Collateral and Secured Debt*

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Abstract

We argue that firms' assets, especially their tangible assets, serve as collateral restricting both secured and unsecured debt. Secured debt is explicitly collateralized, placing a lien on specific assets, which facilitates enforcement. Unsecured debt is backed by unencumbered assets and thus implicitly collateralized. The explicit collateralization of secured debt entails costs but enables higher leverage. Therefore, financially constrained firms use more secured debt both across and within firms. Our dynamic model is consistent with stylized facts on the relation between secured debt and measures of financial constraints and between leverage and tangible assets, and with evidence from a causal forest.

JEL Classification: D25, E22, G32.

Keywords: Collateral; Secured debt; Tangible assets; Intangible capital; Leasing

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1 Introduction

Collateral plays a central role in both macro finance and corporate finance. Kiyotaki and Moore (1997) and a large subsequent literature argue that collateral constraints are an important reason why finance affects macroeconomic dynamics. The effects of collateral constraints on household finance, intermediary finance, and corporate finance in the global financial crisis were arguably substantial. Collateral is also a crucial determinant of firms' ability to raise financing (see, for example, Rampini and Viswanathan (2013) and Li, Whited, and Wu (2016)).

From the perspective of the law, the term collateral refers to assets pledged to secure a claim; that is, collateral and secured debt are part and parcel. This terminology makes it tempting to interpret collateral and secured debt as equivalent, and study the importance of collateral by measuring secured debt. This is misleading in our view. In fact, from the perspective of economics, which is the perspective we take, collateralizable assets are assets that facilitate enforcement, and this perspective suggests that collateral matters for all debt finance, whether such debt is secured or not. Indeed the extant economics literature on collateral typically assumes that debt is subject to collateral constraints, that is, debt has to be collateralized, without drawing a distinction between secured and unsecured debt. But if all types of debt are backed by collateral, what is the distinction between secured and unsecured debt and what are the implications for our understanding of the role of collateral in firm financing and macro finance?

We study this question by considering the role of secured and unsecured debt in a dynamic model of collateralized finance based on Rampini and Viswanathan (2013). We argue that all claims are ultimately backed by collateral and are in this sense collateralized. Secured debt is explicitly collateralized, in that it has a perfected security interest in specific assets. Unsecured debt is implicitly collateralized as it has a claim on the assets not pledged to secured creditors in default. Unsecured debt lacks a perfected security interest but typically includes covenants that protect its claim on borrowers' unencumbered assets; thus, borrowers' unencumbered assets determine the amount of financing an unsecured creditor can extend. Both secured and unsecured debt are thus constrained by collateral.

The key difference between secured and unsecured debt is that secured debt is better collateralized, as the perfected security interest protects its claim on the underlying assets more effectively;[1] given their stronger claim on the underlying assets, secured creditors can

[1]Triantis (1992), for example, argues that "despite legal restrictions on the secured lender's ability to seize and sell the collateral, a secured debtholder can usually gain control of the collateral from the borrower more quickly than a similarly situated unsecured lender who must rely on the state enforcement

extend more credit. Unsecured debt is less well collateralized, but is ultimately backed by borrowers' assets and hence nevertheless constrained by these; unsecured creditors' weaker claim on the assets limits their credit extension. Therefore, in our model both secured and unsecured debt are subject to collateral constraints, with encumbered assets backing secured debt and unencumbered assets backing unsecured debt. The key distinction is that explicit collateralization gives secured lenders a stronger claim, and thus the benefit of secured debt is that it allows firms to borrow more per unit of collateral.

The cost of secured debt is that encumbering assets is costly. This cost could either be a direct cost, such as monitoring costs, or an indirect cost due to the inconvenience of use restrictions or a loss in operating flexibility, as encumbered assets are less easily reallocated. Thus, firms trade off the higher borrowing capacity of secured debt against the cost of encumbering assets. We show that financially constrained firms take out secured loans by encumbering assets to increase their ability to borrow and more constrained firms thus have more secured debt both across firms and within firms over time.

The predictions of our quantitative model are consistent with two basic stylized facts on secured debt which we document: (i) there is a strong positive relation between secured debt and measures of financial constraints; and (ii) there is a strong positive relation between secured debt as well as leverage and the fraction of firms' assets that are tangible. The predictions are also consistent with evidence we provide on the effects of ratings downgrades using a causal forest: firms that are downgraded shift the composition of their debt towards more secured debt away from unsecured debt, and more so for firms whose ratings are already low. Moreover, Azariadis, Kass, and Wen (2016) and Luk and Zheng (2022) find that unsecured debt is procyclical while secured debt is essentially acyclical, and Benmelech, Kumar, and Rajan (2024) find that the fraction of debt issuance that is secured is countercyclical. From the vantage point of our theory, this may be explained by a compositional effect, as firms are more constrained in downturns and their debt structure hence shifts to more secured debt.

Several conceptual aspects of our model are worth emphasizing. First, in practice collateralizable assets are primarily tangible assets, and intangible assets such as patents can be pledged to a much smaller extent. With this in mind, we assume for simplicity that only tangible assets are collateralizable in the model. We at times refer to collateralizable assets simply as collateral; thus, collateral in our terminology includes both assets that are encumbered by liens to secure debt and unencumbered assets.[2] Moreover, we assume

mechanism. Therefore, a firm that defaults on unsecured debt enjoys more time before losing possession of assets than a similarly situated firm that defaults on secured debt."

[2]As discussed before, an alternative use of the term collateral defines it more narrowly as encumbered assets, which would be in line with the legal use of the term as assets that secure loans.

that cash flows themselves are not collateralizable at all, as cash flows can be pledged only to a limited extent in practice. Therefore, the fraction of tangible assets needed for production (which we refer to as asset tangibility) determines the fraction of firms' assets that is collateralizable and hence both firms' secured and unsecured debt capacity; this observation is key to understanding the strong relation between firms' leverage and asset tangibility across firms and industries in the data in our view.

Second, collateral constraints imply that firms' net worth matters; indeed, firm net worth, that is, assets, net of liabilities, plus current cash flow, is the state variable in the model. Firm net worth includes both encumbered and unencumbered assets, but is net of liabilities. Importantly, it is net worth and not collateral itself that determines firms' decisions, including how much collateral firms hold; hence collateral is endogenous. Firms' net worth determines their investment and asset holdings, as well as the extent to which they lever and encumber these assets, and thus the composition of secured and unsecured debt they use, that is, their debt structure.

Third, previous work, discussed in more detail in the section on the related literature, studies whether secured debt is costly or not relative to unsecured debt by comparing interest rates. This literature intuitively argues that secured debt should be relatively cheap due to the collateral backing it, and largely finds evidence consistent with this prediction when properly controlling for firms' risk characteristics. This way of thinking however raises the puzzle why firms do not always borrow secured. In contrast, we argue that the benefit of secured debt is that it allows firms to borrow more per unit of asset. Therefore, firms that have larger financing needs may choose to borrow secured despite the fact that doing so is more costly. The cost of secured debt could be a direct cost or a result of the inconvenience of having the secured lender weigh in on decisions regarding the encumbered assets. While we argue that secured debt is costly, whether the interest rate on secured debt reflects these costs depends on whether the lender bears them. To the extent that the costs are borne by the borrower, the interest rate on secured debt may be the same or even lower than that on unsecured debt, as seems to be the case in the data, despite the fact that secured debt is in fact costly for the borrower. The focus should be on the quantity of debt a secured lender can extend per unit of collateral, not just the price of such debt.[3]

Fourth, we argue that secured debt is primarily about enforcement of payment rather than simply about priority. Our model emphasizes secured lenders' ability to enforce payment not just in but importantly also outside of bankruptcy, which increases borrowers' ability to credibly pledge to pay and thus facilitates financing and investment

[3] In our model default does not occur in equilibrium and thus does not affect the interest rate on loans.

ex ante. In the law literature on secured debt, Mann (1997) argues that secured credit has direct benefits in terms of enforcement of payment, in that it "increases the lender's ability to collect the debt forcibly through liquidation of the collateral," and "enhances the lender's remedy (so that the lender can coerce payment more quickly than it could if its debt were not secured)" (page 639). Secured credit also has both direct costs, such as information and transactions costs, as well as indirect costs, as one borrower interviewed by the author explained "you just don't have the same flexibility of dealing with your properties as if you owned them unencumbered" (page 665). This discussion is consistent with the basic trade-off in our model.[4] Mann (1997) emphasizes that the borrowers and lenders are "reacting to the 'shadow' of the law – the parties' anticipation of what would happen if formal legal proceedings were to occur" (page 645). This is also the case in our model, in which default does not occur in equilibrium. Finally, the author observes that secured credit is used only infrequently by companies with strong financial records, and argues that "as a borrower's financial strength increases, secured credit becomes a less attractive alternative: its benefits decrease and its costs at best, remain constant" and that as a consequence "borrowers exhibit an increasing tendency toward unsecured debt as their financial strength increases" (page 674).[5] This is consistent with the main prediction of our theory across and within firms. That said, the law literature does not seem to recognize that due to its advantage in enforcement of payment, one of the main benefits of secured debt is that it allows firms to borrow more.

Fifth, in our model, optimal financing with secured and unsecured debt is implemented with one-period claims. However, one could implement the optimal contract with longer term claims that are protected by covenants. Unsecured debt, for example, might include covenants which require a minimum amount of net worth or other restrictions on leverage, subsequent financing (such as negative pledge covenants), or investment, as is often the case in practice. Before or following violations, such covenants may be renegotiated and lenders may require security, turning unsecured debt into secured debt as firms' financial conditions deteriorate. Consistent with this interpretation, Schwarcz (1997) states that "unsecured creditors frequently choose to waive negative pledge covenants in exchange

[4] Jackson and Kronman (1979) emphasize the role of secured lending in protecting lenders against competing creditors. However, they also state that "[p]rotection against third parties is, of course, not the only advantage afforded by a security interest. A creditor with a security interest in his debtor's property may also find it easier to enforce his claim against the debtor in the event the debtor defaults. Upon default, and unless otherwise agreed, the secured party may take possession of the collateral without judicial process if he can do so without breaching the peace. U.C.C. § 9-503" (p. 1143).

[5] In a similar spirit, Scott (1997) argues that "[t]he most plausible reason why solvent, high-risk debtors can issue only secured debt is that the leverage security provides can substantially reduce the risk of nonpayment for the secured creditor."

for a quid pro quo, such as becoming equally and ratably secured" (page 451).

Further, note that borrowers' incentives to pay, we argue, depend on the value borrowers would lose if they were to default, that is, the value of the collateral to them, which is the replacement value of the collateral, not the value that lenders could recover by repossessing the asset, that is, the liquidation value. This feature of our model is consistent with the U.S. Supreme Court's *Rash* decision[6] which holds that "[u]nder §506(a), the value of property retained because the debtor has exercised Chapter 13's 'cram down' option is the cost the debtor would incur to obtain a like asset for the same proposed use" (page 953). "[T]he replacement-value standard accurately gauges the debtor's 'use' of the property. ... That actual use, rather than a foreclosure sale that will not take place, is the proper guide under a prescription hinged to the property's 'disposition or use'" (page 954). The Supreme Court explicitly rejects using the value that "the secured creditor could obtain through foreclosure sale of the property (the 'foreclosure-value' standard)" (page 955) and "the midpoint between the replacement and foreclosure values" (page 954). The U.S. Bankruptcy Court of the Southern District of New York extends this reasoning to Chapter 11 of the bankruptcy code in its *ResCap* decision[7] concluding that "[a]lthough this case involves the consensual use of collateral in the context of a sale under chapter 11, the reasoning of *Rash* is equally applicable here." In our model, repossession does not occur in equilibrium, and hence the value of collateral in the model should be interpreted as the replacement value, not the liquidation value, which we do not need to take a stand on and which could be considerably lower both in the model and in practice. Moreover this suggests that in empirical work the value of collateral should be assessed using the replacement value, not the liquidation value, as long as liquidation does not actually occur.

Finally, leasing enjoys a further repossession advantage (see Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013)) giving the financier an even stronger claim on leased assets, as the financier, that is, the lessor, retains ownership. Leases are executory contracts that are not subject to automatic stay and lessees must either continue to make payments or reject the lease and forfeit the leased assets. The repossession advantage of lessors over secured lenders means that leasing allows even higher leverage than secured debt does, presumably at a further cost due to the separation of ownership and control. We show how to extend our model of secured and unsecured debt to include leasing; there is a collateralization pecking order of sorts, with the most constrained firms leasing assets, moderately constrained firms issuing secured debt, and less constrained

[6] *Associates Commercial Corp. v. Rash,* 520 U.S. 953 (1997).

[7] *In re: Residential Capital, LLC, et al.,* 501 B.R. 549 (Bankr. S.D.N.Y 2013).

firms borrowing unsecured. Leasing is thus an additional form of collateralized finance and adjusting our stylized empirical facts on the importance and patterns in collateralized finance by taking leasing into account accentuates them further. Moreover, similar to the cyclical properties of secured debt, Gal and Pinter (2017) find that the fraction of capital that firms lease is countercyclical, which may be the result of a similar compositional shift to leased capital by financially constrained firms, as predicted by our theory.

Section 2 summarizes the related literature. Section 3 describes key stylized facts on secured debt. Section 4 provides our model of secured and unsecured debt. Section 5 extends the model by including leasing as well as secured debt. Section 6 provides evidence on the choice between secured and unsecured debt from rating downgrades using a causal forest and Section 7 concludes.

2 Related literature

In this section we discuss the related literature on dynamic models of firm financing, as well as the theoretical and empirical literature on collateral and secured debt.

Literature on dynamic contracting models of firm financing. We consider a dynamic model of collateralized finance. In a seminal paper, Kiyotaki and Moore (1997) study a dynamic model with non-contingent debt subject to collateral constraints motivated by the inalienability of entrepreneurs' human capital as in Hart and Moore (1994). Our model builds on Rampini and Viswanathan (2010, 2013), who derive collateral constraints in a model with limited enforcement without exclusion allowing for state-contingent claims and show that restricting attention to one-period claims is without loss of generality.[8] In these papers, debt needs to be collateralized, but no distinction is made between secured and unsecured debt.[9]

The literature on dynamic contracting models of firm financing focuses on several different classes of contracting problems. Our model is based on limited enforcement without exclusion and puts collateral center stage. In a similar spirit, Albuquerque and

[8] Using this class of models, Li, Whited, and Wu (2016) and Nikolov, Schmid, and Steri (2019, 2021) study the quantitative implications for firms' capital structure and liquidity policy, Ai and Li (2015) study the implications of two-sided limited commitment, and Rampini (2019) studies the effect of durability of capital for firm financing.

[9] Indeed, Rampini and Viswanathan (2013) note that they "do not consider whether liabilities are explicitly collateralized or only implicitly in the sense that firms have tangible assets exceeding their liabilities. [Their] reasoning is that even if liabilities are not explicitly collateralized, they are implicitly collateralized, since restrictions on further investment, asset sales, and additional borrowing through covenants and the ability not to refinance debt allow lenders to effectively limit borrowing to the value of collateral in the form of tangible assets" (p. 469).

Hopenhayn (2004) study firm financing subject to limited enforcement with an exogenous outside option.[10] A sizable literature studies dynamic firm financing and investment when the main frictions are incentive problems due to private information about cash flows or moral hazard.[11] In these models, collateral does not play a prominent role and none of these models distinguish between secured and unsecured debt.

Theoretical literature on collateral and secured debt. Several other aspects of collateral and secured debt have been considered in the theoretical literature. Barro (1976) argues that collateral affects the interest rate that borrowers pay when default occurs in equilibrium. Diamond (1984), Lacker (2001), and Rampini (2005) show that collateralized lending with costly default may be an optimal mechanism to induce repayment when cash flows are private information. Bester (1985) and Besanko and Thakor (1987) argue that collateral alleviates credit rationing due to adverse selection. Rajan and Winton (1995) show that collateral and covenants give lenders an incentive to monitor.[12] Dubey, Geanakoplos, and Shubik (2005) argue that collateralized claims with default render markets more complete. Stulz and Johnson (1985) show secured debt can reduce under-investment problems à la Myers (1977). Donaldson, Gromb, and Piacentino (2020, 2022a) and DeMarzo (2019) argue that secured debt prevents debt dilution. Finally, Donaldson, Gromb, and Piacentino (2022b) argue that pledging assets as collateral impedes reallocation.

Empirical literature on collateral and secured debt. A sizable literature studies the effect of collateral on the financing of firms empirically. Gan (2007) and Chaney, Sraer, and Thesmar (2012) show that changes in the value of collateral affect investment in large firms and Adelino, Schoar, and Severino (2015) show that such changes affect employment

[10] Cooley, Marimon, and Quadrini (2004) consider the aggregate implications of firm financing with limited enforcement and Cao, Lorenzoni, and Walentin (2019) study the relation between investment and Tobin's q in a model with limited enforcement similar to ours.

[11] This literature includes Quadrini (2004), Clementi and Hopenhayn (2006), DeMarzo and Fishman (2007a), and DeMarzo, Fishman, He, and Wang (2012). Bolton and Scharfstein (1990) consider a two-period firm financing problem with privately observed cash flows. Several authors consider dynamic firm financing with such incentive problems but without an investment choice, including DeMarzo and Sannikov (2006), DeMarzo and Fishman (2007b), and Biais, Mariotti, Plantin, and Rochet (2007). Finally, an influential earlier literature studies dynamic firm financing with costly external finance, borrowing constraints, and cost of default taking the claims firms issue as given, so without considering the optimal contracting problem, including Leland (1994), Gomes (2001), Hennessy and Whited (2005, 2007), and Bolton, Chen, and Wang (2011).

[12] Smith and Warner (1979) and Leland (1994) discuss the role of covenants in financial contracts. Chava and Roberts (2008) document the prevalence of covenants and the consequences of covenant violations (see also Roberts and Sufi (2009)). Greenwald (2019) studies the macroeconomic implications of interest coverage covenants for firm investment.

in small firms. Catherine, Chaney, Huang, Sraer, and Thesmar (2022) estimate the aggregate effects of firms' collateral constraints quantitatively. Note that the papers in this literature typically do not consider whether firms' debt is secured, that is, explicitly collateralized or not. Mann (2018) studies the use of patents as collateral.

Several papers study the choice between secured debt and unsecured debt in the data. Berger and Udell (1990) show that secured debt is issued by riskier firms and is riskier than unsecured debt. Interpreting riskier firms as more financially constrained, this is consistent with the predictions of our model. Berger and Udell (1998) find that in 1993 NSSBF data "91.94% of all small business debt to financial institutions is secured" concluding that "[t]his very high percentage implies the vast majority of virtually all types of financial institution loans and [capital] leases to small businesses – including loans drawn under lines of credit – are backed by collateral" (page 638). The fact that secured debt constitutes the bulk of debt for small firms is consistent with our results that smaller publicly traded firms secure a much larger fraction of their debt. Rauh and Sufi (2010) study the debt structure of public firms and show that low credit-quality firms have substantially more secured debt. Benmelech and Bergman (2009) show that among U.S. airlines secured debt with more redeployable collateral has lower credit spreads and higher loan-to-value ratios. Collier, Ellis, and Keys (2022) and Pan, Pan, and Xiao (2025) estimate the cost of pledging collateral for households and small businesses, respectively. Luck and Santos (2024) find that in U.S. bank loan data secured debt has lower loan spreads, especially among smaller and medium size firms, with marketable securities and real estate having larger effects than other types of collateral (such as receivables, other fixed assets, or blanket liens). Benmelech, Kumar, and Rajan (2022) show that both secured loans and bonds have lower loan spreads relative to the corresponding unsecured claims, especially when firms' credit quality deteriorates.

A couple of recent papers show that secured debt is relatively limited among large public firms. Benmelech, Kumar, and Rajan (2024) document a secular decline in secured debt among such firms and argue that secured debt is increasingly taken out on a contingent basis, as firms approach distress. This interpretation is in a very similar spirit to the mechanism in our model – securing debt is costly and firms that get more financially constrained increasingly switch to secured debt. Lian and Ma (2021) distinguish between cash-flow and asset-based lending, which we interpret as unsecured and secured debt,[13]

[13]They argue that the distinction between cash-flow based and asset-based lending is different from the distinction between unsecured and secured lending. While they argue that unsecured debt is typically cash-flow based, they also classify debt that is secured by the "going-concern cash flow value of the firm" as cash-flow based lending. They write that "the essence of secured versus unsecured debt is priority in bankruptcy under U.S. law (Baird and Jackson 1984), not necessarily the economic variables that

and find that asset-based lending is relatively small among large public firms. They argue that this implies that collateral constraints are not the most relevant constraints for such firms, challenging the quantitative importance of collateral for large firms and hence in the aggregate in the US. In our view, this conclusion is not warranted because it implicitly assumes that collateral only matters for secured debt. In contrast, our theory suggests a rather different interpretation of the facts: collateral is relevant even for unsecured debt; as firms get more financially constrained, they progressively switch to secured debt; and secured debt constitutes the bulk of financing for smaller firms and, accounting for leasing, is substantial among larger firms, too. In light of this we conclude that the evidence is consistent with the view that collateral is a primary determinant of capital structure for all firms, small and large.

3 Stylized facts on secured debt

This section documents two key stylized facts. The first fact is that secured debt increases in measures of financial constraints; specifically, while highly rated firms have limited secured debt, firms with lower credit ratings have substantially more secured debt. Moreover, following downgrades, firms' secured debt increases and their unsecured debt weakly decreases. We also show that there is a sizable relation between secured debt and size, another measure of financial constraints; large firms, which are likely less constrained, have relatively little secured debt, whereas a much larger fraction of smaller firms' debt is secured. The second fact is that secured debt, unsecured debt, and leverage increase substantially with the tangibility of firms' assets. Throughout, we use annual data from Compustat from 1981 to 2018, excluding firms in SIC codes 6000-6999. We measure secured debt using the variable *Debt – Mortgage and Other Secured* which includes "all long-term debt secured or collateralized by a mortgage, property, receivable, stock, or other assets" and is available from 1981 onward.[14] Details of the data and variable construction are in Appendix A.

determine creditors' payoffs" (pp. 245 and 248), and that "[their] classification [of asset-based versus cash flow-based debt] focuses on the economic bases of creditors' claims and payoffs (i.e., liquidation value of specific assets versus going-concern cash flow value of the firm)" (p. 245).

[14]Note that this variable does not include secured short-term debt and may hence still understate the importance of secured debt when compared to total debt rather than total long-term debt only.

3.1 Secured debt and financial constraints: cross section

We start by studying the relation between secured debt and financial constraints, using firms' credit ratings as the measure of financial constraints. In the theory, net worth is the endogenous state variable determining the marginal value of net worth and how constrained firms are; we interpret firms' credit ratings as a measure of their marginal value of net worth. Figure 1 displays the patterns in firms' financing, investment, and payout policy across deciles by firms' ratings, from the lowest ratings decile (which includes firms with ratings of B and below) to the highest ratings decile (which includes firms with ratings of AA- and above. For each decile, we display a Box plot with the mean (dot), median (dash), inter-quartile range (bottom and top dash of grey box), and the 10th and 90th percentile (whiskers) of the variable. The mean and median values for each decile and overall are reported in Panel A of Table 1. All deciles are computed based on the pooled data.

First, consider firms' financing and debt structure. Panel A displays firms' secured debt to assets, which we also refer to as secured debt leverage. Firms in the top five deciles by ratings category all have essentially no secured debt; the median is close to 0 in these deciles and the mean less than 3%. In the bottom five deciles, the mean (median) secured debt leverage rises monotonically up to 22% (15%) in the lowest decile. Notice that there is a strong relation between secured debt and credit ratings even among non-investment grade firms, and the pattern is not simply a matter of non-investment grade vs. investment grade firms. The overall mean (median) secured debt leverage is 10% (1%). Panel B shows the fraction of total debt that is secured, which we refer to as the secured debt ratio. This mean (median) ratio is low for the top five deciles, below 8% (1%). For the lower five deciles, the mean (median) secured debt ratio rises progressively to 41% (34%), albeit not quite monotonically so. The overall mean (median) secured debt ratio is 23% (4%). There is a clear and substantial relation between secured debt and firms' credit ratings.[15] Panel C shows firms' mean (median) unsecured debt to assets, which decreases from 33% (29%) in the lowest rating decile to 18% (17%), so significantly but not as substantially as secured debt (and not quite monotonically). Panel D shows (total) debt to assets, that is, leverage, across rating categories. Mean (median) leverage decreases monotonically from 55% (52%) in the lowest rating decile to 22% (21%) in the highest rating decile, so differs by a factor of about 2.5 between the top and bottom

[15]Since our measure of secured debt includes long-term debt only, we also compute the fraction of total long-term debt that is secured, which we refer to as the secured long-term debt ratio. The patterns across rating deciles are very similar, although the level is slightly higher (see Panel A of Table D1 and Panel A of Figure D1 in Appendix D).

decile. Mean (median) leverage overall is at about 37% (34%). The higher leverage of lower rated firms suggests these firms are more financially constrained.

The patterns in firms' investment and payout policy are also consistent with lower rated firms being considerably more constrained. Panel E shows that higher rated firms are considerably larger (with median size measured as total assets varying by more than a factor 10 across rating categories). The fraction of dividend paying firms and dividends to assets dramatically increase across rating deciles. Fewer than 12% of firms in the lowest rating category pay dividends and more than 80% of firms pay dividends in each of the top five rating categories. Overall, 60% of firms pay dividends. Panel F shows that median dividends to assets are zero in the bottom four deciles and rise monotonically to 3% of assets in the top decile, while the mean rises monotonically from close to 0% to 3% as well. Clearly, lower rated firms are much more financially constrained, justifying the use of ratings as a measure of financial constraints.

An alternative way to measure financial constraints is by firms' size in terms of total assets. Indeed, size is the main factor in several prominent indices of financial constraints (see Whited and Wu (2006) and Hadlock and Pierce (2010)). Figure 2 illustrates firms' financial structure, size, and payout policy across deciles by size (see also Panel B of Table 1). Consider Panel E of Figure 2 first: this panel shows that we have constructed the deciles by size; in addition, comparing to the corresponding panel in Figure 1, we see that the rated firms we consider there are considerably larger and mostly in the top three or four deciles of the broader sample considered here. In terms of financial structure, Panel A shows that secured debt leverage is relatively flat for most of the firm size distribution at roughly 9% to 11%, but decreases quite a bit across the top three deciles from 11% to 9% and then 5%. The patterns in the secured debt ratio in Panel B are more apparent: the mean (median) secured debt ratio in deciles two to five is in the 41%-45% (36%-44%) range, and decreases monotonically from decile five to ten from 44% to 14% (40% to 2%), so rather substantially.[16] The patterns for the secured long-term debt ratio are even more pronounced and the level is considerably higher: the mean (median) secured long-term debt ratio in deciles two to five is in the 52%-57% (57%-67%) range, and again decreases substantially and monotonically in the higher deciles.[17] As Panel C shows, mean (median) unsecured debt leverage is in the 10%-13% (2%-4%) range in deciles two to six, and then rises monotonically up to 25% (23%) in the top four deciles. Panel D shows that mean (median) leverage is roughly constant across deciles two to six in the range 21%-23% (13%-16%) and then progressively increases in deciles seven

[16]In the first decile, the secured debt leverage and secured debt ratio are considerably lower; we provide an explanation for this in Section 5 where we take leased capital into account.

[17]See Panel A of Table D1 and Panel B of Figure D1 in Appendix D.

through ten to 31% (30%). Despite this, larger firms seem less constrained as the fraction of dividend-paying firms increases dramatically from 2% to 80% and Panel F shows that the mean dividends to assets monotonically increase from close to 0% to about 2% (while the median is zero except in the top two deciles).

All told, the patterns by size, another measure of financial constraints, are broadly consistent with the patterns across firms' credit ratings. The fraction of debt that is secured is sizable for smaller firms, which are likely more constrained, and decreases considerably among larger firms. Comparing Figures 1 and 2 shows that firms in the broader sample are more constrained on average than the rated firms, as they are smaller, less likely to pay dividends, and pay lower dividends. Firms in the broader sample moreover also have a larger fraction of secured debt; indeed, the secured debt ratio among non-rated firms is about 39% compared to 23% for rated firms.

3.2 Secured debt and financial constraints: within-firm

The within-firm dynamics are consistent with these cross-sectional patterns. Figure 3 displays the changes in the financing, investment, and payout policy following downgrades, to a lower ratings decile, across deciles by ratings (see also Panel C of Table 1). The figure shows the mean and the 95% confidence interval for each decile. The change is computed as the difference between the variable two years after the downgrade from its value the year before the downgrade. We choose a two year lag because adjusting debt structure may take time in practice depending on the maturity of the existing debt. The figure also displays interesting heterogeneity of the effect of downgrades across rating classes. Panel A shows that firms' secured leverage increases after downgrades, especially for firms with low credit ratings before the downgrade. The heterogeneity in the effect has a rather plausible interpretation: firms in high rating categories mostly do not use secured debt, so there is no change following downgrades, whereas among lower rated firms secured debt to assets increases by between 2% and 4%, which is substantial given the secured debt leverage is between 2% and 18% for such firms. The unsecured debt leverage shows the opposite pattern (see Panel C); if anything, low rated firms' unsecured leverage decreases, while higher rated firms' unsecured leverage increases following downgrades. This substitution from unsecured to secured debt for lower rated firms is also evident in Panel B which displays the change in the secured debt ratio. For firms rated *BBB* and below, the secured debt ratio increases by 3% to 8%, which is large relative to the average secured debt ratio among such firms which varies from 7% to 37%. Again, higher rated firms show no or small changes as many of them do not borrow secured even after being downgraded.[18] Following downgrades moreover there is an increase in overall leverage (Panel D) and a reduction in size of lower rated firms by as much as 26% (and a slight increase in size for higher rated firms) (Panel E). In addition, there is a drop in dividends, especially for higher rated firms (Panel F), and in the fraction of firms' paying dividends, especially for lower rated firms. We interpret these patterns as evidence that firms that are downgraded become more constrained and substitute increasingly toward secured debt. The heterogeneity of the effect across rating deciles is a result of the limited use of secured debt by highly rated firms.

We summarize our empirical findings on the relation between firms' ratings and their financing, investment, and payout policy both across rating deciles and within-firm following rating downgrades here:

Fact 1 (**Secured debt and net worth**). *Across deciles by ratings, a proxy for "net worth," secured debt leverage and the secured debt ratio decrease; further, leverage decreases and firm size, dividends to assets, and the fraction of dividend-paying firms increase. Following a downgrade, firms' secured debt leverage and the secured debt ratio increase, while among lower rated firms the unsecured debt leverage weakly decreases; firms' assets, dividends to assets, and the fraction of dividend-paying firms decrease.*

The patterns by firm size (measured by total assets) are broadly consistent with this fact.

3.3 Secured debt and tangible assets

Next we consider the patterns across firms which differ in the composition of their assets, specifically, in the extent to which tangible assets are used for production. This composition varies substantially across firms, due to differences in technologies used in different firms and industries. We study the variation in firms' financing, investment, and payout policy across deciles of firms based on their ratio of tangible assets to total assets, which we refer to as the tangible assets ratio or simply tangibility. Note that we do not restrict the sample to firms which have a credit rating here, so include a much broader set of firms, including many considerably smaller firms.

Figure 4 displays the results using a similar approach to Figures 1 and 2 (see also Table 2). Panels A through D of the figure show that firms' leverage and debt structure vary considerably and monotonically with tangibility. Mean (median) secured debt leverage increases from 5% (0%) to 18% (8%) across deciles by tangibility. The mean

[18] The change in the secured long-term debt ratio shows very similar patterns (see Panel A of Table D1 and Panel C of Figure D1 in Appendix D).

(median) secured debt ratio increases from 26% (0%) to 45% (41%).[19] Moreover and importantly, even mean (median) unsecured debt leverage increases substantially and almost monotonically with tangibility, from 12% (0%) to 19% (12%-14%). Finally, mean (median) leverage increases from 18% (1%) to 38% (36%) with tangibility; mean leverage thus increases by a factor more than two and median leverage increases dramatically. The increase in leverage reflects the fact that both secured and unsecured debt increase with tangibility. Clearly, firms with more tangible assets have substantially higher secured, unsecured, and total leverage. Firms with more tangible assets also seem somewhat less constrained as evidenced by the fact that they are larger (with assets varying by a factor of about 7-11 between the top and the bottom decile) (Panel E), more likely to pay dividends, and paying higher dividends per assets (Panel F). We summarize these findings here:

Fact 2 (**Secured debt and tangibility**). *Across deciles by tangible assets (to total assets), secured debt leverage and the secured debt ratio increase, as does unsecured leverage and (total) leverage; further, firm size, dividends to assets, and the fraction of dividend-paying firms increase.*

We emphasize that the fact that even unsecured debt leverage increases with tangibility strongly suggests that tangible assets, that is, collateral, are a key determinant of unsecured debt as well.

4 Model with secured and unsecured debt

We consider a model of a firm which can finance investment with secured and unsecured debt. Secured and unsecured debt are explicitly and implicitly collateralized, respectively, but secured debt provides stronger collateralization, which allows higher leverage but entails costs. We show that more financially constrained firms use more secured debt, lever more, and invest less, consistent with the stylized facts. We calibrate the model to evaluate the model quantitatively. Proofs are in Appendix B.

4.1 Environment and benefits and costs of secured debt

Consider an economy in discrete time with an infinite horizon, with time $t = 0, 1, 2, \ldots$. There is a risk-neutral firm which discounts expected dividends at rate $\beta \in (0, 1)$. The

[19] Similar patterns obtain for the secured long-term debt ratio (see Panel A of Table D1 and Panel B of Figure D1 in Appendix D), although these patterns are somewhat less pronounced, possibly because the debt of firms in low tangibility deciles is more short term.

firm has access to a production technology with two types of capital, tangible capital and intangible capital deployed in fixed proportions, with fraction $\varphi \in (0, 1]$ of capital being tangible and fraction $1 - \varphi$ being intangible.[20] An investment of capital k that yields a stochastic cash flow $A(z')f(k)$ where $A(z')$ is the total factor productivity of the technology in state z' which follows a Markov chain described by the transition function $\Pi(z, z')$ on $z' \in Z$. The production function exhibits strictly decreasing returns and satisfies the following Inada conditions:

Assumption 1 (Production function)**.** *The production function f is strictly increasing, strictly concave, $f(0) = 0$, $\lim_{k\to 0} f'(k) = +\infty$, and $\lim_{k\to+\infty} f'(k) = 0$.*

Further, all capital depreciates at rate $\delta \in (0, 1)$.

The firm is subject to financial constraints and dividends have to be non-negative. The firm has limited net worth w_0 at time 0. The firm has to finance intangible capital $(1-\varphi)k$ out of internal funds. Tangible capital φk can be partially financed with secured and unsecured debt (or some of both). Both secured and unsecured debt are explicitly or implicitly collateralized with tangible capital serving as collateral. If the firm pledges an amount of tangible capital k_s to a secured lender, the remaining unencumbered tangible assets $k_u = \varphi k - k_s$ back unsecured lenders' claims.

One benefit of secured debt, Mann (1997) argues, is that it "increas[es] the lender's ability to collect the debt forcibly through liquidation of the collateral" and thus "enhanc[es] the lender's remedy (so that the lender can coerce payment more quickly than it could if its debt were not secured)" (page 639). We therefore assume that secured debt allows the borrower to pledge up to fraction θ_s per unit of capital by perfecting a security interest in specific assets. But perfecting a security interest involves a cost κ per unit of capital. According to Mann (1997), this cost could be a direct cost or an indirect cost as in a secured loan "[y]ou just don't have the same flexibility of dealing with your properties as if you owned them unencumbered" (page 665). In contrast, unsecured debt is only implicitly collateralized, giving the lender a weaker claim and hence allowing the borrower to pledge only a smaller fraction θ_u per unit of capital, while conserving the cost of perfecting a security interest. Appendix C shows that when encumbered capital is less efficient, perhaps because of its limited redeployability or use restrictions that reduce operating flexibility, so that the cost of encumbering assets is an indirect cost, similar

[20] Capital is aggregated using the Leontief aggregator $k \equiv \min\{k_p/\varphi, k_i/(1-\varphi)\}$, where k_p denotes tangible (or physical) capital, k_i intangible capital, and φ the factor share of tangible capital. Since it is optimal to choose $k = k_p/\varphi = k_i/(1-\varphi)$, we can use k_p as the choice variable, which implies $k = k_p/\varphi$ and $k_i = k_p(1-\varphi)/\varphi$.

results obtain. We summarize the collateralization benefits and costs of secured debt in the following assumption:

Assumption 2 (Collateralizability benefit and cost of secured debt)**.** $1 > \theta_s > \theta_u \geq 0$ *and* $\kappa > 0$.

Per unit of tangible capital, which costs 1, the firm can pledge fraction θ_s of the residual value, which is $1-\delta$, as repayment next period; thus, a lender can lend up to the present value of that amount, that is, up to $R^{-1}\theta_s(1-\delta)$, where R is the interest rate lenders charge; we can therefore define the down payment required with secured debt as $\wp_s \equiv 1 - R^{-1}\theta_s(1-\delta) + \kappa$, which includes the cost of encumbering assets. Similarly, the down payment with unsecured debt is $\wp_u \equiv 1 - R^{-1}\theta_u(1-\delta)$.

Due to its stronger claim on the firm's tangible assets, a secured lender can extend more credit. However, this additional debt capacity comes at a cost due to the cost of collateralization. Let $R_s \equiv \frac{(\theta_s-\theta_u)(1-\delta)}{\wp_u-\wp_s}$ which can be interpreted as the interest rate on the additional amount of borrowing implied by secured debt. We make the following assumptions on the cost of secured debt κ:

Assumption 3 (Benefits and costs of secured and unsecured debt)**.** $\wp_u > \wp_s$ *and* $R_s > \beta^{-1} > R$*; equivalently,* $R^{-1}(\theta_s - \theta_u)(1-\delta) > \kappa > (R^{-1} - \beta)(\theta_s - \theta_u)(1-\delta)$.

This assumption implies that secured debt is neither dominated by unsecured debt (first inequality) nor does it dominate unsecured debt (second set of inequalities). Since $\wp_u > \wp_s$, secured debt allows more borrowing, but this additional borrowing is costly because $R_s > R$. Further, the second set of inequalities implies that dividend-paying firms do not use secured debt. In addition, the assumption that $\beta^{-1} > R$ implies that external finance is relatively cheap even for dividend-paying firms.[21]

4.2 Simple, deterministic model of secured and unsecured debt

To illustrate the key economic insights, we start by considering a simplified version of the model without uncertainty (that is, A' is a constant) and without intangible assets ($\varphi = 1$). We write the model recursively denoting values for the next period with a prime.

The firm chooses dividends d, investment in both capital pledged to secure loans k_s and unencumbered capital k_u, secured debt b'_s, unsecured (but implicitly collateralized) debt b'_u, and net worth next period, to maximize the present value of dividends

$$v(w) = \max_{\{d,k_s,k_u,w',b'_s,b'_u\}\in\mathbb{R}^4_+\times\mathbb{R}^2} d + \beta v(w') \tag{1}$$

[21]This wedge could be a result of the tax-advantage of debt as assumed in much of the literature or a consequence of collateral scarcity in general equilibrium as in Rampini and Viswanathan (2022).

subject to the budget constraints for the current and next period

$$
\begin{aligned}
w+\sum_{j\in\mathcal{J}} b'_j &\geq d+\sum_{j\in\mathcal{J}} k_j+\kappa k_s && (2)\\
A'f(k)+\sum_{j\in\mathcal{J}} k_j(1-\delta) &\geq w'+\sum_{j\in\mathcal{J}} Rb'_j, && (3)
\end{aligned}
$$

where $k\equiv\sum_{j\in\mathcal{J}} k_j$, and the collateral constraints on secured and unsecured borrowing

$$
\theta_j k_j(1-\delta)\geq Rb'_j, \qquad \forall j\in\mathcal{J}, \tag{4}
$$

where $\mathcal{J}\equiv\{s,u\}$.

Denoting the multipliers on the constraints (2) to (4) by μ, $\beta\mu'$, and $\beta\lambda'_j$, and on the non-negativity constraints for k_j and d by $\underline{\nu}_j$ and $\underline{\nu}_d$, the first-order conditions with respect to d, b'_j, k_s, k_u, and w' are

$$
\begin{aligned}
\mu &= 1+\underline{\nu}_d && (5)\\
\mu &= \beta R\mu'+\beta R\lambda'_j, \qquad \forall j\in\mathcal{J}, && (6)\\
\mu(1+\kappa) &= \beta\mu'[A'f_k(k)+(1-\delta)]+\beta\lambda'_s\theta_s(1-\delta)+\underline{\nu}_s && (7)\\
\mu &= \beta\mu'[A'f_k(k)+(1-\delta)]+\beta\lambda'_u\theta_u(1-\delta)+\underline{\nu}_u && (8)\\
\beta\mu' &= \beta v_w(w'). && (9)
\end{aligned}
$$

The envelope condition is $v_w(w)=\mu$.

From (6) for both $j\in\mathcal{J}$ we conclude that $\lambda'_u=\lambda'_s\equiv\lambda'$ and (6) simplifies to $1=\beta R\mu'/\mu+\beta R\lambda'/\mu$. Moreover, taking the difference between (7) and (8) we obtain

$$
\kappa=\beta\frac{\lambda'}{\mu}(\theta_s-\theta_u)(1-\delta)+\frac{\underline{\nu}_s}{\mu}-\frac{\underline{\nu}_u}{\mu}. \tag{10}
$$

Note that, since $\kappa>0$ by Assumption 2, if θ_s were less than or equal to θ_u, then $\underline{\nu}_s>0$, that is, secured debt would be dominated; however, $\theta_s>\theta_u$ by Assumption 2.

Using the definitions of the down payment required with secured and unsecured debt, $\wp_s=1-R^{-1}\theta_s(1-\delta)+\kappa$ and $\wp_u=1-R^{-1}\theta_u(1-\delta)$, respectively, and substituting for λ'_j using (6) in (7) and (8), we obtain the firm's investment Euler equations (IEE) for investment financed with secured and unsecured debt

$$
1=\beta\frac{\mu'}{\mu}\frac{A'f_k(k)+(1-\theta_j)(1-\delta)}{\wp_j}+\frac{\underline{\nu}_j/\mu}{\wp_j}, \qquad \forall j\in\mathcal{J}. \tag{11}
$$

Defining the "stochastic" discount factor as $\mathcal{M}'\equiv\beta\frac{\mu'}{\mu}$ and the levered return on net worth from investment financed with secured and unsecured debt as

$$
R'_j(k)\equiv\frac{A'f_k(k)+(1-\theta_j)(1-\delta)}{\wp_j}, \qquad j\in\mathcal{J}, \tag{12}
$$

we can state the IEEs (11) compactly as $1 \geq \mathcal{M}' R_j'(k)$, $\forall j \in \mathcal{J}$, with equality if $k_j > 0$. Alternatively, let $r \equiv R-1$ and define $u \equiv r+\delta$ as Jorgenson's (1963) frictionless user cost of capital and rewrite the IEEs (11) for investment financed with secured and unsecured debt, respectively, as

$$u + R\kappa + R\frac{\lambda'}{\mu'}\wp_s \geq A' f_k(k) \tag{13}$$

$$u + R\frac{\lambda'}{\mu'}\wp_u \geq A' f_k(k), \tag{14}$$

with equality if $k_j > 0$. Therefore, the choice between secured and unsecured debt is determined by the trade-off between the cost of encumbering assets κ and the down payments $\wp_j$ when financing investment with secured and unsecured debt.

If $\wp_s$ were weakly larger than $\wp_u$, then comparing the IEEs for investment financed with secured and unsecured debt stated as in (13) and (14) would imply that $\underline{\nu}_s > 0$, that is, secured debt would be dominated; effectively, this would mean that the cost of encumbering assets would be so high, that borrowing secured would free up less funds than borrowing unsecured. However, by Assumption 3, $\wp_s < \wp_u$ or equivalently $\kappa < R^{-1}(\theta_s - \theta_u)(1-\delta)$. Subtracting (11) for capital with secured finance multiplied by $\wp_s$ from (11) for capital with unsecured debt multiplied by $\wp_u$ and rearranging we obtain

$$1 = \beta\frac{\mu'}{\mu}\frac{(\theta_s - \theta_u)(1-\delta)}{\wp_u - \wp_s} + \frac{\underline{\nu}_u/\mu - \underline{\nu}_s/\mu}{\wp_u - \wp_s}. \tag{15}$$

Recall that $R_s = \frac{(\theta_s-\theta_u)(1-\delta)}{\wp_u-\wp_s} = R\frac{1}{1-R\kappa/((\theta_s-\theta_u)(1-\delta))}$ which can be interpreted as the implied interest rate on the additional amount of borrowing enabled by secured debt. If R_s were weakly less than R, then, using the fact that $1 = \beta\frac{\mu'}{\mu}R + \beta\frac{\lambda'}{\mu}R$, we would conclude that $\underline{\nu}_u \geq 0$, so secured debt would at least weakly dominate unsecured debt. However, by Assumption 2, $\kappa > 0$ or equivalently $R_s > R$. Secured debt is more costly, but allows the firm to borrow more per unit of capital than unsecured debt.

In a steady state, the firm pays dividends and $\mu = \mu' = 1$, so $\beta\mu'/\mu = \beta$ and $\beta\lambda'/\mu = R^{-1} - \beta$. Substituting into (15) and (10), respectively, and using the fact that $R_s > \beta^{-1}$ or equivalently $\kappa > (R^{-1} - \beta)(\theta_s - \theta_u)(1-\delta)$ by Assumption 3, we conclude that dividend paying firms have no secured debt as $\underline{\nu}_s > 0$. Further, $\underline{\nu}_u = 0$ and the IEE (11) for unencumbered capital reduces to

$$1 = \beta\frac{A' f_k(k) + (1-\theta_u)(1-\delta)}{\wp_u}$$

which implicitly defines the capital $\bar{k}$ of a dividend paying firm.

Consider a severely constrained firm, that is, suppose $w \to 0$. Then (2) together with (4) imply that $w \geq \sum_{j\in\mathcal{J}} \wp_j k_j$ and therefore, $k_j \to 0$, for all $j \in \mathcal{J}$, and hence $k \to 0$, and the investment Euler equation (11) in turn implies that $\beta\mu'/\mu \to 0$ and thus $\beta\lambda'/\mu \to R^{-1}$. Therefore, since $\kappa < R^{-1}(\theta_s - \theta_u)(1-\delta)$ by Assumption 3, (10) implies $\underline{\nu}_u > 0$, that is, severely constrained firms have only secured debt.

Suppose the firm is indifferent between secured and unsecured finance at the margin, then $\underline{\nu}_u = \underline{\nu}_s = 0$ and thus $1 = \beta\frac{\mu'}{\mu}R_s$; further, (11) for unencumbered capital reduces to

$$R_s = \frac{A' f_k(k) + (1-\theta_u)(1-\delta)}{\wp_u}.$$

This equation implicitly defines the level of investment at which the firm is indifferent between secured and unsecured finance $\underline{k}$. Moreover, since $\frac{\lambda'}{\mu'} = (\beta\frac{\mu'}{\mu})^{-1}R^{-1} - 1 = \frac{R_s - R}{R} = \frac{\kappa}{R^{-1}(\theta_s-\theta_u)(1-\delta)-\kappa}$, (14) at equality implies that $\underline{k}$ is strictly decreasing in κ. Since $R_s > \beta^{-1}$ by Assumption 3, $\underline{k} < \bar{k}$.

We have therefore established the following (see Appendix B for a detailed proof):

Proposition 1 (Deterministic case)**.** *Given Assumptions 1 to 3, there exist thresholds* $0 < \underline{w}_s < \bar{w}_s < \bar{w} < +\infty$ *such that:* **(i)** (Financing policy) *Firms with net worth* $w \leq \underline{w}_s$ *issue only secured debt; firms with net worth* $w \in (\underline{w}_s, \bar{w}_s)$ *gradually substitute from secured debt to unsecured debt, and firms with net worth* $w \geq \bar{w}_s$ *use only unsecured debt.* **(ii)** (Investment policy) *Investment* k *weakly increases in* w*, and strictly so for firms with* $w < \underline{w}_s$ *and* $w \in (\bar{w}_s, \bar{w})$*.* **(iii)** (Payout policy) *Firms with net worth* $w > \bar{w}$ *pay dividends.* **(iv)** (Firm life cycle) *Over time, firms accumulate net worth, increase investment, substitute from secured debt to unsecured debt, and eventually initiate dividends.*

4.3 Secured and unsecured financing with uncertainty

Consider now the general stochastic version of the model with intangible assets ($\varphi \in (0,1]$) as described in Section 4.1. We maintain Assumptions 1 to 3 and further assume that

Assumption 4. *For all* $z_+, z \in Z$ *such that* $z_+ > z$*,* **(i)** $A(z_+) > A(z)$ *and* **(ii)** $A(z) > 0$*.*

We denote variables that depend on the state z' next period at times simply with a prime, for example, $A' \equiv A(z')$. The firm has access to secured debt b'_s and unsecured (but implicitly collateralized) debt b'_u, both of which can be state-contingent; that is, the amount paid to each type of lender can depend on the state z' next period.

The firm solves

$$v(w,z) = \max_{\{d,k_s,k_u,w',b'_s,b'_u\}\in\mathbb{R}^{3+Z}_+\times\mathbb{R}^{2Z}} d + \beta E[v(w',z')|z] \tag{16}$$

subject to the budget constraints for the current and next period, $\forall z' \in Z$,

$$w + E\Big[\sum_{j\in\mathcal{J}} b'_j\Big|z\Big] \;\; \geq \;\; d + \frac{1}{\varphi}\sum_{j\in\mathcal{J}} k_j + \kappa k_s \tag{17}$$

$$A'f(k) + \frac{1}{\varphi}\sum_{j\in\mathcal{J}} k_j(1-\delta) \;\; \geq \;\; w' + \sum_{j\in\mathcal{J}} Rb'_j, \tag{18}$$

where $k \equiv \frac{1}{\varphi}\sum_{j\in\mathcal{J}} k_j$, and the collateral constraints (4) on secured and unsecured borrowing, $\forall\{j, z'\} \in \mathcal{J} \times Z$. Since fraction φ of capital is tangible and fraction $1-\varphi$ intangible, the firm needs to invest $1/\varphi$ units of capital for each unit of (encumbered or unencumbered) tangible capital, as reflected in (17) and (18); intangible capital does not serve as collateral in our model and so the collateral constraints (4) are unchanged.

The firm's financing problem in (16) to (18) and (4) is a well-behaved dynamic programming problem and there exists a unique value function v, which is continuous, strictly increasing, and weakly concave (in w), that solves the problem.[22]

Denoting the multipliers on (18) and (4) by $\Pi(z, z')\beta\mu'$ and $\Pi(z, z')\beta\lambda'_j$, respectively, the first-order conditions are (5), (6), and (9), $\forall z' \in Z$, and the first-order conditions for secured and unencumbered capital, stated as investment Euler equations (IEEs), are

$$1 = E\left[\beta\frac{\mu'}{\mu}\frac{A'f_k(k) + (1-\varphi\theta_j)(1-\delta)}{\wp_j^{\varphi}}\right|z\Bigg] + \frac{\varphi\underline{\nu}_j/\mu}{\wp_j^{\varphi}}, \tag{19}$$

where we define the down payment with intangible capital as $\wp_j^{\varphi} \equiv 1 - \varphi + \varphi\wp_j$, for all $j \in \mathcal{J}$, which is the weighted average of the down payment on intangible capital (which equals 1) and the down payment on tangible capital financed with type-j debt $\wp_j$, with weights $1-\varphi$ and φ, respectively.

We can rewrite the IEEs (19) as

$$u + R\varphi\kappa + R\frac{E[\lambda'|z]}{E[\mu'|z]}\wp_s^{\varphi} \;\; \geq \;\; E\left[\frac{\mu'}{E[\mu'|z]}A'f_k(k)\right|z\Bigg] \tag{20}$$

$$u + R\frac{E[\lambda'|z]}{E[\mu'|z]}\wp_u^{\varphi} \;\; \geq \;\; E\left[\frac{\mu'}{E[\mu'|z]}A'f_k(k)\right|z\Bigg], \tag{21}$$

with equality if $k_j > 0$, which shows that the choice between financing investment with secured and unsecured debt boils down to a tradeoff between the cost of encumbering

[22] Define operator T as $(Tg)(w, z) = \max_{x\in\Gamma(w,z)} d + \beta\sum_{z'\in Z}\Pi(z, z')g(w(z'), z')$, where $x \equiv [d, k_s, k_u, w', b'_s, b'_u]$ and $\Gamma(w, z)$ is defined as the set of $x \in \mathbb{R}_+^{3+Z} \times \mathbb{R}^{2Z}$, given the state variables w and z, such that (17), (18), and (4) are satisfied. The result obtains using standard arguments, because $\Gamma(w, z)$ is convex, given (w, z), and convex in w and monotone in the sense that $w \leq w_+$ implies $\Gamma(w, z) \subseteq \Gamma(w_+, z)$, and the operator T satisfies Blackwell's sufficient conditions for a contraction.

assets and the difference in down payments. We can also define a notion of the user cost of capital financed with secured and unsecured debt, respectively, to a financially constrained firm as the left-hand side of (20) and (21), that is, $u_s(w,z) \equiv u + R\varphi\kappa + R\frac{E[\lambda'|z]}{E[\mu'|z]}\wp_s^{\varphi}$ and $u_u(w,z) \equiv u + R\frac{E[\lambda'|z]}{E[\mu'|z]}\wp_u^{\varphi}$.

Using the IEEs (19) for secured and unencumbered capital we have

$$1 = E\left[\beta\frac{\mu'}{\mu}\bigg|\, z\right]\frac{(\theta_s-\theta_u)(1-\delta)}{\wp_u-\wp_s} + \frac{\underline{\nu}_u/\mu - \underline{\nu}_s/\mu}{\wp_u-\wp_s}, \tag{22}$$

where $R_s = \frac{(\theta_s-\theta_u)(1-\delta)}{\wp_u-\wp_s}$ as in Section 4.2 above. Recall that Assumption 2 implies that $R_s > R$ and so unsecured debt is not dominated.

For a dividend-paying firm, the marginal value of net worth $\mu = 1$ and therefore $E\left[\beta\frac{\mu'}{\mu}\Big|\, z\right] \geq \beta$; by Assumption 3, $\beta R_s > 1$ and thus (22) implies that dividend-paying firms use only unsecured debt. Another way to see this is as follows: for a dividend-paying firm, $\frac{E[\lambda'|z]}{E[\mu'|z]} \leq (\beta R)^{-1} - 1$; given Assumption 3, this implies $u_s(w,z) > u_u(w,z)$, that is, for dividend-paying firms the user cost of encumbered capital exceeds the user cost of capital financed with unsecured debt.

Since (17) and (4) imply that $w \geq \frac{1}{\varphi}\sum_{j\in\mathcal{J}}\wp_j^{\varphi}k_j$, as $w \to 0$, k_s and $k_u \to 0$, and hence $k \to 0$ and $f_k(k) \to +\infty$. Using (19) we have

$$1 \geq E\left[\beta\frac{\mu'}{\mu}\frac{A'f_k(k) + (1-\varphi\theta_j)(1-\delta)}{\wp_j^{\varphi}}\bigg|\, z\right] \geq \beta\frac{\mu'}{\mu}\frac{A'f_k(k) + (1-\varphi\theta_j)(1-\delta)}{\wp_j^{\varphi}},$$

implying that $\beta\frac{\mu'}{\mu} \to 0$, $\forall z' \in Z$. Equation (22) then implies that as $w \to 0$, $\underline{\nu}_u > 0$. Therefore, severely constrained firms issue only secured debt. We have proved:

Proposition 2 (Financing policy)**.** *Given Assumptions 1-3, firms with sufficiently low net worth use only secured debt and firms with sufficiently high net worth, including all dividend-paying firms, use only unsecured debt.*

4.4 Quantitative evaluation

This section provides a quantitative evaluation of our model. We calibrate our model based on Li, Whited, and Wu (2016) who structurally estimate a version of the model of Rampini and Viswanathan (2013) using the simulated method of moments (SMM). That model of course does not distinguish between secured and unsecured debt, which is the main novel contribution of this paper.

In our calibration, we use both parameters that Li, Whited, and Wu (2016) calibrate and parameters that they structurally estimate.[23] Firms' discount factor is calibrated to

[23] We use the estimates given a tax rate of 20%; see Panel B of their Table 1 (p. 1471).

$\beta = 0.985$ based on the average real three-month Treasury-bill rate from 1965-2012 which is 1.5% annualized.[24] The discount factor of lenders is calibrated to $R^{-1} = 0.988 > \beta$, where the difference is motivated by a tax wedge with $\tau = 20\%$. Moreover, we use the following parameter values based on their structurally estimated values. In the model, the production function is $f(k) = k^{\alpha}$ and the estimated coefficient $\alpha = 0.6$. The productivity process $A(z') = \exp(z')$ has an estimated standard deviation $\sigma_z = 0.5$ and an estimated autocorrelation $\rho_z = 0.5$. We use a symmetric two-state Markov chain with $\Pi(z, z) = 0.75$ to match ρ_z and the estimated value of σ_z. We calibrate the depreciation rate to $\delta = 0.1$, which is the standard value, whereas their estimated value is $\delta = 0.04$.

We now turn to the calibration of collateralizability. As noted above, the Rampini and Viswanathan (2013) model does not distinguish between secured and unsecured debt. In estimating this model, Li, Whited, and Wu (2016) obtain an estimated value of collateralizability $\hat{\theta} = 0.4$. Moreover, they do not distinguish between tangible and intangible capital, and one should thus interpret their estimated value $\hat{\theta} = \varphi \times \theta$, that is, the product of the fraction of capital that is tangible and the collateralizability. We calibrate the fraction of capital that is tangible $\varphi = 0.6$ based on Falato, Kadyrzhanova, Sim, and Steri (2022), which would imply that $\theta = 0.66$. Since in the overall data roughly a third of the debt is secured (see Panel B of Table 1), we set the collateralizability of encumbered and unencumbered capital to $\theta_s = 0.8$ and $\theta_u = 0.6$, respectively, to match the weighted average to their implied value. Finally, we set the cost of encumbering assets to $\kappa = 0.01$. This cost is chosen to match the patterns in secured debt leverage in the cross-section of firms in Panel A of Figure 1.

Figure 5 provides the quantitative evaluation. This figure shows firms' financial structure, investment, and payout as a function of current net worth, with an analogous structure as Figure 1 which shows the basic stylized fact. The model-implied patterns in Figure 5 are strikingly similar to the empirical patterns in Figure 1. Each panel in Figure 5 shows the optimal policy conditional on the firm being in the high (low) productivity state as a blue dashed (red dash-dotted) line, respectively, and the unconditional expected policy as a black solid line.

Let us first focus on the unconditional expected policy. Panels A and B show that firms with low net worth have more secured debt and a sizable fraction of their debt is secured; as net worth increases, secured debt leverage and the secured debt ratio (that is, secured debt to total debt) decrease. Firms with sufficiently high net worth do not borrow secured. Such firms are also larger (see Panel E), as in the data, and more likely

[24] Using the short-term real risk-free rate to calibrate the discount factor is standard in the recent quantitative models of corporate finance.

to pay dividends (see Panel F). Thus the model is consistent with the data, and captures the fact that larger firms have little or no secured debt. We emphasize, however, that this does not imply that collateral does not matter for such firms, as even unsecured debt is determined by collateral constraints. Unsecured debt leverage and total leverage are both decreasing for firms with relatively low net worth and constant for dividend-paying firms (see Panels C and D, respectively). These patterns match the empirical facts (see the corresponding panels in Figure 1). That said, notice that in the model firms with sufficiently high net worth actually have negative debt, which can be interpreted as firms holding cash.[25] Since the model does not distinguish between debt and cash, one could also plausibly compare the predictions to the patterns in net debt, but we leave this distinction for future work.

Consider now the optimal policy conditional on high (low) current productivity, denoted by blue dashed (red dash-dotted) lines in the figure. Since productivity is persistent, firms with high current productivity have high expected productivity and are hence more constrained given net worth. This is reflected in the fact that, for given net worth, such firms have more secured debt (Panels A and B) and are more levered overall (Panel D). The higher leverage in turn allows them to invest more (Panel E). Such firms are also less likely to pay dividends for given net worth (Panel F). The more productive firms also have more unsecured debt, except at very low levels of net worth where they secure all their debt, as Panel C shows. Note that Panel C also shows that less productive firms have rather substantial negative unsecured debt, that is, have sizable cash holdings. This is so because such firms conserve funds in case their productivity suddenly improves, when their cash holdings allow them to invest a substantial amount to scale up. Thus our model also explains potentially sizable cash holdings for some firms.

While we emphasize the match between the basic properties of the model and the data across firms that differ in net worth, the model's quantitative implications for the level of the financial structure variables are overall quite plausible, too. All told, the model captures the basic facts about the role of secured and unsecured debt in corporate finance remarkably well. The distinction we draw between collateral and secured debt is central to understanding the facts, including the near absence of secured debt for large, less constrained firms.

[25] Debt in our model is state-contingent and negative debt is hence more accurately interpreted as positive holdings of state-contingent claims rather than cash per se.

5 Secured debt and leasing

Leasing is a particularly strong form of collateralized finance, as the financier, that is, the lessor, retains ownership of the assets, affording a repossession advantage even when compared to secured debt (see Eisfeldt and Rampini (2007) and Rampini and Viswanathan (2013)). In this section, we consider firms' financing and debt structure policy taking leasing into account. We first revisit the pertinent stylized facts adjusted for leasing, finding consistent and often accentuated patterns and concluding that secured debt is even more quantitatively relevant once leasing is properly accounted for. We then show how to take leasing into account in the model.

5.1 Stylized facts on secured debt and leasing

We show that using a measure of lease-adjusted secured debt, there is a strong positive relation between secured debt and financial constraints, consistent with our previous results. In fact, the patterns by size and by tangibility are accentuated. Moreover, secured debt plays an even more prominent role: the mean (median) lease-adjusted secured debt ratio among all firms is 68% (79%), compared to 36% (20%) without lease adjustment.

There are two types of leases: operating leases and capital leases. The bulk of leasing is operating leasing and was off balance sheet and not reflected on firms' balance sheets and in measured debt prior to 2019, so throughout our sample period which ends in 2018.[26] We therefore capitalize operating leases by adding 10 times the annual *Rental Expense* to firms' secured debt, total debt, tangible assets, and total assets (see Appendix A for details). In contrast, capital leases are reflected on firms' balance sheets and in our measure of secured debt throughout. First, we emphasize that the level of lease-adjusted secured debt to assets among all firms is 24% on average, which is considerably higher than the 9% average when leasing is simply ignored as most of the literature does, and the bulk of lease-adjusted debt is secured as noted above. Figure 6 shows the relation between secured debt and financial constraints as measured by firms' credit rating, adjusting secured debt, total debt, and assets for leasing (see also Panel A of Table 3). Panels A and B show that mean (median) lease-adjusted secured debt leverage decreases from 35% (32%) to 10% (10%) and the lease-adjusted secured debt ratio decreases from 57% (57%) to 33%-38% (28%-38%) in the top five deciles.[27] Panel C shows that the mean

[26] The US and international accounting standards boards have recently changed accounting rules to capitalization of much of operating leases effective in 2019. Going forward, firms' balance sheets and the financial data researchers use will hence reflect operating leases and obviate the need for the adjustments necessary in the pre-2019 data.

[27] The patterns in the lease-adjusted secured long-term debt ratio are very similar, although the level

(median) lease-adjusted unsecured debt leverage also decreases across rating deciles, from 27% (24%) to 17% (16%). Panel D shows the mean (median) lease-adjusted leverage decreases from 62% (61%) to 28% (29%). Finally, Panel E shows that the mean (median) lease-adjusted leasing debt to assets (which we refer to as leasing leverage), which is part of lease-adjusted secured debt, decreases from 17% (11%) to 8%-11% (6%-8%) in the top five deciles; in the broad sample, mean (median) leasing leverage is 16% (12%) of lease-adjusted assets, so quite substantial.

Figure D3 in Appendix D shows the pattern by size, our alternative measure of financial constraints (see also Panel B of Table 3). The patterns are again similar to the ones we find when we do not consider leasing (see Figure 2). The level of secured debt leverage and leverage is higher when lease-adjusted (Panels A and D); mean (median) secured debt leverage again declines in the top four deciles from 25% (22%) to 16% (11%). Note that the secured debt leverage no longer drops off substantially in the decile of smallest firms once we adjust for leasing. Panel B shows that the median secured debt ratio is above 80% in the bottom six size deciles and falls significantly in the top five deciles with the mean (median) secured debt ratio declining from 73% (88%) to 41% (36%). The pattern in the lease-adjusted secured long-term debt ratio is even more dramatic; the median is above 96% in the bottom five size deciles and the mean (median) declines from 81%-86% (96%-97%) in those deciles to 43% (39%).[28] In contrast, mean (median) unsecured debt to assets increases somewhat across size deciles from 15% (4%) to 22% (20%) (Panel C). Finally, mean (median) leasing leverage declines from 19% (15%) to 11% (7%) (Panel E); so this type of strongly collateralized finance decreases by roughly a factor 2 across size deciles.

Figure 7 illustrates the effect of a downgrade when firms' financial structure is lease-adjusted (see also Panel C of Table 3). The basic stylized facts are similar to the ones when leasing is not taken into account (see Figure 3), but are accentuated and quantitatively more sizable. Panel A shows that secured debt leverage increases by 3%-4% among firms rated *BBB* or below but is roughly constant in the top three deciles, whereas unsecured debt leverage weakly decreases for firms rated *BBB* or below but increases somewhat above (Panel C). Panel B shows that the secured debt ratio increases by as much as 7% and increases significantly for firms rated *BBB* or below.[29] Panel D moreover shows that firms' leverage increases following downgrades by about 2%-3% across most deciles. Finally, Panel E shows that leasing leverage also increases following downgrades, by up

is even higher (see Panel B of Table D1 and Panel A of Figure D2 in Appendix D).

[28]See Panel B in Table D1 and Panel B in Figure D2 in Appendix D.

[29]The results for the secured long-term debt ratio are quite similar (see Panel B in Table D1 and Panel C in Figure D2 in Appendix D).

to 2% in the bottom three deciles, which is large given an overall mean leasing leverage of 16%. Thus, firms which are downgraded and become financially more constrained increase both secured debt leverage and leasing leverage, especially so when their current rating is relatively low.

Table 4 and Figure D4 in Appendix D show that the relation between secured debt and tangibility is even more pronounced once leasing is taken into account. Panels A and D show that the secured debt leverage and total leverage increase more substantially across deciles by tangibility. Even the mean (median) unsecured debt rises with tangibility from roughly 12% (1%) to 15% (7%), suggesting again that tangible assets serving as collateral are critical for unsecured debt, too (Panel C). Panel B shows that the median secured debt ratio is above 75% for all but the lowest tangibility decile.[30] Finally, Panel E shows that the mean leasing leverage also increases considerably with tangibility from about 3% to about 21%-24% in the top four tangibility deciles.

We summarize these key empirical observations here:

Fact 3 (**Secured debt and leasing**). *Taking leasing into account, the quantitative importance of secured debt (which includes leasing) is substantially larger both in terms of secured debt leverage and the secured debt ratio; in fact, the bulk of debt is secured except for the largest and least constrained firms. The patterns in secured debt leverage and total leverage across deciles by firms' credit ratings and tangibility are accentuated. Leasing leverage decreases across credit rating and size deciles and increases substantially with tangibility.*

5.2 Model with secured and unsecured debt and leasing

Leasing facilitates repossession as the financier retains ownership. In fact, the bulk of leasing are operating leases, which are true leases that are executory contracts, and firms that default have to either continue making payments or forfeit the assets. In terms of enforcement, this gives the lessor an even stronger claim than a secured lender has. We model the repossession advantage by assuming that the lessee can pledge the entire residual value to the lessor.[31] Because leased capital separates ownership from control, we assume that the lessor has to monitor the lessee and incurs a monitoring cost per unit of capital leased. This could also be an indirect cost, say the inconvenience of use restrictions when capital goods are leased.

[30]The median secured long-term debt ratio is above 85% for all tangibility deciles (see Panel B in Table D1 and Panel D in Figure D2 in Appendix D).

[31]The assumption that the entire residual value can be pledged is for simplicity; the key is that the fraction that can be pledged is larger than for other forms of financing.

Specifically, let k_l denote leased capital, $m > 0$ is the cost of monitoring leased capital, and recall that $u = r+\delta$ is Jorgenson's (1963) frictionless user cost. The leasing fee, which is paid up front, is $R^{-1}u + m$, that is, the "down payment" on leased capital equals the leasing fee as $\wp_l \equiv 1 - R^{-1}(1-\delta) + m = R^{-1}(r+\delta) + m$. This specification of the leasing fee reflects our assumptions that the entire residual value of leased capital can be pledged and that the monitoring cost is incurred at the beginning of the period. Let $R_l \equiv \frac{(1-\theta_s)(1-\delta)}{\wp_s - (R^{-1}u+m)} = R\frac{1}{1-R(m-\kappa)/((1-\theta_s)(1-\delta))}$, which can be interpreted as the interest rate on the additional amount of borrowing implied by leasing. We assume the following about the monitoring cost m:

Assumption 5 (Benefits and costs of leasing)**.** *$\wp_s > \wp_l$ and $R_l > R_s$; equivalently, $R^{-1}(1-\theta_s)(1-\delta) > m - \kappa > \frac{1-\theta_s}{\theta_s - \theta_u}\kappa$.*

The assumption that $\frac{m}{1-\theta_u} > \frac{\kappa}{\theta_s-\theta_u}$ implies that $R_l > R_s$; otherwise, leasing would dominate secured borrowing. Intuitively, the cost per unit of extra funds for leasing exceeds the cost per unit of extra funds for secured loans. The assumption that $m - \kappa < R^{-1}(1-\theta_s)(1-\delta)$ ensures that $R^{-1}u + m < \wp_s$, that is, leasing requires a smaller down payment than purchasing capital with a secured loan, as otherwise leasing would be dominated. Leasing is more costly, but allows higher leverage.

The firm can finance capital using internal funds, unsecured debt, and secured debt, and by leasing capital, and solves

$$v(w, z) = \max_{\{d,k_s,k_u,k_l,w',b'_s,b'_u\} \in \mathbb{R}_+^{4+Z} \times \mathbb{R}^{2Z}} d + \beta E[v(w', z')|z] \tag{23}$$

subject to the budget constraints for the current and next period, $\forall z' \in Z$,

$$w + E\Big[\sum_{j\in\mathcal{J}} b'_j \Big| z\Big] \geq d + \frac{1}{\varphi}\sum_{j\in\mathcal{J}} k_j + \kappa k_s + \frac{1-\varphi+\varphi(R^{-1}u+m)}{\varphi} k_l \tag{24}$$

$$A' f(k) + \frac{1}{\varphi}\Big(\sum_{j\in\mathcal{J}} k_j + (1-\varphi)k_l\Big)(1-\delta) \geq w' + \sum_{j\in\mathcal{J}} R b'_j, \tag{25}$$

where $k \equiv \frac{1}{\varphi}\big(\sum_{j\in\mathcal{J}} k_j + k_l\big)$, and the collateral constraints (4) on secured and unsecured borrowing, $\forall \{j, z'\} \in \mathcal{J} \times Z$.

The first-order conditions are (5), (6), (9), (19), and the first-order condition for leased capital stated as an investment Euler equation is

$$1 = E\left[\beta \frac{\mu'}{\mu} \frac{A' f_k(k) + (1-\varphi)(1-\delta)}{1-\varphi+\varphi(R^{-1}u+m)} \middle| z\right] + \frac{\varphi \underline{\nu}_l/\mu}{1-\varphi+\varphi(R^{-1}u+m)}. \tag{26}$$

Comparing (26) and (19) we see that Assumption 5 ensures that leasing is not dominated.

Using (26) and (19) we have

$$1 = E\left[\beta \frac{\mu'}{\mu} \middle| z\right] \frac{(1-\theta_s)(1-\delta)}{\wp_s - (R^{-1}u + m)} + \frac{\underline{\nu}_s/\mu - \underline{\nu}_l/\mu}{\wp_s - (R^{-1}u + m)}. \tag{27}$$

Recall that $R_l = \frac{(1-\theta_s)(1-\delta)}{\wp_s - (R^{-1}u+m)}$ which we interpret as the interest rate on the additional amount of borrowing implied by leasing. By Assumption 5, $R_l > R_s$, so leasing does not dominate secured borrowing.

Consider again the simple, deterministic version of the model with tangible capital only ($\varphi = 1$) as in Section 4.2, but suppose the firm can also lease capital. Suppose the firm is indifferent between leasing and secured finance at the margin, then $\underline{\nu}_l = \underline{\nu}_s = 0$ and thus (27) implies $1 = \beta \frac{\mu'}{\mu} R_l$; further, (19) for secured capital reduces to

$$R_l = \frac{A' f_k(k) + (1-\theta_s)(1-\delta)}{\wp_s}.$$

This equation implicitly defines the level of investment at which the firm is indifferent between leasing and secured finance $\underline{k}_l$. Since $R_l > R_s$ by Assumption 5, using $R'_j(k)$ defined in (12) we have $R'_s(\underline{k}_l) = R_l > R_s = R'_s(\underline{k})$, which implies $\underline{k}_l < \underline{k}$.

The model's predictions for firms' financing, investment, and payout policy in the cross-section by net worth and over firms' life cycle are summarized by the following proposition:

Proposition 3 (Deterministic case with leasing). *Given Assumptions 1 to 5, there exist thresholds* $0 < \underline{w}_l < \bar{w}_l < \underline{w}_s < \bar{w}_s < \bar{w} < +\infty$ *such that:* **(i)** (Financing policy) *Firms with net worth* $w \leq \underline{w}_l$ *lease all tangible capital; firms with net worth* $w \in (\underline{w}_l, \bar{w}_l)$ *substitute from leasing to secured debt; firms with* $w \in [\bar{w}_l, \underline{w}_s)$ *issue only secured debt; firms with net worth* $w \in (\underline{w}_s, \bar{w}_s)$ *substitute from secured debt to unsecured debt, and firms with net worth* $w \geq \bar{w}_s$ *use only unsecured debt.* **(ii)** (Investment policy) *Investment* k *weakly increases in* w*, and strictly so for firms with* $w < \underline{w}_l$, $w \in (\bar{w}_l, \underline{w}_s)$ *and* $w \in (\bar{w}_s, \bar{w})$. **(iii)** (Payout policy) *Firms with net worth* $w > \bar{w}$ *pay dividends.* **(iv)** (Firm life cycle) *Over time, firms accumulate net worth, increase investment, substitute from leasing to secured debt and then to unsecured debt, and initiate dividends.*

A similar characterization obtains in the general stochastic case as well:

Proposition 4 (Financing policy with leasing). *Given Assumptions 1 to 5, firms with sufficiently low net worth use lease finance only, and firms with sufficiently high net worth, including all dividend-paying firms, use only unsecured debt. Moreover, firms do not lease and use unsecured debt at the same time.*

The model thus predicts that severely constrained firms lease all tangible assets, and sufficiently unconstrained firms use only unsecured debt.[32] The prediction that sufficiently unconstrained firms do not use secured debt (see Proposition 4 and Proposition 2 for the case without leasing) is consistent with the data as Panels A and B of Figures 1 and 2 show; indeed, firms with high ratings have essentially no secured debt and secured debt drops to close to zero in the largest decile by assets. Furthermore, the theory may also explain why secured debt leverage and the secured debt ratio drop off in the smallest firm decile when leasing is not taken into account (see Panels A and B of Figure 2), but no longer drop off once one adjusts for leasing (see Panels A and B of Figure D3).

However, Proposition 4 also implies that firms do not simultaneously lease and use unsecured debt and that sufficiently unconstrained firms do not engage in leasing; while the data show that leasing decreases significantly with firms' ratings and assets (see Panel E of Figures 6 and D3), we do find some leasing even by highly rated and large firms. We can account for this in the model by taking heterogeneity in the monitoring cost of leased capital into account. Specifically, suppose that the monitoring cost for each unit of tangible assets is 0 with probability p (and m otherwise). If each unit of capital is composed of a continuum of capital goods, each with idiosyncratic stochastic monitoring cost, this is consistent with a baseline amount of leasing of fraction p of tangible assets. Thus leasing for sufficiently unconstrained firms decreases to this baseline level of leasing, which is still positive. Indeed, Panel E of Figure 6 shows a roughly constant amount of leasing among highly rated firms. Alternatively, instead of assuming that leased and owned capital are perfect substitutes in production, as we do, if leased and owned capital were imperfect substitutes in production, the model would predict that all firms lease some of their capital, but constrained firms lease more, consistent with the data.

The basic patterns in both lease finance and secured debt are consistent with the view that these modes of financing, while costly, give financiers stronger claims on the collateral, facilitating enforcement and in turn allowing greater financing ex ante.

6 Evidence from downgrades using causal forest

In this section, we evaluate the implications of our model using a causal forest approach by estimating the heterogeneous treatment effects of a ratings downgrade by one notch on financial structure, investment, and payout. We first provide a brief introduction to

[32]Notice that the proposition does not necessarily imply that as net worth increases firms substitute first from leasing to secured debt and then from secured debt to unsecured debt in a monotone way, but numerically we do find such monotone behavior.

causal forest. We then show that the financial structure of treated firms, that is, firms that are downgraded, shifts toward secured debt, relative to comparable firms that are not treated. The treatment effects are heterogenous across ratings, substantially larger for firms with low ratings and small for more highly rated firms. We also document the heterogenous effects of treatment on leverage, investment, and payout. The evidence from the causal forest is consistent with our theory and the within-firm evidence in Section 3.

6.1 Primer on causal forest

Causal forest uses the machine learning classification approach pioneered by Breiman (2001) and applies it to causal inference (see Wager and Athey (2018) and Athey and Wager (2019)).[33] Breiman's random forest classifies data using many trees, each of which recursively partitions the data into several subsets referred to as leaves, and computes estimates using an average of nearby observations with the "neighborhoods," that is, the leaves, chosen in a data driven way. Standard random forests grow each tree on a random sample of the data by recursively splitting the sample via covariates; here this is done in a way to maximize the variance of the treatment effects across leaves. Athey and Wager (2019) propose an honest causal forest approach in which at each step the sample is divided into two sub-samples, one that is used for splitting the sample and one that is held-out for within-sample estimation. This approach provides centered confidence intervals and asymptotic normality.

Essentially the causal forest approach creates within each leaf (or partition of a tree), a treated sub-group and a comparison non-treated sub-group that are otherwise similar.[34] The causal forest approach then averages over all trees to obtain an overall estimate of the causal difference, which under the null, is asymptotically normally distributed allowing for valid inference. An estimate of the causal effect can be obtained for each observed covariate vector. One advantage of this approach is that it makes the leaves narrow in directions where the covariate signal is changing fast and wide in other directions, potentially leading to an increase in power.

6.2 Effect of downgrades on financial structure

The key endogenous state variable in our theory is firms' net worth, which determines how financially constrained firms are. To measure the extent of financial constraints,

[33]Gulen, Jens, and Page (2024) study the effects of covenant violations using a causal forest.

[34]Within a leaf, the assumption of unconfoundedness (see Rosenbaum and Rubin (1983)) is valid and hence we can compare the treated and non-treated sub-groups within each leaf of a tree.

we use credit ratings as well as several other variables that are related to net worth. Credit ratings are discrete, ordinal variables and firms that are downgraded experience a discontinuous increase in financial constraints. This may be the case because firms' financiers, customers, or other counterparties use the credit ratings to assess credit worthiness, affecting their willingness to provide credit, or because credit ratings directly affect financing via covenants, for example. The causal forest allows the comparison of downgraded firms to firms that are not downgraded which are otherwise very similar, by controlling for pertinent covariates, that is, other financial variables. By conditioning on these variables, we can isolate the effect of treatment, that is, a downgrade, which discontinuously affects financial constraints, on financial structure and other firm policies. Causal forest moreover enables us to take into account that the magnitude of the treatment effect plausibly varies depending on the covariates.

We focus on downgrades by one notch (or more) of firm's debt rating (the treatment). We study the effect of treatment on the outcome variables two years after the downgrade using covariate values one year before the downgrade. The outcome variables that we focus on are financial structure (secured debt to assets, secured debt to total debt, unsecured debt to assets, and debt to assets), investments (log assets) and payout policy (dividends to assets and dummy for positive dividends). The covariates we use are secured debt to assets, secured debt to total debt, unsecured debt to assets, total debt to assets, log assets, dividends to assets, ratings, net income to assets, market capitalization to assets, market capitalization, and tangible assets to assets. We use a honest causal forest approach with 4000 trees each using a sample of 50% of the data and within each sample, 50% honesty, that is, setting aside 50% of the sample for estimation.[35]

Our theory predicts that firms that get more financially constrained secure more of their debt and increase the fraction of their debt that is secured. Moreover, the theory predicts that, as firms get more financially constrained, they substitute away from unsecured debt, although total leverage and unsecured leverage may increase. Further, the model implies that firms that get more financially constrained reduce investment or even divest and reduce dividends and may cut dividends completely. Finally, the theory predicts that the effect of an increase in financial constraints varies depending on the level of firms' financial constraints or net worth, that is, the effects are plausibly heterogenous. For example, firms with high net worth, that are relatively unconstrained, do not use secured debt and an increase in their financial constraints may not have much of an effect as they are still not constrained enough to use secured debt; firms with very low net

[35]Table D2 in Appendix D provides specifics of the parameter values used in the causal forest estimation and descriptive statistics for the outcome variables and covariates.

worth, that are severely constrained, may have already pledged all their collateral, and thus a further deterioration in their financial constraints may again not have much of an effect. For firms in an intermediate range, the model predicts a substantial effect of financial constraints on secured financing.

Panel A of Table 5 reports the average treatment effects overall, as well as on treated and control firms separately, for each outcome variable. The average treatment effects are consistent with our theory and significant. The average treatment effects are positive for secured debt to assets, secured debt to total debt, and total debt to assets, as predicted by theory, and negative for log assets, dividends to assets, and the dummy for firms paying positive dividends, also consistent with the model. Note that the predicted sign of the treatment effect on unsecured debt to assets varies depending on firms' level of net worth, so the model makes no sharp prediction about the average treatment effect.

To highlight the heterogeneity of the treatment effects depending on firms' financial constraints predicted by the theory, we plot the estimated treatment effect for each observed covariate vector against the rating covariate in Figure 8.[36] In each panel, the line shows the conditional average treatment effect (conditional on the rating) with the red (blue) dots showing the significant (insignificant) estimated treatment effects for each observation. The considerable heterogeneity in estimated treatment effects is noteworthy.

Panel A of Figure 8 shows that there is a significant increase in secured debt to total assets especially for firms with intermediate ratings; the magnitude of the increase tails off at the very lowest rating levels, where firms may have already pledged all their collateral. For firms with high ratings before the downgrade, a downgrade leads to a much smaller increase in secured debt to total assets, though it is still positive. Panel B shows the conditional average treatment effect for the secured debt ratio (secured debt to total debt). Here again, there is a sharp increase in secured debt to total debt for firms with intermediate ratings. For firms that are highly rated before the downgrade, a downgrade leads to an increase in secured debt, though this effect is smaller. These two findings are consistent with the theoretical predictions, mirror the stylized facts in Section 3, and are reminiscent of the patterns in the corresponding panels in Figure 3 showing the effect of a downgrade across rating deciles. The causal forest approach allows us to conclude that treatment has a significant, causal effect on the extent to which firms secure their debt.

Panel C shows that for highly rated firms, a downgrade leads to an increase in unsecured debt, but this increase is smaller the lower the firms' prior rating and the effect turns negative for firms in the lowest rating categories. Panel D shows the treatment

[36]We observe that the estimates of the treatment effects on the treated and control are comparable, both on average and in terms of their distribution as illustrated in Panels A and B of Appendix Figure D5.

effect on total leverage, that is, total debt to assets, which is positive for most firms, except the firms with the lowest ratings. These patterns are broadly consistent with the predictions of the theory.

Further, Panel E displays the conditional average treatment effect for log assets, showing that firms that are downgraded are forced to divest, especially if their prior rating is already low. Finally, Panel F shows that a downgrade results in firms cutting their dividends, with the effect larger for more highly rated firms. Cutting dividends is only an option for dividend paying firms, which are primarily the more highly rated firms; this is one reason why the estimated treatment effect is larger in absolute value for firms with high prior ratings, whereas it is essentially zero for firms with low prior ratings as almost none of these firms are paying dividends to begin with. The findings on investment and dividends are consistent with the theory and illustrate the benefits of estimating heterogeneous treatment effects well, as such heterogeneity in effects is predicted by theory.

The findings from the causal forest are similar when we adjust all variables for leasing as in Section 5. We report the average treatment effects in Panel B of Table 5, the distribution of the estimated treatment effects in Panels C and D of Figure D5 in Appendix D, and plot the conditional average treatment effects in Figure 9. The patterns in Figure 9 are again reminiscent of the corresponding patterns in Figure 7. For brevity, we focus here on the most noteworthy differences to the results from the baseline causal forest in Figure 8. The results for the secured debt leverage are quite similar to the ones before. The secured debt ratio, however, now shows much more monotone behavior: the conditional average treatment effect for firms with low prior ratings is sizable and positive, meaning that such firms shift to secured financing in a substantial way; the size of the treatment effect is decreasing the higher firms prior rating, and is essentially zero or even negative for highly rated firms. Taking leasing into account, firms with low prior rating respond to a downgrade by further increasing the fraction of borrowing that is secured the most. Panels C and D are very similar to the corresponding panels in Figure 8. Panel E shows the conditional average treatment effect for leasing debt to assets. Our theory predicts that in the leasing region, that is, for firms with low net worth, a downgrade or further drop in net worth leads to an increase in leasing while a drop in net worth in the non-leasing region, that is, for high net worth firms, should have little effect. In Panel E, the conditional average treatment effect of downgrades for low rated firms is strongly positive and decreasing as ratings quality improves and is close to zero in the highest rating categories. This is consistent with the theoretical predictions of our model.

The evidence using a causal forest approach for the effect of a ratings downgrade on the financing, investment, and payout policies of firms is consistent with our theory.

These results, along with the stylized facts in Sections 3 and 5.1, strongly support the prediction that firms shift from unsecured to secured debt and leasing when they become more financially constrained.

7 Conclusion

This paper argues that secured debt is explicitly collateralized by specific assets whereas unsecured debt is backed by unencumbered assets of the firm and hence implicitly collateralized. Tangible assets serve as collateral and restrict both secured and unsecured debt and are a key determinant of firms' capital structure. The explicit collateralization of secured debt gives secured lenders a stronger claim on firms' assets, allowing lenders to lend more and enabling higher leverage. However, explicit collateralization entails direct and indirect costs. This implies that more constrained firms have more secured debt and when firms become more constrained, they increasingly switch to secured debt.

Our theory and quantitative model are consistent with key stylized facts about secured debt and with evidence using a causal forest. We show that firms with lower credit ratings and smaller firms, which are arguably more financially constrained, have more secured debt relative to assets and as a fraction of total debt. Moreover, following downgrades, firms' secured debt increases while their unsecured debt weakly decreases and secured debt as a fraction of total debt increases. In addition, firms with more tangible assets have higher secured debt and substantially higher leverage. While large and highly rated firms have relative little secured debt, they progressively shift to secured debt when they get more financially constrained.

In contrast to some recent work, we conclude that secured debt is quantitatively sizable for all firms but the ones in the top two or three size deciles, and except for these very large firms, secured debt constitutes the bulk of debt once one accounts for leasing. Furthermore, the tangibility of firms' assets is a key determinant of leverage, since even unsecured debt is backed by firms' unencumbered assets and hence restricted by firms' tangible assets which implicitly serve as collateral. It would be misleading to interpret the relatively limited amount of explicitly secured debt of large firms as evidence that collateral and collateral constraints are not first order. This conclusion is not warranted because: (i) firms secure a larger fraction of their debt when they get more constrained; (ii) smaller firms do in fact have a substantial amount of secured debt; (iii) accounting for leasing, the bulk of financing is secured for most firms; and (iv) perhaps most importantly even unsecured debt is backed by unencumbered assets and hence implicitly collateralized. We therefore argue that collateral is essential to understanding the capital structure.

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Table 1: **Debt Structure and Financial Constraints**

This table shows the financial structure, investment, and payout policy across deciles (based on the pooled data) by ratings (Panel A) and assets (Panel B). Panel C reports the effect of rating downgrades across rating deciles. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

Panel A: Financial Structure, Investment, and Payout Policy across Rating Deciles (%)

Decile		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
Secured debt/Assets	Mean	22.1	17.8	15.9	12.7	5.9	2.3	2.0	1.6	1.5	1.2	10.1	30,140
	Median	15.0	10.1	10.3	6.4	0.4	0.1	0.1	0.1	0.1	0.1	1.0	
Secured debt/Total debt	Mean	40.9	35.0	36.7	32.4	17.3	7.4	5.8	5.7	5.6	6.0	22.5	29,834
	Median	34.0	24.4	29.1	21.7	2.0	0.5	0.3	0.3	0.2	0.7	4.1	
Unsecured debt/Assets	Mean	32.6	30.4	25.7	25.1	25.7	27.7	26.2	23.8	23.7	18.2	26.8	30,140
	Median	29.0	29.1	24.6	23.0	24.7	27.0	25.5	23.0	22.9	17.4	24.7	
Total debt/Assets	Mean	55.3	48.2	42.0	38.1	32.3	31.3	29.8	28.4	26.8	21.9	36.7	38,083
	Median	51.9	46.3	40.5	35.8	31.5	30.9	29.6	28.1	26.4	20.9	33.7	
Log assets	Mean	20.7	20.8	21.2	21.6	22.2	22.5	22.7	22.8	22.9	23.4	22.0	38,083
	Median	20.5	20.6	21.1	21.5	22.1	22.4	22.7	22.7	22.8	23.5	21.9	
Positive dividends	Mean	11.2	22.6	32.2	45.7	66.4	83.7	86.8	91.9	96.0	95.9	59.5	38,078
Dividends/Assets	Mean	0.3	0.5	0.6	0.8	1.2	1.7	1.9	2.2	2.7	3.4	1.4	38,078
	Median	0.0	0.0	0.0	0.0	0.7	1.3	1.6	2.0	2.5	3.2	0.6	

Panel B: Financial Structure, Investment, and Payout Policy across Asset Deciles (%)

Decile		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
Secured debt/Assets	Mean	7.3	9.2	9.4	9.4	9.1	9.3	10.4	10.7	9.4	5.1	9.0	176,779
	Median	0.0	0.6	1.1	1.1	1.0	1.2	1.4	1.3	0.8	0.4	0.7	
Secured debt/Tot. debt	Mean	28.4	40.5	44.7	45.0	44.3	41.9	38.3	32.6	25.6	13.7	35.6	148,447
	Median	6.4	35.5	43.9	43.3	40.1	32.7	23.4	12.2	5.9	1.8	19.8	
Unsecured debt/Assets	Mean	20.6	12.7	10.6	10.2	10.6	12.4	15.2	18.6	21.1	24.5	15.4	176,779
	Median	5.6	3.6	2.7	2.4	2.2	3.4	7.4	15.4	19.3	23.2	7.3	
Total debt/Assets	Mean	30.0	22.8	21.0	20.5	20.6	22.7	26.3	29.7	31.2	30.7	25.6	198,538
	Median	14.2	14.1	13.3	12.9	12.9	16.4	22.9	27.3	29.4	29.8	20.9	
Log assets	Mean	15.3	16.5	17.3	18.0	18.6	19.3	19.9	20.7	21.7	23.5	19.1	198,538
	Median	15.3	16.5	17.3	18.0	18.6	19.3	19.9	20.7	21.7	23.3	18.9	
Positive dividends	Mean	1.9	6.4	11.5	16.3	23.0	29.2	38.2	47.5	62.1	79.7	31.6	198,529
Dividends/Assets	Mean	0.1	0.3	0.4	0.5	0.7	0.8	1.0	1.2	1.6	1.9	0.8	198,529
	Median	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.4	0.0	

Panel C: Effect of Rating Downgrades across Rating Deciles (Change %)

Decile		2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
Secured debt/Assets	Change	3.0	2.2	1.7	4.0	2.3	0.7	-0.2	0.8	0.4	1.9	2,261
Secured debt/Total debt	Change	5.8	4.7	2.9	8.0	5.4	1.7	-1.4	1.7	-1.5	3.7	2,234
Unsecured debt/Assets	Change	-2.1	-0.3	-0.8	0.5	-2.4	1.0	1.6	2.7	5.8	0.1	2,261
Total debt/Assets	Change	1.0	1.7	1.0	3.5	-0.3	0.7	1.2	3.8	4.8	1.8	3,117
Log assets	Change	-0.3	-0.2	-0.1	-0.1	-0.1	-0.0	0.0	0.1	0.1	-0.1	3,117
Positive dividends	Change	-12.3	-18.8	-19.1	-26.0	-13.0	-8.4	-6.7	-6.9	-1.9	-13.4	3,116
Dividends/Assets	Change	-0.2	-0.3	-0.3	-0.4	-0.3	-0.4	-0.5	-0.4	-0.4	-0.4	3,116

Table 2: **Debt Structure and Tangible Assets**

This table shows the financial structure, investment, and payout policy across deciles by fraction tangible assets. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

Decile		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
Secured debt/Assets	Mean	4.6	5.0	5.5	6.6	7.3	8.3	9.8	12.0	15.6	18.2	9.0	176,530
	Median	0.0	0.0	0.1	0.5	1.2	1.8	3.0	4.3	6.5	8.4	0.7	
Secured debt/Tot. debt	Mean	26.4	29.4	31.2	33.2	34.1	35.0	36.8	39.2	42.7	45.1	35.6	148,226
	Median	0.1	4.9	10.5	15.6	18.1	20.1	24.3	29.1	35.7	40.6	19.8	
Unsecured debt/Assets	Mean	12.1	12.1	13.0	14.4	15.4	15.8	16.8	17.6	18.7	19.3	15.4	176,530
	Median	0.2	1.5	3.2	5.8	8.8	10.2	11.8	12.9	13.5	11.9	7.3	
Total debt/Assets	Mean	17.8	17.9	19.3	21.6	23.4	24.7	27.1	30.2	35.0	38.4	25.5	198,236
	Median	1.3	6.4	10.1	14.8	18.4	20.6	23.4	26.9	32.6	36.3	20.9	
Log assets	Mean	17.8	18.4	18.6	18.8	19.1	19.2	19.4	19.6	20.0	19.8	19.1	198,236
	Median	17.6	18.2	18.4	18.6	19.0	19.1	19.3	19.5	20.1	20.0	18.9	
Positive dividends	Mean	10.3	13.2	19.3	25.6	33.4	39.3	42.2	41.3	45.9	45.3	31.6	198,227
Dividends/Assets	Mean	0.5	0.4	0.5	0.7	0.8	1.0	1.1	1.0	1.2	1.3	0.8	198,227
	Median	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table 3: **Leasing-Adjusted Debt Structure and Financial Constraints**

This table shows the lease-adjusted financial structure across deciles by ratings (Panel A) and assets (Panel B). Panel C reports the effect of rating downgrades across rating deciles. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

Panel A: Financial Structure, Investment, and Payout Policy across Rating Deciles (%)

Decile		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
Secured debt/Assets	Mean	35.1	30.7	27.9	25.2	18.6	14.4	12.5	11.6	12.3	10.1	22.0	30,140
(lease-adj.)	Median	32.0	26.6	24.6	20.9	13.4	10.5	9.3	8.4	9.8	9.7	15.2	
Secured debt/Total debt	Mean	56.7	53.3	54.8	52.6	43.4	36.3	32.8	33.5	35.8	38.2	45.8	30,089
(lease-adj.)	Median	56.9	53.9	54.1	51.6	38.8	32.0	28.6	28.4	32.5	37.5	41.7	
Unsecured debt/Assets	Mean	26.9	25.6	22.1	21.8	22.6	24.6	23.6	21.6	21.3	16.7	23.2	30,140
(lease-adj.)	Median	23.7	23.8	20.6	19.6	21.6	23.6	22.9	20.6	20.4	15.6	21.3	
Total debt/Assets	Mean	62.4	56.2	50.3	47.1	41.1	39.2	36.7	35.0	34.4	28.4	44.5	38,083
(lease-adj.)	Median	61.2	54.9	49.0	45.8	40.3	38.6	36.8	35.4	34.2	28.5	41.4	
Leasing debt/Assets	Mean	16.6	15.4	14.0	13.9	12.5	11.0	9.5	8.8	9.9	8.1	12.4	38,083
(lease-adj.)	Median	11.1	11.0	9.8	9.5	8.5	8.0	7.2	6.2	7.8	7.4	8.6	

Panel B: Financial Structure, Investment, and Payout Policy across Asset Deciles (%)

Decile		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
Secured debt/Assets	Mean	24.9	26.5	25.7	24.7	24.3	23.9	25.9	25.2	23.2	16.4	24.3	176,769
(lease-adj.)	Median	21.6	23.7	21.9	20.6	19.3	18.5	20.2	19.5	16.5	10.9	19.2	
Secured debt/Tot. debt	Mean	67.1	75.5	77.4	78.0	76.7	72.7	68.1	60.6	53.8	40.6	67.8	171,615
(lease-adj.)	Median	80.7	88.2	91.0	92.1	91.8	88.1	79.4	64.1	52.5	35.5	79.4	
Unsecured debt/Assets	Mean	15.1	9.9	8.6	8.3	8.9	10.6	12.9	15.8	18.1	21.5	12.7	176,769
(lease-adj.)	Median	3.9	2.8	2.2	1.9	1.9	3.0	6.0	12.6	15.9	20.2	5.7	
Total debt/Assets	Mean	41.4	37.2	35.1	33.7	33.8	35.3	39.1	41.2	41.1	38.1	37.6	198,527
(lease-adj.)	Median	34.6	33.6	31.4	30.0	30.0	31.9	37.4	39.8	39.0	37.2	35.2	
Leasing debt/Assets	Mean	18.9	19.0	17.9	16.9	16.4	15.9	16.6	15.6	14.1	10.8	16.2	198,527
(lease-adj.)	Median	15.1	15.7	14.5	13.1	12.6	11.5	11.7	10.4	9.1	7.4	11.6	

Panel C: Effect of Rating Downgrades across Rating Deciles (Change %)

Decile		2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
Secured debt/Assets (lease-adj.)	Change	4.2	2.8	2.9	4.2	2.7	1.7	0.6	1.0	0.3	2.6	2,261
Secured debt/Total debt (lease-adj.)	Change	6.8	4.1	3.6	5.7	4.8	2.1	0.1	0.3	-4.4	3.4	2,258
Unsecured debt/Assets (lease-adj.)	Change	-2.5	-0.7	-1.1	-0.1	-2.5	0.7	1.2	2.3	5.2	-0.2	2,261
Total debt/Assets (lease-adj.)	Change	1.9	2.1	1.9	3.2	-0.0	1.2	1.6	3.6	4.3	2.1	3,117
Leasing debt/Assets (lease-adj.)	Change	2.3	1.5	1.7	0.8	0.6	0.8	0.9	0.5	0.2	1.1	3,117

Table 4: **Leasing-Adjusted Debt Structure and Tangible Assets**

This table shows the lease-adjusted financial structure across deciles by fraction tangible assets. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

Decile		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
Secured debt/Assets	Mean	8.2	13.2	16.7	19.9	23.4	26.6	30.3	34.0	37.6	37.7	24.3	176,520
(lease-adj.)	Median	4.5	11.1	15.6	19.5	23.5	27.1	31.8	36.0	40.2	36.3	19.3	
Secured debt/Tot. debt	Mean	58.1	67.9	68.8	68.0	68.7	69.4	69.8	70.0	70.2	66.7	67.8	171,377
(lease-adj.)	Median	69.9	85.4	81.7	76.5	76.3	76.5	77.3	79.7	83.9	83.7	79.4	
Unsecured debt/Assets	Mean	11.7	10.8	11.2	12.4	12.7	12.9	13.6	13.8	13.5	14.8	12.7	176,520
(lease-adj.)	Median	0.7	1.8	3.3	5.7	6.9	7.9	8.6	8.7	7.2	6.9	5.7	
Total debt/Assets	Mean	20.9	24.7	28.5	32.7	36.3	39.6	43.8	47.4	50.0	51.8	37.6	198,225
(lease-adj.)	Median	9.5	17.3	22.7	28.3	33.0	37.4	42.6	47.0	49.7	48.9	35.2	
Leasing debt/Assets	Mean	3.3	8.3	11.4	14.0	16.5	19.1	21.7	23.4	23.7	20.9	16.2	198,225
(lease-adj.)	Median	2.7	8.9	12.0	14.2	16.5	18.4	20.0	19.3	14.4	6.3	11.6	

Table 5: **Average Treatment Effects from Causal Forest**

This table presents the predicted average treatment effect (ATE), the average treatment effect on the treated (ATT), and the average treatment effect on the control (ATC) of a rating downgrade by one notch or more. Panel A reports the baseline results and Panel B the results using lease-adjusted variables. t-statistics are in parenthesis. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

Panel A: Treatment Effects on Financial Structure, Investment, and Payout Policy

Outcome variable	ATE	ATT	ATC	Obs.
Secured debt/Assets	0.025	0.019	0.026	20,873
	(8.831)	(6.694)	(8.347)	
Secured debt/Total debt	0.041	0.037	0.042	20,873
	(7.919)	(7.163)	(7.282)	
Unsecured debt/Assets	0.011	0.004	0.013	20,873
	(3.362)	(0.947)	(3.460)	
Total debt/Assets	0.036	0.023	0.039	20,873
	(9.772)	(5.628)	(9.539)	
Log assets	-0.124	-0.141	-0.121	20,873
	(-12.095)	(-13.933)	(-10.625)	
Dividends/Assets	-0.004	-0.003	-0.004	20,873
	(-14.330)	(-13.500)	(-13.173)	
Positive dividends	-0.110	-0.109	-0.110	20,873
	(-16.549)	(-16.455)	(-14.976)	

Panel B: Treatment Effects on Financial Structure (Lease-adj.)

Outcome variable	ATE	ATT	ATC	Obs.
Secured debt/Assets (lease-adj.)	0.028	0.025	0.029	21,517
	(10.479)	(8.832)	(9.567)	
Secured debt/Total debt (lease-adj.)	0.018	0.031	0.016	21,517
	(4.151)	(6.924)	(3.201)	
Unsecured debt/Assets (lease-adj.)	0.010	-0.004	0.012	21,517
	(3.340)	(-1.143)	(3.744)	
Total debt/Assets (lease-adj.)	0.038	0.022	0.041	21,517
	(11.611)	(6.238)	(11.207)	
Leasing debt/Assets (lease-adj.)	0.012	0.016	0.011	21,517
	(6.731)	(9.382)	(5.485)	

Figure 1: **Secured Debt and Net Worth Measured by Credit Rating**

This figure shows the financial structure, investment, and payout policy across deciles by ratings. There is one box plot for each decile; in each box plot, the red dot denotes the mean, the horizontal dash the median, the grey rectangle the inter-quartile range, and the whiskers the 5th and 95th percentile, respectively. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

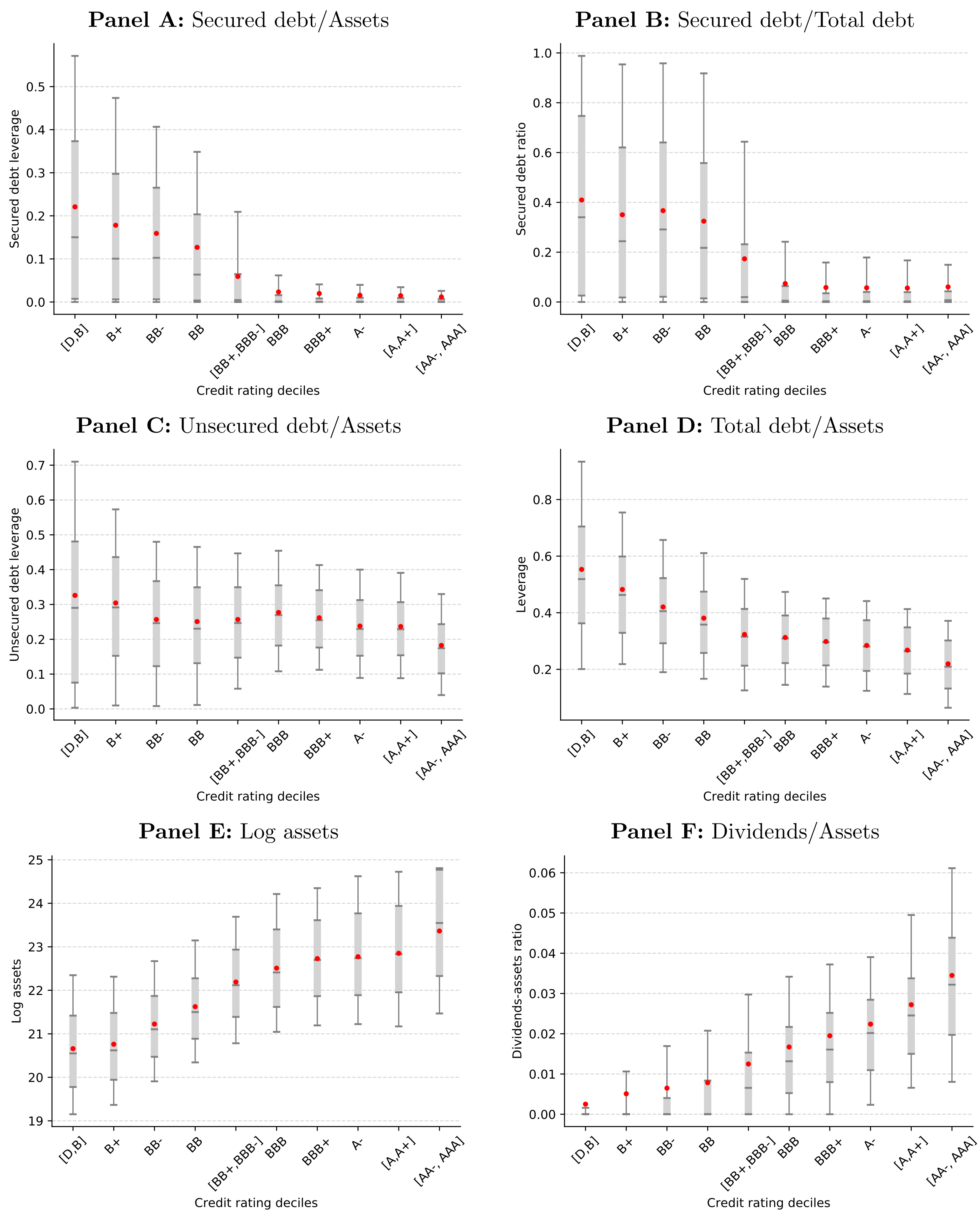


Figure 2: **Secured Debt by Assets**

This figure shows the financial structure, investment, and payout policy across deciles by assets. There is one box plot for each decile; in each box plot, the red dot denotes the mean, the horizontal dash the median, the grey rectangle the inter-quartile range, and the whiskers the 5th and 95th percentile, respectively. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

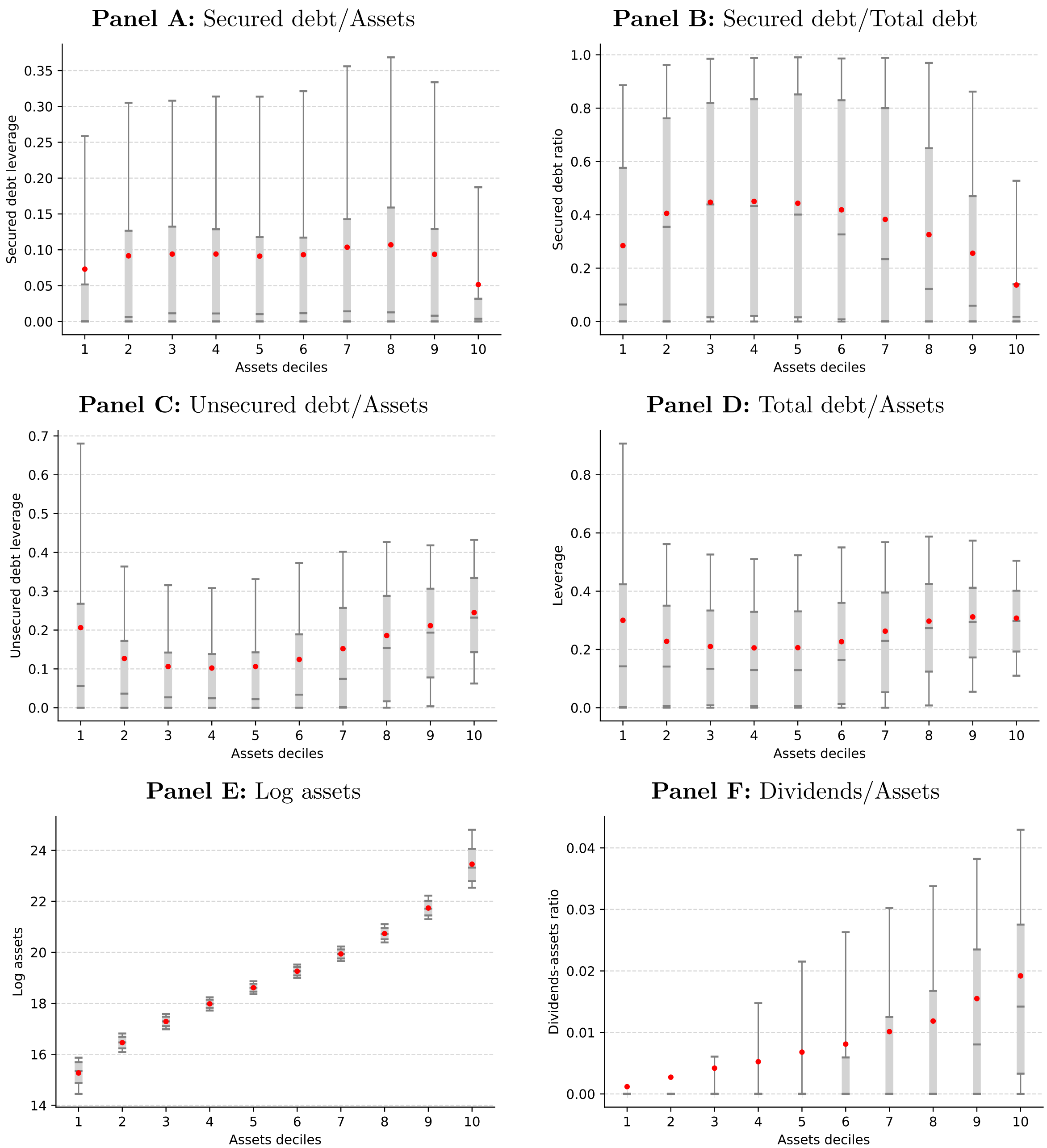


Figure 3: **Secured Debt and Net Worth: Effect of Downgrades**

This figure shows the effect of rating downgrades on financial structure, investment, and payout policy across rating deciles. For each decile, the figure shows the mean and the 95% confidence interval for the change between the variable one year before the downgrade to two years after the downgrade. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

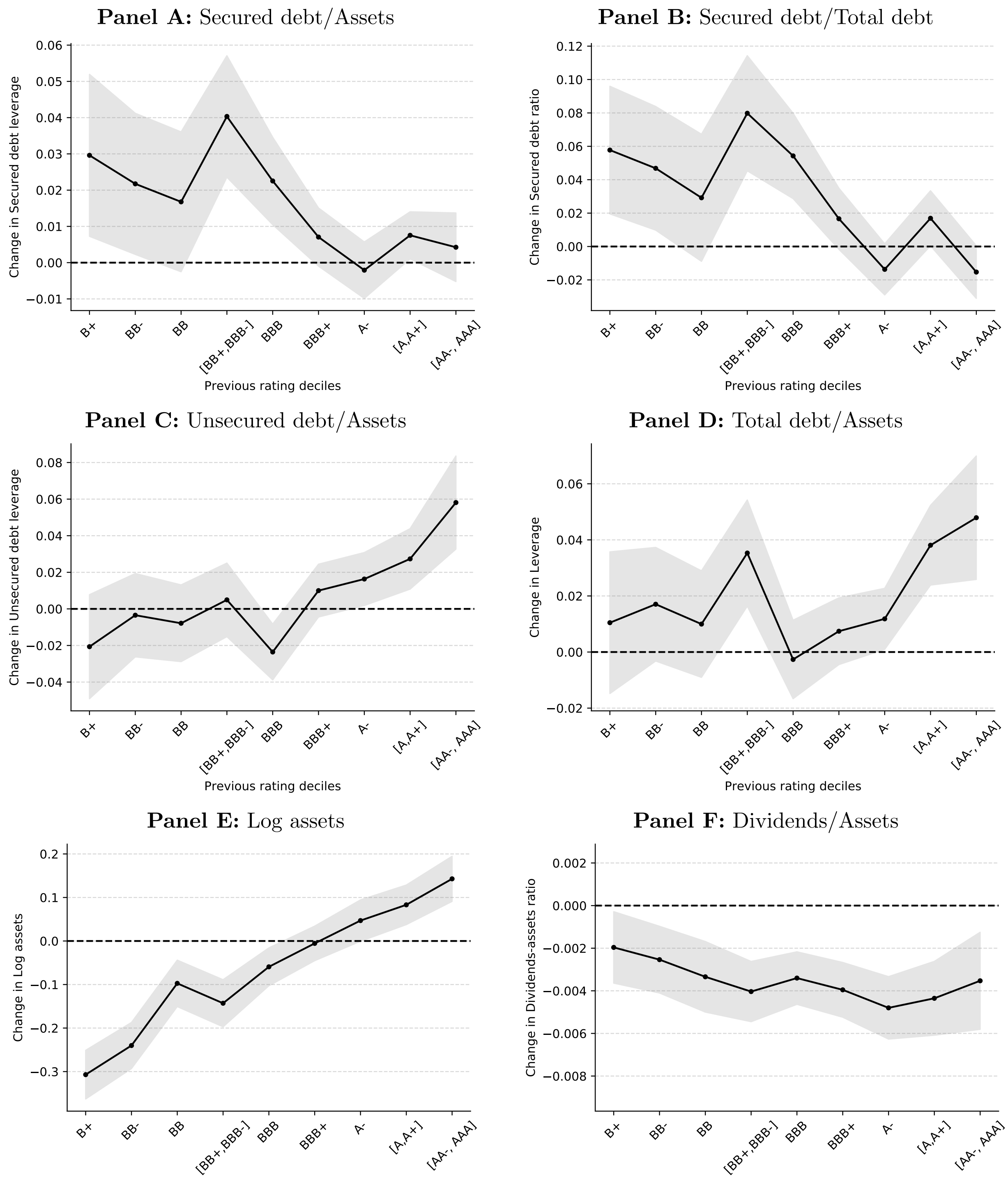


Figure 4: **Secured Debt by Fraction Tangible Assets**

This figure shows the financial structure, investment, and payout policy across deciles by the fraction of tangible assets. There is one box plot for each decile; in each box plot, the red dot denotes the mean, the horizontal dash the median, the grey rectangle the inter-quartile range, and the whiskers the 5th and 95th percentile, respectively. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

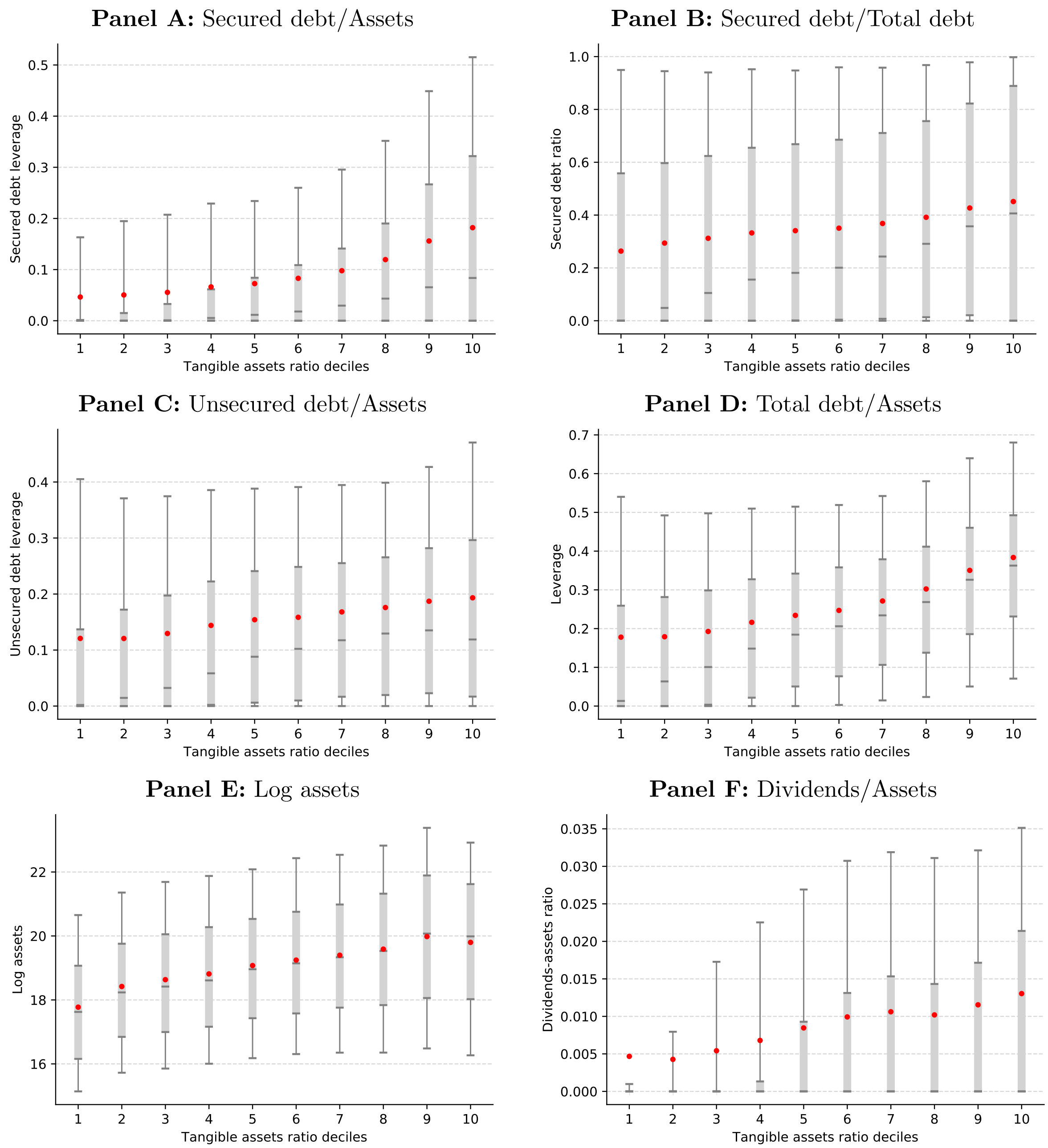


Figure 5: **Financial Structure in Calibrated Model**

This figure shows the financial structure, investment, and payout policy by net worth in the calibrated model. Each panel plots the policy function as a function of net worth; the policy conditional on the high (low) state is blue dashed (red dash-dotted) and the unconditional expected policy is black solid. Parameter values: discount factor $\beta = 0.985$; interest rate $R^{-1} = 0.988$; productivity process: symmetric two-state Markov chain with $\Pi(z, z) = 0.75$ and productivity $A(z') = \exp(z')$ with $\sigma_z = 0.5$ and $\rho_z = 0.5$; production function: $f(k) = k^{\alpha}$ and $\alpha = 0.6$; depreciation rate $\delta = 0.1$; fraction tangible assets $\varphi = 0.6$; collateralizability of encumbered (secured) and unencumbered (unsecured) capital: $\theta_s = 0.8$; $\theta_u = 0.6$; cost of encumbering capital: $\kappa = 0.01$.

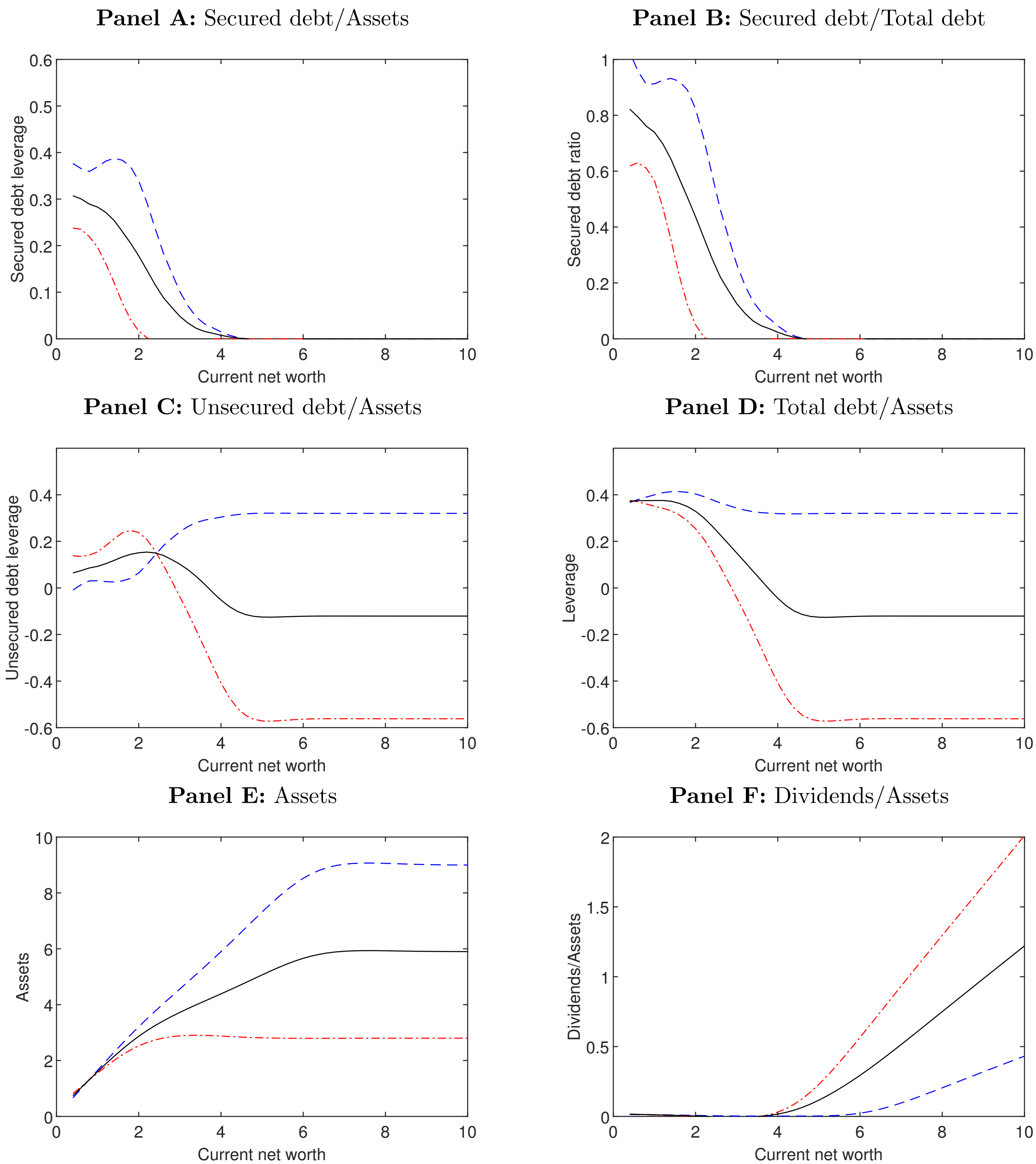


Figure 6: **Secured Debt by Credit Rating (Lease-adj.)**

This figure shows the lease-adjusted financial structure across deciles by ratings. There is one box plot for each decile; in each box plot, the red dot denotes the mean, the horizontal dash the median, the grey rectangle the inter-quartile range, and the whiskers the 5th and 95th percentile, respectively. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

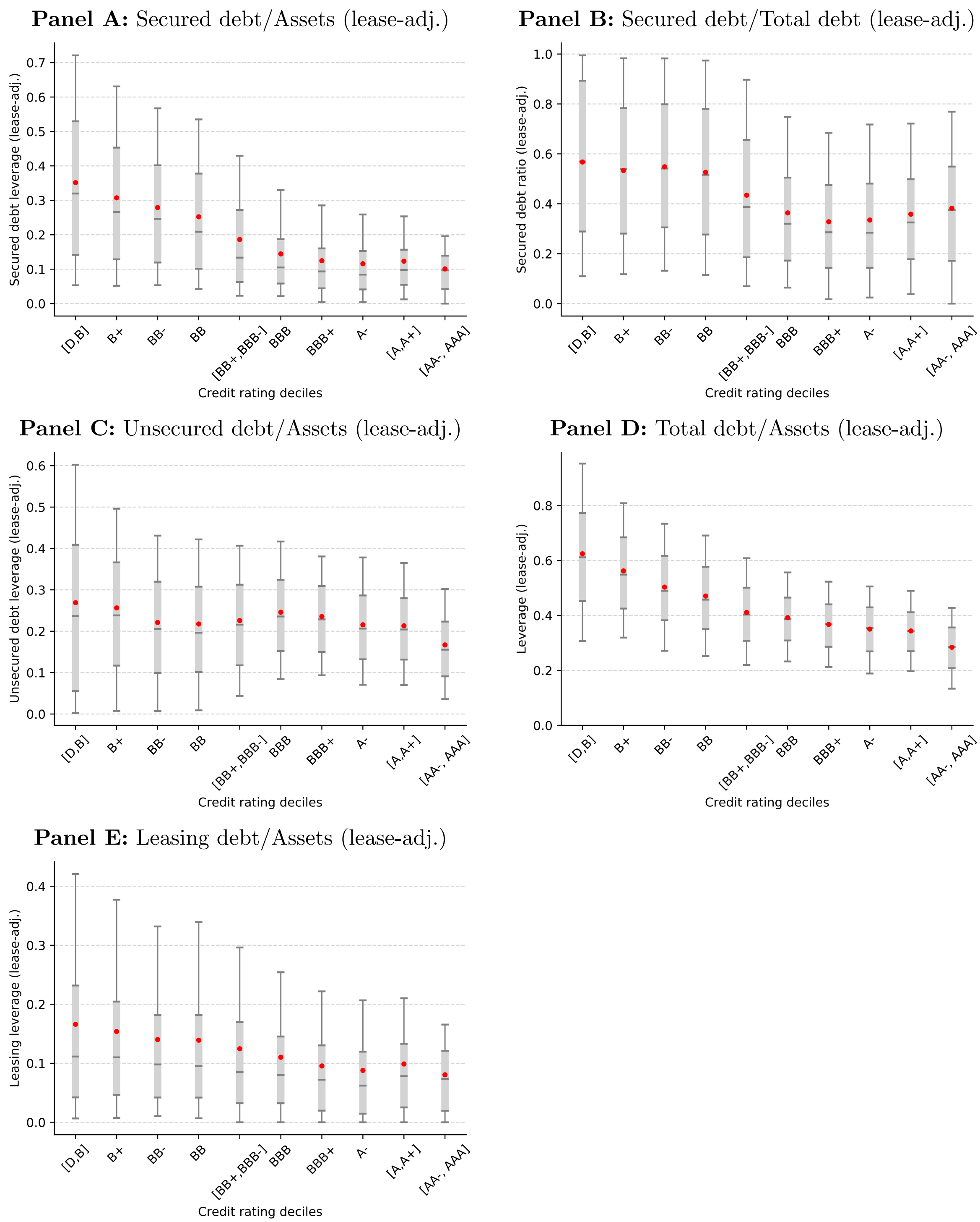


Figure 7: **Secured Debt and Net Worth: Effect of Downgrades (Lease-adj.)**

This figure shows the effect of rating downgrades on the lease-adjusted financial structure across rating deciles. For each decile, the figure shows the mean and the 95% confidence interval for the change between the variable one year before the downgrade to two years after the downgrade. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

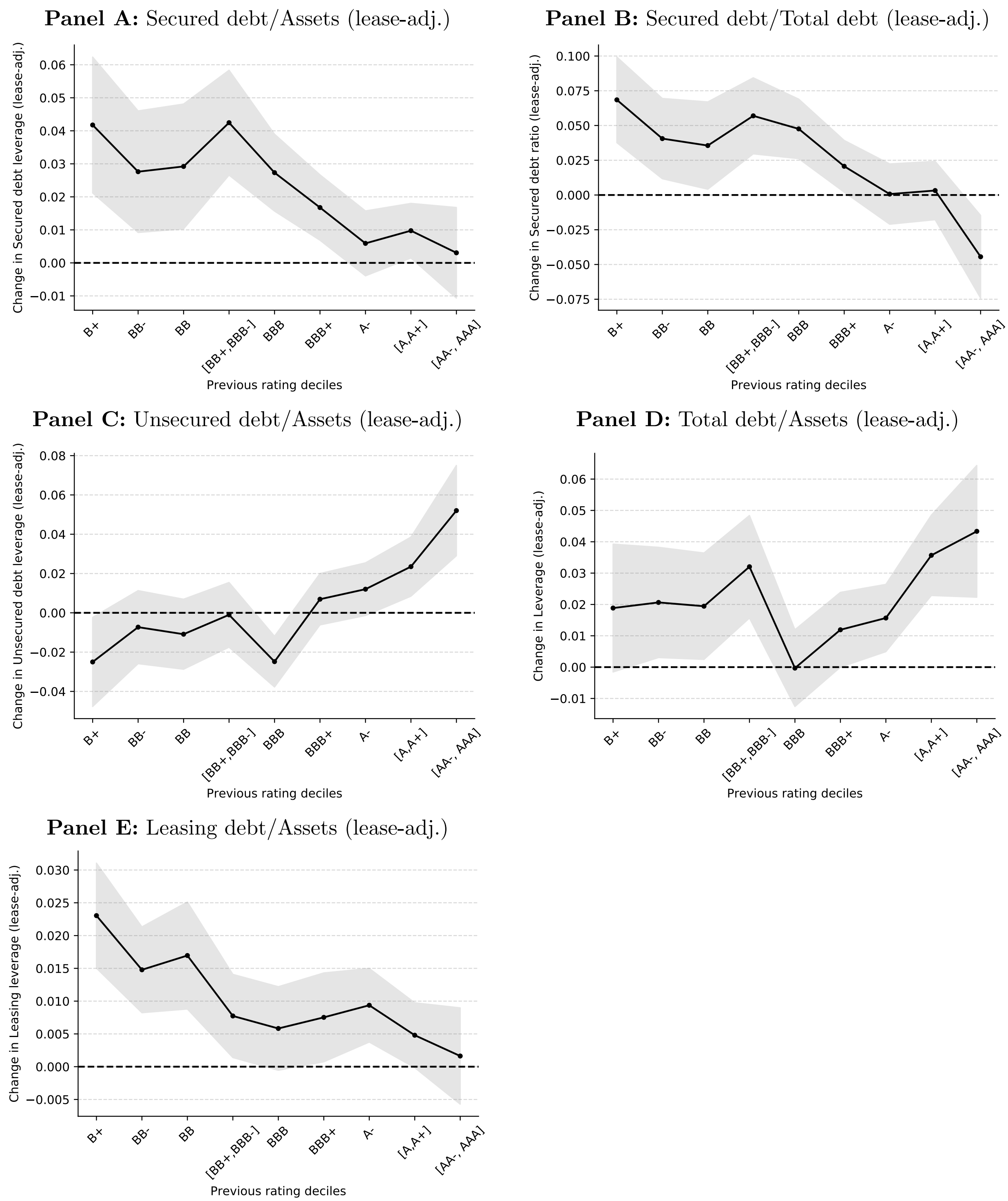
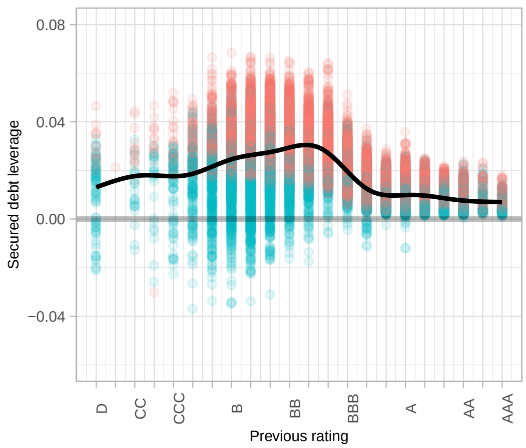


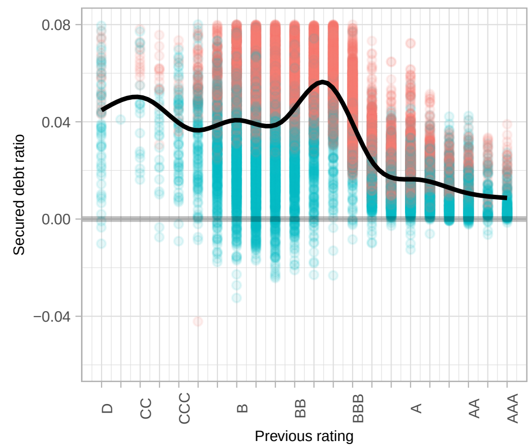
Figure 8: **Evidence from Downgrades using Causal Forest**

This figures shows the treatment effects of rating downgrades by one notch or more on financial structure, investment, and payout policy estimated using a causal forest and plotted against the ratings covariate. We estimate the effect on the outcome variable two years after the downgrade using the values of covariates one year before the downgrade. The black line shows the conditional average treatment effect. Significant (insignificant) estimates and their conditional average are denoted by red (blue) dots and lines, respectively. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

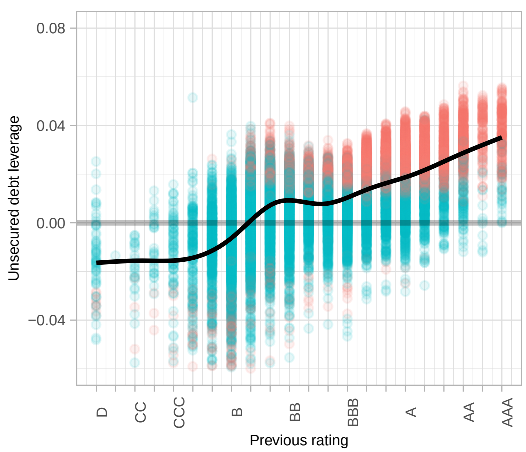
Panel A: Secured debt/Assets



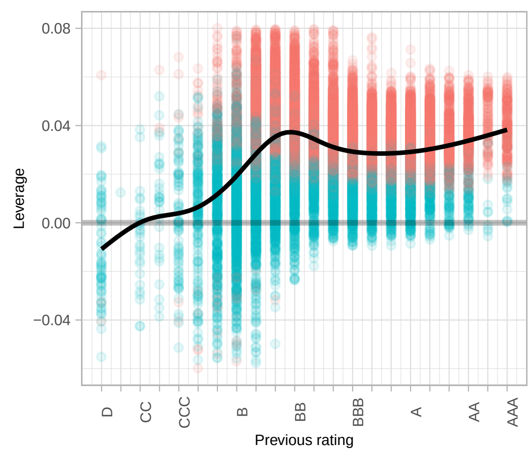
Panel B: Secured debt/Total debt



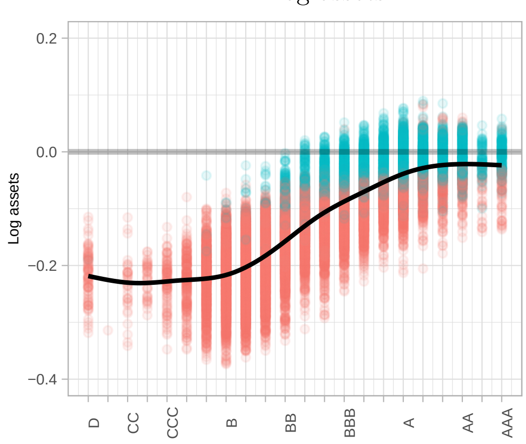
Panel C: Unsecured debt/Assets



Panel D: Total debt/Assets



Panel E: Log assets



Panel F: Dividends/Assets

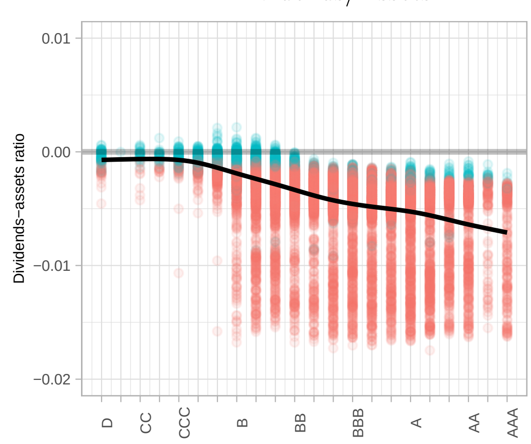
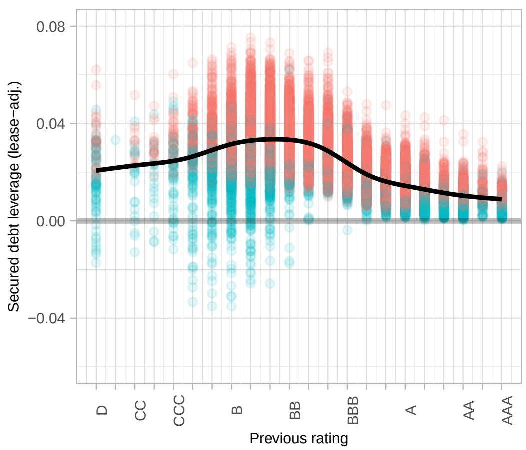


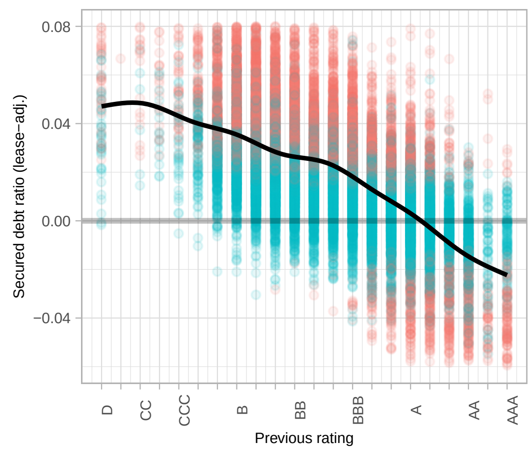
Figure 9: **Evidence from Downgrades using Causal Forest (Lease-adj.)**

This figures shows the treatment effects of rating downgrades by one notch or more on the lease-adjusted financial structure estimated using a causal forest and plotted against the ratings covariate. We estimate the effect on the outcome variable two years after the downgrade using the values of covariates one year before the downgrade. The black line shows the conditional average treatment effect. Significant (insignificant) estimates and their conditional average are denoted by red (blue) dots and lines, respectively. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

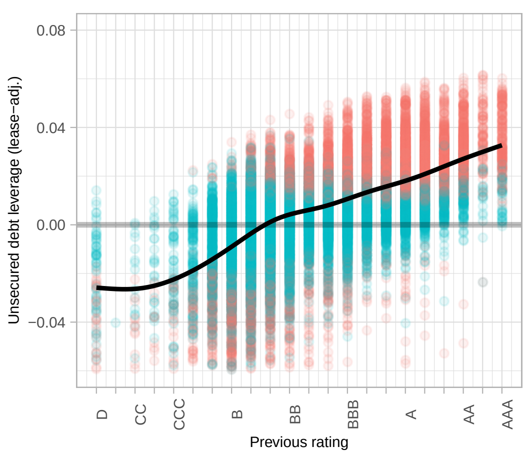
Panel A: Secured debt/Assets (lease-adj.)



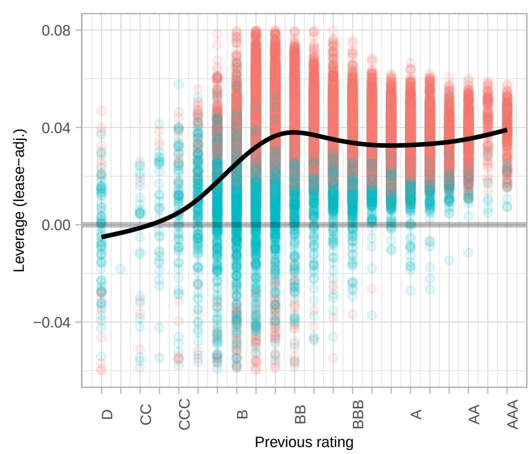
Panel B: Secured debt/Total debt (lease-adj.)



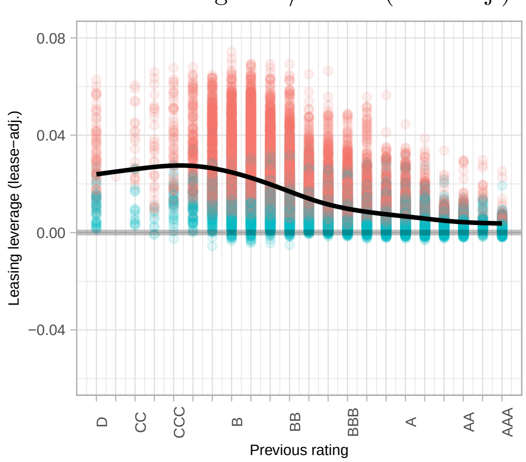
Panel C: Unsecured debt/Assets (lease-adj.)



Panel D: Total debt/Assets (lease-adj.)



Panel E: Leasing debt/Assets (lease-adj.)



Appendix A: Data and variable descriptions

Table A1: **Data and Variable Definitions**

This table presents the definitions of the variables used in the empirical analysis. All data are from *Compustat* unless noted otherwise.

Panel A: Benchmark Variables

Variable	Definition
Secured debt	Debt–Mortgages and Other Secured (DM; Item 241)
Total debt	Debt in Current Liabilities–Tot. (DLC; Item 34) + Long-Term Debt–Tot. (DLTT; Item 9)
Assets	Assets–Total (AT; Item 6)
Tangible assets	Property, Plant and Equipment–Total (Net) (PPENT; Item 8)
Rating	S&P Long-Term Domestic Issuer Credit Rating–Hist. (SPLTICRM; Item 280)
Dividends	Dividends–Common (DVC; Item 21)
Positive dividends	Dummy = 1 if Dividends > 0 and 0 otherwise
Secured debt leverage	Secured debt / Assets
Secured debt ratio	Secured debt / Total debt
Unsecured debt lev.	(Total debt − Secured debt) / Assets
Leverage	Total debt / Assets
Tangible assets ratio	Tangible assets / Assets
Log assets	Assets in real terms (2010 dollars) deflated using yearly average of monthly CPI-U (CPI for all urban consumers) from BLS
Total long-term debt	Debt—Due in 1 Year (DD1; Item 44) + Long-Term Debt–Tot. (DLTT; Item 9)
Sec. l.-t. debt ratio	Secured debt / Total long-term debt
Market capitalization	Common Shares Outst. (CSHO; Item 25) × Price Close–Ann. (PRCC; Item 24)
Market cap./Assets	Market capitalization / Assets
Dividends/Assets	Dividends / Assets
Net income/Assets	Net Income (Loss) (NI; Item 172) / Assets

Panel B: Lease-adjusted Variables

Variable	Definition
Leasing debt	10 × Rental Expense (XRENT; Item 47)
Secured debt (lease-adj.)	Secured debt + Leasing debt
Total debt (lease-adj.)	Total debt + Leasing debt
Assets (lease-adj.)	Assets + Leasing debt
Tangible assets (lease-adj.)	Tangible assets + Leasing debt
Secured debt lev. (lease-adj.)	Secured debt (lease-adj.) / Assets (lease-adj.)
Secured debt ratio (lease-adj.)	Secured debt (lease-adj.) / Total debt (lease-adj.)
Unsecured debt lev. (lease-adj.)	(Total debt (lease-adj.) − Sec. debt (lease-adj.)) / Assets (lease-adj.)
Leverage (lease-adj.)	Total debt (lease-adj.) / Assets (lease-adj.)
Leasing leverage (lease-adj.)	Leasing debt / Assets (lease-adj.)
Tangible assets ratio (lease-adj.)	Tangible assets (lease-adj.) / Assets (lease-adj.)
Total long-term debt (lease-adj.)	Total long-term debt + Leasing debt
Sec. l.-t. debt ratio (lease-adj.)	Secured debt (lease-adj.) / Total long-term debt (lease-adj.)
Market cap./Assets (lease-adj.)	Market capitalization / Assets (lease-adj.)
Net income/Assets (lease-adj.)	Net Income (Loss) (NI; Item 172) / Assets (lease-adj.)

Appendix B: Proofs

Proof of Proposition 1. First, note that the return function is continuous and weakly concave and the constraint set is convex. The operator defined by the Bellman equation satisfies Blackwell's sufficient conditions for a contraction. Therefore, there exists a unique value function that solves the Bellman equation which is strictly increasing and weakly concave.

Suppose $d > 0$ at w, so $\nu_d = 0$ and $\mu = 1$. By concavity, $\forall w_+ > w$, $1 = \mu \geq \mu_+ \geq 1$, implying that $\mu_+ = 1$ and $\nu_d^+ = 0$. Let $\bar{w} \equiv \inf\{w : d > 0\}$. Clearly, $\bar{w} < +\infty$ as otherwise paying out all net worth immediately would achieve a higher value. This characterizes the payout policy and establishes part (iii) of the proposition.

For $w < \bar{w}$, $d = 0$ and hence $v(w) = \beta v(w') < v(w')$. Since v is strictly increasing, $w' > w$, that is, firms accumulate net worth over time (which establishes the first claim of part (iv) of the proposition). Moreover, by weak concavity of v, $\mu' \leq \mu$, that is, the marginal value of net worth is weakly decreasing. Since $\mu' \leq \mu$, (6) implies that $\beta R \frac{\lambda'}{\mu} = 1 - \beta R \frac{\mu'}{\mu} \geq 1 - \beta R > 0$ by Assumption 3, so $\lambda' > 0$; the collateral constraint binds for non-dividend paying firms. Thus, $w = \wp_s k_s + \wp_u k_u$, $\forall w < \bar{w}$.

Take $w < w_+ \leq \bar{w}$ and suppose $k_u > k_u^+$. Since $w = \wp_s k_s + \wp_u k_u$ at both w and w_+, we conclude that $k_s^+ > k_s$. Moreover, since $w = \wp_u k - (\wp_u - \wp_s) k_s$ at both w and w_+, we further conclude that $k_+ > k$. Clearly, $k_u > 0$ and $k_s^+ > 0$, so at w we have $1 = \mathcal{M}' R_u'(k)$ and $1 \geq \mathcal{M}' R_s'(k)$, and at w_+ we have $1 = \mathcal{M}_+' R_s'(k_+)$ and $1 \geq \mathcal{M}_+' R_u'(k_+)$, implying that $R_u'(k) \geq R_s'(k)$ while $R_u'(k_+) \leq R_s'(k_+)$. However, $\frac{\partial}{\partial k} R_s'(k) = \frac{A' f_{kk}(k)}{\wp_s} < \frac{A' f_{kk}(k)}{\wp_u} = \frac{\partial}{\partial k} R_u'(k)$, so $R_u'(k) \geq R_s'(k)$ implies $R_u'(k_+) > R_s'(k_+)$, a contradiction. Thus, $k_u \leq k_u^+$; in other words, the amount of unencumbered capital is increasing in net worth.

Note that Assumption 1 implies that $\lim_{k \to 0} R_j'(k) = +\infty$. Moreover, since $w \geq \wp_s k_s + \wp_u k_u$, as $w \to 0$, k_u, k_s, and hence k all go to zero, and therefore the IEE (11) $1 \geq \mathcal{M}' R_j'(k)$ implies that $\mathcal{M}' \to 0$ as $w \to 0$. From (15), $1 = \mathcal{M}' R_s + \frac{\underline{\nu}_u/\mu - \underline{\nu}_s/\mu}{\wp_u - \wp_s}$, we conclude that $\underline{\nu}_u > 0$ as $w \to 0$, so firms with sufficiently low net worth, which we interpret as severely constrained, borrow only secured.

Since $\frac{\partial}{\partial k} R_s'(k) < \frac{\partial}{\partial k} R_u'(k)$, the return on net worth from secured and unencumbered capital will cross at most one. Moreover, for w sufficiently low, $R_s'(k) > R_u'(k)$. If $R_s'(k) = R_u'(k)$, then $\underline{\nu}_u = \underline{\nu}_s = 0$ and (15) implies that $R_s^{-1} = \mathcal{M}'$ and the IEE (11) for unencumbered capital implies $R_s = \frac{A' f_k(k) + (1-\theta_u)(1-\delta)}{\wp_u}$, which implicitly defines $\underline{k}$; firms that use both secured and unsecured finance invest a constant amount of capital $\underline{k}$, and by Assumption 3 $R_s > \beta^{-1}$ so $\underline{k} < \bar{k}$. Moreover, for $k < \underline{k}$, $R_s'(k) > R_u'(k)$, and vice versa for $k > \underline{k}$. Since the collateral constraints are binding, $\underline{k}$ is feasible with secured finance at $\underline{w}_s = \wp_s \underline{k}$ and with unencumbered finance at $\bar{w}_s = \wp_u \underline{k}$, where $0 < \underline{w}_s < \bar{w}_s < \bar{w}$, the cutoff values in the proposition; firms use secured finance only for $w \leq \underline{w}_s$, substitute to unsecured finance on the interval $(\underline{w}_s, \bar{w}_s)$, and use unsecured finance only above $\bar{w}_s$, the financing policy in part (i). Capital strictly increases below $\underline{w}_s$ and on the interval $(\bar{w}_s, \bar{w})$, is constant at $\underline{k}$ on $[\underline{w}_s, \bar{w}_s]$ and at $\bar{k}$ for $w \geq \bar{w}$, the investment policy in part (ii). The firm life cycle implications obtain from these properties and the fact that firm net worth strictly increases as long as $w < \bar{w}$. $\square$

Proof of Proposition 4. Using $R_l = \frac{(1-\theta_s)(1-\delta)}{\wp_s - (R^{-1}u+m)}$, the first-order condition for substituting leasing for secured debt (27) can be stated as

$$1 = E\left[\beta \frac{\mu'}{\mu}\middle| z\right] R_l + \frac{\underline{\nu}_s/\mu - \underline{\nu}_l/\mu}{\wp_s - (R^{-1}u+m)}. \tag{B1}$$

Using $R_s = \frac{(\theta_s-\theta_u)(1-\delta)}{\wp_u - \wp_s}$, the first-order condition for substituting secured for unsecured debt (19) can be stated as

$$1 = E\left[\beta \frac{\mu'}{\mu}\middle| z\right] R_s + \frac{\underline{\nu}_u/\mu - \underline{\nu}_s/\mu}{\wp_u - \wp_s}. \tag{B2}$$

Recall that Assumption 5 implies $\beta R_l > \beta R_s > 1$. For dividend-paying firms, $\mu = 1$ and thus $E[\beta \frac{\mu'}{\mu}|z] \geq \beta$. Therefore, for such firms (B1) and (B2) imply $\underline{\nu}_l > 0$ and $\underline{\nu}_s > 0$; dividend-paying firms use only unsecured debt. By continuity, firms with net worth sufficiently close to the dividend-paying threshold use only unsecured debt.

For severely constrained firms, that is, as $w \to 0$, $k \to 0$ and thus the IEEs imply that $E[\beta \frac{\mu'}{\mu}|z] \to 0$. Therefore, for such firms (B1) and (B2) imply $\underline{\nu}_s > 0$ and $\underline{\nu}_u > 0$; severely constrained firms lease all tangible capital.

Subtracting (B2) from (B1) yields

$$0 = E\left[\beta \frac{\mu'}{\mu}\middle| z\right] (R_l - R_s) + \frac{\underline{\nu}_s/\mu - \underline{\nu}_l/\mu}{\wp_s - (R^{-1}u+m)} + \frac{\underline{\nu}_s/\mu - \underline{\nu}_u/\mu}{\wp_u - \wp_s}. \tag{B3}$$

Therefore, either $\underline{\nu}_l > 0$ or $\underline{\nu}_u > 0$, that is, firms do not lease and use unsecured debt at the same time. $\square$

Appendix C: Efficiency cost of encumbered capital

This appendix considers a version of the stochastic model in Section 4.3 in which encumbered capital is less efficient; specifically, suppose encumbered capital k_s is equivalent to only ϕk_s efficiency units in production with $\phi \in (0,1)$, for example, because it cannot be optimally deployed due to use restrictions or reallocated as easily. The firm's total capital is then $k = \frac{k_u + \phi k_s}{\varphi}$. There is no direct cost of encumbering collateral, and we adjust Assumption 2 by replacing $\kappa > 0$ with $\phi \in (0,1)$.

The firm maximizes (16) subject to the budget constraints for the current and next period, $\forall z' \in Z$,

$$
\begin{aligned}
w + E\Big[\sum_{j\in\mathcal{J}} b'_j \Big| z\Big] &\geq d + \frac{1}{\varphi}\sum_{j\in\mathcal{J}} k_j && \text{(C1)}\\
A' f\left(\frac{k_u + \phi k_s}{\varphi}\right) + \frac{1}{\varphi}\sum_{j\in\mathcal{J}} k_j(1-\delta) &\geq w' + \sum_{j\in\mathcal{J}} R b'_j, && \text{(C2)}
\end{aligned}
$$

and the collateral constraints (4) on secured and unsecured borrowing, $\forall \{j, z'\} \in \mathcal{J} \times Z$.

The first-order conditions are (5), (6), and (9), $\forall z' \in Z$, and the first-order conditions for secured and unencumbered capital, stated as investment Euler equations, are (19) for $j = u$ and for $j = s$ we have

$$
1 = E\left[\beta \frac{\mu'}{\mu} \frac{\phi A' f_k(k) + (1-\varphi\theta_s)(1-\delta)}{\wp_s^{\varphi}} \middle| z\right] + \frac{\varphi \underline{\nu}_j/\mu}{\wp_s^{\varphi}}. \quad \text{(C3)}
$$

We can rewrite the IEEs (C3) as

$$
\phi^{-1} u + R\frac{E[\lambda'|z]}{E[\mu'|z]}\phi^{-1}\wp_s^{\varphi} \geq E\left[\frac{\mu'}{E[\mu'|z]} A' f_k(k) \middle| z\right], \quad \text{(C4)}
$$

with equality if $k_s > 0$, which can be compared to the analogous expression for unsecured capital (21). Because encumbered capital is less efficient, its frictionless user cost per efficiency unit is higher than that for unsecured capital, $\phi^{-1}u > u$. Therefore, encumbering capital must provide a financing advantage by requiring a lower down payment per efficiency unit compared to unsecured capital, that is, $\phi^{-1}\wp_s^{\varphi} < \wp_u^{\varphi}$, as encumbered capital would be dominated otherwise. We adjust Assumption 3 by replacing $\wp_u > \wp_s$ with $\phi\wp_u^{\varphi} > \wp_s^{\varphi}$.

Using (C3) and (19) for $j = u$ for secured and unencumbered capital we have

$$
1 = E\left[\beta \frac{\mu'}{\mu} \middle| z\right] \frac{\left(\phi(1-\varphi\theta_u) - (1-\varphi\theta_s)\right)(1-\delta)}{\phi\wp_u^{\varphi} - \wp_s^{\varphi}} + \frac{\phi\varphi\underline{\nu}_u/\mu - \varphi\underline{\nu}_s/\mu}{\phi\wp_u^{\varphi} - \wp_s^{\varphi}}. \quad \text{(C5)}
$$

Define $R_s \equiv \frac{(\phi(1-\varphi\theta_u)-(1-\varphi\theta_s))(1-\delta)}{\phi\wp_u^{\varphi}-\wp_s^{\varphi}}$ and note that $\phi \in (0,1)$ and the adjusted Assumption 3 imply that $R_s > R$, so unsecured debt is not dominated. Therefore, the results from Section 4.3 can be extended to the case where encumbering capital affects the productivity at which capital is deployed.

Appendix D: Additional tables and figures

Table D1: **Secured Long-Term Debt Ratio and Financial Constraints**

This table shows the secured long-term debt ratio across deciles by ratings, assets, tangibility, and the effect of rating downgrades across rating deciles. Panel A reports the benchmark results and Panel B the results for lease-adj. variables. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

Panel A: Secured debt/Total long-term debt across Deciles (%)

Decile		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
By Rating	Mean	42.8	36.0	37.7	33.5	18.1	8.0	6.6	6.5	6.5	7.4	23.6	28,901
	Median	36.8	25.8	30.7	23.0	2.1	0.6	0.4	0.3	0.2	0.9	4.9	
By Assets	Mean	43.6	54.9	56.5	54.8	51.8	47.8	42.8	35.2	27.4	14.9	42.7	137,480
	Median	44.4	64.1	67.0	63.0	57.1	47.2	33.4	15.9	7.7	2.1	36.2	
By Tangibility	Mean	35.4	37.5	39.2	41.8	42.6	42.8	43.5	44.6	46.7	49.6	42.7	137,341
	Median	13.7	25.6	31.3	35.9	35.7	34.2	36.6	38.8	45.0	53.3	36.2	
By Previous Rating	Change		5.3	5.1	3.6	8.2	5.6	1.1	-1.5	1.2	-2.9	3.7	2,141

Panel B: Secured debt/Total long-term debt (lease-adj.) across Deciles (%)

Decile		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All	Obs.
By Rating	Mean	59.0	54.7	56.1	54.0	45.1	38.1	34.7	36.4	39.2	43.6	48.0	29,270
	Median	60.5	56.0	56.5	53.1	41.3	33.8	30.3	31.1	36.4	44.6	45.0	
By Assets (lease-adj.)	Mean	80.7	85.3	85.6	84.5	81.8	77.2	71.8	63.2	56.2	43.4	73.8	166,954
	Median	97.2	97.4	97.3	97.2	96.5	94.2	87.0	68.3	56.2	38.9	90.7	
By Tangibility (lease-adj.)	Mean	68.0	74.5	75.3	74.6	75.3	75.3	75.0	74.4	73.7	71.2	73.8	166,794
	Median	93.9	95.8	93.9	91.2	90.7	88.8	87.3	87.6	89.3	89.3	90.7	
By Previous Rating	Change		6.8	4.3	4.3	4.7	4.6	0.8	-1.2	-0.7	-6.3	3.0	2,183

Table D2: **Causal Forest: Parameters and Descriptive Statistics**

This table shows the estimation parameters (Panel A) and the descriptive statistics for the sample used in the causal forest (Panel B). Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

Panel A: Causal Forest Estimation Parameters

Parameter	Description	Value
num.trees	Number of trees to grow in a forest	4000
sample.fraction	Sample fraction of data used to build each tree	0.5
mtry	Number of variables tried for each split	ceil($\sqrt{\text{\# of covariates}} + 20$)
honesty.fraction	Fraction of data used for determining splits	0.5
min.node.size	Target for minimum number of observations in each leaf	5
honesty.prune.leaves	Cut leaves from estimation sample if no nodes on the leaf	TRUE
alpha	Controls the maximum imbalance on a split	0.05
imbalance.penalty	(tuning parameter) controls how harshly imbalanced splits are penalized	0
tune.parameters	Tune parameters by cross-validation if true	FALSE
stabilize.splits	Whether or not treatment should be taken into account when determining split imbalance	TRUE

Panel B: Descriptive Statistics for Sample used in Causal Forest

	N	Mean	Std dev	1%	10%	25%	Median	75%	90%	99%
Rating downgrade$_t$	20,873	0.136	0.343	0	0	0	0	0	1	1
ΔRating$_{t-1,t}$	20,873	-0.097	0.997	-4	-1	0	0	0	1	2
Secured debt lev.$_{t+2}$	20,873	0.092	0.161	0	0	0	0.007	0.116	0.328	0.756
Secured debt ratio$_{t+2}$	20,873	0.210	0.309	0	0	0	0.029	0.342	0.770	1
Unsecured debt lev.$_{t+2}$	20,873	0.265	0.183	0	0.040	0.144	0.244	0.356	0.482	0.916
Leverage$_{t+2}$	20,873	0.359	0.223	0.010	0.127	0.211	0.320	0.456	0.630	1.216
Log assets$_{t+2}$	20,873	22.058	1.496	18.692	20.145	21.034	21.985	23.130	24.206	24.807
Dividend/Assets$_{t+2}$	20,873	0.014	0.021	0	0	0	0.006	0.021	0.040	0.110
Positive dividends$_{t+2}$	20,873	0.598	0.490	0	0	0	1	1	1	1
Secured debt lev.$_{t-1}$	20,873	0.090	0.155	0	0	0	0.008	0.114	0.321	0.724
Secured debt ratio$_{t-1}$	20,873	0.204	0.300	0	0	0	0.032	0.325	0.730	1
Unsecured debt lev.$_{t-1}$	20,873	0.265	0.173	0	0.054	0.150	0.246	0.354	0.474	0.837
Leverage$_{t-1}$	20,873	0.356	0.209	0.020	0.134	0.215	0.320	0.454	0.617	1.097
Log assets$_{t-1}$	20,873	21.978	1.452	18.972	20.155	20.937	21.850	22.993	24.093	24.807
Dividend/Assets$_{t-1}$	20,873	0.014	0.021	0	0	0	0.006	0.020	0.038	0.119
Rating$_{t-1}$	20,873	12.753	3.753	5	8	10	13	16	18	22
Net income/Assets$_{t-1}$	20,873	0.025	0.128	-0.407	-0.055	0.007	0.039	0.072	0.109	0.224
Market cap./Assets$_{t-1}$	20,873	0.984	0.962	0.042	0.230	0.424	0.734	1.222	1.935	4.704
Market cap.$_{t-1}$	20,873	21.599	1.807	17.126	19.231	20.410	21.644	22.898	24.023	24.762
Tangible assets ratio$_{t-1}$	20,873	0.360	0.240	0.012	0.075	0.160	0.312	0.538	0.724	0.904

Figure D1: **Secured Long-Term Debt Ratio**

This table shows the ratio of secured debt to long-term debt across deciles by ratings (Panel A), assets (Panel B), and tangibility (Panel D). There is one box plot for each decile; in each box plot, the red dot denotes the mean, the horizontal dash the median, the grey rectangle the inter-quartile range, and the whiskers the 5th and 95th percentile, respectively. Panel C shows the effect of downgrades on the secured debt to long-term debt ratio; for each decile, this panel shows the mean and the 95% confidence interval for the change between one year before the downgrade and two years after the downgrade. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

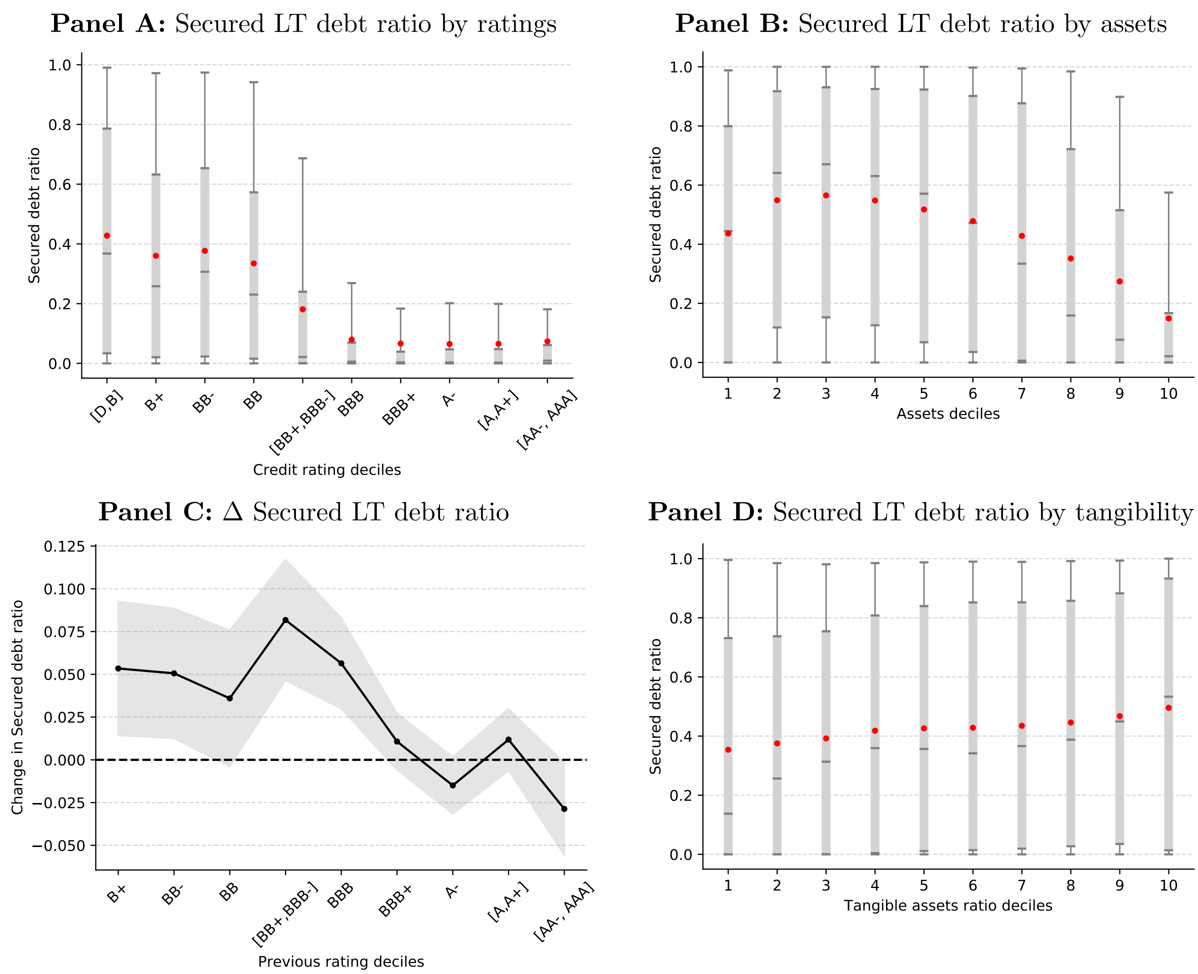
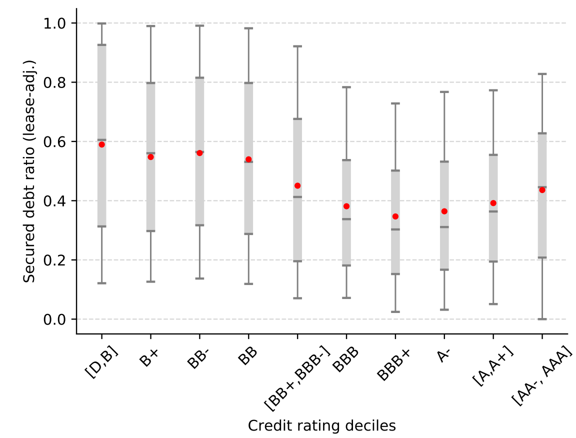


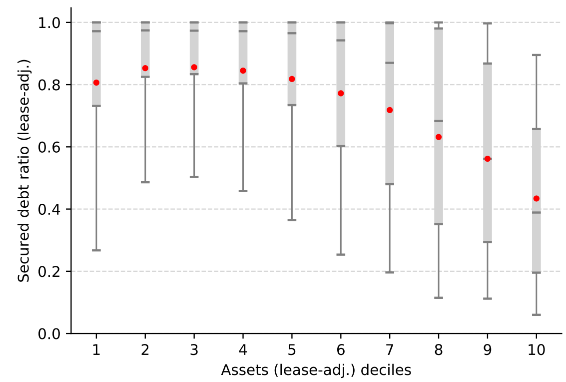
Figure D2: **Secured Long-Term Debt Ratio (Lease-adj.)**

This table shows the lease-adjusted ratio of secured debt to long-term debt across deciles by ratings (Panel A), assets (Panel B), and tangibility (Panel D). There is one box plot for each decile; in each box plot, the red dot denotes the mean, the horizontal dash the median, the grey rectangle the interquartile range, and the whiskers the 5th and 95th percentile, respectively. Panel C shows the effect of downgrades on the secured debt to long-term debt ratio; for each decile, this panel shows the mean and the 95% confidence interval for the change between one year before the downgrade and two years after the downgrade. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

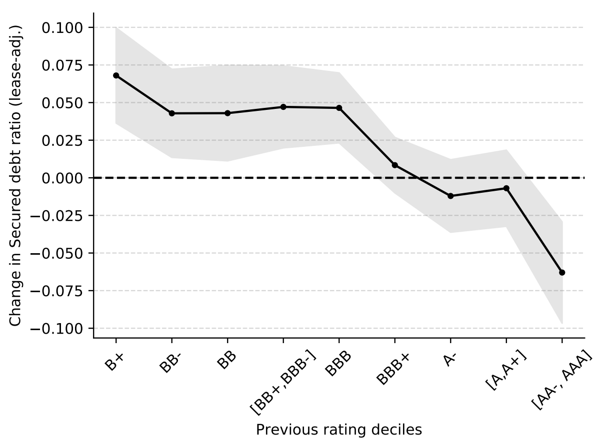
Panel A: Secured LT debt ratio by ratings (lease-adj.)



Panel B: Secured LT debt ratio by assets (lease-adj.)



Panel C: Δ Secured LT debt ratio (lease-adj.)



Panel D: Secured LT debt ratio by tangibility (lease-adj.)

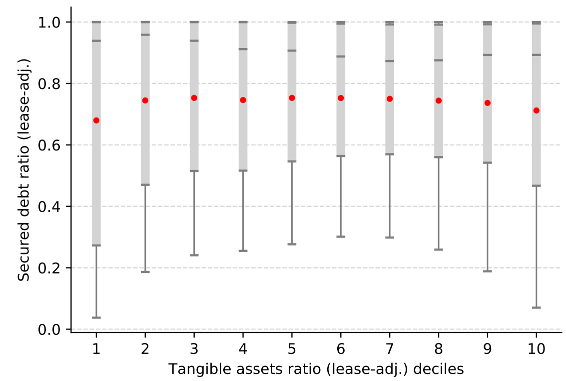


Figure D3: **Secured Debt by Assets (Lease-adj.)**

This table shows the lease-adjusted financial structure across deciles by assets. There is one box plot for each decile; in each box plot, the red dot denotes the mean, the horizontal dash the median, the grey rectangle the inter-quartile range, and the whiskers the 5th and 95th percentile, respectively. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

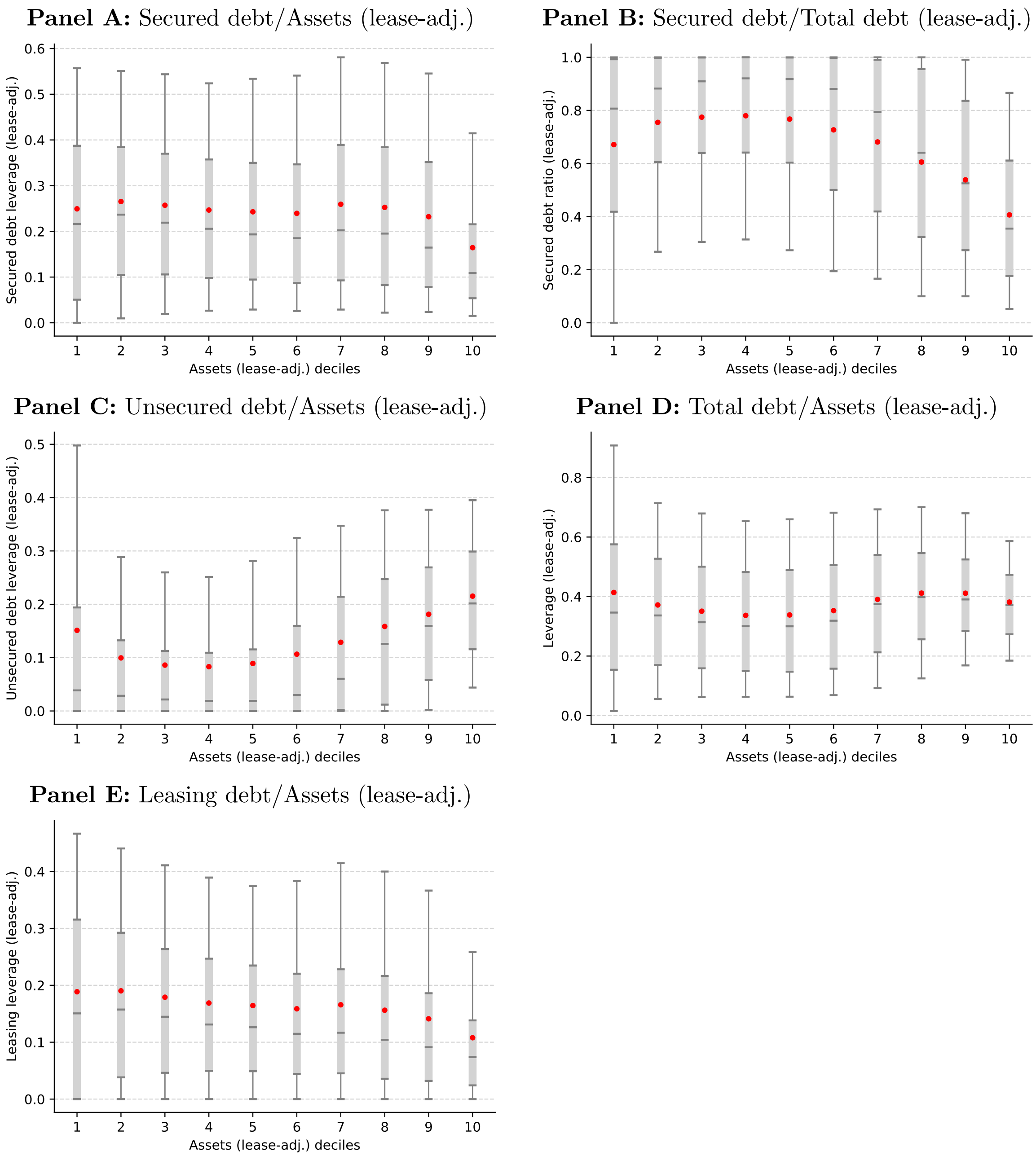
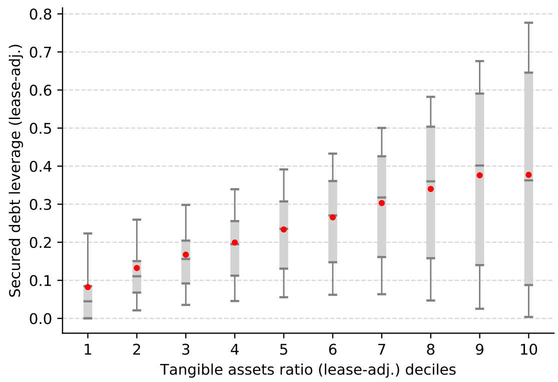


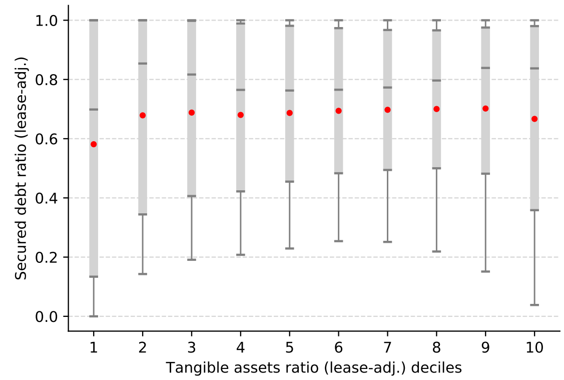
Figure D4: **Secured Debt by Fraction Tangible Assets (Lease-adj.)**

This table shows the lease-adjusted financial structure across deciles by the fraction of tangible assets. There is one box plot for each decile; in each box plot, the red dot denotes the mean, the horizontal dash the median, the grey rectangle the inter-quartile range, and the whiskers the 5th and 95th percentile, respectively. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.

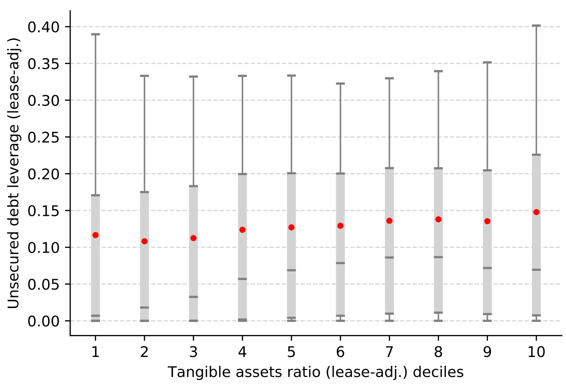
Panel A: Secured debt/Assets (lease-adj.)



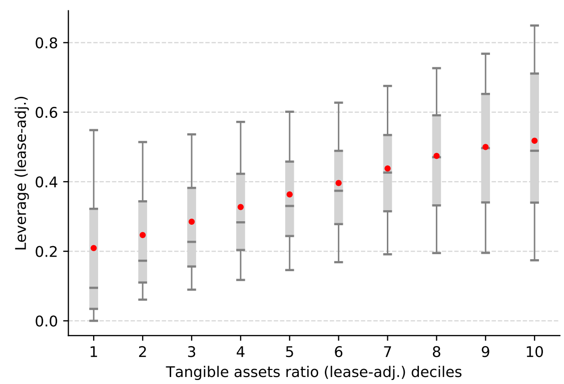
Panel B: Secured debt/Total debt (lease-adj.)



Panel C: Unsecured debt/Assets (lease-adj.)



Panel D: Total debt/Assets (lease-adj.)



Panel E: Leasing debt/Assets (lease-adj.)

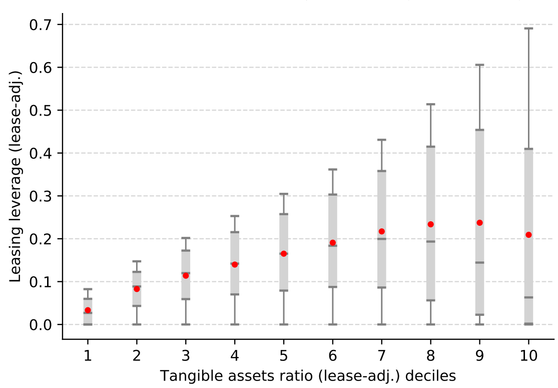


Figure D5: **Distribution of Treatment Effect Estimates from Causal Forest**

This figures shows the distribution of treatment effects of rating downgrades by one notch or more on the secured debt leverage and secured debt ratio for treated and control observations. Panel A shows the baseline results and Panel B shows the results with lease-adjusted variables. We estimate the effect on the outcome variable two years after the downgrade using the values of covariates one year before the downgrade. Variables are defined in Appendix Table A1. Data are annual for 1981-2018.