Bankruptcy Code, Optimal Liability Structure and Secured Short-Term Debt

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Abstract

When the bankruptcy code protects the rights of lenders, as in Hart (1999), we show that there is no intrinsic reason to issue debt with safe harbor provisions. When the code violates APR or results in significant deadweight losses, the optimal liability structure includes secured short-term debt, with safe harbor protection. The borrower is able to trade off between "run prone" safe harbored short-term debt and long-term debt depending on the inefficiencies in bankruptcy code, and the availability of eligible collateral to increase the overall value of the firm. The presence of a secured short-term debt will increase the spread of long term debt, and this reduces the long-term debt capacity of firms. Overall, the combined debt capacity increases for the firm. Using the onset of credit crisis in 2007 as an exogenous adverse shock to the collateral value of assets and to the riskiness of collateral, we find that the leverage and short-term debt of financial firms fell much more rapidly than non-financial firms due to the greater exposure of financial firms to “run risk”. The provision of short-term credit by the Fed is shown to significantly buffer the reduction in short-term debt and leverage of financial firms, supporting the presence of a supply (of credit) effect in the data. While the Fed’s intervention resulted in credit spreads returning to the pre-crisis levels, there was still a net fall in the short-term debt and leverage of financial firms, suggesting a possible demand effect as well. These results are in broad conformity with the theory developed in our paper. (JEL classification: G12, G23)
1 Introduction

We develop a structural model of default in which the optimal capital structure and the optimal mix of short-term debt and long-term debt, known as the liability structure are determined endogenously. Specifically, the paper links the optimal liability structure and the emergence of secured short-term debt protected by “safe harbor” structures to the underlying bankruptcy code, and its lack of effectiveness in protecting the rights of creditors, or entailing dead-weight losses\(^1\).

It is well known that very short-term loans/debt provided by lenders as in repurchase agreements (repo), and asset-backed commercial paper are protected by safe harbor provisions and bankruptcy remote structures respectively. The provision of safe harbor protection to lenders (such as money market mutual funds, for example) who supply short-term financing can be traced back to the Securities Exchange Act of 1934, which was amended in 2005 by the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA) to give similar protection to repo loans based on mortgage collateral. The original purpose for giving safe harbor protection was to prevent systemic risk that may arise when a major repo borrower fails, and enmesh a number of repo lenders and other significant counterparties in lengthy and costly bankruptcy proceedings that can precipitate a domino effect. Duffie and Skeel (2012) provide a backdrop to this and other arguments that have been presented in favor of safe harbor provisions.

The BAPCPA of 2005 extended the safe harbor protection to mortgages and mortgage-backed securities in the Bankruptcy Code. This implies that when a repo borrower, who has pledged Treasury, Agency or mortgage-related collateral to borrow cash, files for bankruptcy, the repo lender does not have to join the other creditors and can walk free with the repo collateral. These features make it clear that an important feature of the safe harbor provisions is that it provides super-senior rights to lenders in seizing the collateral which is held outside the bankruptcy code.

Our paper’s focus is to develop a theory of liability structure in which short-term secured debt and long-term unsecured debt arise optimally. Our theory applies to any secured short-term debt. But of particular interest is “safe harbored” short-term debt, which we model as a special case. To our knowledge, there has been no explicit treatment of how a firm decides on its optimal liability structure when it has the ability to issue such super senior short-term debt, that subjects the firm to “run” risk. In addressing this problem, our paper falls right in the middle of two strands of literature. The first strand is the literature that focuses on how short-term debt such as repo financing can exacerbate aggregate risk by precipitating fire-sale of assets, when there is an aggregate macro shock. The

\(^1\)There can be other reasons for creating bankruptcy-remote SPV structures, relating to capital relief, and accounting disclosures. These are not treated in our analysis
second strand is the literature that attempts to explore how a firm selects its optimal capital/liability structure. Our empirical work fits into the growing body of literature, which examines the empirical determinants of liability and capital structure. We briefly review the literature to place our work in a perspective.

1.1 Literature survey and an Overview of Main Results

A number of authors have weighed in on the super-senior rights of repo lenders and the holders of collateral in derivatives transactions. Several authors, notably Gorton and Metrick (2012) have identified the “repo run” due to declining value of collateral and increased “hair cuts” as an important triggering event in pushing the financial sector to the brink of insolvency. Krishnamurthy, Nagel and Orlov (2012) argue that the “run” was more severe in repos backed by private sector securities, and that the crisis looked less like a traditional bank run of depositors and more like a credit crunch among dealer banks.

There is a series of papers that discuss about special treatment of bankruptcy code on derivatives. Roe (2011) concludes that “the Bankruptcy Code’s safe-harbor, super-priorities for derivatives and repurchase agreements are ill conceived”. He observes that “Not only do the provisions facilitate runs on financial institutions during financial crises, they also seriously weaken counter-parties’ ex ante incentives for financial stability”. Roe (2011) suggests the following counter-factual: in the absence of safe harbor provisions, we should ordinarily expect players to substitute into other financing channels. Bolton and Oehmke (2011) also conclude that safe harbor provisions in derivative markets may lead to undesirable outcomes. They suggest that such provisions for derivatives can lead to inefficiencies by shifting credit risk to the firm’s creditors. They further note that as a result of safe harbor provisions, firms may take on derivative positions that are too large from a social perspective. Acharya, Anshuman and Vishwanthan (2012) argue that the automatic stay provisions may be ex-post optimal for loans made under repo agreements, due to the “fire sale” of collateral of firms that were highly levered. They are not concerned with the issue of firm’s optimal liability/capital structure, ex-ante. Antinolfi, Carapella, Kahn, Mills, and Nosal (2012) argue that the exemption from bankruptcy may result in increased repo lending, and lead to damaging fire sales in the secondary markets. Duffie and Skeel (2012) and Skeel and Jackson (2012) have argued that repo loans should not be insulated from bankruptcy provisions such as automatic stay, although they have concluded that repo loans based on cash-like securities need not be subjected to automatic stay. They suggest that repo loans based on illiquid collateral should be covered by automatic stay.

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2This discussion can be traced back to Edwards (2005).
In the context of this strand of literature, we make the following contributions\(^3\): first, we examine what should be the optimal response of the borrower when faced with the choice of issuing short-term, secured debt (which subjects the borrower to run risk) and long-term unsecured debt. We show that the borrower will internalize the run risk and choose in general a finite amount of secured, short-term debt. In our framework, when the illiquidity of the pledged collateral reaches a certain threshold low value, borrowers will optimally choose not to issue short-term debt protected by safe harbor. This result is consistent with the one of the policies advocated by Duffie and Skeel (2012).

The optimal capital literature in a structural setting has tended to work with a single, homogeneous debt setting, following the insights of Merton (1971, 1974), Black and Scholes (1973), Black and Cox (1975) and Leland (1994).\(^4\) More recently, some papers have attempted to determine the optimal liability structure. Hackbarth and Mauer (2012) emphasize the importance of priority structure of debt in the context of growth options, but they do not address the problem run risk posed by short-term creditors nor do they model super senior rights. Hackbarth, Hennessey and Leland (2007) consider bank debt and public debt, and model a situation where the bank debt can be negotiated outside the bankruptcy code. But they treat both debt as perpetual: in their setting, there is no short-term debt, which can expose the borrower to run risk.

He and Xiong (2011) provide a dynamic model of debt runs. They derive an equilibrium and interpret it in a model where each creditor, in deciding whether or not to roll-over his debt, must reflect on other creditors’ roll-over actions. Chen, et.al (2012) also build a dynamic model of debt structure and make a distinction between idiosyncratic risk and systematic risk of firms, and note that this distinction plays an important role in the choice of maturity structure and roll over decisions. Brunnermeier and Oehmke (2010) develop a model that endogenously determines maturity structure of financial institutions in the presence of multiple creditors. The model has a prediction that, during the economic turmoil, each creditor has an incentive to shorten their loan to the bank which would result excessive short-term financing and unnecessary roll-over risk. These papers, by and large, are not concerned with the question of the link between the bankruptcy code and the emergence of safe harbor protected debt as an optimal outcome. Nor are they concerned explicitly about the optimal liability structure of the firms when there is a possibility of a “run” by short-term lenders protected by super-senior provisions. These issues form the basis of our paper. Our paper thus focuses on the question of the level of short-term debt that a firm should optimally select, and abstracts from the question of the implications of such debt in the aggregate when there is a macro-economic

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\(^3\)The policy implications of systemic risk arising from the fire sale of repo collateral is examined by Acharya and Oncu (2012) and Oehmke (2013). We abstract from this question.

\(^4\)Black and Cox (1975) consider both senior and subordinated debt of finite maturity.
shock. We believe that this is the first necessary step in tackling that more ambitious policy question.

First, we derive the optimal liability structure of the firm, and show the conditions under which short-term debt with or without safe harbor protection emerges as a component of the optimal liability structure. Second, we show that the borrowers recognize that the short-term lenders (such as money market lenders) have an incentive to “run” and make their loans risk-free. This opportunistic behavior of short-term lenders, who run with their safe harbored collateral is fully internalized by the borrowers when they choose their optimal capital and liability structure. Third, we explore how the extent of dead-weight losses, and the extent to which absolute priority rights are respected influences the optimal liability structure and the use of short-term debt with super-senior provisions. By virtue of the fact that we have a structural framework, we can compute the credit spreads of long-term debt, which internalizes the run risk of safe harbored short-term debt, and effectively reduces the long-term debt capacity of the firm issuing short-term debt protected by safe harbor. The overall debt capacity of the borrower is shown to be higher. Our paper shows that safe harbored short-term debt may increase the value of the firm by lowering the expected dead-weight costs of bankruptcy and escaping potential APR violations.

On the empirical front, Rauh and Sufi (2010) document that lower rated firms tend to have a multi-tiered debt structure consisting of both secured bank debt with tight covenants and subordinated non-bank debt with relatively loose covenants, in comparison with more highly rated firms. Colla et. al. (2012) find that unrated firms are much more specialized in their use of debt than rated firms. Within rated firms, degree of debt specialization is hump-shaped. Specifically, the middle group (A and BBB) relies on senior bond and notes and the lower group (BB and B) have multi-tier debt such as term loans, senior bonds and subordinate bonds. Highly rated groups (AAA and AA) use senior bond and commercial paper. This evidence is consistent with our model, which predicts that, in cross-section, only high quality firms will use short-term debt. Billet et. al. (2007) deliver an insight that the debt structure and leverage decision are made jointly, rather than independently. Supply-side and financial contracting views suggest debt structure and leverage are tightly linked. Lemmon et. al. (2008) document two stylized facts: (1) leverage ratios exhibit a significant amount of convergence over time; firms with relatively high (low) leverage tend to move toward more moderate levels of leverage and (2) despite this convergence, leverage ratios are remarkably stable over time; firms with relatively high (low) leverage tend to maintain relatively high (low) leverage for over 20 years. Thus, they argue that leverage ratios are characterized by both a transitory and a permanent component that is not identified yet. Benmelech et. al. (2012) use Asian crisis in 1997 as a natural experiment and show that the average maturity within the long-term debt category of banks shortened during the crisis. Their study is about the potential causal relationship between debt maturity and crisis. In order to avoid
endogeneity, they focus on long-term debt that was issued well before the crisis but has a maturity date during the crisis period. They conjectured that if short-term debt is the primary cause of the bank failure, then we should expect the probability of failure to be increasing when there is any debt maturing. They do not find any evidence of this and conclude that a decrease in the duration of long-term debt is an equilibrium result of the crisis which is consistent with a prediction of Diamond and Rajan (2001b). Almeida et. al. (2010) show that the heterogeneity of the debt structure has an effect on the real economy (investment). They focus on firms with a large fraction of their long-term debt maturing right at the time of the crisis and observe that they reduce investment by 2.5% more than matching firms that do not have such debt.

On the empirical front, we examine the following implications of our model: when there is an unanticipated adverse shock to the collateral values and an increase in the riskiness of the collateral, in our model, financial firms face the risk of a run by short-term creditors, which is by far greater than the run risk faced by non-financial firms. It is then optimal for the financial firms to reduce their level of short-term debt and de-lever more than non-financial firms. Using the onset of the credit crisis of 2007 as an exogenous shock to the collateral value and riskiness of collateral, we find support for the model’s predictions. We use the ABX prices as a proxy for collateral value, and show that the financial firms, post-crisis, significantly reduced their leverage and short-term debt, when they are exposed to ABX risk. By mapping the Fed’s provision of credit to the cross section of firms in our sample, we also demonstrate a supply effect: the Fed’s provision of short-term credit buffered the financial firms’ decline in leverage and the use of short-term debt. Even after accounting for the Fed’s interventions, which brought the credit spreads in the money markets to the pre-crisis levels, there was still a fall in short-term debt and leverage for financial firms, post-crisis. This evidence suggests the presence of a demand effect as well.

The road map of the paper is as follows. Section 2 outlines the pay off functions to creditors and borrowers when the borrowers optimally decide to restructure under the shadow of a bankruptcy code. Section 3 contains the main results of the paper on restructuring, optimal leverage, liability structure, and how they relate to the underlying bankruptcy code. Section 4 contains results about the relationship between the secondary market liquidity of the assets pledged and the incentives of the borrower to use safe harbor debt. This section also contains results about long-term and short-term debt capacities with and without safe harbor provisions. Section 5 contains a detailed empirical analysis of the theory developed in the paper and its related implications for leverage, liability structure and the incentives to use safe harbor debt. We treat the emergence of credit crisis in 2007 as an exogenous event causing a negative shock to the value of collateral that is eligible for pledging and for increasing the riskiness of that collateral. These interpretations allow us to test the empirical implications of our model. Section 6 concludes.
Appendix to the paper contains all the derivations, and some supporting evidence.

2 Bankruptcy code & the incentives to issue safe harbor debt

The bankruptcy code and its implications for the design of debt contracts has been stressed in the work of Hart (1999), in which he identifies the following desirable goals for an “optimal” bankruptcy code: first, the code must deliver efficient ex-post outcome in terms of maximizing the value available to all claimants. Second, the code must deliver ex-ante efficiency inducing borrowers to commit themselves to service debt obligations. Such a commitment should be enforced by penalizing borrowers in bankruptcy states. Finally, Hart suggests that a good bankruptcy procedure must respect absolute priority (APR), with the exception that some portion of value should possibly be reserved for shareholders\(^5\).

We explore, in the context of a structural model of default, how these desired properties of the bankruptcy code influences, ex-ante, the choice of firm’s optimal liability structure and optimal capital structure. Specifically, we assume that the unlevered asset value of the borrowing firm follows a Geometric Brownian Motion (GBM) process:

\[
\frac{dV}{V} = (r - \delta)dt + \sigma dW^Q
\]

(1)

where, \(r\) is risk-free rate, \(\delta\) is the dividend yield, \(\sigma\) is the volatility of asset return and \(W^Q\) is standard Wiener process under risk neutral measure \(Q\).

The specification above implies that the investment policy is fixed. This assumption, while restrictive, allows us to focus on the optimal liability structure and optimal leverage decisions of the borrower. In our stylized setting, the borrower can issue two types of debt: one type is instantaneously maturing debt, which serves as a metaphor for short-term secured debt. The debt can be simply secured within the bankruptcy code. Or, lenders of this type may either require the super seniority provisions of safe harbor or a bankruptcy remote structure. We assume that they will be able to monitor the firm closely and “run” at the right moment to make their debt risk-free. The other type of debt is the long-term, unsecured debt, which in our setting is simply a perpetual debt with a specified coupon.

The setting is very similar to the classic structural models of default such as Merton (1974), and Leland (1994). What distinguishes our setting from these papers is the fact that we consider two types of liabilities, and that the

\(^5\) The proviso that “some portion of value should possibly be reserved for shareholders” arises because the borrowers can take excessive amount risk near bankruptcy in the absence of such provisions. In our model, this possibility is ruled out as the investment policy is assumed to be fixed. See Milbradt and Oehmke (2013) and Ing-Haw Cheng and Milbradt (2012) who study the link between investment decisions and optimal maturity structure
short-term lenders make their debt risk-free. Key to our model is the nature of the bankruptcy code, and the implied restructuring possibilities that the code presents to lenders and borrowers. We turn to this next.

2.1 Bankruptcy, “run risk” and restructuring

The presence of a bankruptcy code can lead to endogenous restructuring as noted in papers such as Anderson and Sundaresan (1996), Mella-Barral and Perraudin (1997), François and Morellec (2004), and in Broadie, Chernov and Sundaresan (2007). In these papers, a well defined bankruptcy code, with an automatic stay provision and an associated exclusivity period allows the borrowers to file for bankruptcy and suspend their contractual debt payments as they decide whether to restructure or liquidate. These papers show, under the shadow of such a bankruptcy code, lenders and borrowers will endogenously restructure their claims, without formally entering the bankruptcy process. They provide micro-foundations for the restructuring triggers and relate them to the provisions of the bankruptcy code. In this context, the default event can be generally interpreted as a restructuring event between debt holder and equity holder where liquidation of the firm is the special case of the restructuring event. Fan and Sundaresan (2000) present a model of endogenous restructuring under the shadow of Chapter 7 liquidation. Consistent with the approach taken by these papers, we focus our attention on the endogenously determined restructuring boundary $V_B$, which is the threshold level of the value of the firm at which the borrower decides to restructure. The restructuring boundary is assumed to be optimally chosen by the borrower.

When the borrower has raised capital by issuing both short-term and long-term debt, the question of restructuring becomes more complicated. The short-term lender can “run” precipitating a restructuring of the firm between the long-term lenders and equity holders. Alternatively, the borrower can decide to restructure before the short-term lenders can run.

The firm’s short-term debt is assumed to mature at each instant. This nature of the maturity gives the short-term creditor a priority over the long-term creditor. The advantage of short-term debt in our context is that it is essentially risk-free: with the GBM process in Equation (1) for the underlying value of the firm’s assets, and continuous monitoring, the short-term creditors (who have full information) can promptly act and be repaid the amount lent. This process may come from either channels: (a) run of the short-term creditors culminates in the restructuring of the firm resulting in pay outs to all claim holders, or (b) short-term lender seizes the assets via security or super-senior rights optimally to make their claims risk-free.

The motive for issuing debt can be either due to the tax code or due to agency theoretic considerations. Following the structural models of default, we will assume that the interest expenses associated with servicing debt
contracts are tax-deductible. Thus, value is created by short-term debt (and long-term debt) in this model. We assume that the tax rate is $\tau$.

2.2 Short-term Secured Debt

We denote the value of short-term debt as $S$. A fraction $\theta \in [0, 1]$ of the assets of the firm is pledged to the short-term creditors. If these pledged assets are held outside the bankruptcy code (as in safe harbor), the short-term lenders can liquidate them at a proportionate liquidation cost of $\beta$.

The short-term creditors get the assets that have been pledged outside the bankruptcy code. The parameter $\theta$ reflects the fraction of assets of the borrower that are eligible to be pledged to secure short-term financing. Not all borrowers will have the same level of eligible collateral. We denote by $\bar{\theta} \leq 1$ as the upper limit on this fraction. This can vary from one borrower to another. Formally, at the “run” boundary, $V_R$, the payoffs to the short-term lender will be given by the expression below.

$$S(V_R) = \theta(1 - \beta)V_R \equiv S$$

From the short-term creditor’s perspective, they will stop lending when restructuring event occurs. This is the instant when $V_R = \frac{S}{\theta(1-\beta)}$. While our theory will focus on safe harbored short-term debt, the model is general enough to treat secured debt inside the bankruptcy code as we will explain below. Consider a firm that operates in a bankruptcy code in which upon filing for chapter 11, the firm will either emerge with restructured debt and equity claims or liquidate under chapter 7. We assume that the underlying bankruptcy code will lead to a restructuring boundary $V_B$ at which the borrowers (equity holders) get a payout as shown next.

$$E(V_B) = (1 - \theta)\alpha_2 V_B$$

The parameter $\alpha_2$ captures the extent to which the borrowers (equity holders) are able to extract some surplus in the restructuring process, and hence reflects the degree to which the underlying bankruptcy code allows borrowers to violate absolute priority rule (APR). If we set $\alpha_2 = 0$ then the equity holders get nothing and the absolute priority

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6One may question whether repo debt, an important short-term financing channel for financial firms, would yield any tax benefits, since the transaction is technically selling the asset to the lender with an agreement to buy it back. However, according to GAAP, the difference between original sales proceeds and repurchase amount is considered as interest expenses (see FASB ASC paragraph 860-10-40-24(c)). Also court decisions have ruled that, for tax purposes, repo transactions constitute money borrowings from secured loan. (see Nebraska v. Lowenstein, 513 U.S. 123 (1994); American National Bank of Austin v. United States, 421 F. 2nd 442 (5th Cir. 1970); First American National Bank of Nashville v. United States, 467 F.2nd 1098 (6th Cir. 1972); Rev. Rul. 77-59, 1977-1 C.B. 196.)

7He and Milbradt (2012) model how corporate default decisions interact with the endogenous secondary market liquidity through the roll over channel, and identify the potential for a feedback loop between default and secondary market liquidity. We abstract from such issues in our paper.
rule is fully respected. The possibility that $\alpha_2 > 0$ implies that the bankruptcy code may result in the violation of creditor’s rights to the entire residual value of the firm. In the context of Hart (1999), the parameter $\alpha_2$ captures the extent to which some value is reserved for the equity holders in the bankruptcy procedure, and addresses Hart’s goal 3 for a desirable bankruptcy code. Note, however, in our model, there is no scope for the borrower to increase the riskiness of investments as the firm approaches financial distress. Hence the APR violations are pure rents that the borrowers are extracting from the long-term lenders due to some deficiency in the bankruptcy code. This presents another reason as to why safe harbor can add value to the firm, by diminishing this avenue of rent extraction by equity holders.

Long-term debt holders will receive at the restructuring boundary the following payout.

$$D(V_B) = (1 - \theta)\alpha_1 V_B$$

(4)

$\alpha_1$ indicates the fraction of the firm that the long-term creditor get at default. Therefore $1 - (\alpha_1 + \alpha_2) \equiv \alpha$ is the total loss in the bankruptcy process. We assume that $\alpha_1 + \alpha_2 \leq 1$ with the understanding that when $\alpha_1 + \alpha_2 = 1$, the restructuring process (under the shadow of the bankruptcy code) is fully efficient in the sense that there are no deadweight losses, and the entire residual value is split between equity holders and long-term debt holders. Thus, we distinguish two things: the dead-weight losses associated with restructuring, and the violation of creditor’s rights to the full residual value of the firm. The magnitude of $1 - (\alpha_1 + \alpha_2) \geq 0$ addresses the question of “ex post efficient outcomes” that is delivered by the bankruptcy code.

We formally distinguish between secured debt within the rubric of bankruptcy code, and secured safe harbored debt as follows. If $\beta = \alpha$ and $\alpha_2 > 0$, then we can think of the short-term debt as secured and inside the bankruptcy code. The reasoning is as follows: the short-term lender is subject to the APR violations attributable to the code, but can seize the secured assets at a cost of $\alpha$. If $\beta < \alpha$, then the safe harbor provision provides an advantage to the lender in seizing the collateral at a lower cost $\beta$. We will formally show that the relationship between $\beta$ and $\alpha$ as well as the presence or absence of APR violations will determine whether or not it is optimal to issue short-term secured debt, and conditional on issuing such short-term, secured debt, whether it should be safe harbored or not.
3 Optimal Restructuring and Liability Structure

Let $C$ be the dollar coupon rate promised by the borrower to long-term creditors. Let $S$ be the par value of short-term debt issued by the borrower, which matures at each instant. We begin by asking the following question: given a liability structure $\{C, S\}$ how would the borrower select the optimal restructuring boundary? As in any structural model of default, we assume that the borrower commits to maintain this level and composition of debt until default. Typically, negative pledges are placed to prohibit further issuance of debt and sale of assets. Such provisions can serve to limit significant changes in the capital and liability structure. Based on data gathered from Capital IQ, out of 6315 issuances of financial debt from Jan 1967- April 2012, 88.9% have negative pledge covenants or restriction of asset sales. In addition, 69.7% have negative pledge covenants or cross acceleration provisions.

Let us first suppose that the borrower ignores the “run risk” presented by the short-term lenders in selecting the equity-value maximizing restructuring boundary, $V_B$. Alternatively, let us suppose that the short-term creditors do not run until the firm chooses to default. We will later explicitly incorporate the run risk imposed by the short-term lenders in the determination of the optimal liability structure and the restructuring boundary by the borrower. This problem is no different from the one studied in the literature before except that we replace the debt cash flows $C$ in the single debt case to $C + Sr$ in the context of our model. This leads to the restructuring boundary, which is stated below.

**Proposition 1** Optimal restructuring boundary for equity holders is:

$$V_B = (1 - \tau) \left( \frac{C + Sr}{r_x} \right) \left( \frac{x}{1 + x} \right) \frac{1}{1 - (1 - \theta)\alpha_2}$$

where $x > 1$ is the root of the equation below:

$$0 = \frac{1}{2} x^2 \sigma^2 - x \left( r - \delta - \frac{\sigma^2}{2} \right) - r$$

Note that as the APR violations admitted by the code increases, i.e., as $\alpha_2$ increases, the borrower would like to restructure early to get his share of the residual value of the firm earlier. Finally, note that when $\theta = 1$, APR violations do not influence the choice of restructuring boundary: this is due to the fact that the debt is secured by all assets that the borrower is able to pledge.
Now we relax the assumption that there is no run risk. In the presence of a run risk, the borrower will rationally anticipate that the short-term lenders will run precisely when the market value of the collateral held by them reaches the value $S$. In other words, when $V \downarrow V_R \equiv \frac{S}{\theta(1-\beta)}$, the lenders will run and refuse to lend any further. Lenders behave this way in our model as they are very risk averse and are content to earn risk-free rate on their loans. Borrowers will reflect the actions of the lenders and choose $S^*$ such that $S^* = V_B\theta(1-\beta)$. This is stated next.

**Proposition 2** Borrowers pick $S^*$ such that a) it is equity value-maximizing, and b) the short-term debt is risk-free. In other words, $S^*$ is chosen so that $V_B$, is set to be equal to the “run” boundary of short-term creditors, $V_R$, i.e., $S^* = V_B\theta(1-\beta)$.

□

The economic intuition for the proposition is the following: the run boundary must be such that the short-term debt is risk-free. This is due to the fact that the lenders can continuously monitor the firm and run and make their debt risk-free, and will effectively insulate themselves from default. Hence $V_R$ cannot be less than $V_B$. On the other hand, if $V_R > V_B$, the borrower will have to retire the short-term debt much sooner, and operate only with long-term debt. The borrower loses the tax-shield, and incurs costs of liquidating collateral, as well as the opportunity costs of losing collateral. So, at the equity-maximizing default boundary $V_B$ the pair $\{C, S\}$ will satisfy the following locus as shown in Figure 1 next.

Figure 1 provides the economic intuition behind Proposition 1 and 2. Let us set $S = 0$ and note that $\alpha_2 = 0$. In this case, there is only long-term debt and the default boundary coincides with the one found by Leland (1994) as can be seen from Proposition 1. This is the $Y$-intercept of the line $V_B$ in Figure 1. As we increase $S$, it is intuitive that $V_B$ should increase, but so does $V_R$. In fact, $V_R$ increases much more rapidly, as the short-term lender will exit sooner to make his loans risk-free. The point where $V_R$ and $V_B$ intersect pins down the level of $S$ that the borrower will choose to pick the restructuring boundary, which maximizes his equity value. It must be emphasized that the level $S$ found will depend on $C$, and later we will determine the value-maximizing level of $C$ and the associated level of $S$.

Combining the two results above, we can express the optimal restructuring boundary solely as a function of the promised coupon rate $C$ on long-term debt. This is presented below.

$$V_B(\theta) = \left(\frac{C}{r}\right) \cdot f(\theta)$$ (5)
Figure 1: **Illustration of choosing $V_B$ and $S$ for a given $C$**: This figure illustrates the equity holder’s optimal choice of restructuring boundary and the level of short-term debt. For a given level of $C$, equity holder chooses $V_B$ and $S$. The solid line with steeper slope is $V_R$ imposed by the short-term lender. The solid line with flatter slope is $V_B$ the optimal restructuring boundary associated with each value of $S$. The dotted line is 45 degrees line. With a given $C$, the optimal choice is to pick $S$ and $V_B$ at the point where two solid lines cross. In this figure, $C = 0.045$, $\theta = 0.8$, $\alpha_1 = 0.7$ and $\alpha_2 = 0$ is assumed. Also the following deep parameter values have been assumed: $V_0 = 1$, $r = 0.04$, $\delta = 0.02$, $\tau = 0.35$, $\sigma = 0.25$, $\beta = 0.05$.

where, we have defined $f(\theta)$ below:

$$f(\theta) = \left( \frac{(1 - \tau)(\frac{x}{1+x})(\frac{1}{1-(1-\theta)\alpha_2})}{1 - (1 - \beta)\theta(1 - \tau)(\frac{x}{1+x})(\frac{1}{1-(1-\theta)\alpha_2})} \right)$$

We now turn to the value-maximizing choice of optimal liability structure. The optimal liability structure which maximizes the total value of the firm is given next.

**Proposition 3** *Optimal liability structure is:*

\[
C^*(\theta) = \frac{rV}{f(\theta)} \left[ \frac{1 + f(\theta) \cdot (1 - \beta)\theta}{(1 + x)(1 - f(\theta) \cdot g(\theta)/\tau)} \right]^\frac{1}{x}
\]

\[
S^*(\theta) = V \left[ \frac{1 + f(\theta) \cdot (1 - \beta)\theta}{(1 + x)(1 - f(\theta) \cdot g(\theta)/\tau)} \right]^\frac{1}{x} \cdot (1 - \beta)\theta
\]
Figure 2: **Effect of APR violations and eligibility to pledge on optimal liability structure**: These figures plot short-term debt to long-term debt ratio ($S/D$) with respect to the APR violation, $\alpha_2$ (left) and eligibility to pledge, $\bar{\theta}$ (right). The left figure is with three different value of $\bar{\theta} = 0.525$ (solid), 0.5 (dashed) and 0.475 (dotted), keeping $\alpha_1 = 0.5$. The right figure uses three different value of $\alpha_1 = 0.9$ (solid), 0.5 (dashed) and 0.1 (dotted), keeping $\alpha_2 = 0.0$. For both figures, the following deep parameter values have been assumed: $V_0 = 1$, $r = 0.04$, $\delta = 0.02$, $\tau = 0.35$, $\sigma = 0.5$ and $\beta = 0.05$.

where $g(\theta)$ is:

$$g(\theta) = ((1 - \tau)(1 - \beta)\theta + (1 - \theta)(\alpha_1 + \alpha_2) - 1)$$

Proposition 3 is one of the main implications of our model. It shows how the firm chooses the optimal mix of short-term and long-term debt levels, fully internalizing the run risk posed by the short-term lenders. In addition, it links the optimal liability structure to the deep parameters of the model such as a) the fraction of assets that are eligible for pledging, b) deviations from APR admitted by the bankruptcy code, c) the extent to which the financial distress and the resulting restructuring is costly, and d) the volatility of the underlying assets of the borrower.

We discuss below in detail these implications of Proposition 3. In the left panel of Figure 2, we plot along the X-axis, $\alpha_2$, which measures the extent to which the bankruptcy code admits deviations from absolute priority, and along the Y-axis, the value-maximizing ratio of short-term debt to long-term debt implied by our model. These are plotted for three levels of $\theta$: the lowest line refers to the lowest $\theta$ and the topmost line refers to the highest $\theta$. We note that when the bankruptcy code admits no violations of APR, generally the firm is able to support a much higher level of long-term debt in all the three cases, with the observation that the firm with greater fraction of eligible collateral for pledging tends to use more short-term debt. As the code begins to admit greater deviations from APR, all the firms (irrespective of their $\theta$) tend to increase their use of short-term debt, although the incentives are much greater for the firms with lowest $\theta$ as they have the lowest level of short-term debt to begin with.
Figure 3: **Effect of asset volatility on optimal Liability structure and leverage:** These figures plot short-term debt to long-term debt ratio (left) and total leverage of a firm (right) with respect to the asset volatility ($\sigma$). The solid line uses $\theta = 0.8$ and the dashed and dotted line use $\theta = 0.6$, $\theta = 0.4$ respectively. In the right pane, thicker line represents the leverage in Leland (1994) with only unprotected long-term debt, keeping other parameters same. For all three lines, the following deep parameter values have been assumed: $V_0 = 1$, $r = 0.04$, $\delta = 0.02$, $\tau = 0.35$, $\beta = 0.05$, $\alpha_1 = 0.5$ and $\alpha_2 = 0.1$.

The right panel of Figure 2 plots along the X-axis, $\bar{\theta}$, which measures the fraction of eligible collateral that may be used for pledging, and along the Y-axis, the value-maximizing ratio of short-term debt to long-term debt implied by our model. These are plotted for three levels of $\alpha_1$: the lowest line refers to the lowest $\alpha_1$ and the topmost line refers to the highest $\alpha_1$. We note that when the bankruptcy code results in high financial distress costs associated with restructuring, generally the firm is able to support a much lower level of long-term debt. The firm with the greater fraction of eligible collateral for pledging tends to use more short-term debt. In this case, we assume that $\alpha_2 = 0$ so that there are no deviations from APR. This implies that even in the absence of APR deviations, firms in our model have an incentive to use short-term debt. This incentive arises due to the fact that once the assets are pledged outside the code, the costs associated with recovery as summarized by $\beta$ may be much less than the costs $\alpha_1$ when the assets are inside the jurisdiction of the bankruptcy code.

The right panel of Figure 2 shows yet another role played by arrangements such as safe harbor and bankruptcy-remote SPVs: when the restructuring process is perceived to be very costly, moving assets outside the bankruptcy code can add value to the borrowing firm as a whole. To the extent that we believe that the bankruptcy and the financial distress resolution process faced by financial institutions is much messier than the ones faced by non-financial firms, then it is reasonable to expect financial firms to use more of these arrangements than non-financial firms. Their ability to use safe harbored debt and SPVs may also be further enhanced by the fact that they may be holding more eligible collateral.

The left panel of Figure 3 plots the optimal liability structure for increasing levels of underlying asset volatility.
parameter \( \sigma \). Note the liability structure of less risky firms tend to have a greater proportion of short-term debt. In addition, if the firm has a greater fraction of eligible collateral, it is able to sustain a greater proportion of short-term debt in its liability structure.

The optimal leverage in our model is generally higher than Leland (1994). This is due to the fact that the firm is able to trade off between short-term and long-term debt to optimally take advantage of any inefficiencies in the bankruptcy code. With a costly bankruptcy code, the firm will issue more short-term debt protected by safe harbor. Likewise when the firm has more eligible collateral, it can take advantage of that to increase its optimal leverage. The right panel of Figure 3 examines the relationship between optimal leverage and the volatility of the underlying assets of the borrower.

Note that at very low levels of asset volatility, the borrower tends to use higher levels of leverage, irrespective of the fraction of the assets that are eligible to be posted as collateral. This is due to the fact that at such low levels of \( \sigma \) the borrower’s long-term debt capacity is rather high, and this compensates the inability to issue short-term debt when \( \theta \) is low. This effect can also be appreciated by reviewing the optimal liability structure in the left panel of Figure 3, for various levels of \( \theta \). In the right panel of Figure 3, we also report the level of optimal leverage in an otherwise identical Leland (1994) economy with a single issue of unprotected debt. It is clear that the firm’s value in our economy is higher due to the increased level of optimal leverage.

3.1 Creditor’s Rights and the Relevance of Safe Harbor Debt

In this section we formalize the economic intuition that with a bankruptcy code, which admits lesser deviations from APR, and lower dead-weight losses, there is no role for safe harbor, unless the costs of liquidating the collateral under safe harbor are lower than the costs under the bankruptcy process. Hence we begin with the assumption that APR is enforced. When Absolute priority rule (APR) is respected, we have \( \alpha_2 = 0 \). In this case, by virtue of Proposition 3, we get

\[
\frac{C}{r} = \frac{S}{f(\theta)(1 - \beta)\theta}
\]

where,

\[
1 + \frac{1}{f(\theta)(1 - \beta)\theta} = \frac{1 + x}{x(1 - \tau)} \frac{1}{\theta(1 - \beta)}
\]
This implies that \( C/r + S = S(1 + \frac{1}{f(\theta)(1-\theta)p}) = V_B \frac{1+x}{x(1-\tau)} \). We can now write the total value of the borrower’s firm as follows:

\[
v(V) = V + \left( V_B \frac{\tau(1+x)}{x(1-\tau)}(1-p) \right) + pV_B \left( \theta((1-\alpha_1) - \beta) - (1 - \alpha_1) \right)
\]

(7)

Recall that when \( \alpha_2 = 0 \), \( (1 - \alpha_1) \) becomes the total loss from the bankruptcy, i.e., \( \alpha = (1 - \alpha_1) \) and \( \beta \) is the cost of liquidating collateral outside of the bankruptcy code. Then the last term of the Equation (7) becomes \( pV_B (\theta(\alpha - \beta) - \alpha) \). Note that when \( \alpha = \beta \), the firm’s value is independent of \( \theta \). This leads to our Theorem 1, which is stated next.

**Theorem 1** When the bankruptcy code protects creditor’s rights and the recovery rates to the creditor under the code are identical to the recovery rates when the debt is protected by safe harbor, then the firm’s value is unaffected by the presence of safe harbor rights. The value of the firm is independent of the liability structure.

□

An implication of the theorem is that when \( \alpha > \beta \), which is a more natural assumption, the firm will secure all its eligible assets for pledging in safe harbor to issue riskless short-term debt, and will only issue unsecured long-term debt.

Now we examine the problem of designing the optimal liability structure facing the borrowing firm when APR is not respected, so that \( \alpha_2 > 0 \). Here, there are two interesting cases: The first case wherein \( \alpha_1 + \alpha_2 = 1 \) implying that the code in the background results in a restructuring that avoids dead-weight losses. The second case is one in which \( \alpha_1 + \alpha_2 < 1 \), so that there are some dead-weight losses associated with restructuring in the shadow of bankruptcy code. The value of the firm is

\[
v(V) = V + \left( V_B \frac{\tau(1+x)}{x(1-\tau)}(1-p) \right) + pV_B \left( \theta\left[ \frac{1-\beta}{1-\alpha_2(1-\theta)} - (\alpha_1 + \alpha_2) \right] - (1 - (\alpha_1 + \alpha_2)) \right)
\]

(8)

It is easy to show that \( \frac{\partial v(V)}{\partial \theta} > 0 \) when the bankruptcy code violates creditor’s rights and the total bankruptcy leakage is equal or larger than the pure market friction, i.e., \( 1 - (\alpha_1 + \alpha_2) = \alpha > \beta \). It is interesting to see that even though the dead-weight loss from the bankruptcy is equal to the liquidation cost (\( \alpha = \beta \)), the equity holder wants to pledge as much as he could. This is a stark contrast to the first case when APR is fully respected. In that case, when \( \alpha = \beta \), the firm value is independent of \( \theta \). We summarize this result in the following theorem.
Theorem 2 When the bankruptcy code violates creditor’s rights and \( \alpha > \beta \), and it is optimal to set \( \theta = \bar{\theta} \) and issue short-term debt protected by safe harbor. When \( \alpha = \beta \), it is optimal to issue secured debt within the bankruptcy code. The optimal liability structure will have secured, short-term debt with or without safe harbor protection and unsecured or partially secured long-term debt.

In the specification above, there are no explicit costs to securing assets outside the bankruptcy code. In reality, however, we may expect both explicit and implicit costs: securing assets outside may require the borrowing form to set up a collateral management program, monitor covenants that long-term creditors may impose by way of negative pledges, restrictions on “sale” of assets, etc. Although, once we model these costs, it is possible to make the optimal level of \( \theta \) less than \( \bar{\theta} \), our existing specification is simple enough to deliver the basic intuition.

Theorem 1 and 2 suggest that the short-term liability will be, in fact, not only senior to unsecured long-term debt but also secured debt, depending on the nature of the underlying costs of restructuring debt. This has an important implication in our model if we were to calibrate the model to explain the credit spreads. Our framework is potentially capable of mitigating the credit spread puzzle in structural models of default as the existing models do not consider a) the subordination of long-term debt, and b) the higher spreads that long-term creditors would demand since they do not have access to the assets that have been pledged outside the bankruptcy process. Moreover, the existing models do not calibrate to the liability structure of firms.\(^8\). In the special case, where there are APR violations, i.e., \( \alpha_2 > 0 \), and \( \alpha = \beta \), there will be an incentive to issue secured debt inside the bankruptcy code, even though there is no incentive for safe harbor.

In Figure 4 we examine the optimality of issuing secured short-term debt within the bankruptcy code. The left panel plots the firm value as a function of \( \theta \) for different levels of APR violations. When there are no APR violations, there is no advantage to issuing short-term, secured debt within the bankruptcy code in our model: note that the value of the firm is unaffected by \( \theta \) when \( \alpha_2 = 0 \). On the other hand, for \( \alpha_2 > 0 \), there is an advantage to issuing short-term, secured debt, as the value of the firm is increasing in \( \theta \).

The right panel plots the ratio of short-term debt to long-term debt as a function of \( \bar{\theta} \) for different levels of \( \alpha_1 \), under the assumption that there are APR violations. The greater the value of \( \alpha_1 \) is, the higher are the benefits of issuing short-term, secured debt.

\(^8\)A number of authors have appealed to macro-economic factors, and time varying risk aversion to help explain the credit spread puzzle. Our argument would be that the issuance of senior short-term debt will automatically increase the spreads at which longer-term debt will be issued. This dimension has not been explored in the credit spread literature. This is a topic of ongoing research.
Figure 4: **Case of secured but not safe harbored debt:** These plots describe the case when the short-term debt is secured debt but not safe harbored. Since the short-term debt is under the bankruptcy code, they share the bankruptcy cost but there is no APR violation because it is secured. The left figure shows that firm value is increasing in $\theta$ when $\alpha_2 > 0$. Solid and dashed line use $\alpha_2 = 0.2, 0.1$, respectively and 0 for dotted line. The right figure is the corresponding debt structure with respect to $\bar{\theta}$ when $\alpha_2 = 0.2$ with three different values of $\alpha_1 = 0.3$ (dotted), 0.4 (dashed) and 0.5 (solid). For both figures, other parameters are used as follows: $V_0 = 1$, $r = 0.04, \delta = 0.02, \tau = 0.35$ and $\sigma = 0.25$.

Theorems 1 and 2 have strong predictions as to how the secondary market liquidity of the eligible collateral might influence the desirability safe harbored short-term debt. We take this issue up in section 4.

### 3.2 Linking Restructuring to the Underlying Bankruptcy Code

In the formulation above, we operated in a reduced-form setting and did not establish a direct link between the sharing rules proposed in the restructuring rules in Equation (3) and (4) and the provisions of the underlying code as discussed by Mella-Barral (1999), François and Morellec (2004), and in Broadie, Chernov and Sundaresan (2007). We illustrate that link in this section, by using the approach of François and Morellec (2004) to illustrate how the provisions of the bankruptcy code influence the choice of the restructuring boundary and the payoffs to borrowers and lenders at the boundary. Two key parameters of the bankruptcy code that are modeled by François and Morellec (2004), and Broadie, Chernov and Sundaresan (2007) are the following: a) the length of the automatic stay, denoted as $d$, and b) the flow rate of costs, $\phi$, associated with the firm being in the chapter 11 process, attempting to restructure its loans. Using the approach of François and Morellec (2004), we can link the parameters $\alpha_1$ and $\alpha_2$ to these parameters and the bargaining power $\eta$ of the borrowers as implied by the provisions of the bankruptcy code as in Fan and Sundaresan (2000).

In Figure 5, we plot the implied $\alpha_2$ for different values of $d$ in years, and for different bargaining powers $\eta$ (left panel) and for different flow rate of costs (dissipative dead-weight losses of being in the chapter 11 process) $\phi$.
Corresponding $a_2$ in the length of automatic stay, $d$ (by $\eta$)

Corresponding $a_2$ in the length of automatic stay, $d$ (by $\phi$)

Figure 5: **Illustrations of APR violations arising from the provisions of the bankruptcy code:** These plots depict how our reduced form of APR violation parameter, $\alpha_2$, is linked to the characteristics of the bankruptcy code at a more fundamental level, using the framework of Francois and Morellec (2004). Both figures map the length of automatic stay of the code to the parameter $\alpha_2$, which captures APR violations. The left panel varies the bargaining power of shareholder by using $\eta = 0.7$ (solid), 0.6 (dashed) and 0.5 (dotted), keeping $\phi = 0.03$. The right panel varies the cost of being in the Chapter 11 by using $\phi = 0.03$ (solid), 0.02 (dashed) and 0.01 (dotted), keeping $\eta = 0.5$. For both figures, total bankruptcy loss is fixed at 0.2 and other parameters are used as follows: $V_0 = 1$, $r = 0.04$, $\delta = 0.02$, $\tau = 0.35$, $\sigma = 0.25$, $\beta = 0.05$.

(right panel). Note that if the code allows the borrower to remain in the chapter 11 process for a long period with automatic stay in effect, then the implied deviations from APR can be rather high. As seen in the left panel, the greater the bargaining power of the borrower, the higher is the implied violations of APR. The right panel shows that, as the costs associated with the chapter 11 process decrease, there is more room for shareholder’s strategic behavior, hence the APR violations increase. These are fairly intuitive conclusions.

4 **Asset Liquidity & Incentives to Use Safe Harbor**

The liquidity of the collateral in the secondary market and its appropriateness for backing a safe harbor debt, which is exempt from automatic stay has received some discussion in the literature. Duffie and Skeel (2012) have argued the following: “.. repos [and certain closely related (Qualified Financial Contracts) – QFCs] that are backed by liquid securities should be exempt from automatic stays, or receive an effectively similar treatment. Repos backed by illiquid assets, on the other hand, should not be given this safe harbor.” In our model, we can address this question formally: will the borrower optimally choose not to issue safe harbored debt when the secondary market liquidity of its eligible collateral falls below a certain threshold? Intuitively, if $\beta$ (which represents the secondary market friction parameter in our model) is higher than a certain threshold level, it might not be optimal for the borrower to issue any safe-harbored debt at all. Theorem 1 says that if there are no APR violations and the restructuring
process is no more costly than liquidating collateral in the safe harbor, then the firm value is independent of the amount pledged. In fact, if the restructuring cost $1 - \alpha_1 = 0$ then, Theorem 1 implies that $\theta = 0$ as well to prevent a welfare loss. This implies that there is no place for safe harbor under such conditions.

We examine the incremental effect of secondary market friction on the firm’s value. We find that there exists $\bar{\beta}$, such that $\frac{\partial v^\star (V, \beta)}{\partial \theta} < 0$ if $\beta > \bar{\beta}$. This threshold value $\bar{\beta}$ is a function of $\alpha_1, \alpha_2$ and $\theta$. This implies that if $\beta > \bar{\beta}$, then it is optimal not to use safe-harbor. In other words, the collateral has to be at least more liquid than what is implied by $\bar{\beta}$, given the basic parameters of the bankruptcy code. We can show that it is a decreasing function of $\alpha_1$ and $\alpha_2$. If the bankruptcy code implies a costly restructuring ($\alpha_1$ is high) then the constraint on secondary market liquidity becomes less binding. In a similar vein, if the code results in more APR violations, the constraint on market liquidity becomes more relaxed. This is to say that if the code is efficient, only very liquid asset with very low values of $\beta$ can be used as the collateral. In this sense, our model implies that the recommendation of Duffie and Skeel (2012) may be based on some desirable properties for the underlying bankruptcy code. This result is summarized in the following corollary.

**Corollary 1** If $\beta > \bar{\beta}$, it is optimal not to use safe harbored debt, where

$$\bar{\beta} = \frac{(1 - (\alpha_1 + \alpha_2))(1 + x\alpha_2(1 - \theta) - \tau) + \alpha_2((1 - \theta)(1 - (\alpha_1 + \alpha_2)) + ((1 - \theta)\alpha_1 + \theta)(x + 1))\tau}{(1 - \alpha_2(1 + x\theta))(1 - \tau)}$$

Figure 6 characterizes the region of $\bar{\beta}$ for different levels of frictions ($\alpha_1$) associated with restructuring under the shadow of bankruptcy code and the possible range of violations of APR that the code admits as captured by $\alpha_2$.

Note from the left panel of Figure 6 that for $\alpha_1$ close to 1 (high recovery rates for long-term creditors) and $\alpha_2$ close to zero (low violations of APR), the value maximizing $\bar{\beta}$ is close to zero, implying that it is only optimal for the firm to use extremely liquid collateral in safe harbored debt. This provides a theoretical context for the recommendation of Duffie and Skeel (2012). On the other hand, if the code admits significant APR violations (high $\alpha_2$), and the recovery rates to long-term creditors are low, then the firm might wish to use even relatively illiquid collateral in issuing safe harbor debt. Note that in our model the firm is not internalizing the costs associated with the systemic risk implications of issuing safe harbored debt, and any policy action in addressing that question should also take into consideration the nature and efficiency of the bankruptcy code under which the firms are operating.
Figure 6: **Constraint on liquidity of pledged asset to justify safe harboring activity:** These figures visualize the minimum level of liquidity that collateralized asset should satisfy for safe harboring to be beneficial. In the left figure, the vertical axis represents $\bar{\beta}$, the maximum market friction the asset can afford, on different combinations of $\alpha_1$ and $\alpha_2$. The figure assumes $\alpha_2 \leq \alpha_1$ and $\alpha_1$ takes value from 0.5 to 1, $\alpha_2$ from 0 to 0.5. The right figure, the vertical axis plots the firm value in $\theta$ for different value of $\beta$, assuming $\alpha_1 = 0.8$ and $\alpha_2 = 0.1$. The lighter area is the region where the firm value increase in $\theta$ whereas it decreases in $\theta$ in darker region. The borderline of these regions pins down the value of $\bar{\beta}$. For both, the following deep parameter values have been assumed: $V_0 = 1$, $r = 0.04$, $\delta = 0.02$, $\tau = 0.35$, $\theta = 1$ and $\sigma = 0.5$.

The right panel of Figure 6, plots the value of the firm with respect to $\beta$ and $\theta$. It is important to note that a higher $\theta$ may either have a beneficial or a negative effect on the total value of the firm. The lighter region indicates that the total firm value increases in $\theta$. On the other hand, the darker region indicates that the total firm value decreases in $\theta$, which occurs precisely when $\beta > \bar{\beta}$, the vertical cut-off point in $\beta$ axis.

### 4.1 Debt Capacity

The firm may lose some long-term debt capacity by issuing short-term debt backed by collateral that is under safe harbor. This is due to the fact that the long-term lenders will demand an extra spread to lend when they know that some assets have been pledged away. What about the overall debt capacity of the firm, when the firm decides to use both short-term and long-term debt? This is characterized in the following corollary.

**Corollary 2** *With short-term debt and long-term debt, the maximum debt capacity is given as:*

$$C_{MAX} = \frac{rV}{f(\theta)} \left[ \frac{1}{1+x} \right] \left( \frac{1 + \theta(1 - \beta) \cdot f(\theta)}{1 - (1 - \theta)\alpha_1 \cdot f(\theta)} \right)^{\frac{1}{2}}$$
Figure 7: **Maximum debt capacity with Safe Harbor:** This figure plots maximum debt capacity when there is a short-term debt that a firm can borrow with pledging. The dashed line is the benchmark case where there is no short-term debt. To make a stark contrast, we assume \( \theta = 1 \) for the solid line when pledging activity is possible. So in this case, the total debt capacity comes from both long-term and short-term debt. We also assume that there is no APR violation. For all lines, the following deep parameter values have been assumed: \( V_0 = 1, r = 0.04, \delta = 0.02, \tau = 0.35, \sigma = 0.25, \beta = 0.05, \alpha_1 = 0.7 \) and \( \alpha_2 = 0.0 \).

It is easy to show that when \( \theta = 0 \) and \( \alpha_2 = 0 \), then the firm takes no short-term debt and we recover the debt capacity results of Leland (1994) setting. Using this as benchmark model (dotted line), in Figure 7, we compare the debt capacity from our model (blue line; \( \theta = 1 \)):

From Figure 7, we see that the debt capacity with short term debt is higher than the benchmark setting. We know that when \( \theta = 0 \) and \( \alpha_2 = 0 \), the optimal level of the debt is same as the benchmark model (see the expression for \( C^* \)).

But this result suggests yet another motivation for firms to use short-term debt with safe harbor: it enables the firm to potentially raise more debt capital at time \( t = 0 \) and take on bigger projects that might be otherwise not feasible. This will be especially relevant if the code is very inefficient.

The next figure shows the difference of the maximum debt capacity between the benchmark model (\( \theta = 0 \)) and our model with \( \theta = 1 \) when there is APR violation. We vary \( \alpha_1 \) to give some insights about the incremental debt capacity:

For three different levels of \( \alpha_2 \), Figure 8 shows that the difference becomes bigger as \( \alpha_2 \) gets larger. The dotted line is the case without APR violation (\( \alpha_2 = 0 \)) and the difference becomes 0 when there is no dead-weight loss of the bankruptcy, i.e, \( \alpha_1 = 1 \).
Figure 8: **Difference in debt capacity with APR violation:** This figure presents the difference of maximum debt capacity between the model with pledgibility and the benchmark model where there is no short-term debt. Each line represents different level of $\alpha_2$. The blue line has $\alpha_2 = 0.2$, and $\alpha_2 = 0.1, 0.0$ for dashed and dotted line, respectively. The horizontal axis is $\alpha_1$. Therefore, the plot depicts the difference of debt capacity with respect to the efficiency of the code, for a given $\alpha_2$. For all three lines, the following deep parameter values have been assumed: $V_0 = 1, r = 0.04, \delta = 0.02, \tau = 0.35, \sigma = 0.25, \beta = 0.05$ and $\theta = 1$.

5 Empirical Implications & Empirical strategy

5.1 Empirical implications of the model

The model developed in the paper has several empirical implications. We focus on two specific implications of the model and explore them empirically to examine whether the model’s predictions are consistent with the data.

First, the model implies that an adverse shock to the market value of eligible collateral, $\bar{\theta}V$, will lead to both a decrease in leverage [Figure 3, right panel] and a decrease in the use of secured short-term debt relative to long-term debt [Figure 3, left panel]. This implication occurs through the following channel: a sudden and unanticipated drop in the value of collateral, increases the probability of a “run” by the suppliers of short-term credit. This is due to the fact the borrower is not able to instantaneously de-lever and lower the short-term debt as predicted by our model. This causes the probability of default/run to go up as well. Since the short-term creditors continue to remain risk-free, the increased probability of default causes the long-term credit spreads to increase. One way to think about this outcome is to note that the short-term creditors do not adjust the price of their credit via higher credit spreads, but they simply refuse to lend if their loans are not risk-free. This captures the behavior of many money market mutual funds during the crisis: many simply refused to lend short-term at any price during the crisis. Gorton and Metrick (2012) provide a detailed treatment of such repo runs. The long-term creditors, in our model, make a price adjustment in response to a crisis, and are prepared to lend, but require high credit spreads. As a result, the borrower would like to reduce the level of short-term debt in response to an adverse shock to the value
of the collateral.

Second, the model predicts that an increase in the volatility of assets causes the ratio of short-term debt to long-term debt to go down [Figure 3, left panel] and the leverage to go down [Figure 3, right panel]. When the volatility increases, the default boundary (and hence the “run” boundary”) goes up triggering a higher probability of a run. By our earlier arguments, once again, the borrower will wish to lower the short-term debt.

In addition, an increase in the volatility of assets coupled with a sudden drop in the value of the assets operate in our model through two channels: a sudden drop in the value of assets causes $\bar{\theta}$ to go down. This increase the “run” risk by short-term creditors, and causes a natural drop in the ability of firms to issue short-term debt. When the drop in the value of the assets is coupled with an increase in the volatility of the assets, there is an amplification mechanism: both the ratio of short-term debt to long-term debt as well as the leverage go down rather significantly.

In view of the fact that financial firms rely much more on collateralized short-term borrowings such as repo, asset-backed commercial paper, etc. (we provide evidence to this effect in Figure 10). We expect the shocks to $\bar{\theta}V$ and the increased volatility of assets to have a disproportionately bigger impact on financial firms than non-financial firms. Note that, as shown in Proposition 3, the optimal capital structure is stable over the state of the economy. Firms do change their capital structure when there are significant changes in the state of the economy and when the firm characteristics such as volatility of assets change significantly. This is consistent with Roberts and Leary (2005) and Strebulaev (2007) who they empirical evidence and intuition that firms adjust their capital structure only infrequently in the presence of adjustment costs.

5.1.1 Simulating shocks to $\bar{\theta}V$ and $\sigma$ in the model

Our model differentiates financial firms from non-financial firms in terms of their ability to pledge assets to raise short-term debt. This variation is modeled by the parameter $\bar{\theta}$ in our framework. We assume in our simulation that $\bar{\theta}$ is drawn from a normal distribution, truncated between 0 and 1 with variance $\eta$. Financial firms are expected to have a higher level of pledging capacity than non-financial firms, in general. Hence we set the mean of the distribution for financial firms (denoted by $\mu_F$) to be higher than that of non-financial firms (denoted by $\mu_{NF}$).

In this exercise, financial firms differ from non-financial firms only on two dimensions: $\bar{\theta}$ and $\sigma$. We proxy the $\sigma$ from the monthly return volatility of the equity in the past 12 months to the each observation in the pre-crisis period. In the model $\sigma$ is the asset return volatility, whereas in the simulation we use equity volatility, for illustrative purposes. We expect asset volatility to be lower than equity volatility due to leverage. It is worth noting that, empirically, average firm-year equity volatility for financial firms is lower than that for non-financial
Figure 9: **Distribution of optimal leverage and optimal maturity structure:** These histograms illustrate the model-implied predictions of optimal leverage and optimal maturity ratio before and after the financial crisis. The lighter bars account for non-financial firms whereas darker bars denote financial firms. Each vertical line indicates the mean of the distribution. They differ in mean of truncated normal distribution of $\bar{\theta}$: $TN(\mu_{\{F,NF\}}, \eta)$ bounded by 0 and 1. We assume $\mu_F = 0.6, \mu_{NF} = 0.2$ and $\eta = 0.15$. We use the mean equity volatility of 12 month return as a proxy for $\sigma$. For financial firms $\sigma = 0.21, 0.39$ for pre and post crisis, respectively. For non-financial firms, we use $\sigma = 0.37, 0.47$ for pre and post crisis, respectively. Other parameters are assumed as follows: $V_0 = 1, r = 0.04, \delta = 0.02, \tau = 0.15, \alpha_1 = 0.5, \alpha_1 = 0.1$ and $\beta = 0.05$.

firms. Moreover, financial firms are more heavily levered than non-financial firms. Combining these two facts, it is reasonable to assert that the average firm-year asset volatility of financial firms is lower than that of non-financial firms. Hence, our simulation results essentially proceed on this basic fact.

The hypothetical distribution of $\bar{\theta}$ would in turn determine in our model the distribution of optimal leverage ratios and the optimal maturity structure. In our simulation, we define the leverage ratio as $(D+S)/(D+S+E)$ and the maturity structure as $S/(S+D)$. These definitions are consistent with our empirical counterparts that we use in the following section. The two figures in top panel of Figure 9 illustrate the derived model-implied distribution before the financial crisis. The lighter (darker) bars indicate the distribution of non-financial (financial) firms. The dashed (solid) vertical bar is the mean of the each distribution.

The crisis results in a contraction of the pledging capacity, $\bar{\theta}$. We show in the two figures in lower panel of Figure 9 what would happen to the model-implied optimal leverage and optimal maturity structure if there is a reduction of $\bar{\theta}$. We assume that there is a 20% reduction of $\bar{\theta}$ due to the crisis. Again, we use the past 12 month

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9 We assume the crisis start from Jan 2007, which we discuss in detail in the following section.
equity volatility (monthly return) in post-crisis period to proxy the $\sigma$.

Figure 9 shows the consequence of a decrease in $\bar{\theta}$ and an increase in $\sigma$ to the model-implied optimal leverage and optimal liability structure. Note that the distance between the means of the distributions (indicated by vertical bars) shrinks after the shocks. Considering the fact that there is no common time trend for these quantities in the way we conducted our simulation, we should expect the financial firms to reduce the optimal leverage and the optimal maturity structure much more than non-financial firms. In reality, we would expect some common time trends and other cross-sectional variations of firms that our simulation does not consider. Our simulation thus provide a useful counter-factual, in terms of holding everything fixed, and is intended to give some intuition about the kind of the effects we may see in real life. The goal of the empirical strategy is to try tease out from the data whether there is some support for these implications of our model. Rather than pursuing a structural estimation of our model, we rely on a difference-in-differences approach by using the 2007 credit crisis as an instrument for shocks to the value of collateral as well as to its riskiness. In our empirical work, we address the common time trend and other cross-sectional variations.

### 5.2 Financial crisis as an instrument

We use 2007 financial crisis as an instrument to explore the empirical implications of the model. This strategy allows us to capture the “run risk” of short-term debt from an empirical perspective. In our theory, the run risk plays a key role in the way in which firms select their liability structure and leverage. The credit crisis of 2007 had two effects in the context of our model: first, the crisis dramatically reduced the value of certain types of collateral such as mortgages, and mortgage-related collateral. In addition to mortgage related collateral, the crisis generally rendered most risky collateral to be ineffective to obtain secured short-term funding. We interpret this consequence of the credit crisis, in the context of our model, as an adverse (negative) shock to $\bar{\theta}V$. We further hypothesize that this shock will affect financial firms much more severely than non-financial firms.

The credit crisis, in addition to adversely impacting $\bar{\theta}V$, also increased the riskiness of certain types of collateral. This is captured by $\sigma$ in our model or liquidity cost of collateral, $\beta$. We posit that the financial crisis caused the volatility of the assets, $\sigma$, of financial firms to increase much more than that of non-financial firms in addition to a negative shock to $\bar{\theta}$ as discussed earlier. Krishnamurthy et. al. (2012) documents that there was a significant drop in repo with non-agency MBS/ABS and ABCP funding after the crisis (Figure 4 of their paper), which is consistent with our assumption.

Therefore, the effect of the crisis was to impose a much tighter limitation on a financial firm’s capacity to pledge
assets to secure short-term funding. In turn, short-term lenders to financial firms will have an incentive to run, and that effect itself will cause adjustments to liability ratio and leverage. In addition, the borrowers may also wish to lower the level of short-term debt and leverage after the crisis in order to reflect the altered market conditions after the crisis.

5.3 Sample Period & Dating the Crisis

Our sample period spans 2003 to 2011. Most observers would agree that the period 2003 through the end of 2006 was one in which credit spreads were extremely low. We provide evidence in B.2 of Appendix B concerning the credit spreads during this period. We wish to use this period to document the differing entry states of financial and non-financial firms when the credit crisis began. The dating as to precisely when the crisis began has to be necessarily subjective. Although the worst period of the crisis was the post-September 2008 period when Lehman Brothers filed for bankruptcy, it is reasonable to argue that the crisis had began well before that. Bear-Stearns experienced problems with its hedge funds as early as in June 2007, and the Federal Reserve began to initiate its policy actions (directed at the crisis) in June 2007. To achieve exogeneity, we need to select the starting point of the crisis such that the crisis was not reasonably anticipated in the period prior to the date that we select. We think that it is reasonable to assume that market did not fully anticipate the full extent of the credit crisis at the end of 2006.

In our data, more than 78% of the financial statements were filed at the end of the calendar year as shown in Table B.3 in Appendix B. Accordingly we select pick January 2007 as the starting point of the post crisis. We performed some robustness checks on our results using other reasonable choices for the dating of the credit crisis. We find that our results are qualitatively similar.

5.4 Data description & Characterization

We start with all the public firms traded on the three major exchanges in the U.S. (NYSE, Nasdaq and AMEX). We impose the criteria that they must have been listed for at least for one year and covered by intersection of Compustat and CRSP database (46,514 observation) from 2003 to 2011. We remove firms with missing information regarding total assets or total liabilities (40,961 remaining). We then match the resulting data with the Capital IQ database, resulting in 21,974 matched observations. Following Colla et. al (2011), we remove firms from our data set if the difference in the total asset values reported by these two databases is greater than 10% (2,204 removed).

We provide in Table B.1 the distribution of firms in terms of their liability structure from several different angles. We use the industry classification of Fama and French (1997) to define financial firms. Using their classification,
our definition of financial firms comprises of Banking (SIC 6000-6099, 6100-6199), Real Estate (SIC 6500-6553) and Trading (SIC 6200-6299, 6700-6799).

From Table B.1, we note that a much higher fraction of financial firms uses multiple classes of debt in terms of their time to maturity. Noticeably larger fraction of financial firms employ short-term debt relative to non-financial firms (93% versus 83%). It is also of interest to see that a number of firms do not have any debt liability at all. These firms have no explicit debt and their liabilities consist of non-debt liabilities such as account payable to vendors or tax liability to the government. Since the focus of our analysis here is to empirically examine the changes in the liability structure when there is a shock to collateral values and the riskiness of the collateral, firms that have no debt are removed from the sample. However, to avoid any selection bias, we include firms that have either only short-term debt or only long-term debt. This way of filtering the data leaves us with 19,244 firm-year observation and 2,961 unique firms. This is our baseline database and it includes 15,208 observations for non-financial firms and 4,036 observations for financial firms: clearly non-financial firms form a much bigger share of our sample.

We further match SNL database to the resulting sample. SNL database provides us with a more detailed information about debt structure and asset composition of financial institutions. Unfortunately, the financial firms in our baseline database are not fully covered by SNL database: SNL covers only 3,139 firms out of 4,036 financial firms in the baseline database. In the formal tests that we present, we use the baseline database but we use the combined data base to provide more disaggregated information about the liability structure.

Since we are interested in analyzing how the firm leverage ratio and debt structure, $S/D$, interacts with $\bar{\theta}V$ and $\sigma$, we have to define the empirical counterparts for these variables. We proxy our theoretical ratio of debt structure $S/D$ by the short-term debt (NP) over total debt (DLTT+DLC) ratio. This definition of short-term debt (NP) and long-term debt (DLTT+DLC) is widely used in the literature: see for example, Baker Greenwood and Wurgler (2003). We use this variable instead of short-term debt over long-term debt which might look like a more direct measure. Our choice is motivated by the following considerations: first, our choice bounds the ratio from 0 to 1 and allows us to use more observations. Had we chosen the ratio of short-term debt over long-term debt, for the firms which use lots of short-term debt, the ratio measure would have take on very high values. Also, if a firm has no long-term debt and has only short-term debt, the ratio will approach infinity, and would have to be removed from any analysis, introducing a possible sampling bias. However our results are robust to this alternative way of measuring the liability structure. For the Leverage, we use total debt (DLTT+DLC) over total asset (AT). Table B.2 presents summary of selected variables for financial firms and non-financial firms.

Table B.2 makes it is clear that non-financial firms differ in many important respects on observable character-
istics such as market capitalization, market to book ratio, proportion of firms that have long-term debt ratings, and the extent of Government support that they received after the onset of credit crisis. In our empirical work we will explicitly control for these observable characteristics on which these two groups differ. In addition, financial firms as a group may also differ from non-financial firms as a group on unobserved characteristics as well. Such unobserved characteristics could be costs of financial distress, differential growth opportunities, etc. We nevertheless believe that our results are sufficiently strong so that they are unlikely to be overturned due to such differences.

In our model, the short-term debt is collateralized debt either within or outside the safe harbor provisions. Although a high proportion of short-term debt issued by financial firms is indeed secured debt such as repo and ABCP, they can also issue unsecured short-term debt as well. Commercial paper (CP) is a typical short-term debt without any explicit security. However, in fact, there is implicit security for CP as they are typically backed by a letter of credit or a credit line from banks. Likewise, some long-term debt might have secured debt as well. It would be ideal to disentangle the maturity structure on the dimension of security but we have serious limitations of data. Compustat information for the debt structure in term of underlying collateral is far from complete.

As a remedy, Capital IQ data provide a slightly different angle by grouping debt into secured and unsecured debt, but they do not further sub-classify such debt into long-term and short-term debt. Given the limitation of the data, we use Capital IQ information to see if our definition of short-term debt is a reasonable proxy for the secured debt and vice versa. The Figure B.1 in the Appendix B shows that the correlation between our measure of short-term debt and total secured debt as reported by Capital IQ is 92%. Likewise, the correlation is 95% for our measure of long-term debt and total unsecured debt in Capital IQ. Also we look at the correlation between the changes in short-term (long-term) and that of secured debt (unsecured debt). The correlation is reasonably high and these results indicate that when the secured debt (unsecured debt) increases, this variation is very well captured by the change in our measure of short-term (long-term) debt definition. Therefore, despite the data limitations, we have some comfort that our measure of short-term debt and long-term debt captures the spirit of the definitions of short-term and long-term debt in our model.

5.5 Some Motivating Evidence

5.5.1 Evolution of $S/D$ ratio, Leverage & Default Likelihood

The model developed here has implications as to how the liability structure and leverage responds with respect to the asset volatility $\sigma$. It is intuitive to posit that the asset volatility of firms becomes higher when the economy
Figure 10: **Time series of debt maturity structure and leverage:** These figures plot the time series pattern of the mean leverage ratio (left) and mean debt maturity structure (right) of financial and non-financial firms. Thick darker lines stand for mean leverage (maturity structure) of financial (RHS axis). Thick lighter lines represent mean leverage (maturity structure) of non-financial firms (RHS axis). Thin solid line is the A-tranche ABX index which is normalized to 1 at its inception date, beginning of 2006 (LHS axis). The vertical dashed line is the starting point of the crisis period.

enters into recession. Our model predicts that firms when confronted with an increase in asset volatility will de-lever and reduce the proportion of short-term debt in their liability structure. In Figure 10, we show the time-series of the liability structure of financial and non-financial firms during the period 2003 to 2011. We have also plotted the ABX prices, which serve as a proxy for the collateral value of assets supporting short-term debt.

The left graph shows the corresponding information for the evolution of leverage for both financial firms and non-financial firms. The right graph shows the evolution of the liability structure for both financial firms and non-financial firms. The time series pattern of changes in the liability structure is much more stable for non-financial firms. It is clear that both financial and non-financial firms lower the fraction of the short term debt after the crisis. For financial firms, the proportion of repo debt increases within the short-term debt, shortly after the crisis. Figure 11 summarizes the empirical implication of our model in relation with $\sigma$ and $\bar{\theta}$. We will use this figure as a lens to interpret our empirical evidence.

### 5.5.2 S/D ratio and Leverage with respect to $\sigma$ and $\bar{\theta}V$ (2007 financial crisis)

The financial crisis of 2007 imposed a significant negative shock to $\bar{\theta}V$, the value of collateral eligible for securing short-term debt. This was, in our view, particularly severe for financial firms relative to non-financial firms as
The latter relied, on average, much less on secured short-term debt, and the former relied a great deal on repo and ABCP. The crisis also caused a significant deterioration in the quality of the assets that financial firms could pledge: mortgages and mortgage-related collateral are obvious examples of such assets. In the context of our model, this is captured by $\sigma$. Our model predicts that both $S/D$ ratio and Leverage should decrease once the economy has been battered by the credit crisis. Since financial firms as a group experienced a relatively bigger shock than non-financial firms, we may expect to see a higher reduction on both short-term debt to long-term debt ratio as well as the leverage for financial firms when compared to non-financial firms.

It is well known that the Federal Reserve, FDIC and the Treasury mounted a coordinated response to the credit crisis. These interventions could have had a significant impact on both leverage and liability structure of firms in general and financial firms in particular. In this section, we provide a brief summary of those interventions and examine the extent to which they could be driving our results. Fed’s interventions that are of direct consequence to our empirical work are the following: a) the Term Auction Facility (TAF), b) the ABCP money markets mutual funds facility, (AMLF), c) Commercial paper funding facility (CPFF), and d) Money markets investor funding facility (MMIFF). These facilities were instrumental in providing a backstop for short-term funding availability to financial firms. These interventions would have had an important impact on the liability structure as well as the leverage of firms in general, and financial firms in particular. In the absence of these facilities, we conjecture that the short-term funding might have collapsed even further than what we have documented in our empirical work.

The Treasury under the Troubled Assets Relief Program or TARP program provided funding to re-capitalize many banks. See Glasserman and Wang (2011) for a detailed treatment of TARP and their valuation issues. Under
TARP, about $450 billion was provided, overall. A significant part of the TARP funding went to banks and automobile industry. TARP was a hybrid security: it provided the borrowers with a redemption option to repay the loans in two years. In this sense, they could be viewed as debt. On the other hand, if the borrowers chose not to pay at the end of two years, TARP funds become preferred stock with very onerous terms to the borrowers. TARP is treated as equity capital in accounting statements, and in the way in which Compustat records TARP. Accordingly, we report our results in Tables 1 and 2 treating TARP as equity. Therefore having more TARP would negatively affect to the leverage ratio. The $TARP$ variable is defined as $\frac{TARP_{amount}}{Total_{Capital}}(DTC + DLTT + SEQ + MIB)$ and it is used to address the concern that our leverage definition includes TARP, hence suppressing the leverage of financial firms who received the TARP fund. The qualitative results are unaffected if we treated TARP as debt, instead. Also, under the Temporary Liquidity Guarantee Program (TLGP) banks were able to issue both short-term and long-term debt (with a maturity of more than a year) with FDIC-guarantee for a fee.

As noted earlier, the Federal Reserve also actively supplied short-term credit through its various money market oriented programs such as the Term Auction Facility (TAF) introduced in December 2007, Commercial Paper Funding Facility (CPFF) introduced in October 2008, and the short-term portion of the TDGP facility. We mapped in our sample of firms those which received short-term credit from the Fed, and created the variable $Fund$, which measured the proportion of the firm’s short-term debt accounted by the Fed’s supply. The list of borrowers and amount of loan/ debt is available at the Fed and the FDIC web sites. Unfortunately, the information available for verifying the borrowers’ identification is very limited; only the entity names and states are given. This poses a difficulty when we hand-match the borrowers with our sample of firms; the program debt borrowers are often private firms or foreign institutions that are not part of our sample, and therefore the existence of a borrower in the borrower’s list does not necessarily mean that there is a matching firm. Given this limitation, we use the borrower’s address as the second identifier when the borrower’s name is not clear enough to find a match. If neither identifier gives us a confidence for the matching, we assume that there is no matching firm. Note that we have not accounted for all the supply of short-term credit by the Fed in our analysis and mapped them to each firm in our sample:

We examine these predictions using the following regression specification:

$$ Y = \beta_0 + \beta_1 \cdot Fin + \beta_2 \cdot Post + \beta_3 \cdot (Fin \cdot Post) + \beta_4 \cdot (Fin \cdot Post \cdot Fund) + \beta \cdot X + e \quad (9) $$
where, $Y$ can be our variable of interest: $S/D$ or Leverage as defined above, $Fin$ is 1 if the firm is classified as financial firm, otherwise 0, $Post$ is 1 if the time is in the post-crisis period, otherwise 0. The variable $Fund$ is the proportion of Fed’s short-term credit availed by the firm as a fraction of its total short-term debt. In this regression we use the sample period from January 2003 to December 2011. We report result with and without the triple interaction term $(Fin \cdot Post \cdot Fund)$ in the result table. $X$ is a vector of control variable. For the control variable, we use $M/B$, $\log(MV)$, the rating status of the firms, and whether the firm used TARP money. In this specification, the coefficient of interest is $\beta_3$ that measures the different reaction of the financial firms in post-crisis period. To deal with outliers, all the ratio variables are winsorized at 1% and we use robust standard error clustered at the industry level for the statistical inference.

Per our theory, we expect that $\beta_3 < 0$, as financial firms which experienced significant run risk in the crisis, to significantly lower their leverage and their short-term debt. In our model, this adjustment occurs at the time of issuance only. But in the empirical context, financial firms arriving at the crisis face a sharp drop in collateral value and face an increased probability of run. This would cause them to reduce short-term debt. In addition, the volatility during the crisis went up. This would cause them to reduce long-term debt as well.

We expect $\beta_4 > 0$ if there is a strong supply (of credit) effect. The run by short-term creditors will leave a hole in the supply of short-term credit to financial firms. Therefore, the Fed’s supply of short-term credit will be availed very actively by financial firms if they continue to have demand for it.

Table 1 tabulates the results of our analysis on leverage ratios as specified in Equation (9). We have a total of eight specifications, to account for year fixed-effects, control variables, and government interventions following the credit crisis. While specifications in columns (1B) to (4B) in Table 1 use the triple interaction terms in Equation (9), columns (1A) to (4A) do not use the this term. For all the specifications, the coefficient $\beta_3$ is negative and significant at 1% level. The point estimates across all eight specifications are of very similar magnitude. The first row confirms the fact that financial firms, as a group, are much more heavily levered than their non-financial counterparts. The coefficient $\beta_2$ suggest that, at the aggregate level, there was no de-leveraging activities due to the crisis. Although they are not consistent, they suggest that the leverage ratio has either remained invariant or slightly increased after the crisis. The control variables that we have used (market-to-book, credit rating indicator variable, and market capitalization all load significantly. The coefficients on $M/B$ are consistently negative, indicating that growth firms use less level of leverage. The coefficient on $\log(MV)$ and $Rated$ suggest an interesting interaction. In the specification (2) and (3) the coefficients on $\log(MV)$ is positive, indicating high market cap firms use higher leverage. However, when it is conditioned on whether the firm is rated, it shows the opposite sign. This means that,
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Table 1: Difference-in-differences analysis of leverage: This table reports the result of panel regression of leverage using the regression equation specified in Eq. (9). The dependent variable Leverage which is defined in the text. Column (1A)-(4A) in each set use different combination of control variables $X$. Column (1B)-(4B) further add the triple interaction variable $Fin·Post·Fund$. $Fin$ is 1 if financial firm otherwise 0. $Post$ is 1 if the data date is after the event date, which is Jan 2007. $Fund$ is the percentage of government short-term funding (TAF, CPFF and short-term portion of TDGP) in percentage of total capital. Details on the definition of other variables are provided in the Table B.2. The standard errors are robust to heteroscedasticity and clustered at the industry level. Asterisks denote statistical significance at the 0.01(***), 0.05(**), and 0.1(*) conditions.

Conditioning on having been rated, bigger market cap firms use less leverage. The coefficients on the rating is also intuitive that having rating opens up the access to the public debt market, the leverage increases. One might argue that rating itself is an endogenous variable because the credit rating depends on the leverage ratio and also debt maturity structure. However we use an indicator variable to flag whether a firm has a rating or not. Hopefully this would mitigate this problem, while controlling the variation of firms’ access to the public debt market.

The coefficient of interest is $\beta_3$. This captures how the financial firms adjusted their leverage, relative to that of non-financial firms. Across all the specifications, these coefficients are consistently negative and significant. This means that financial firms reduced their leverage, much more when compared to the non-financial firms, in response to the crisis.

The result that the coefficient $\beta_3$ is negative and significant is consistent with our model’s predictions: the credit crisis represented a major adverse shock to the collateral values (see Figure 10) and their riskiness. The financial firms were much more adversely affected than non-financial firms. As a result, their leverage fell much
Table 2: Difference-in-differences analysis of maturity structure. This table reports the result of panel regression of leverage using the regression equation specified in Eq. (9). The dependent variable Maturity which is defined in the text. Column (1A)-(4A) in each set use different combination of control variables X. Column (1B)-(4B) further add the triple interaction variable Fin·Post·Fund. Fin is 1 if financial firm otherwise 0. Post is 1 if the data date is after the event date, which is Jan 2007. Fund is the percentage of government short-term funding (TAF, CPFF and short-term portion of TDGP) in percentage of total capital. Details on the definition of other variables are provided in the Table B.2. The standard errors are robust to heteroscedasticity and clustered at the industry level. Asterisks denote statistical significance at the $0.01^{\ast\ast\ast}$, 0.05$^{\ast\ast}$ and 0.1$^{\ast}$ more significantly than non-financial firms.

The coefficient $\beta_4$ is positive and significant across all specifications. This points to the existence of a supply effect: the run in the money markets left a hole in the supply of short-term credit. The Fed’s supply allowed financial firms, on average, to reduce their leverage less.

Table 2 shows the results of our analysis for debt maturity structure. Similar to the previous case, columns (1B) to (4B) in Table 2 use the triple interaction terms in Equation (9) whereas columns (1A) to (4A) do not use the this term. Note that financial firms use a much higher level of short-term debt than non-financial firms, which is picked up by the coefficient $\beta_1$. One noticeable fact is that the coefficient of Rated is consistently negative, suggesting that firms without long-term rating does not have access to the long-term debt market and must rely on private funding such as bank debt which is likely to be classified as short-term debt.

Again, the coefficient $\beta_3$ is the main interest of the analysis. They are consistently negative and significant across all the eight specifications. We interpret this evidence as being strongly consistent with our model’s pre-
diction: when the parameter $\bar{\theta}$ contracts due to the crisis, financial firms were much more adversely affected than non-financial firms, resulting in more than proportionate reduction in the short-term debt. Our model would have predicted that the probability of a run by short-term creditors would have increased as a result of the crisis. This in turn, would lead rational borrowers to lower short-term debt: thus, our model would have predicted that the suppliers of short-term credit will reduce credit, and the borrowers will demand less as well. The $Fund$ variables is included to address the effect of the supply of short-term credit by the Fed, and the effect that the government guarantee program (TDGP) might have had on the liability structure decisions of the firms. Since the guarantee program spans only a year (Oct 2008 to Oct 2009), maturities of most of issues are less or equal to the end date of the guarantee period. There are usually multiple issues through the program with different principal amounts and maturity from each issuer. We aggregate these issues for each firm. We classify the aggregated issued amount as long-term if the par-value-weighted maturity is longer than 1 year. To compute $TARP$ variable, we divide this aggregate issue amount, classified as long-term, by the total capital of the firm. In this respect, the fact that $TDGP$ has a positive and significant coefficient is interesting. Issuing more long-term bond using the facility would have reduced the debt maturity but it appears that these firms also increased their short-term debt. This might be because there are very small number of firms who issued the long-term bond through this program (only 28 firms). The coefficient $\beta_3$ is unaffected by these interventions.

The result that the coefficient $\beta_3$ is negative and significant is consistent with our model’s predictions: the credit crisis represented a major adverse shock to the collateral values and their riskiness, causing a greater probability of a “run” by short-term lenders. The financial firms were much more adversely affected than non-financial firms by the run risk. As a result, their short-term debt to long-term debt ratio fell much more significantly than non-financial firms.

These results are broadly consistent with our model’s predictions. The coefficient $\beta_4$ is positive and significant across all specifications: this implies that those financial firms which received short-term funding from the Fed, post crisis, reduced their short-term debt less in their liability structure. Once again, this suggests the presence of a supply effect. Fed’s supply of short-term credit appears to have made a big difference to the liability structure of financial firms, on average.

Our results here should be also viewed in the context of the following observations: The credit spreads in money markets, as captured by the LIBOR to OIS spreads and CP to T-bill spreads are reported in Figure B.2 in Appendix B. We note that after the interventions by the Fed, FDIC and Treasury, the spreads returned to nearly pre-crisis levels. Moreover, many of the Fed’s short-term lending facilities were closed as there was no demand
Table 3: Difference-in-differences analysis on leverage within financial firms: This table reports the result of panel regression of leverage using the regression equation specified in Eq. (10). The dependent variable Leverage which is defined in the text. Column (1)-(6) in each set use different combination of control variables $X$. $Fin$ is 1 if financial firm otherwise 0. $Post$ is 1 if the data date is after the event date, which is Jan 2007. $Mortgage$ is the percentage of mortgage-related-asset to total asset. Details on the definition of other variables are provided in the Table B.2. Robust standard error is used. Asterisks denote statistical significance at the 0.01(***), 0.05(∗∗) and 0.1(∗) levels.

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Table 3: Difference-in-differences analysis on leverage within financial firms: This table reports the result of panel regression of leverage using the regression equation specified in Eq. (10). The dependent variable Leverage which is defined in the text. Column (1)-(6) in each set use different combination of control variables $X$. $Fin$ is 1 if financial firm otherwise 0. $Post$ is 1 if the data date is after the event date, which is Jan 2007. $Mortgage$ is the percentage of mortgage-related-asset to total asset. Details on the definition of other variables are provided in the Table B.2. Robust standard error is used. Asterisks denote statistical significance at the 0.01(***), 0.05(∗∗) and 0.1(∗) levels.

at these facilities for short-term credit. For example, TAF closed on March 2010, CPFF on February 2010, and so on. Our results show that the short-term debt and leverage of financial firms fell even after these facilities closed. This is evidence that borrowers were also reducing their demand for short-term debt, and leverage. While this is consistent with the theory’s implication that a fall in collateral values should lead firms to de-lever and demand less short-term debt, the result may also be driven by unobserved factors such as the reduced opportunity set after the crisis.

5.5.3 $S/D$ ratio and Leverage of Financial Firms with Significant Mortgage Exposure

In this section, we focus just on financial firms. In so doing, we are hoping to tease out the effects of shocks to $\hat{\theta}$ on a subset of financial firms with a higher exposure to mortgage related activities. Since we restrict our analysis to only financial firms, we may expect that the shocks to the $\sigma$ of the assets are relatively less variable, in cross-section, than in our previous specification where we compared financial firms with non-financial firms. Consider a financial
Table 4: Difference-in-differences analysis on maturity structure within financial firms: This table reports the result of panel regression of maturity structure using the regression equation specified in Eq. (10). The dependent variable $Maturity$ which is defined in the text. Column (1)-(6) in each set use different combination of control variables $X$. $Fin$ is 1 if financial firm otherwise 0. $Post$ is 1 if the data date is after the event date, which is Jan 2007. $Mortgage$ is the percentage of mortgage-related-asset to total asset. Details on the definition of other variables are provided in the Table B.2. Robust standard error is used. Asterisks denote statistical significance at the 0.01($\ast\ast\ast$), 0.05($\ast\ast$) and 0.1($\ast$) levels.

A firm which holds a significant amount of mortgage related assets. Given that the mortgages were at the heart of the credit crisis, the ability of this subset of financial firms to secure assets to raise short-term debt shrinks, when the economy is battered by the crisis. Therefore, this subset of financial firms will experience a greater decline in leverage. Furthermore, their debt structure will experience a greater decline in the use of short-term debt. Capital IQ provides some level of disaggregated security-class break-down for financial firms. One of the categories of assets is mortgages. We define the variable $Mortgage$ by dividing the amount of the mortgage related security held by the firm by the total assets of the firm. Our empirical specification is as follows.

$$ Y = \beta_0 + \beta_1 \cdot Post + \beta_2 \cdot Mortgage + \beta_3 \cdot (Post \cdot Mortgage) + \beta \cdot X + e $$ (10)

The coefficient of interest is $\beta_3$. If the amplification mechanism is present, the value should be negative because a firm with higher mortgage security delevers and reduces the $S/D$ ratio more dramatically than other firms. Since this analysis is within financial sector, we only have 3 different industry classification. Having too few cluster
Table 5: Difference in leverage decisions between financial and non-financial firms: This table reports the result of panel regression of leverage using the regression equation specified in Eq. (11). The dependent variable Leverage which is defined in the text. Column (1)-(6) in each set use different combination of control variables \( X \). \( \text{Fin} \) is 1 if financial firm otherwise 0. \( \text{ABX} \) is ABX price level of A tranche, normalized to 1 at 2003. Details on the definition of other variables are provided in the Table B.2. Robust standard error is used. Asterisks denote statistical significance at the \( 0.01^{* * *}, 0.05^{* *}, \) and \( 0.1^{*} \) levels.

Table 3 provides the evidence. We have used each firm’s fraction of mortgage backed securities to their total assets to capture the differential effect of the crisis. The regression specification we use is as in Equation (10), where we define \( \text{Mortgage} = \frac{\text{MBS}}{\text{TotalAsset} (AT)} \).

The negative and significant coefficient \( \beta_1 \) indicates that financial firms universally de-lever after the crisis. The coefficients \( \beta_2 \) are positive and highly significant, implying that firms with a higher ownership of mortgages are more highly levered.

The coefficient \( \beta_3 \) would pick up the diff-in-diffs of leverage ratio between financial firms with high level of mortgage related asset and firms without. As model predicted, they are negative when they are significant. Although every specification does not show significance, this generally seems to support the prediction.

We present the regression analysis of debt maturity structure using only financial firms in Table 4. As in Table
Table 6: **Differences in debt maturity structure decisions between financial and non-financial firms**: This table reports the result of panel regression of debt maturity structure using the regression equation specified in Eq. (11). The dependant variable *Maturity* which is defined in the text. Column (1)-(6) in each set use different combination of control variables X. *Fin* is 1 if financial firm otherwise 0. *ABX* is ABX price level of A tranche, normalized to 1 at 2003. Details on the definition of other variables are provided in the Table B.2. Robust standard error is used. Asterisks denote statistical significance at the 0.01(***), 0.05(**), and 0.1(*) levels.

3, we use the regression specification in Equation (10). In this case the coefficient $\beta_3$ is more consistently negative and significant than the case of leverage. This is strongly supportive of the hypothesis that financial firms with a higher level of mortgage security suffered a greater reduction in $\bar{\theta}$ and hence decreased their short-term debt much more than other financial firms.

It is also of interest to compare these results with those of leverage reported in Table 3, where the effect was much weaker. Keeping the $\sigma$ constant, our model shows that the $S/D$ ratio is far more sensitive to $\bar{\theta}$ than leverage as shown in the left panel of Figure 11. We may assume that, since these specifications are within the financial industry, the shocks to $\sigma$ associated with the crisis did not vary too much cross-sectionally.

However, comparing Table 1 and Table 2 does not give us the same pattern: the effect on leverage was very significant with large magnitude. This is because the shock in $\sigma$ was presumably very different to financial and non-financial firms. The financial crisis triggered larger uncertainty on financial firms. In other words, the crisis imposed a greater shock to $\sigma$ and negative shock to $\bar{\theta}$ to all firms, but the magnitude of the shock was much more severe on financial firms. Our model implies that the cross-derivatives $\frac{\partial^2(Leverage)}{\partial \theta \partial \sigma} > 0$, under very reasonable assumption of $\beta < 1 - (\alpha_1 + \alpha_2)$, i.e., the liquidation cost of collateral asset is less than the total bankruptcy loss.

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This implies that when the shock simultaneously causes $\sigma$ to go up and $\bar{\theta}$ to go down, the leverage drops much dramatically. While the cross-derivatives $\frac{\partial^2 (S/D)}{\partial \theta \partial \sigma} < 0$, indicating the impact of decreasing $\bar{\theta}$ is partly mitigated by rise of $\sigma$.

Finally, we examine more directly the nature of the shock to collateral values of assets, which supported short-term credit. Since we do not have cross-sectional information on the actual collateral posted by financial firms, we use the ABX prices to proxy for the sub-prime mortgage value. Our goal is to interact the ABX prices with the financial firms in our regression specifications to examine whether firms tended to behave differently when the sub-prime mortgage prices fell dramatically. The regression specification is shown below:

$$ Y = \beta_0 + \beta_1 \cdot Fin + \beta_2 \cdot (Fin \cdot ABX) + \bar{\beta} \cdot X + e $$

(11)

Table 5 shows the results for the leverage variable. Note that the coefficient $\beta_2 > 0$ across all specifications and is statistically significant. Since the fall in ABX prices coincided with the onset of the credit crisis, our results support the view that the fall in the values of sub-prime mortgages is an important channel for the delevering outcomes that we document.

Table 6 documents the results with respect to the debt maturity structure. We note that the coefficient $\beta_2 > 0$ across all specifications and is statistically significant. Our results suggest that negative shocks to the collateral was an important factor in explaining the drop in short-term debt after the crisis.

6 Conclusion

We have developed a structural model of optimal liability structure and optimal leverage in which the borrower internalizes the risk of a run by short-term lenders in choosing his liability structure and leverage. When there are violations of APR and dead-weight losses associated with the underlying restructuring process, we show that the borrower has an incentive to use safe harbored debt such as secured repo debt or asset-backed commercial paper. The model has some predictions about how firms will change their liability structure and leverage when there are shocks to eligible collateral that is used for securing short-term debt and when the riskiness of the collateral increases due to an exogenous shock. Using the credit crisis of 2007 as an exogenous shock to the value and riskiness of collateral, we examine the changes in the liability structure and leverage decisions of financial firms relative to the changes in those variables by non-financial firms. The evidence that we report is in broad agreement with the theoretical results developed in this paper.
Using the ABX prices as a proxy for collateral value, we show that the financial firms, post-crisis, significantly reduced their leverage and short-term debt, when they are exposed to ABX risk. We map the Fed’s provision of credit to the cross section of firms in our sample, and demonstrate a supply effect: the Fed’s provision of short-term credit buffered the financial firms’ decline in leverage and the use of short-term debt. Even after accounting for the Fed’s interventions, which brought the credit spreads in the money markets to the pre-crisis levels, there was still a fall in the use of short-term debt and leverage after the crisis for financial firms. This evidence suggests the presence of a demand effect as well.

Some caveats are in order: our model does not consider dynamic adjustments to leverage and liability structure. This is clearly an important question. He and Xiong (2011) have considered a framework to include this possibility. We do not allow for variations in the investment opportunity set to the borrower. Clearly, these issues warrant further research.
Appendices

A  Proofs

Proof of Proposition 1

The value of equity satisfies the following ODE:

\[
\frac{1}{2} \sigma^2 E_{VV} + (r - \delta) V E_V - \tau E + \delta V - (C + Sr)(1 - \tau) = 0
\]  (A.1)

The boundary conditions are:

\[
E(V \uparrow \infty) = V - (C/r + S)(1 - \tau)
\]

\[
E(V_B) = (1 - \theta) \alpha_2 V_B
\]

\[
E_V(V_B) = (1 - \theta) \alpha_2
\]

The general solution of the Equation (A.1) is known as

\[
a_0 + a_1 V + a_2 V^{-x}
\]  (A.2)

where, \( x > 0 \) is the root of the characteristic equation below:

\[
\frac{1}{2} x^2 \sigma^2 - x \left( r - \delta - \frac{\sigma^2}{2} \right) - r = 0
\]  (A.3)

Using the boundary conditions, we determine \( a_0, a_1, a_2 \) and \( V_B \). Defining \( p \equiv (V/V_B)^{-x} \), we obtain the valuation function for the equity, \( E(V) \):

\[
E(V) = V - (C/r + S)(1 - \tau)(1 - p) - (1 - (1 - \theta)\alpha_2)V_B p
\]  (A.4)

\( V_B \) can be determined from maximizing Equation (A.4) such that \( \frac{\partial E}{\partial V} \bigg|_{V=V_B} = 0 \) giving the expression in the Proposition 1:

\[
V_B = (1 - \tau)(C/r + S) \left( \frac{x}{1 + x} \right) \frac{1}{1 - (1 - \theta)\alpha_2}
\]  (A.5)
Proof of Proposition 2

We start from our equilibrium where the equity holder triggers restructuring simultaneously when the run happens. From Equation (A.4), we know the equity pricing formula when there is no run risk. We denote the equity in this case $E^\star$ and it has the following form:

$$
E^\star(V) = V - (C/r + S)(1 - \tau)(1 - (V/V_B)^{-x}) - (1 - (1 - \theta)\alpha_2) \cdot V_B \cdot (V/V_B)^{-x}
$$  \hspace{1cm} (A.6)

where, the optimal restructuring boundary is

$$
V_B = (1 - \tau)(C/r + S) \left( \frac{x}{1 + x} \right) \frac{1}{1 - (1 - \theta)\alpha_2}
$$

$$
= V_R = \frac{S}{\theta (1 - \beta)}
$$  \hspace{1cm} (A.7)

Consider now an off-the-equilibrium case where the equity holder picks an arbitrary $S$ such that $\frac{S}{\theta (1 - \beta)} > V_B$. The short-term lender will run when $V_R = \frac{S}{\theta (1 - \beta)}$ is reached which is the minimum point of asset value that they can recover the full amount. This would imply that the equity holder allows the short-term lender to liquidate the pledged assets when $V \downarrow V_R$. At that time, the short-term lender will take out $\theta V_R$, leaving only $(1 - \theta)V_R \equiv \hat{V}_R$ in the firm. With this left-over asset, the equity holder can operate the firm until their new restructuring boundary $\hat{V}_B$ is hit. Let us define a state-price $\hat{p}$, that pays out $\$1$ when $\hat{V}_R \downarrow \hat{V}_B$:

$$
\hat{p} = \left( \frac{\hat{V}_R}{\hat{V}_B} \right)^{-x}
$$  \hspace{1cm} (A.8)

After the point when short-term lender stops rolling over at $V_R$, the firm only has long-term debt. The equity value at $V_R$, therefore follows the standard expression as in Leland (1994). Let us denote it $\hat{E}$ and it can be written as follows. At $V = V_R$:

$$
\hat{E}(\hat{V}_R) = \hat{V}_R - (C/r)(1 - \tau)(1 - \hat{p}) - (1 - \alpha_2)\hat{V}_B \cdot \hat{p}
$$  \hspace{1cm} (A.9)

Using standard techniques, the optimal post-run restructuring boundary $\hat{V}_B$ can be easily found:

$$
\hat{V}_B = (C/r)(1 - \tau) \left( \frac{x}{1 + x} \right) \left( \frac{1}{1 - \alpha_2} \right)
$$  \hspace{1cm} (A.10)
So, when \( \alpha_2 = 0 \), we recover the standard Leland equity valuation. Now the off-the equilibrium equity claim has the following PDE:

\[
\frac{1}{2} \sigma^2 V^2 E_{VV} + (r - \delta) V E_V - r E + \delta V - (C + Sr)(1 - \tau) = 0
\]

(A.11)

with the boundary conditions:

\[
E(V_R) = \hat{E}(\hat{V}_R)
\]

(A.12)

\[
E(V \uparrow \infty) = V - (C/r + S)(1 - \tau)
\]

(A.13)

We can interpret (A.12), which is the value matching condition, as follows: It says that the equity value immediately after the short-term lenders run, is equal to the continuation value associated with the firm operating with only long-term debt after the run by short-term lenders. We guess the following form for \( E(\cdot) \):

\[
E(V) = a_0 + V + a_1 V^{-x}
\]

(A.14)

The second boundary condition in (A.13) immediately pins down \( a_0 = -(C/r + S)(1 - \tau) \). The first boundary condition (A.12) and Equation (A.9) yield the following equation:

\[
V_R - (C/r + S)(1 - \tau) + a_1 V_R^{-x} = \hat{V}_R - (C/r)(1 - \tau)(1 - \hat{p}) - (1 - \alpha_2) \hat{V}_B \cdot \hat{p}
\]

(A.15)

We solve for \( a_1 V_R^{-x} \):

\[
a_1 V_R^{-x} = (\hat{V}_R - V_R) + (1 - \tau) [(C/r + S) - (C/r)(1 - \hat{p})] - (1 - \alpha_2) \hat{V}_B \cdot \hat{p}
\]

\[
= -S \left[ \beta \over 1 - \beta + \tau \right] + (1 - \tau) \left[ S + (C/r) \hat{p} \right] - (1 - \alpha_2) \hat{V}_B \cdot \hat{p}
\]

\[
= -S \left[ \beta \over 1 - \beta + \tau \right] + (1 - \tau)(C/r) \left( 1 - \alpha_2 \right) \hat{V}_B \cdot \hat{p}
\]

The last equality uses the expression in (A.10). Therefore, we can pin down \( a_1 \):

\[
a_1 = \left( -S \left[ \beta \over 1 - \beta + \tau \right] + (C/r)(1 - \tau) \left( 1 \over 1 + x \right) \hat{p} \right) V_R^x
\]

(A.16)
Plugging (A.16) to (A.14), we obtain off-the-equilibrium equity valuation:

\[ E(V) = V - (C/r + S)(1 - \tau) + \left( -S \left[ \frac{\beta}{1 - \beta} + \tau \right] + \left( \frac{C}{r} \right) (1 - \tau) \left( \frac{1}{1 + x} \right) \hat{p} \right) \cdot \left( \frac{V}{V_R} \right)^{-x} \] (A.17)

At \( t = 0 \), equity holder decides whether they would deviate from the equilibrium by computing:

\[ E^*(V_0) - E(V_0) = (C/r)(1 - \tau) \left( \frac{1}{1 + x} \right) \left( \frac{V_0}{V_R} \right)^{-x} \hat{p} \cdot (V_0/V_B)^{-x} \]
\[ + S(1 - \tau) \left( \frac{1}{1 + x} \right) \cdot (V_0/V_B)^{-x} + S \left[ \frac{\beta}{1 - \beta} + \tau \right] \cdot (V_0/V_R)^{-x} \] (A.18)

From the definition of \( \hat{p} \) in (A.8) and the fact that when \( V_R \) is hit, the asset value immediately drops to \( \hat{V}_R \), \( \hat{p} \cdot (V_0/V_R)^{-x} \) is the price of the state contingent claim at \( t = 0 \) that pays $1 when \( V \downarrow \hat{V}_B \). Hence, this value must be smaller than \( (V_0/V_B)^{-x} \) which is the value of a state contingent claim that pays $1 when \( V_0 \downarrow V_B \), because \( V_B > \hat{V}_B \). Therefore, \( [(V_0/V_B)^{-x} - \hat{p} \cdot (V_0/V_R)^{-x}] > 0 \), resulting \( E^*(V_0) - E(V_0) > 0 \). Hence, we conclude that the equity holder has no incentive to deviate from the equilibrium of \( V_R = V_B \) and this equilibrium will sustain.

\[ \square \]

**Proof of Proposition 3**

First, we solve the ODE satisfied by the value of long-term debt.

\[ \frac{1}{2} \sigma^2 D_{VV} + (r - \delta) V D_V - rD + C = 0 \] (A.19)

with boundary conditions:

\[ D(V \uparrow \infty) = \frac{C}{r} \]
\[ D(V_B) = (1 - \theta) \alpha_1 V_B \]

The second boundary condition specifies that short term debt is secured by a fraction \( \theta \) of assets and short-term lenders have seniority to long-term debt holders. The debt value is:

\[ D(V) = C/r(1 - p) + p(1 - \theta)\alpha_1 V_B \] (A.20)
Next, the valuation function for the short-term debt, $B$, is always $S$ due to the fact that the short-term lender can always recover the full amount.

$$\begin{align*}
B(V) &= S 
\end{align*}$$

(A.21)

Now, we add up Equation (A.4), (A.20) and (A.21) to compute the firm value, $v$:

$$\begin{align*}
v(V) &= E(V) + D(V) + B(V) \\
&= V + \tau(C/r + S)(1-p) + Sp - pV_B + p(1 - \theta)(\alpha_1 + \alpha_2)V_B 
\end{align*}$$

(A.22)

Note that when the restructuring boundary is reached the firm’s value becomes:

$$v(V_B) = S + (1 - \theta)(\alpha_1 + \alpha_2)V_B$$

(A.23)

In other words, in restructuring, short-term creditors get back their principal $S$ from liquidating the $\theta V_B$ and the amount $(1 - \theta)(\alpha_1 + \alpha_2)V_B$ is split between long-term creditors and borrowers.

We now start from the rational belief that the short-term lender must make their claim risk free. That is, for any given restructuring boundary $V_B$, they should be able to recover everything they lent. Also, we assume that the short-term lender is better off staying with the firm as long as they can recover everything. This beliefs form the following equilibrium, as shown in Proposition 2:

$$S = V_B(1 - \beta)\theta$$

(A.24)

Plugging (A.24) to (A.5) results the following:

$$V_B = \left(\frac{C}{r}\right) \cdot f(\theta)$$

(A.25)

where,

$$f(\theta) = \left(\frac{(1 - \tau)(\frac{x}{1+z})(\frac{1}{1-(1-\theta)\alpha_2})}{1 - (1 - \beta)\theta(1 - \tau)(\frac{x}{1+z})(\frac{1}{1-(1-\theta)\alpha_2})}\right)$$

(A.26)

Then substituting $S$ and $V_B$ in (A.22) with (A.24) and (A.25) gives us:

$$v(V) = V + \tau(C/r)(1 + (1 - \beta)\theta \cdot f(\theta) - p) + pV_B \cdot g(\theta)$$

(A.27)
where,
\[ g(\theta) = ((1 - \tau)(1 - \beta)\theta + (1 - \theta)(\alpha_1 + \alpha_2) - 1) \]  
(A.28)

The first order condition of (A.27) with respect to \( C \) determines the optimal \( C^* \) and \( S^* \):
\[
\begin{align*}
C^* &= \frac{rV}{f(\theta)} \left[ \frac{1 + f(\theta) \cdot (1 - \beta)\theta}{(1 + x)(1 - f(\theta) \cdot g(\theta)/\tau)} \right]^{\frac{1}{2}} \\
S^* &= \left( \frac{C^*}{r} \right) \cdot f(\theta) \cdot (1 - \beta)\theta
\end{align*}
\]

\[ \square \]

**Proof of Theorem 1**

When \( \alpha_2 = 0 \) and \( \alpha = \beta \), that is \( 1 - \alpha_1 = \beta \), the third term of the Equation (7) becomes \(-pV_B(1 - \alpha_1)\). Also \( V_B \) in Equation (A.5) becomes independent of \( \theta \). Therefore, the firm value is independent of \( \theta \). This means we can replicate the firm value with only using long-term debt, hence the optimal liability structure is not uniquely pinned-down.

\[ \square \]

**Proof of Theorem 2**

The result is very intuitive. When \( \alpha > \beta \), there is a saving in dead-weight loss of restructuring. Therefore, to engage more into safe-harboring activity improves the firm value. As a result, the equity holders pledge as much as possible, setting \( \theta = \bar{\theta} \) where, \( \bar{\theta} \) is the maximum level of portion of asset that they can pledge.

\[ \square \]

**Proof of Corollary 1**

Plugging in optimal \( C^*(\theta) \) and \( S^*(\theta) \) found in 3 into Equation (A.22) provides the the optimized level of the firm value, \( v^*(\theta) \). It is straight forward to show, with positive \( \alpha_1 \) and \( \alpha_2 \) such that \( \alpha_1 + \alpha_2 < 1 \), \( \frac{\partial v^*(\theta)}{\partial \beta} |_{\beta = 0} > 0 \) and \( \frac{\partial v^*(\theta)}{\partial \beta} |_{\beta = 1} < 0 \). Since \( \beta \) is continuous between 0 and 1, there exists a point in \( \beta \) such that \( \frac{\partial v^*(\theta)}{\partial \beta} = 0 \). We denote this point by \( \bar{\beta} \). Note that \( \bar{\beta} \) is a function of parameters that are related to bankruptcy code such as \( \alpha_1 \) and \( \alpha_2 \) and the pledging capacity \( \theta \). Thus, we express \( \bar{\beta} \) in terms of these parameters:
\[ \tilde{\beta}(\alpha_1, \alpha_2, \theta) = \frac{(1 - (\alpha_1 + \alpha_2))(1 + x\alpha_2(1 - \theta) - \tau)}{(1 - \alpha_2(1 + x\theta))(1 - \tau)} + \frac{\alpha_2(1 - \theta)(1 - (\alpha_1 + \alpha_2)) + ((1 - \theta)\alpha_1 + \theta)(x + 1))\tau}{(1 - \alpha_2(1 + x\theta))(1 - \tau)} \]  
(A.29)

Therefore, in any level of \( \beta > \tilde{\beta} \), the firm value is decreasing in \( \theta \), making safe-harboring activity sub-optimal. It is also clear that \( \tilde{\beta} \) is an increasing in \( \alpha \) and \( \alpha_2 \) (keeping \( \alpha \) same). Hence, as the code gets messier (higher \( \alpha \)) and as there is more APR violation (higher \( \alpha_2 \)), this constraints on liquidity becomes more relaxed (higher \( \tilde{\beta} \)). This is to say that if the code is very efficient, only very liquid asset with tiny \( \beta \) can be used as the collateral.

□

**Proof of Corollary 2**

We know that the valuation formula for the long-term debt is:

\[ D = \frac{C}{r}(1 - p) + p(1 - \theta)\alpha_1 V_B \]  
(A.30)

and the short-term debt is always \( S \). Therefore, the total debt is \( D + S \). From the equilibrium result where \( V_B = V_R \), we can express the total debt in terms of \( C \).

\[ D + S = \frac{C}{r}(1 - p) + p(1 - \theta)\alpha_1 + \theta(1 - \beta))V_B \]  
(A.31)

where,

\[ V_B = \left( \frac{C}{r} \right) \cdot f(\theta) \]  
(A.32)

and

\[ f(\theta) = \left( \frac{1 - \tau}{1 - (1 - \beta)\theta(1 - \tau)} \frac{x}{1 + x} \right) \left( \frac{1}{1 - (1 - \theta)\alpha_2} \right) \]  
(A.33)

Differentiating (A.31) with respect to \( C \) gives us the dollar-coupon that delivers maximum total debt capacity:

\[ C_{MAX} = \frac{rV}{f(\theta)} \left[ \left( \frac{1}{1 + x} \right) \left( \frac{1 + \theta(1 - \beta) \cdot f(\theta)}{1 - (1 - \theta)\alpha_1 \cdot f(\theta)} \right) \right]^{\frac{1}{2}} \]  
(A.34)

□
## Supplemental Tables and Figures

<table>
<thead>
<tr>
<th>(Whole sample)</th>
<th>Has debt ≥ 1 year</th>
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<th></th>
<th></th>
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<td>No</td>
<td>Total</td>
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<td>N. (%)</td>
<td>N. (%)</td>
<td>N. (%)</td>
<td>N. (%)</td>
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<td>16,863 (85.3)</td>
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<td>2,907 (14.7)</td>
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<td>1,415 (100)</td>
<td>19,770 (100)</td>
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<td>No</td>
<td>Total</td>
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<tr>
<td>Has debt &lt; 1 year</td>
<td>N. (%)</td>
<td>N. (%)</td>
<td>N. (%)</td>
<td>N. (%)</td>
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<td>4,060 (100)</td>
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<td>Total</td>
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<tr>
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<td>N. (%)</td>
<td>N. (%)</td>
<td>N. (%)</td>
<td>N. (%)</td>
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<td>746 (59.8)</td>
<td>13,088 (83.3)</td>
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<td>502 (40.2)</td>
<td>2,622 (16.7)</td>
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<td>Total</td>
<td>14,462 (100)</td>
<td>1,248 (100)</td>
<td>15,710 (100)</td>
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Table B.1: **Distribution of debt structure in maturity**: This table presents the distribution of the firms in terms of the debt structure. The top panel covers all the firms in our sample. The middle panel covers only financial firms under our definition and the bottom panel covers only non-financial firms. Column under $N.$ stands for the number of observation and number in parenthesis is the corresponding percentage of observations.
Figure B.1: **Correlation of debt by maturity and security**: These plots present the correlation between our definition of short-term (long-term) debt and total secured (unsecured) debt defined by Capital IQ. The top two graphs use levels of variables and bottom two use the change. Solid line is the fitted line of those observations and dashed line is 45 degrees line.

Figure B.2: **Short-term debt spread during the crisis**: These plots show the spread between Commercial Paper and 3m T-bill rate (left) and the spread between the 3m LIBOR (right) and Overnight Index Swap (OIS) rate. Two vertical lines indicate the starting point of the each short-term facility.
<table>
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<th>Variables</th>
<th>Mean</th>
<th>St.Dev.</th>
<th>Median</th>
<th>75th Pct.</th>
<th>N</th>
<th>Mean</th>
<th>St.Dev.</th>
<th>Median</th>
<th>75th Pct.</th>
<th>N</th>
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<td>37,509</td>
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<td>974</td>
<td>3,704</td>
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<td>158,851</td>
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<td>Total liability</td>
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<td>96</td>
<td>529</td>
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<td>22,684</td>
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<td>Market value of equity (MV)</td>
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<td>Stock volatility for past 12 month</td>
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<td>31.7%</td>
<td>25.0%</td>
<td>36.7%</td>
<td>54.1%</td>
<td>24.1%</td>
<td>17.6%</td>
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<td>14.7%</td>
<td>32.3%</td>
<td>51.1%</td>
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<td>Short-term to total debt ratio (Maturity)</td>
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<td>9.4%</td>
<td>12.7%</td>
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<td>5.53%</td>
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<td>4.80%</td>
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<td>2.5%</td>
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<td>7.28%</td>
<td>10.12%</td>
<td>0.00%</td>
<td>10.90%</td>
<td>80</td>
</tr>
<tr>
<td>Market equity to book asset (M/B)</td>
<td>123.6%</td>
<td>125.8%</td>
<td>50.3%</td>
<td>88.3%</td>
<td>151.8%</td>
<td>28.8%</td>
<td>64.2%</td>
<td>8.5%</td>
<td>13.9%</td>
<td>21.6%</td>
</tr>
<tr>
<td>Duration of long-term debt repayment</td>
<td>2.7</td>
<td>1.1</td>
<td>1.9</td>
<td>2.8</td>
<td>3.5</td>
<td>13,849</td>
<td>1.8</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Years from IPO</td>
<td>11.1</td>
<td>6.3</td>
<td>6.0</td>
<td>11.0</td>
<td>15.0</td>
<td>7,841</td>
<td>8.8</td>
<td>5.1</td>
<td>5.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Rating (Rating)</td>
<td>3.4</td>
<td>1.1</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
<td>6,679</td>
<td>2.8</td>
<td>1.0</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Pct. of firms that have LT Rating (Rated)</td>
<td>43.9%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>15,208</td>
<td>15.9%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4,036</td>
</tr>
</tbody>
</table>

Table B.2: Summary Statistics: This table show summary statistics of the sample firms for selected variables. We divided them into financial group and non-financial group according to our definition. Total asset and total liability are the Compustat variables, AT and LT, respectively. Total debt is from Compustat DLTT + DLC. Short-term debt is the Compustat variable, NP. Total secured debt and total unsecured debt are from Capital IQ. Leverage ratio (Leverage) is from Compustat variables, (DLTT + DLC)/(DLTT + DLC + MIB + SEQ). Short-term to total debt ratio (Maturity) is from Compustat variables, NP/(DLTT + DLC). Mortgage asset fraction (Mortgage) is the Mortgage related asset / AT where, Mortgage related asset is from the Capital IQ database. TARP/Total Capital (TARP) is the TARP money received in percentage of total capital (DLTT + DLC + MIB + SEQ). TDGP (TDGP) is the long-term portion (> 1 year) of issuance through TDGP over total capital. ST. Funding / Total Capital (Fund) is the amount received via TAF and CPFF program and short-term portion of TDGP issuance. Statistics for TARP and TDGP and Fund are only within firm-year observations that have matched value to the funding program. Stock volatility for past 12 month uses monthly equity return from CRSP for the past 12 month period from the data reporting month. Market value of equity (MV) is the from the Compustat variable CSHO * PRCCF. Market equity to book asset (M/B) is defined as MV/AT. Duration of long-term debt repayment is the weighted average of the number of year to repay the long-term debt within 5 years: \( \frac{\sum_{i=1}^{5} i \times DD_i}{\sum_{i=1}^{5} DD_i} \) where DD_i is the portion of long-term debt due in \( "i" \)th year from Compustat. Rating is numerically assigned Standard and Poor’s long-term domestic issuer rating where 1 = CC, 2=CCC, 3=B, 4=BB, 5=BBB, 6=A, 7=AA and 8=AAA. The number of observations are not same for all variables because some of variables uses subset of our sample firms. For example, rating variable only uses firms which have rating the agency. Pct.of firm that have LT rating (Rated) is calculated from counting firms that have domestic long-term issuer rating from S&P.
Table B.3: Fiscal month frequency in 2007: This table shows the filing month distribution of our sample firms in 2007. Most of firms (78.6%) are reporting at the year-end. This pattern of distribution is almost constant across all sample year.

<table>
<thead>
<tr>
<th>Fiscal Month</th>
<th>Freq.</th>
<th>Percent</th>
<th>Cum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38</td>
<td>1.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>0.4%</td>
<td>2.1%</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>1.6%</td>
<td>3.7%</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>0.8%</td>
<td>4.5%</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>0.6%</td>
<td>5.1%</td>
</tr>
<tr>
<td>6</td>
<td>118</td>
<td>5.4%</td>
<td>10.5%</td>
</tr>
<tr>
<td>7</td>
<td>23</td>
<td>1.1%</td>
<td>11.5%</td>
</tr>
<tr>
<td>8</td>
<td>29</td>
<td>1.3%</td>
<td>12.8%</td>
</tr>
<tr>
<td>9</td>
<td>132</td>
<td>6.0%</td>
<td>18.8%</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
<td>1.6%</td>
<td>20.4%</td>
</tr>
<tr>
<td>11</td>
<td>22</td>
<td>1.0%</td>
<td>21.4%</td>
</tr>
<tr>
<td>12</td>
<td>1,722</td>
<td>78.6%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>2,192</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>

Table B.4: Unconditional Diff-in-Diffs for different variable definition: This table exhibits unconditional Diff-in-Diffs results with different Leverage and Maturity definition associated with the government funding program. Leverage is our baseline definition: \((DLTT + DLC)/(DLTT + TLC + MIB + SEQ)\). Leverage (ex TARP) is leverage without having TARP fund in the firm’s equity: \((DLTT + TLC)/(DLTT + TLC + MIB + SEQ - TARP)\). Leverage (ex TDGP) does not include long-term debt issued through TDGP: \((DLTT - TGDP + DLC)/(DLTT - TGDP + TLC + MIB)\). Leverage (ex TARP ex TDGP) does not include neither TARP money nor TDGP debt: \((DLTT + DLC)/(DLTT + TLC + MIB + SEQ - TARP)\). Leverage (treating TARP as debt) treats TARP money as a debt for its calculation: \((DLTT + DLC + TARP)/(DLTT + TLC + MIB + SEQ - TARP)\). Maturity is our baseline definition for the maturity structure: \((NP)/(DLTT + DLC)\). Maturity (ex TDGP) subtracts TDGP debt from the long-term debt: \((NP)/(DLTT - TGDP + DLC)\).
References


