are reported on an annual basis.

| | No CDS | | | | With CDS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Obs. | Mean | Median | SD | Obs. | p-Value |
| Firm Value | 130.02 | 129.88 | 38.33 | 249411 | 132.03 | 137.18 | 37.61 | 240736 | 0.00 |
| Assets | 88.65 | 91.13 | 36.45 | 246961 | 90.07 | 91.13 | 34.55 | 238372 | 0.00 |
| Debt (book) | 83.89 | 85.91 | 34.23 | 246961 | 111.89 | 114.55 | 33.00 | 238372 | 0.00 |
| Debt (market) | 78.43 | 81.81 | 30.68 | 249411 | 102.53 | 109.09 | 29.93 | 240736 | 0.00 |
| Equity | 51.58 | 48.07 | 8.36 | 249411 | 29.49 | 28.09 | 8.64 | 240736 | 0.00 |
| Hedge Ratio | 0.00 | 0.00 | 0.00 | 249411 | 1.00 | 1.00 | 0.01 | 240736 | 0.00 |
| Investment/Assets | 0.14 | 0.06 | 0.47 | 249411 | 0.09 | 0.06 | 0.39 | 240736 | 0.00 |
| EBITDA/Assets | 0.20 | 0.17 | 0.06 | 249411 | 0.20 | 0.17 | 0.05 | 240736 | 0.00 |
| Payouts/Assets | 0.09 | 0.09 | 0.03 | 249411 | 0.08 | 0.07 | 0.05 | 240736 | 0.00 |
| Q-Ratio | 1.55 | 1.54 | 0.16 | 249411 | 1.59 | 1.53 | 0.14 | 240736 | 0.00 |
| Market Leverage | 0.60 | 0.60 | 0.06 | 249411 | 0.78 | 0.78 | 0.02 | 240736 | 0.00 |
| Book Leverage | 0.95 | 0.94 | 0.01 | 249411 | 1.29 | 1.26 | 0.10 | 240736 | 0.00 |
| Chg. Debt/Assets | 0.08 | 0.00 | 0.44 | 249411 | 0.03 | 0.00 | 0.39 | 240736 | 0.00 |
| Credit Spread (bps) | 1.56 | 0.56 | 1.22 | 249411 | 0.13 | 0.10 | 0.09 | 240736 | 0.00 |
| Renegotiation (pct) | 0.00 | | | | 0.00 | | | | |
| Liquidation (pct) | 0.00 | | | | 0.00 | | | | |

Table X: **Financially Unconstrained Firms.** We perform a $2 \times 3$ double sort on cashflow available for investment and $z$, and select observations with high available cashflow and high $z$. Available cashflow is defined as $\pi - b$. This table provides sample moments for the following variables: firm value $(v + m')$; assets $(k)$; face value of debt $(b)$; debt value $(m')$; ex dividend equity value $(v)$; hedge ratio $(h)$; investment rate $((k' - k(1-\delta))/k)$; EBITDA/assets $(\pi/k)$; payouts/assets $((\pi + k(1-\delta) - k' - b + m')/k)$; Q–ratio $((v + b')/k')$; market leverage $(b'/(b' + v))$; book leverage $(b'/k')$; change in debt / assets $((b' - b)/k)$; credit spread $(b'/m - (1 + r)$, in basis points); renegotiation (annual frequency of renegotiation); liquidation (annual frequency of liquidation). All moments are reported on an annual basis.

| | No CDS | | | | With CDS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Obs. | Mean | Median | SD | Obs. | p-Value |
| Firm Value | 106.47 | 92.62 | 27.86 | 129463 | 117.13 | 97.98 | 31.65 | 138137 | 0.00 |
| Assets | 34.91 | 38.32 | 8.91 | 128097 | 37.74 | 43.37 | 10.71 | 136685 | 0.00 |
| Debt (book) | 32.95 | 36.82 | 8.42 | 128097 | 59.76 | 65.45 | 10.81 | 136685 | 0.00 |
| Debt (market) | 63.50 | 50.64 | 23.62 | 129463 | 92.80 | 77.91 | 26.88 | 138137 | 0.00 |
| Equity | 42.98 | 41.98 | 4.44 | 129463 | 24.33 | 21.96 | 4.94 | 138137 | 0.00 |
| Hedge Ratio | 0.00 | 0.00 | 0.00 | 129463 | 0.99 | 1.00 | 0.01 | 138137 | 0.00 |
| Investment/Assets | 1.18 | 1.16 | 0.84 | 129463 | 1.20 | 1.16 | 0.94 | 138137 | 0.00 |
| EBITDA/Assets | 0.23 | 0.21 | 0.06 | 129463 | 0.24 | 0.21 | 0.07 | 138137 | 0.00 |
| Payouts/Assets | 0.04 | 0.04 | 0.04 | 129463 | 0.06 | 0.04 | 0.05 | 138137 | 0.00 |
| Q-Ratio | 1.57 | 1.63 | 0.13 | 129463 | 1.61 | 1.66 | 0.13 | 138137 | 0.00 |
| Market Leverage | 0.60 | 0.57 | 0.05 | 129463 | 0.80 | 0.80 | 0.02 | 138137 | 0.00 |
| Book Leverage | 0.95 | 0.96 | 0.01 | 129463 | 1.33 | 1.38 | 0.09 | 138137 | 0.00 |
| Chg. Debt/Assets | 1.08 | 1.08 | 0.81 | 129463 | 1.16 | 1.13 | 0.96 | 138137 | 0.00 |
| Credit Spread (bps) | 2.96 | 2.85 | 3.05 | 129463 | 0.41 | 0.10 | 0.56 | 138137 | 0.00 |
| Renegotiation (pct) | 0.00 | | | | 0.00 | | | | |
| Liquidation (pct) | 0.00 | | | | 0.00 | | | | |

Table XI: **Low Growth Opportunities.** We perform a $2 \times 3$ double sort on $k$ and $z$, and select observations with high $k$ and low $z$. This table provides sample moments for the following variables: firm value $(v + m')$; assets $(k)$; face value of debt $(b)$; debt value $(m')$; ex dividend equity value $(v)$; hedge ratio $(h)$; investment rate $((k' - k(1 - \delta))/k)$; EBITDA/assets $(\pi/k)$; payouts/assets $((\pi + k(1 - \delta) - k' - b + m')/k)$; Q–ratio $((v + b')/k')$; market leverage $(b'/(b' + v))$; book leverage $(b'/k')$; change in debt / assets $((b' - b)/k)$; credit spread $(b'/m - (1 + r)$, in basis points); renegotiation (annual frequency of renegotiation); liquidation (annual frequency of liquidation). All moments are reported on an annual basis.

| | No CDS | | | | With CDS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Obs. | Mean | Median | SD | Obs. | p-Value |
| Firm Value | 45.52 | 46.44 | 2.89 | 25034 | 44.30 | 45.55 | 2.77 | 36447 | 0.00 |
| Assets | 50.56 | 43.37 | 13.58 | 25034 | 49.05 | 43.37 | 12.13 | 36447 | 0.00 |
| Debt (book) | 47.66 | 40.91 | 13.10 | 25034 | 71.14 | 65.45 | 12.26 | 36447 | 0.00 |
| Debt (market) | 14.83 | 15.58 | 1.66 | 25034 | 34.35 | 35.06 | 1.51 | 36447 | 0.00 |
| Equity | 30.68 | 30.85 | 1.51 | 25034 | 9.96 | 10.48 | 1.37 | 36447 | 0.00 |
| Hedge Ratio | 0.00 | 0.00 | 0.00 | 25034 | 1.00 | 1.00 | 0.03 | 36447 | 0.00 |
| Investment/Assets | -0.58 | -0.61 | 0.08 | 25034 | -0.62 | -0.57 | 0.06 | 36447 | 0.00 |
| EBITDA/Assets | 0.04 | 0.05 | 0.01 | 25034 | 0.04 | 0.05 | 0.01 | 36447 | 0.00 |
| Payouts/Assets | -0.01 | -0.01 | 0.01 | 25034 | -0.08 | -0.08 | 0.02 | 36447 | 0.00 |
| Q-Ratio | 2.65 | 2.54 | 0.18 | 25034 | 2.91 | 2.83 | 0.18 | 36447 | 0.00 |
| Market Leverage | 0.34 | 0.35 | 0.02 | 25034 | 0.78 | 0.78 | 0.02 | 36447 | 0.00 |
| Book Leverage | 0.90 | 0.90 | 0.06 | 25034 | 2.39 | 2.28 | 0.42 | 36447 | 0.00 |
| Chg. Debt/Assets | -0.62 | -0.60 | 0.08 | 25034 | -0.70 | -0.66 | 0.11 | 36447 | 0.00 |
| Credit Spread (bps) | -0.00 | -0.00 | 0.00 | 25034 | 52.97 | -0.00 | 1362.48 | 36447 | 0.00 |
| Renegotiation (pct) | 6.85 | | | | 0.50 | | | | |
| Liquidation (pct) | 0.36 | | | | 0.33 | | | | |

Table XII: **High Growth Opportunities.** We perform a $2 \times 3$ double sort on $k$ and $z$, and select observations with low $k$ and high $z$. This table provides sample moments for the following variables: firm value ($v + m'$); assets ($k$); face value of debt ($b$); debt value ($m'$); ex dividend equity value ($v$); hedge ratio ($h$); investment rate ($(k' - k(1-\delta))/k$); EBITDA/assets ($\pi/k$); payouts/assets ($(\pi + k(1-\delta) - k' - b + m')/k$); Q–ratio ($(v + b')/k'$); market leverage ($b'/(b' + v)$); book leverage ($b'/k'$); change in debt / assets ($(b' - b)/k$); credit spread ($b'/m - (1 + r)$, in basis points); renegotiation (annual frequency of renegotiation); liquidation (annual frequency of liquidation). All moments are reported on an annual basis.

| | No CDS | | | | With CDS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Obs. | Mean | Median | SD | Obs. | p-Value |
| Firm Value | 102.28 | 91.36 | 22.03 | 83145 | 107.84 | 97.98 | 20.36 | 49183 | 0.00 |
| Assets | 30.43 | 26.44 | 7.76 | 83145 | 24.98 | 26.44 | 5.82 | 49183 | 0.00 |
| Debt (book) | 28.98 | 24.55 | 7.61 | 83145 | 46.88 | 49.09 | 5.96 | 49183 | 0.00 |
| Debt (market) | 60.63 | 50.64 | 18.81 | 83145 | 85.92 | 77.91 | 17.63 | 49183 | 0.00 |
| Equity | 41.65 | 40.73 | 3.35 | 83145 | 21.92 | 20.07 | 3.01 | 49183 | 0.00 |
| Hedge Ratio | 0.00 | 0.00 | 0.00 | 83145 | 0.99 | 0.98 | 0.01 | 49183 | 0.00 |
| Investment/Assets | 1.38 | 1.16 | 0.86 | 83145 | 1.92 | 1.30 | 1.02 | 49183 | 0.00 |
| EBITDA/Assets | 0.23 | 0.21 | 0.06 | 83145 | 0.24 | 0.21 | 0.06 | 49183 | 0.00 |
| Payouts/Assets | 0.02 | 0.03 | 0.04 | 83145 | 0.03 | 0.00 | 0.06 | 49183 | 0.00 |
| Q-Ratio | 1.57 | 1.63 | 0.11 | 83145 | 1.62 | 1.66 | 0.09 | 49183 | 0.00 |
| Market Leverage | 0.60 | 0.57 | 0.04 | 83145 | 0.80 | 0.80 | 0.01 | 49183 | 0.00 |
| Book Leverage | 0.96 | 0.96 | 0.01 | 83145 | 1.35 | 1.38 | 0.06 | 49183 | 0.00 |
| Chg. Debt/Assets | 1.28 | 1.08 | 0.84 | 83145 | 1.89 | 1.24 | 1.06 | 49183 | 0.00 |
| Credit Spread (bps) | 3.42 | 2.85 | 3.61 | 83145 | 0.91 | 1.53 | 0.69 | 49183 | 0.00 |
| Renegotiation (pct) | 0.00 | | | | 0.00 | | | | |
| Liquidation (pct) | 0.00 | | | | 0.00 | | | | |