Managerial Protections, Capital Requirements, and Bank Lending*

Joshua Bosshardt
MIT

Ali Kakhbod
MIT

Abstract

We introduce a model to illustrate how the effect of capital requirements on bank lending can qualitatively depend on the extent of managerial protections against shareholder actions. Protections encourage managers to pursue unprofitable projects. Protected managers can still be disciplined by debt. If debt is constrained by capital requirements, then a higher level of investment can serve as a partial substitute. Capital requirements can therefore spur increased investment for firms with managerial protections. Empirically, bank stress-testing after the 2008 financial crisis led to an increase in lending for banks with strong protections compared to banks with weak protections.

Keywords: D24, G32.

JEL Classification: Managerial protections, Banking, Corporate governance, Stress testing, Capital structure, Ownership structure, Investment.

---

*This Draft: July 2020. We thank Daron Acemoglu, Ricardo Caballero, Andrey Malenko, David Thesmar, Rob Townsend and Ivan Werning for very helpful and constructive comments. Bosshardt: Department of Economics, Massachusetts Institute of Technology (MIT), Cambridge, MA 02139, USA. Email: jbosshar@mit.edu, Kakhbod: Department of Economics, Massachusetts Institute of Technology (MIT), Cambridge, MA 02139, USA. Email: akakhbod@mit.edu.

1 Introduction

Bank regulations that are intended to improve financial stability, such as capital requirements, can have important side effects on lending. Theoretically, there are numerous conflicting channels by which bank capital can affect lending.[1] Empirically, recent studies have analyzed this relationship in the context of the introduction of the bank stress tests after the 2008 financial crisis, which operate like forward-looking capital requirements (Acharya, Berger and Roman (2018)).[2] However, little is known about how capital requirements interact with managerial protections against shareholders, which refers to antitakeover laws, restricted shareholder rights, and other laws and provisions that could enable a manager to obtain private benefits from controlling a firm. This interaction is important because managerial protections have been shown to affect investment more generally through a variety of channels.[3] As empirical motivation, Figure 1 shows that, among bank holding companies that were subject to the stress tests conducted by the Federal Reserve, those with relatively strong managerial protections, as measured by the Governance Index constructed in Gompers, Ishii and Metrick (2003), exhibited a relative increase in lending compared to those with weak protections.

This paper shows that the effect of capital requirements on bank lending can qualitatively depend on the degree of managerial protections. We illustrate this result using a model in which a firm chooses its value-maximizing capital structure and level of investment, which can be interpreted as loans in the context of banks, while taking into account the incentives of managers as well as regulatory capital requirements. The manager of the firm then learns about the quality of the investment project during development and chooses whether to terminate or complete it. Managerial protections provide an incentive for managers to complete unprofitable projects in order to obtain a private benefit from controlling the firm.

To illustrate the mechanism by which managerial protections influence the effect of capital requirements on investment, we first characterize the firm's optimal capital

[1]On the one hand, the safety from a large capital buffer can lead banks to decrease lending because they have more severe financing frictions (Diamond and Rajan (2000)) or higher charter values that motivate them to lend more cautiously (Keeley (1990)). On the other hand, a greater capital stock can increase the capacity to make loans by improving monitoring (Holmstrom and Tirole (1997)) or by mitigating debt overhang (Admati et al. (2013)).

[2]Some of these studies have shown that the stress tests were negatively associated with lending (Acharya, Berger and Roman (2018) and Cortés et al. (2018)), while others have found weaker or contrary effects (Bassett and Berrospide (2018)).

[3]On the one hand, they have been associated with greater levels of investment (Gompers, Ishii and Metrick (2003)), possibly by providing greater freedom for managers to maintain "empires". On the other hand, Bertrand and Mullainathan (2003) show that managerial protections can lead to reductions in potentially efficient investments, suggesting that they allow managers to enjoy a "quiet life".

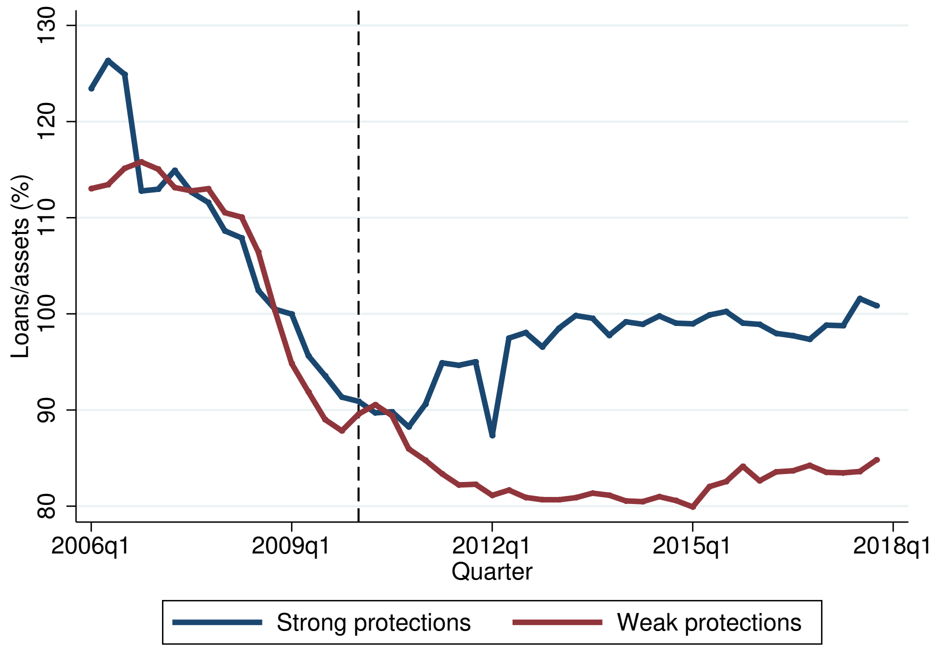


Figure 1: Lending for banks with strong vs. weak managerial protections. This plot shows the mean ratio of loans and unused commitments to assets for a balanced sample of bank holding companies (BHCs) that were subject to the stress tests conducted by the Federal Reserve (the Supervisory Capital Assessment Program in 2009 and annual rounds of the Comprehensive Capital Analysis and Review starting in 2011), split by the strength of managerial protections. Managerial protections are measured using the G-index from Gompers, Ishii and Metrick (2003). BHCs with a G-index greater than the median among this subset are designated as having strong managerial protections, and BHCs with a G-index less than the median are designated as having weak managerial protections. The dashed line indicates the approximate start of the US bank stress tests in 2010. See Section 3.1 for more details about the sample construction.

structure in the absence of capital requirements. In particular, if a firm has strong managerial protections, then shareholders have limited ability to directly prevent excessive project completion by managers. However, protected managers can still be disciplined with debt. The firm's optimal level of debt balances this disciplining effect against the expected losses from liquidation costs if the firm defaults.

Capital requirements that force banks to issue a suboptimally low level of debt affect investment through two channels. On the one hand, distortions to the firm's capital structure reduce the return on investment, which discourages investment. On the other hand, for a firm with strong managerial protections against shareholders, capital requirements can undermine the role of debt in disciplining the manager. At the same time, under the canonical assumptions of a linear liquidation cost and a concave expected return, the manager's incentive to liquidate unprofitable projects is increasing in the level of investment. As a result, the value-maximizing level of investment can increase in response to tightening capital requirements since it serves as a partial substitute for debt in disciplining the manager. The dominant channel determining the firm's investment response to capital requirements depends on other firm characteristics, such as the earnings distribution. For example, the pro-investment channel can dominate if the firm has an earnings distribution with a strictly concave cdf, such as an exponential distribution, whereas the anti-investment channel dominates if the firm has an earnings distribution with a convex or linear cdf, such as a uniform distribution.

An extended version of the model allowing for managerial choice of capital structure and investment has other features that are consistent with facts from the corporate governance literature. First, the model illustrates channels by which protections can cause managers to issue either too much or too little debt. In particular, if managerial protections and voting power associated with equity share are complementary sources of managerial power, then protections can intensify the incentive for managers to increase their voting power by financing the firm with debt rather than issuing shares to outside equityholders. However, they can also lead managers to issue less debt in order to reduce the probability of liquidation. The first channel is consistent with the positive association between managerial protections and debt ratios documented in John and Litov (2010).

The model also offers a novel explanation for why managerial protections can lead to reduced investment, which is consistent with the evidence in Bertrand and Mullainathan (2003). In particular, if managers can only obtain the private benefit of control from projects that are brought to completion, and if additionally the probability of liquidating a project is increasing in the level of investment, then managers underinvest in order to increase their expected private benefit of control.

Finally, we examine the interaction between managerial protections and capital requirements by considering how bank holding companies (BHCs) adjusted lending in response to the stress tests conducted by the Federal Reserve. The stress tests require a subset of large banks to maintain sufficient capital to lend under potential adverse scenarios. The stress tests function like forward-looking capital requirements and have been associated with increased capital ratios (Acharya, Berger and Roman (2018)). We represent the degree of managerial protections with the "Governance Index" or G-index constructed in Gompers, Ishii and Metrick (2003), which represents the number of firm provisions and state laws that provide defenses against shareholder actions and takeover threats. Using regulatory FR Y-9C data covering the subset of BHCs that were included in the initial stress tests conducted by the Federal Reserve, we show using a difference-in-differences specification that lending increased for stress-tested BHCs with a high G-index relative to stress-tested BHCs with a low G-index.

1.1 Literature Review

The key distinction of this paper relative to the literature is to examine the effect of capital requirements on bank lending through the lens of managerial protections. This paper relates to four strands of the literature.

This paper contributes to the literature on the effect of bank regulations on lending by presenting a novel channel through which policies that constrain debt ratios, such as bank stress tests and capital requirements, affect investment. The theoretical literature on the role of bank capital offers mixed predictions regarding the effect of a tightening. One perspective is that the safety from a larger capital buffer could result in more severe financing frictions (Diamond and Rajan (2000)) or higher charter values (Keeley (1990)), leading banks to lend more conservatively.[4] Another perspective is that a greater capital stock can improve monitoring (Holmstrom and Tirole (1997)) and mitigate debt overhang (Admati et al. (2013)), allowing banks to lend more. It could also increase the value of loans by increasing the probability that a bank remains operational to collect the cash flows (Bahaj and Malherbe (2018)). Our model is similar to the latter view in that we illustrate a channel by which policies that constrain debt ratios can increase lending. However, we propose a novel mechanism based on the interaction between debt and corporate governance.

This paper relates more generally to a stream of the literature on the advantages and disadvantages of bank capital requirements (Thakor (2014), Thakor (2019)). For example, Diamond and Rajan (2000), Diamond and Rajan (2001) and DeAngelo and Stulz (2015) provide theoretical evidence that tightening capital requirements may distort banks' provision of liquidity services, while Dewatripont and Tirole (2012) show that stricter capital requirements may introduce governance problems. However, Hellmann, Murdock and Stiglitz (2000), Morrison and White (2005), Repullo (2004) and Acharya, Mehran

[4]Additionally, Thakor (1996) shows that risk-based capital requirements that increase the cost of loans relative to safe investments can also decrease lending.

and Thakor (2015) argue that stringent capital regulation can induce prudent behavior by banks. We add to this literature by showing that the effect of capital requirements could crucially depend on the extent of managerial protections.

This paper also relates to the empirical literature on the effect of tightening capital requirements on lending. Some papers find a negative effect. For example, Acharya, Berger and Roman (2018) and Cortés et al. (2018) find that the U.S. stress tests led banks to decrease credit supply. Fraisse, Lé and Thesmar (2020) and Gropp et al. (2019) present additional evidence from other contexts that increasing capital requirements can reduce lending. Other work has found a weak effect or even a positive effect in some specifications (Bassett and Berrospide (2018)). Rather than estimating the overall effect of capital requirements on lending, we isolate the role of managerial protections by showing that stress-tested BHCs with strong protections increased lending relative to those with weak protections.

This paper also contributes to the literature on the effects of managerial protections on firm performance by illustrating its distortionary effect on capital structure and investment. Gompers, Ishii and Metrick (2003) show that managerial protections are associated with worse firm performance across a variety of indicators, including stock returns, firm valuation, profits, and sales growth. Bertrand and Mullainathan (2003) present causal evidence suggesting that the introduction of antitakeover laws led to reduced firm productivity and profitability, possibly due to weaker incentives for managers to minimize costs and initiate value-enhancing changes. We contribute to this literature by considering additional mechanisms related to how managerial protections distort capital structure and investment decisions.[5]

2 Model

This section introduces a model in which managerial protections affect how managers determine which projects to pursue. It then derives the capital structure and level of investment that maximize the value of the firm. Finally, it describes conditions under which policies that constrain debt ratios can lead to increased investment.[6]

[5]For surveys of the literature on corporate governance see Shleifer and Vishny (1997) and Tirole (2006).

[6]The model relates to ideas from the classical literature linking capital structure and investment. On the one hand, debt increases the probability of liquidation and dampens investment, which is analogous to the debt overhang effect described in Myers (1977). On the other hand, debt constrains managers from pursuing unprofitable projects, which is analogous to the disciplining effect of debt described in Jensen (1986). The model is also related to subsequent work in which these channels affect the determination of firm debt ratios (Morellec, Nikolov and Schürhoff (2012)). We consider specifically how the level of investment varies with a firm's capital structure.

2.1 Timeline

An entrepreneurial firm is run by a manager. The economy extends over three dates $t = 0, 1, 2$. As an overview, at date $t = 0$ the firm raises capital to invest in a risky project. At date $t = 1$ the manager observes a precise signal of the project's profitability and decides whether or not to liquidate it. If the project is continued to completion rather than liquidated, then at date $t = 2$ its cash flow is realized and distributed to the manager and external investors. Additionally, the manager may obtain a private benefit of control.

More specifically, at $t = 0$ the manager chooses to raise capital $K \geq 0$ to invest in a risky project. Investment that continues until $t = 2$ yields a cash flow of $\theta y(K)$, where $\theta \sim H(\cdot)$ is a random variable with log-concave density $h(\theta)$ where $\theta \in [0, \infty)$.[7] We assume that $y(K)$ is increasing and concave. It also has a convex marginal product $y'(K)$ and satisfies the boundary conditions $y(0) = 0$, $y'(0) = \infty$, and $y'(\infty) = 0$.

At $t = 1$, the manager observes θ and decides whether or not to liquidate the project. Liquidation incurs a fractional cost of $c \in (0, 1)$ and therefore yields a liquidation value of $(1 - c)K$.

The manager has sufficient funds to finance a fraction α_F of the investment and acquires external financing for the remaining fraction by issuing claims on the return realized at $t = 2$.[8] There are two types of external investors. *Informed investors* also observe θ and are offered equity shares. Denote the fraction of capital provided by informed investors by α_I. Informed investors are like passive investors who want to invest in the project without getting involved in controlling the firm. The simplest way for them to invest is to buy claims on the (residual values of) firm's cash flows in the form of equities. In particular, the informed investors are assumed to receive a fraction of equity shares corresponding to their initial investment.[9] *Uninformed investors*, which correspond to creditors, do not observe θ. They have no bargaining power and their outside option is to forego investment and obtain zero net returns. If the project is liquidated, the creditors have a senior claim on the liquidation value of the firm. Denote the fraction of capital provided by uninformed investors by α_U. Note that the fraction of capital financed by equity can be written as $\alpha_I + \alpha_F = 1 - \alpha_U$.

[7]Note that the family of log-concave distributions includes the Uniform, Normal, Exponential, and some classes of the Beta and Gamma distributions. Moreover, it is easy to show that if the continuously differentiable p.d.f. $h(\cdot)$ is log-concave on $(\underline{\theta}, \bar{\theta})$, then the corresponding c.d.f. $H(\cdot)$ is also log-concave on $(\underline{\theta}, \bar{\theta})$. In addition, the corresponding hazard rate, i.e., $\frac{h(\theta)}{1-H(\theta)}$, is increasing in θ.

[8]Note that all of our results are robust to supposing that the manager invests a fixed volume of funds rather than a fixed share.

[9]In particular, since the total fraction of capital financed by equity is equal to $\alpha_I + \alpha_F$, informed investors own a fraction $\frac{\alpha_I}{\alpha_I+\alpha_F}$ of the equity value while the manager owns the remaining fraction of $\frac{\alpha_F}{\alpha_I+\alpha_F}$.

If the project is continued until $t = 2$, the creditors are repaid and the equityholders, which include the manager and the informed investors, divide according to their shares the residual value of the firm. Additionally, the manager receives a private benefit of control or rent

$$R(G, 1-\alpha_U, \alpha_F) \equiv G \, \frac{\alpha_F}{1-\alpha_U} \tag{1}$$

The private benefit of control increases in the exogenous degree of managerial protections G, which represents the contribution to managerial power of firm provisions or state laws that restrict shareholder rights. For example, the empirical analog used to represent managerial protections in Section 3 is the G-index introduced in Gompers, Ishii and Metrick (2003).[10]

The private benefit of control also increases in the manager's share of the firm's equity. In particular, the manager's equity share represents the manager's voting power relative to the outside equityholders, which can in turn affect the ability of managers to improve their terms of employment (Morck, Shleifer and Vishny (1988)) or accrue non-pecuniary benefits from influencing the operations of the firm according to their personal preferences (Demsetz and Lehn (1985)).[11] The choice to model managerial protections and the manager's equity share as contributing to the manager's private benefit of control in a complementary way is consistent with evidence showing that ownership concentration is positively associated with factors that increase a manager's potential private benefit of control (Dyck and Zingales (2004)). For simplicity, it is convenient to assume that the private benefit of control depends on managerial protections and the manager's share of the firm's equity in a multiplicative fashion. The results can be extended for more a general functional form $R(G, 1-\alpha_U, \alpha_F, K)$ satisfying $\frac{\partial R}{\partial G} \geq 0$, $\frac{\partial R}{\partial K} \geq 0$, and $R \frac{\partial^2 R}{\partial K \partial(1-\alpha_U)} \leq \frac{\partial R}{\partial(1-\alpha_U)} \frac{\partial R}{\partial K}$.

2.2 Firm equity value

To determine the equity value of the firm, we first characterize the payment to the creditors as well as conditions under which the firm is liquidated or completed.

Since creditors are uninformed about the quality of the project, in order to participate in the investment they need to write an incentive compatible and individually rational contract with the manager. The following lemma characterizes the terms of the

[10] It is worth noting that the private benefit of control captured in equation (1) specifies a conflict of interest between the manager and informed investors. This conflict incrases in the degree of managerial protections G.

[11] Note that the fraction of equity held by managers is not infrequently substantial even in large publicly owned firms (La Porta et al. (1998)).

contract and shows that the unique incentive compatible contract is debt.[12]

Lemma 1. *The unique incentive compatible contract between the manager and the uninformed investors is debt. Specifically, the uninformed investors are payed a fixed amount $p(K,\alpha_U)$ whenever the project is not liquidated at $t=1$. If the project does not generate a large enough return to repay the promised amount, then the project is liquidated at $t=1$ and the uninformed investors are paid the liquidation value up to the value of their investment $\alpha_U K$. Let $\theta^*(K,\alpha_U)$ denote the threshold for θ at which the project is liquidated. Then $p(K,\alpha_U)$ and $\theta^*(K,\alpha_U)$ satisfy the following:*

- *If $\alpha_U \leq 1-c$, then*

$$p(K,\alpha_U) = \alpha_U K \tag{2}$$
$$\theta^*(K,\alpha_U)y(K) = \max\{(1-c)K - G, \alpha_U K\} \tag{3}$$

- *If $\alpha_U \geq 1-c$, then*

$$p(K,\alpha_U) = \theta^*(K,\alpha_U)y(K) \tag{4}$$
$$\alpha_U K = H\Big(\theta^*(K,\alpha_U)\Big)(1-c)K + \Big(1 - H\Big(\theta^*(K,\alpha_U)\Big)\Big)\underbrace{\theta^*(K,\alpha_U)y(K)}_{=p(K,\alpha_U)} \tag{5}$$

Proof. See Appendix. □

The intuition for this result is as follows. First, consider the "high debt" case where $\alpha_U \geq 1-c$. If the project is liquidated, then the liquidation value $(1-c)K$ is insufficient to repay the value of the investment by the creditors $\alpha_U K$. Therefore the firm defaults and the creditors receive all of the liquidation value since they have a senior claim on it. Ex-ante, they charge a risk premium that is determined by an individual rationality condition that equates the creditors' expected payoff with their cost of investment. The risk premium and the default threshold for the quality of the project θ are related by an incentive compatibility condition for the manager, which requires that, conditional on continuing the project to completion, the creditors receive the return of the firm at the marginal state at which it is continued, which is $\theta^*(K,\alpha_U)y(K)$.

Second, consider the "low debt" case where $\alpha_U \leq 1-c$. If the project is liquidated, the liquidation value $(1-c)K$ is sufficient to repay the creditors for their investment $\alpha_U K$. Therefore, by the individual rationality condition, the creditors always receive $\alpha_U K$. If

[12] The contract has similarities with the costly state verification contracts developed by Townsend (1979).

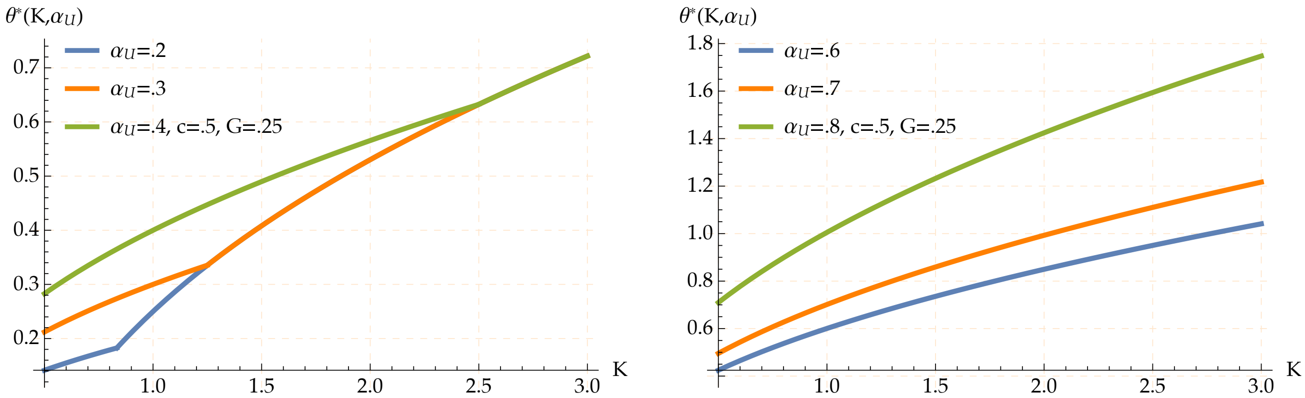


Figure 2: These panels plot $\theta^*(K,\alpha_U)$ for the high debt ($\alpha_U > 1-c$, the right panel) and low debt ($\alpha_U < 1-c$, the left panel) cases, as specified in Lemma 1. We assume $y(K) = \sqrt{K}$, $c = .5$ and the distribution is Uniform$[0,a]$, where a is large enough.

the debt ratio is sufficiently small, then the manager is unconstrained by the debt contract and chooses the default threshold $\theta^*(K,\alpha_U)$ by equating his or her own payoffs from either liquidating or continuing the project:

$$\underbrace{\frac{\alpha_F}{1-\alpha_U}\Big(\theta^*(K,\alpha_U)y(K) - \overbrace{\alpha_U K}^{=p(K,\alpha_U)} + G\Big)}_{\text{continuation payoff}} = \underbrace{\frac{\alpha_F}{1-\alpha_U}((1-c)-\alpha_U)K}_{\text{liquidation payoff}} \tag{6}$$

Increasing the strength of managerial protections increases the manager's incentive to continue projects, which reduces the liquidation threshold. However, feasibility requires the return at the marginal state of continuation to be large enough to pay the creditors the promised amount, which implies $\theta^*(K,\alpha_U)y(K) \geq \alpha_U K$. When the debt ratio is large relative to the degree of managerial protections, this constraint holds with equality.

After the creditors are repaid, the equity value of the firm is equal to

$$V\Big(K,\alpha_U\Big) = H\Big(\theta^*(K,\alpha_U)\Big)\Big[((1-c)-\alpha_U)K\Big]^+ + \int_{\theta^*(K,\alpha_U)}^{\infty}\Big(\theta y(K) - p(K,\alpha_U)\Big)dH(\theta) - (1-\alpha_U)K$$

where $[A]^+ = \max\{A,0\}$. Note that because the creditors obtain zero expected profits, the value of the firm is also equal to the ex-ante welfare, which is defined as the sum of the net payoffs for the manager, outside equityholders, and creditors.

The manager then chooses to liquidate or continue projects to maximize his or her utility

$$u_m \equiv \frac{\alpha_F}{1-\alpha_U} V\Big(K, \alpha_U\Big) + G \frac{\alpha_F}{1-\alpha_U} \Big(1 - H\Big(\theta^*(K, \alpha_U)\Big)\Big) \tag{7}$$

2.3 Efficient capital structure

To provide a benchmark for evaluating the effect of policies that constrain debt ratios, this subsection derives the efficient capital structure that maximizes the equity value of the firm.

To determine the efficient capital structure, we first derive the first-best liquidation rule that maximizes the value of the firm in the absence of external financing frictions and private benefits of control. In particular, eliminating these frictions is equivalent to maximizing the utility of manager (equation (7)) with $\alpha_F = 1$, $\alpha_U = 1$, and $G = 0$. At $t = 1$, it is straightforward to see that liquidating the project is efficient if and only if the return $\theta y(K)$ is less than the liquidation value $(1-c)K$, or equivalently

$$\theta \leq \theta^{opt}(K) \equiv \frac{(1-c)K}{y(K)}. \tag{8}$$

The efficient capital structure that induces the first-best liquidation rule is given by $\alpha_U = 1 - c$. Note that, for tractability, the model focuses on determinants of capital structure involving managerial discretion and omits potentially other relevant considerations. Accordingly, we interpret this result as a benchmark for a qualitative analysis of how these channels interact with policies that constrain debt ratios, and we do not interpret it quantitatively.

Proposition 1. *If $\alpha_U = 1 - c$ then $\theta^*(K, \alpha_U) = \theta^{opt}(K)$. If $G > 0$ then the converse also holds.*

Proof. See Appendix. □

The intuition is as follows. In the "high debt" case where $\alpha_U > 1 - c$, the creditors accrue losses when the project is liquidated. As a result, they require a greater repayment $\theta^*(K, \alpha_U)y(K)$ in states where the project is not liquidated. This implies an increase in the liquidation threshold $\theta^*(K, \alpha_U)$, which also increases the probability of having to liquidate profitable projects. Alternatively, consider the "low debt" case where $\alpha_U < 1 - c$. If managerial protections enable the manager to obtain a private benefit of control, or $G > 0$, then the manager has an incentive to complete unprofitable projects, which is reflected in a decrease in the liquidation threshold $\theta^*(K, \alpha_U)$.[13] This tradeoff is summarized in the

[13]Note that, in the low debt case, eliminating the private benefit of control by setting $G = 0$ restores the efficient liquidation threshold $\theta^*(K, \alpha_U) = \theta^{opt}(K)$.

following proposition:

Proposition 2. *The liquidation threshold is increasing in the firm's debt ratio:*

$$\frac{\partial \theta^*(K, \alpha_U)}{\partial \alpha_U} \geq 0$$

Consequently, if $\alpha_U > 1 - c$, the manager excessively liquidates the project,

$$\theta^*(K, \alpha_U) > \theta^{opt}(K).$$

If $\alpha_U < 1 - c$ and $G > 0$, the manager excessively continues the project,

$$\theta^*(K, \alpha_U) < \theta^{opt}(K).$$

Proof. See Appendix. □

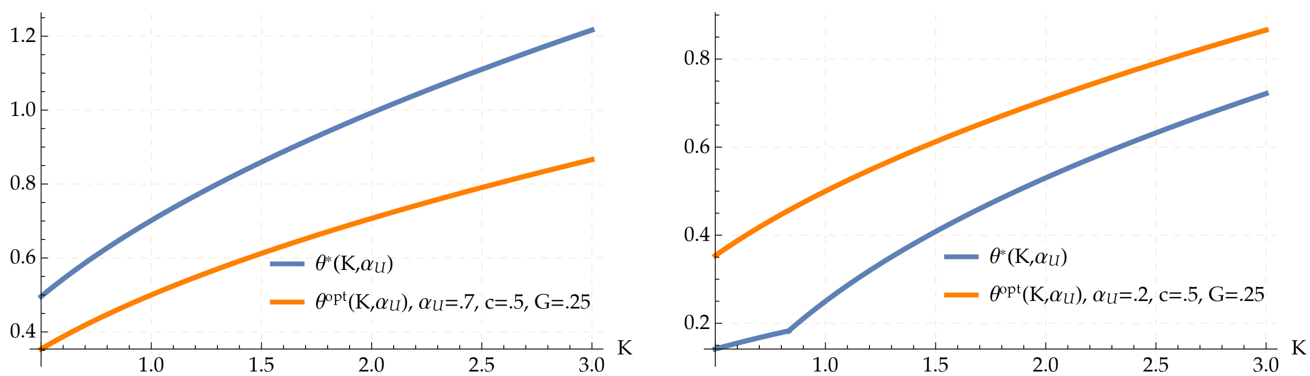


Figure 3: This panel show that when debt is high, i.e., $\alpha_U > 1 - c$ (the left panel), the manager excessively liquidates the project $\theta^*(K, \alpha_U) > \theta^{opt}(K)$. When debt is low, i.e., $\alpha_U < 1 - c$ and $G > 0$ (the right panel), the manager excessively continues the project, $\theta^*(K, \alpha_U) < \theta^{opt}(K)$.

2.4 Investment

This subsection first derives the first-best level of investment that maximizes the value of the firm in the absence of external financing frictions and managerial private benefits of control. It then introduces the conditionally efficient level of investment for a given capital structure and illustrates channels by which it can either increase or decrease in response to policies that constrain debt ratios.

2.4.1 Efficient level of investment

To illustrate how the firm's capital structure affects the level of investment, we first derive as a benchmark the first-best level of investment that maximizes the value of the firm in the absence of external financing frictions and managerial private benefits of control. Given that the first-best liquidation threshold is equal to $\theta^{opt}(K)$, the first-best level of investment solves:

$$\max_K \left\{ \int_{\theta^{opt}(K)}^{\infty} \theta\, y(K) dH(\theta) + \int_0^{\theta^{opt}(K)} (1-c) K \, dH(\theta) - K \right\} \tag{9}$$

Proposition 3. *There exists a unique interior capital level $K^{opt} \in (0,\infty)$ that solves (9) and satisfies the first order condition*

$$1 = (1-c) H\Big(\theta^{opt}(K^{opt})\Big) + y'(K^{opt}) \int_{\theta^{opt}(K^{opt})}^{\infty} \theta \, dH(\theta). \tag{10}$$

Proof. See Appendix. □

Intuitively, the first-best level of investment is chosen to equate the marginal cost of investment with the marginal expected returns, which consists of the liquidation value from bad realizations plus the returns from good realizations.

2.4.2 Effect of capital structure on the level of investment

To determine how capital structure affects the level of investment, consider the level of investment that maximizes the value of the firm for a given capital structure, which is denoted by $K^*(\alpha_U)$. Since the efficient capital structure $\alpha_U = 1-c$ induces the first-best liquidation threshold $\theta^{opt}(K)$ (see Proposition (1)), the corresponding conditionally efficient level of investment is equal to the first-best benchmark. The rest of this subsection illustrates how deviations from the efficient capital structure affect the conditionally efficient level of investment.

If the firm has greater than the efficient debt ratio, or $\alpha_U > 1-c$, then investment is distorted downwards relative to the first-best benchmark K^{opt}.

Proposition 4. *If $\alpha_U > 1-c$, then $K^*(\alpha_U) < K^{opt}$.*

Proof. See Appendix. □

To see this, recall that the cost of debt is increasing in the debt ratio in order to compensate creditors for losses in states where the project is liquidated. Because of the higher cost of debt, the firm may have to liquidate profitable projects (see Proposition (2)). This in turn reduces the marginal expected returns to investment.

If the firm has less than the efficient debt ratio, or $\alpha_U < 1 - c$, it is possible for the conditionally efficient level of investment to be distorted either downwards or upwards relative to the first-best benchmark K^{opt}. The direction of the distortion depends on the parameters, such as the concavity of the firm's earnings distribution cdf.

Proposition 5. *Suppose that the debt ratio is less than the efficient level, or $\alpha_U < 1-c$. If there are no managerial protections, or $G = 0$, then the level of investment is equal to the first-best benchmark and there is no distortion:*

$$K^*(\alpha_U) = K^{opt} = K^*(1-c)$$

If there are managerial protections, or $G > 0$, then the conditionally efficient level of investment can in general be greater or less than the first-best benchmark. If the debt ratio is low enough, or $\alpha_U \leq 1 - c - \frac{G}{K^{opt}}$, and H is strictly concave then investment is distorted upwards, or $K^*(\alpha_U) > K^{opt}$. If the cdf for the return distribution H is weakly convex, then the conditionally efficient level of investment is distorted downwards, or $K^*(\alpha_U) \leq K^{opt}$.

Proof. See Appendix. □

The intuition is that debt disciplines managers by requiring them to liquidate unprofitable projects. In particular, if the manager is not constrained by debt, he or she may continue some unprofitable projects in order to obtain the private benefit of control (see Proposition (2)). On the one hand, continuing unprofitable projects decreases the marginal expected return to investment, which in turn inhibits investment. On the other hand, increasing the level of investment increases the rate at which the firm liquidates unprofitable projects.

Lemma 2. *The termination threshold increases in the level of investment:* $\frac{\partial \theta^*(K,\alpha_U)}{\partial K} \geq 0$.

Proof. See Appendix. □

Intuitively, the increasing relationship between the level of investment and the probability of liquidation follows from the linear liquidation value and concave expected return. Therefore, increasing the level of investment partially corrects the excessive continuation of unprofitable projects by the manager. Accordingly, the level of investment can be interpreted as a partial substitute for debt in disciplining the manager.

Due to these countervailing effects on the incentive to invest, the conditionally efficient level of investment can be either greater or less than the efficient level, depending on the parameters. Figure 5 illustrates a case in which requiring banks to have a lower than the optimal debt ratio can lead to higher investment.

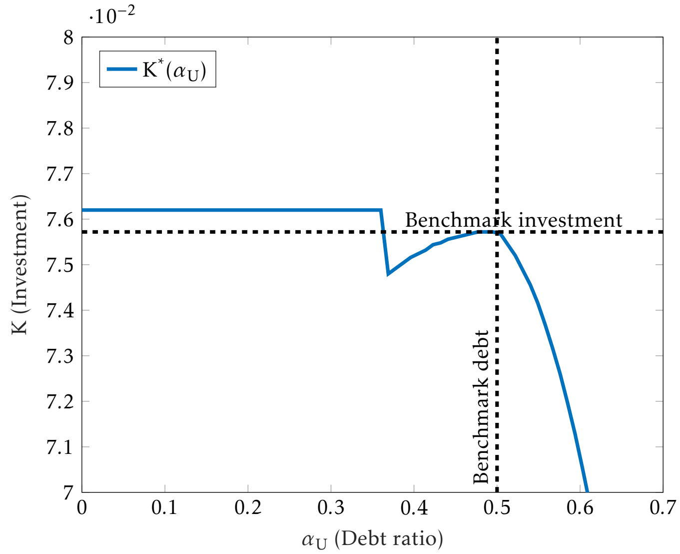


Figure 4: This plot shows the conditionally efficient level of investment and the manager's preferred level of investment as a function of the debt ratio when the return for the project follows an exponential distribution. The plot illustrates that requiring banks to have a lower than the optimal debt ratio can lead to higher investment, as shown in Proposition 5.

An implication of this result is that a firm that initially exhibits the efficient debt ratio $\alpha_U = 1 - c$ can increase investment in response to a policy that requires a reduction of its debt ratio, such as capital requirements or stress-testing. Consistent with this channel, Section 3 shows empirically that the bank stress tests led to a relative increase in lending for bank holding companies (BHCs) with relatively strong managerial protections.

2.5 Other model features

This section shows that an extended version of the model allowing managers to choose the capital structure and level of investment of the firm is consistent other facts in the corporate governance literature. First, we illustrate channels by which managerial protections can cause managers to issue either too much or too little debt relative to the value-maximizing level. Second, we illustrate a novel channel by which managerial protections can cause managers to underinvest relative to the value-maximizing level. The model thereby provides new perspectives on existing evidence linking managerial protections with capital structure and investment.

2.5.1 Manager's preferred capital structure

This section describes channels by which managerial protections can cause a manager to choose an inefficient capital structure. These channels correspond to terms in the derivative of the manager's utility evaluated at the efficient benchmark:

$$\frac{\partial u_m}{\partial \alpha_U}|_{\alpha_U=1-c} = \underbrace{\frac{\alpha_F}{(1-c)^2}V(K,1-c)}_{>0} + \frac{\alpha_F}{1-c}\underbrace{\frac{\partial V}{\partial \alpha_U}|_{\alpha_U=1-c}}_{=0} + \underbrace{G\frac{\alpha_F}{(1-c)^2}\Big(1-H\Big(\theta^*(K,1-c)\Big)\Big)}_{\geq 0} \underbrace{-G\frac{\alpha_F}{1-c}h\Big(\theta^*(K,1-c)\Big)\frac{\partial \theta^*(K,\alpha_U)}{\partial \alpha_U}|_{\alpha_U=1-c}}_{\leq 0} \tag{11}$$

The positive first term, which does not involve managerial protections, shows that managers have an incentive to issue excessive debt in order to increase their share of the value of the firm. The last two terms illustrate the effect of managerial protections, which can distort the manager's chosen level of debt either upwards or downwards. On the one hand, the positive term illustrates that protections can intensify the incentive for managers to increase their voting power by issuing debt rather than equity. This term is driven by the complementarity between the degree of managerial protections and the manager's equity share in determining managerial power and is consistent with evidence showing that ownership concentration is positively associated with estimated private benefits of control (Dyck and Zingales (2004)). On the other hand, the negative term illustrates that protections can lead managers to issue less debt in order to decrease the probability of liquidation.

This analysis provides a novel interpretation for the finding in John and Litov (2010) that managerial protections are positively associated with debt ratios.

2.5.2 Manager's preferred level of investment

This section describes channels by which managerial protections can cause a manager to choose an inefficiently low level of investment.[14]

Denote the manager's preferred level of investment that maximizes his or her utility (equation (7)) for a given debt ratio α_U by $K_m(\alpha_U)$.

Proposition 6. *If there are no managerial protections, or $G = 0$, then the manager's preferred level of investment that maximizes his or her utility (equation (7)) for a given debt ratio α_U, $K_m(\alpha_U)$, is equal to the conditionally efficient level $K^*(\alpha_U)$. If there are managerial protections, or $G > 0$, then the manager's preferred level of investment is less than the conditionally efficient level, or $K_m(\alpha_U) < K^*(\alpha_U)$.*

Proof. See Appendix. □

The intuition is as follows. Because the manager can only obtain the private benefit of control while the firm is operational, the manager has a stronger incentive to avoid liquidating the project compared to other equityholders. Since investing less reduces the probability of liquidation due to the concave expected return (Lemma 2), the manager chooses a lower level of investment to increase the expected private benefit of control. Figure 5 illustrates this result by showing that the conditionally efficient level of investment is greater the than manager's preferred level of investment for different levels of the debt ratio. Appendix Section B shows that this result is robust to alternatively assuming a competitive equity market in which the informed investors make zero rents.

[14] Note that this result differs from the pro-investment effect of the stress tests in Proposition 5 in that it describes the effect allowing the manager to decide the investment level conditional on a given capital structure, whereas Proposition 5 analyzes the effect of varying the capital structure on the value-maximizing level of investment.

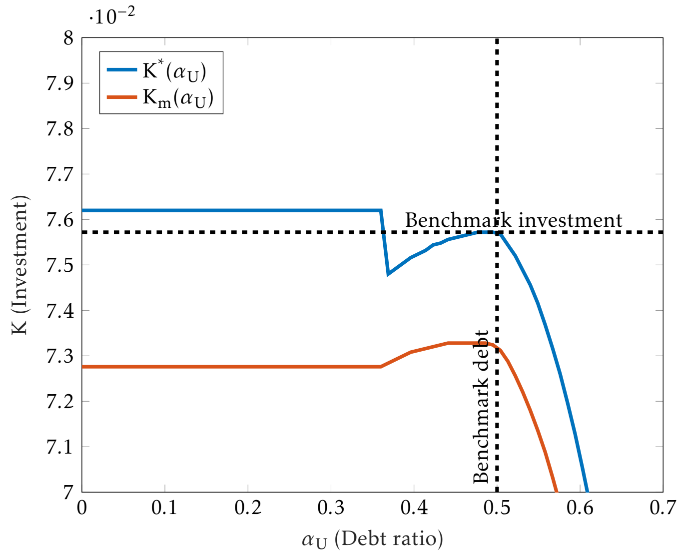


Figure 5: This plot shows the conditionally efficient level of investment and the manager's preferred level of investment as a function of the debt ratio when the return for the project follows an exponential distribution. The plot illustrates that the manager's preferred level of investment is less than the conditionally efficient level, as shown in Proposition 6.

This result provides a novel interpretation for the finding in Bertrand and Mullainathan (2003) that managerial protections are negatively associated with new investments.

3 Empirical evidence

Consistent with Proposition 5, this section presents empirical evidence indicating that the introduction of the stress tests was associated with a relative increase in lending for banks with relatively strong managerial protections.

3.1 Data: G-index and FR Y-9C

To examine how policies that constrain debt ratios interact with managerial protections in determining investment, we combine two data sources: the "Governance Index" or G-index constructed by Gompers, Ishii and Metrick (2003) and quarterly regulatory FR Y-9C reports filed by bank holding companies (BHCs) that were included in the initial stress tests conducted by the Federal Reserve.

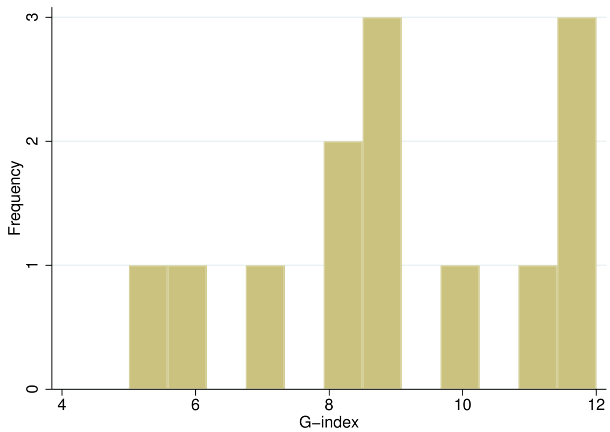
The G-index represents the extent to which managers are protected by firm-level provisions and state laws that protect managers from shareholder actions and takeover threats. Similar to Gompers, Ishii and Metrick (2003), we omit firms with dual-class stock.

The stress tests conducted by the Federal Reserve, particularly the Supervisory Capital Assessment Program (SCAP) in 2009 and Comprehensive Capital Analysis Review (CCAR) conducted annually since 2011, require a subset of large BHCs to maintain sufficient capital to lend under potential adverse scenarios (Goldstein and Sapra (2014)). The SCAP was conducted for 19 BHCs with assets exceeding $100 billion as of 2009. The first three rounds of the CCAR from 2011 to 2013 were conducted for the subset of these firms that remained registered as BHCs, and subsequent rounds of the CCAR were conducted for a wider set of BHCs with assets exceeding $50 billion until 2018.[15] Acharya, Berger and Roman (2018) find evidence that the stress tests led to higher capital levels, which is consistent with interpreting them as a policy that constrains debt ratios.

We construct a balanced sample covering the period from 2006Q1 to 2017Q4. Specifically, we restrict to the subset of these BHCs that were listed as BHCs during the entire sample period and that could be merged to the G-index dataset in 2006, the last year in which the G-index data is available. Figure 6(a) shows the distribution of the G-index among these firms. We designate a BHC as having strong managerial protections if its G-index is greater than the median among this sample, and we similarly designate a BHC as having weak managerial protections if its G-index is less than the median. BHCs whose G-index is equal to the median are excluded. This leaves 10 BHCs for the analysis. Figure 6(b) summarizes the set of firms in the two groups. The set of BHCs designated as having strong managerial protections has a median G-index of 11, which corresponds to the 83rd percentile among all firms in 2006, while the set of BHCs designated as having weak managerial protections has a median G-index of 7, which corresponds to the 25th percentile among all firms.

We consider how the ratio of loans and unused commitments to assets varies with managerial protections while controlling for fundamentals corresponding to the CAMELS rating system, which includes capital adequacy (C) as measured by the fraction of tier 1 equity capital to assets, asset quality (A) as measured by the fraction of non-performing loans, manager quality (M) as measured by non-interest expenses to total assets, earnings (E) as measured by return on assets, liquidity (L) as measured by the fraction of liquid assets, sensitivity to market risk (S) as measured by the absolute value of the dif-

[15] For more detailed background information about the stress tests, see Acharya, Berger and Roman (2018) or Connolly (2018).



(a)

High G (>9)	Low G (<9)
Capital One	Bank of America
Keycorp	BB&T
PNC	Citigroup
Regions	JP Morgan
State Street	Wells Fargo

(b)

Figure 6: The left panel presents the distribution of G-index as of 2006 for stress-tested bank holding companies (BHCs). The right panel presents the sample of BHCs used in the analysis, including the designation of each BHC as having strong or weak managerial protections based on whether its G-index exceeds the median value of 9.

ference between short-term assets and short-term liabilities divided by total assets, and size as measured by the logarithm of total assets.[16] Nominal variables are normalized to 2010Q4 dollars using the GDP deflator. Summary statistics are presented in Table 1.

3.2 Specification: difference-in-differences

This section uses the introduction of the bank stress tests to examine how managerial protections affect the relationship between capital structure and investment.

Similar to Acharya, Berger and Roman (2018), we estimate a difference-in-difference specification during a window around the introduction of stress testing in 2009:

$$Loans/assets_{it} = \beta highG_i \times STactive_t + \mathbf{X}'_{it-1}\gamma + \psi_i + \phi_t + \epsilon_{it} \tag{12}$$

where $Loans/assets_{it}$ is the ratio of loans and unused commitments to assets for BHC i at quarter t, $highG_i$ is an indicator for whether BHC i's 2006 G-index is above the median among the set of stress-tested BHCs, $STactive_t$ is an indicator for whether a quarter occurs on or after $2010Q1$, $\mathbf{X}_{it-1}$ represents a vector of lagged control variables correspond-

[16] Since commitments are partly chosen by customers, we consider the sum of loans and unused commitments to better reflect the lending choices of banks, similar to Acharya, Berger and Roman (2018).

Table 1: Summary statistics for stress-tested bank holding companies. This table presents summary statistics for the sample of bank holding company-quarter observations obtained by matching bank holding companies that were included in the 2009 SCAP stress test with the G-index constructed in Gompers, Ishii and Metrick (2003).

	N	Mean	SD	P25	P75
G-index (2-18)	470	9.10	2.51	7.00	12.00
Loans/assets (%)	470	95.85	37.49	81.73	104.20
Tier 1 capital/assets (%)	470	8.16	1.77	6.73	9.52
NPLs/loans (%)	470	1.42	1.22	0.53	2.14
Non-interest expenses/assets (%)	470	1.17	0.57	0.84	1.23
Net income/assets (%)	470	0.81	1.20	0.67	1.24
Liquid assets/assets (%)	470	11.62	9.69	3.26	19.73
Sensitivity to market risk (%)	470	6.76	7.30	1.69	10.12
Log assets	470	19.84	1.22	18.79	21.25

ing to the CAMELS rating system, and ψ_i represents BHC fixed effects, and ϕ_t represents quarter fixed effects. The difference-in-differences coefficient β summarizes the relative trend of the treatment group after the introduction of the stress tests. Standard errors are clustered by BHC.

The difference-in-differences methodology controls for aggregate trends and systematic differences between the treatment and control groups. The identification of the treatment effect depends on the assumption that the treatment and control groups would have experienced parallel trends if the policy intervention had not occurred. To support this interpretation, Figure 1 shows that there is little evidence of a pre-existing trend. We provide further evidence by estimating the relative trend between the two groups using a specification that is similar to equation (12) except with yearly effects:

$$Loans/assets_{it} = \sum_{t \neq 2010Q1} \beta_t highG_i \times STactive_t + \mathbf{X}'_{it-1}\gamma + \psi_i + \phi_t + \epsilon_{it} \tag{13}$$

The estimates are presented in Figure 7. The variation in the relative trend before the introduction of the stress tests is transient, small, and statistically insignificant, whereas the relative trend exhibits a sustained and statistically significant increase after the introduction of the stress tests.

Additionally, Table 2 compares the treatment and control groups with respect to the control variables for our sample of BHCs in the last quarter of the pre-policy period. It presents the mean for each variable and group in the period preceding the stress tests as well as the t-statistic on the coefficient η from estimating the regression

$$Y_{it} = \eta highG_i + \phi_t + \epsilon_{it}$$

where Y_{it} represents one of the control variables from equation (12). The two groups are similar with respect to most of the characteristics. The only two characteristics for which the difference between the two groups is statistically significant at 5% are log assets and the non-interest expenses to assets ratio. The observable similarity between the treatment and control groups mitigates concerns that characteristics that are correlated with the extent of managerial protections would confound the results.

Table 2: Comparison of observables for high G-index and low G-index bank holding companies. This table presents the means of bank characteristics within the subsample of bank holding companies (BHCs) with a high G-index (i.e. greater than the median among stress-tested BHCs) and banks with a low G-index (i.e. less than the median) in 2009Q4. It also presents the t-statistic for the coefficient η from estimating the regression $Y_{it} = \eta highG_i + \phi_t + \epsilon_{it}$ and computing bank-clustered standard errors.

	Low G	High G	T-statistic
Tier 1 capital/assets	7.614	9.209	1.705
NPLs/loans	3.123	2.501	-.859
Non-interest expenses/assets	0.977	1.440	2.328
Net income/assets	0.394	-0.00890	-.669
Liquid assets/assets	12.77	7.195	-.985
Sensitivity to market risk	4.950	3.920	-.352
Log assets	20.86	18.90	-3.78

3.3 Results

The estimated coefficients from the regression are presented in Table 3. Column (1) presents the results from the baseline specification and indicates that that stress-tested BHCs with managerial protections increased the asset share of loans relative to other stress-tested BHCs by approximately 16%, which is about 17% of the mean ratio of loans to assets and 30% of the standard deviation. The estimated coefficient is significant at the 5% level.

The remaining columns show that this effect depends on other firm characteristics is consistent with Proposition 5. Specifically, we present the results from estimating a similar specification as equation (12) after partitioning BHCs based on the concavity of the observed earnings distribution. Appendix E describes our methodology for determining the concavity of a BHC's earnings distribution cdf. Column (2) indicates that the positive effect of stress testing on the lending for BHCs with a high degree of managerial protections is robust to restricting to BHCs with a dominantly concave return distribution, whereas column (3) indicates that this result is not present among BHCs with a dominantly convex return distribution.

4 Conclusion

This paper theoretically and empirically demonstrates channels by which managerial protections can affect the investment response of policies that constrain firm debt ratios, such as bank capital requirements and stress tests.

We introduce a model in which managerial protections against shareholder actions can distort a manager's decisions about which projects to pursue. The model demonstrates that, in the presence of managerial protections, policies that constrain debt ratios can lead to either decreased or increased investment, depending on other firm characteristics. Specifically, such policies reduce the return to investment, but they also magnify the role of investment as a partial substitute for the effect of debt in disciplining managers from continuing unprofitable projects.

We also show that an extension of the model allowing the manager to choose the firm's capital structure and level of investment is consistent with other facts from the literature. In particular, the manager may have an excessively strong incentive to finance the firm with debt in order to maintain a high equity share, which is consistent with the positive relationship between managerial protections and debt ratios documented in John and Litov (2010). Managerial protections can also lead managers to generally underinvest in order to decrease the probability of liquidation, which is consistent with evidence suggesting that managerial protections can inhibit new investments (Bertrand and Mullainathan (2003)).

Finally, we empirically document the interaction between managerial protections and the U.S. bank stress tests in determining bank lending. Using a sample of bank holding companies (BHCs) that were included in the initial stress tests conducted by the

Federal Reserve, we show that the introduction of the stress tests was associated with relatively greater lending for BHCs with strong managerial protections, as measured by the G-index constructed in Gompers, Ishii and Metrick (2003).

By analyzing the interactions between managerial protections, capital structure, and investment, this paper sheds light on channels by which policies that constrain debt ratios can affect investment and also illustrates mechanisms by which managerial protections can reduce firm performance.

References

Acemoglu, D., A. Ozdaglar, and A. Tahbaz-Salehi. 2015. "Systemic risk and stability in financial networks." *American Economic Review*, 105(2): 564–608.

Acharya, V. V., A. N. Berger, and R. A. Roman. 2018. "Lending implications of U.S. bank stress tests: Costs or benefits?" *Journal of Financial Intermediation*, 34: 58–90.

Acharya, V. V., H. Mehran, and A. V. Thakor. 2015. "Caught between Scylla and Charybdis? Regulating Bank Leverage When There Is Rent Seeking and Risk Shifting." *The Review of Corporate Finance Studies*, 5(1): 36–75.

Admati, A. R., P. M. DeMarzo, M. F. Hellwig, and P. Pfleiderer. 2013. "Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Socially Expensive." Stanford GSB Working Paper No. 2065.

Ashcraft, A. 2005. "Are Banks Really Special? New Evidence from the FDIC-Induced Failure of Healthy Banks." *American Economic Review*, 95(5): 1712–1730.

Bahaj, S., and F. Malherbe. 2018. "The Forced Safety Effect: How Higher Capital Requirements Can Increase Bank Lending." Working Paper.

Baltensperger, E. 1980. "Alternative approaches to the theory of the banking firm." *Journal of Monetary Economics*, 6(1): 1–37.

Bassett, W. F., and J. M. Berrospide. 2018. "The Impact of Post Stress Tests Capital on Bank Lending." FEDS Working Paper 2018-087.

Beck, T., A. Demirguc-Kunt, and R. Levine. 2006. "Bank supervision and corruption in lending." *Journal of Monetary Economics*, 53(8): 2131–2163.

Bernanke, B. S. 2009. "The Crisis and the Policy Response." Speech at the Stamp Lecture, London School of Economics, London, England.

Bertrand, M., and S. Mullainathan. 2003. "Enjoying the Quiet Life? Corporate Governance and Managerial Preferences." *Journal of Political Economy*, 111(5): 1043–1075.

Caballero, R. J. 2010. "Macroeconomics after the Crisis: Time to Deal with the Pretense-of-Knowledge Syndrome." *Journal of Economic Perspectives*, 24(4): 85–102.

Caballero, R. J., and A. Krishnamurthy. 2008. "Collective Risk Management in a Flight to Quality Episode." *Journal of Finance*, 63(5): 2195–2230.

Connolly, M. 2018. “The Real Effects of Stress Testing.” Working Paper.

Cortés, K., Y. Demyanyk, L. Li, E. Loutskina, and P. E. Strahan. 2018. “Stress Tests and Small Business Lending.” NBER Working Paper No. 24365.

DeAngelo, H., and R. M. Stulz. 2015. “Liquid-claim production, risk management, and bank capital structure: Why high leverage is optimal for banks.” *Journal of Financial Economics*, 116(2): 219–236.

Demsetz, H., and K. Lehn. 1985. “The Structure of Corporate Ownership: Causes and Consequences.” *Journal of Political Economy*, 93(6): 1155–1177.

Dewatripont, M., and J. Tirole. 2012. “Macroeconomic Shocks and Banking Regulation.” *Journal of Money, Credit and Banking*, 44: 237–254.

Diamond, D. W., and R. G. Rajan. 2000. “A theory of bank capital.” *Journal of Finance*, 55(6): 2431–2465.

Diamond, D. W., and R. G. Rajan. 2001. “Liquidity Risk, Liquidity Creation, and Financial Fragility: A Theory of Banking.” *Journal of Political Economy*, 109(2): 287–327.

Di Maggio, Marco, Amir Kermani, and Sanket Korgaonkar. 2019. “Partial Deregulation and Competition: Effects on Risky Mortgage Origination.” *Management Science*, 65(10): 4676–4711.

Di Maggio, Marco, and Amir Kermani. 2017. “Credit-Induced Boom and Bust.” *The Review of Financial Studies*, 30(11): 3711–3758.

Dyck, A., and L. Zingales. 2004. “Private Benefits of Control: An International Comparison.” *The Journal of Finance*, 59(2): 537–600.

Fraisse, H., M. Lé, and D. Thesmar. 2020. “The Real Effects of Bank Capital Requirements.” *Management Science*, 66(1): 5–23.

Gennaioli, N., A. Shleifer, and R. W. Vishny. 2013. “A Model of Shadow Banking.” *Journal of Finance*, 68(4): 1331–1363.

Goldstein, I., and H. Sapra. 2014. *Should banks’ stress test results be disclosed? an analysis of the costs and benefits.* 8, 1-54:Foundations and Trends in Finance.

Gompers, P. A., J. L. Ishii, and A. Metrick. 2003. “Corporate Governance and Equity Prices.” *Quarterly Journal of Economics*, 118(1): 107–155.

Gropp, R., T. Mosk, S. Ongena, and C. Wix. 2019. "Banks Response to Higher Capital Requirements: Evidence from a Quasi-Natural Experiment." *Review of Financial Studies*, 32(1): 266–299.

Hellmann, T.F., K. C. Murdock, and J. E. Stiglitz. 2000. "Liberalization, moral hazard in banking, and prudential regulation: Are capital requirements enough?" *American economic review*, 90(1): 147–165.

Holmstrom, B., and J. Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector." *Quarterly Journal of Economics*, 112(3): 663–691.

Ivashina, V., V. B. Nair, A. Saunders, N. Massoud, and R. Stover. 2009. "Bank Debt and Corporate Governance." *Review of Financial Studies*, 22(1): 41–77.

Jensen, M. C. 1986. "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers." *American Economic Review*, 76(2): 323–329.

John, K., and L. Litov. 2010. "Managerial Entrenchment and Capital Structure: New Evidence." *Journal of Empirical Legal Studies*, 7(4): 693–742.

Kashyap, A. K., J. C. Stein, and D. W. Wilcox. 1993. "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance." *American Economic Review*, 83(1): 78–98.

Keeley, M. C. 1990. "Deposit Insurance, Risk, and Market Power in Banking." *The American Economic Review*, 80(5): 1183–1200.

La Porta, R., F. Lopez de Silanes, A. Shleifer, and R. W. Vishny. 1998. "Law and Finance." *Journal of Political Economy*, 106(6): 1133–1155.

Morck, R., A. Shleifer, and R. W. Vishny. 1988. "Management ownership and market valuation: An empirical analysis." *Journal of Financial Economics*, 20: 293–315.

Morellec, E., B. Nikolov, and N. Schürhoff. 2012. "Corporate Governance and Capital Structure Dynamics." *The Journal of Finance*.

Morrison, A. D., and L. White. 2005. "Crises and Capital Requirements in Banking." *American economic review*, 95(5): 1548–1572.

Myers, S. C. 1977. "Determinants of corporate borrowing." *Journal of Financial Economics*, 5(2): 147–175.

Paravisini, D. 2008. "Local Bank Financial Constraints and Firm Access to External Finance." *Journal of Finance*, 63(5): 2161–2193.

Prisman, E., M. B. Slovin, and M. E. Sushka. 1986. "A general model of the banking firm under conditions of monopoly, uncertainty, and recourse." *Journal of Monetary Economics*, 17(2): 293–304.

Repullo, R. 2004. "Capital requirements, market power, and risk-taking in banking." *Journal of financial Intermediation*, 13(2): 156–182.

Shleifer, A., and R. W. Vishny. 1997. "A Survey of Corporate Governance." *The Journal of Finance*, 52(2): 737–783.

Thakor, Anjan V. 2019. *The Purpose of Banking: Transforming Banking for Stability and Economic Growth.* Oxford University Press.

Thakor, A. V. 1996. "Capital Requirements, Monetary Policy, and Aggregate Bank Lending: Theory and Empirical Evidence." *Journal of Finance*.

Thakor, A. V. 2014. "Bank Capital and Financial Stability: An Economic Trade-Off or a Faustian Bargain?" *Annual Review of Financial Economics*, 6(1): 185–223.

Tirole, J. 2006. *The Theory of Corporate Finance.* Princeton University Press.

Townsend, R. M. 1979. "Optimal contracts and competitive markets with costly state verification." *Journal of Economic Theory*, 21(2): 265–293.

A Model: omitted proofs

Lemma 1. *The unique incentive compatible contract between the manager and the uninformed investors is debt. Specifically, the uninformed investors are payed a fixed amount $p(K,\alpha_U)$ whenever the project is not liquidated at $t=1$. If the project does not generate a large enough return to repay the promised amount, then the project is liquidated at $t=1$ and the uninformed investors are paid the liquidation value up to the value of their investment $\alpha_U K$. Let $\theta^*(K,\alpha_U)$ denote the threshold for θ at which the project is liquidated. Then $p(K,\alpha_U)$ and $\theta^*(K,\alpha_U)$ satisfy the following:*

- *If $\alpha_U \leq 1-c$, then*

$$p(K,\alpha_U) = \alpha_U K \tag{2}$$

$$\theta^*(K,\alpha_U)y(K) = \max\{(1-c)K - G, \alpha_U K\} \tag{3}$$

- *If $\alpha_U \geq 1-c$, then*

$$p(K,\alpha_U) = \theta^*(K,\alpha_U)y(K) \tag{4}$$

$$\alpha_U K = H\Big(\theta^*(K,\alpha_U)\Big)(1-c)K + \Big(1 - H\Big(\theta^*(K,\alpha_U)\Big)\Big)\underbrace{\theta^*(K,\alpha_U)y(K)}_{=p(K,\alpha_U)} \tag{5}$$

Proof of Lemma 1. Fix K and α_F. Let $\xi(\theta;\alpha_U)$ denote the payment to the uninformed investors. Then, incentive compatibility requires that

$$\theta \in \arg\max_{\theta'} \left[\frac{\alpha_F}{1-\alpha_U} \max\left\{\theta y(K) - \xi(\theta';\alpha_U) + G, ((1-c)-\alpha_U)K, 0\right\}\right] \tag{14}$$

where the first term is the manager's payoff if she does not terminate the project at $t=1$ and the second term is her payoff when she terminates/liquidates the project at $t=1$. Let $[0,\theta^*(K,\alpha_U))$ (i.e., the termination region) denote the region where in the manager terminates the project. And, when $\theta \in [\theta^*(K,\alpha_U),\infty)$ the manager continues the project at $t=1$.

We need to consider several cases.

Case 1 (High debt). Suppose $1-c-\alpha_U \leq 0$, equivalently, $(1-c-\alpha_U)K \leq 0$. Then, due to Eq. (14), we only need to consider $\theta y(K) - \xi(\theta;\alpha_U) + G$. Since $\theta^*(K,\alpha_U)$ is the termination threshold, thus, following the above specifications, $\theta < \theta^*(K,\alpha_U)$ implies termination and $\theta > \theta^*(K,\alpha_U)$ leads to continuation of the project.

Clearly, when $\theta > \theta^*(K, \alpha_U)$, i.e., θ is in the continuation region, the manager has no incentive to instead misreport it by θ' where $\theta' < \theta^*(K, \alpha_U)$. Simply because if she does so, she misses out $G > 0$. So, for any $\theta', \theta'' \geq \theta^*(K, \alpha_U)$ we must have

$$\xi(\theta'; \alpha_U) = \xi(\theta''; \alpha_U) = p(K, \alpha_U) \leq \inf_{\theta > \theta^*(K, \alpha_U)} \theta y(K) = \theta^*(K, \alpha_U) y(K).$$

Moreover, when $\theta < \theta^*(K, \alpha_U)$, the manager, in order to accrue her private benefit $G > 0$, may want to misreport her true type θ to some higher type θ', for which $\theta' > \theta^*(K, \alpha_U)$. Therefore, for $\theta \leq \theta^*(K, \alpha_U)$, the manager should not have incentive to misreport it to $\theta' > \theta^*(K, \alpha_U)$. For this, we must have

$$p(K, \alpha_U) \geq \sup_{\theta \leq \theta^*(K, \alpha_U)} \theta y(K) = \theta^*(K, \alpha_U) y(K).$$

Therefore,

$$p(K, \alpha_U) = \theta^*(K, \alpha_U) y(K).$$

We further note that, when the manager does not liquidate project, she must be able to pay $p(K, \alpha_U)$ to the uninformed investors, which is enforced by the terms of the contract. Otherwise, she will be penalized by more than her private control rent G. This enforceability can be easily implemented by regulators observing firm's fundamental θ at $t = 2$.

Finally, the uninformed investors individual rationality (IR) must be satisfied. As a result, the termination threshold $\theta^*(K, \alpha_U)$ satisfies the following uninformed investor's IR constraint:

$$H\Big(\theta^*(K, \alpha_U)\Big)(1 - c)K + \Big(1 - H\Big(\theta^*(K, \alpha_U)\Big)\Big)\theta^*(K, \alpha_U) y(K) = \alpha_U K.$$

Case 2 (low debt). Suppose $1 - c - \alpha_U > 0$. Then, we need to consider how large the private reward of the manager is. In this case we need to consider when the following two payoffs (termination vs. continuation payoffs) meet

$$\underbrace{\theta^*(K, \alpha_U) y(K) - p(K, \alpha_U) + G}_{\text{continuation payoff}} = \underbrace{(1 - c - \alpha_U)K}_{\text{termination payoff}} \tag{15}$$

Suppose manager's protection G is sufficiently *large* so that

$$(1 - c - \alpha_U)K - G \leq 0.$$

In this case, then we are back to Case 1, as the above equality never holds.

Next, suppose that G is sufficiently *small* so that

$$(1-c-\alpha_U)K - G = ((1-c)K - G) - \alpha_U K > 0.$$

Thus, due to (15), we have $\theta^*(K,\alpha_U)y(K) - p(K,\alpha_U) > 0$. Moreover, the uninformed investors' individually rational (IR) constraint is also satisfied because

$$\underbrace{H\Big(\theta^*(K,\alpha_U)\Big)\alpha_U K}_{\substack{\text{ex-ante termination payoff}\\ \text{of uninformed investors}}} + \underbrace{\Big(1 - H\Big(\theta^*(K,\alpha_U)\Big)\Big)\theta^*(K,\alpha_U)y(K)}_{\substack{\text{ex-ante continuation payoff}\\ \text{of uninformed investors}}} \geq \alpha_U K.$$

and the above IR constraint binds when $p(K,\alpha_U) = \alpha_U K$. Hence,

$$\theta^*(K,\alpha_U)y(K) = (1-c)K - G.$$

Putting together when debt is small, ie. $\alpha_U < 1-c$, the termination rule $\theta^*(K,\alpha_U)$ is given by

$$\theta^*(\alpha_U)y(K) = \max\{(1-c)K - G, \alpha_U K\}.$$

Payment rule $p(K,\alpha_U)$: Finally, we note that the payment rule $p(K,\alpha_U)$ (both in high and low debt cases) is characterized by the uninformed investors' IR constraint. That is, in the high debt case (i.e., $\alpha_U \geq 1-c$) $p(K,\alpha_U)$ satisfies

$$H\Big(\theta^*(K,\alpha_U)\Big)(1-c)K + \Big(1 - H\Big(\theta^*(K,\alpha_U)\Big)\Big)p(K,\alpha_U) = \alpha_U K,$$

and in the in the low debt case (i.e., $\alpha_U \leq 1-c$) $p(K,\alpha_U)$ satisfies

$$H\Big(\theta^*(K,\alpha_U)\Big)\alpha_U K + \Big(1 - H\Big(\theta^*(K,\alpha_U)\Big)\Big)p(K,\alpha_U) = \alpha_U K.$$

□

Proposition 1. *If $\alpha_U = 1-c$ then $\theta^*(K,\alpha_U) = \theta^{opt}(K)$. If $G > 0$ then the converse also holds.*

Proof of Proposition 1. Fix K. Given that $\theta^{opt}(K) = \frac{(1-c)K}{y(K)}$, the proof immediately follows by Lemma 1. □

Proposition 2. *The liquidation threshold is increasing in the firm's debt ratio:*

$$\frac{\partial \theta^*(K,\alpha_U)}{\partial \alpha_U} \geq 0$$

Consequently, if $\alpha_U > 1-c$, the manager excessively liquidates the project,

$$\theta^*(K,\alpha_U) > \theta^{opt}(K).$$

If $\alpha_U < 1-c$ and $G > 0$, the manager excessively continues the project,

$$\theta^*(K,\alpha_U) < \theta^{opt}(K).$$

Proof of Proposition 2. Let $\alpha \equiv 1-\alpha_U$. Thus, to prove the claim it is sufficient to show $\frac{\partial\theta^*(K,\alpha_U)}{\partial\alpha} \leq 0$. To do this, we need to consider two cases (high debt and low debt). Throughout fix K.

Case1. Low debt $(1-c > \alpha_U)$. In this case depending on the size of the manager's private rent (managerial protection), G, the termination threshold satisfies $\theta^*(K,\alpha_U)y(K) = \max\{(1-c)K-G, \alpha_U K\} = \max\{(1-c)K-G,(1-\alpha)K\}$. Therefore, rearranging gives

$$\theta^*(K,\alpha_U) = \max\{\frac{(1-c)K-G}{y(K)}, \frac{(1-\alpha)K}{y(K)}\}.$$

Suppose $(1-c)K-G < (1-\alpha)K$. Then, using the implicit function theorem, we have $\frac{\partial\theta^*(K,\alpha_U)}{\partial\alpha} = \frac{-K}{y(K)} < 0$. And, when $(1-c)K-G > (1-\alpha)K$, then $\theta^*(K,\alpha_U) = \frac{(1-c)K-G}{y(K)}$ thus $\frac{\partial\theta^*(K,\alpha_U)}{\partial\alpha} = 0$. Putting together, $\frac{\partial\theta^*(K,\alpha_U)}{\partial\alpha} \leq 0$.

Case2. High debt $(1-c < \alpha_U)$. For ease of notation let us denote the termination threshold by ℓ. In this case, the termination threshold satisfies the uninformed investor's IR constraint:

$$H(\ell)(1-c)K + (1-H(\ell))\ell y(K) = \alpha_U K = (1-\alpha)K.$$

We need to first show such threshold exists. Let us define for $\ell \geq \theta^{opt}(K) = \frac{(1-c)K}{y(K)}$,

$$\gamma(\ell) \equiv H(\ell)(1-c)K + \Big(1-H(\ell)\Big)\ell y(K) - \alpha_U K.$$

Thus, $\gamma(\frac{(1-c)K}{y(K)}) < 0$. As a result, the termination threshold is bigger that $\frac{(1-c)K}{y(K)}$. Taking derivative w.r.t. ℓ and substituting $(1-c)K$ by $\theta^{opt}(K)y(K)$ imply

$$\gamma'(\ell) = \Bigg[y(K) + \Big(\theta^{opt}(K) - \ell\Big)\frac{y(K)h(\ell)}{1-H(\ell)}\Bigg]\Big(1-H(\ell)\Big).$$

Clearly, $\lim_{\ell\uparrow\theta^{opt}(K)} \gamma'(\ell) > 0$. However, since (by the monotone hazard rate assumption) $\frac{h(\ell)}{1-H(\ell)}$ is increasing ℓ, thus

$$\lim_{\ell\to\infty}\left[y(K)+\Big(\theta^{opt}(K)-\ell\Big)\frac{y(K)h(\ell)}{1-H(\ell)}\right]=-\infty.$$

Moreover, $y(K)+\Big(\theta^{opt}(K)-\ell\Big)\frac{y(K)h(\ell)}{1-H(\ell)}$ is decreasing in ℓ, thus, there exists a unique $\tilde{\ell}$ so that

$$\gamma'(\tilde{\ell})=0.$$

Hence, $\tilde{\ell}$ is the unique maximizer of $\gamma(\ell)$. Clearly, if $\gamma(\tilde{\ell})\le 0$ then the IR constraint is always violated (i.e., issuing debt is impossible). So, $\gamma(\tilde{\ell})>0$ and there exists $\theta^*(K,\alpha_U)$ (where $\theta^{opt}(K)<\theta^*(K,\alpha_U)<\tilde{\ell}$) so that $\gamma(\theta^*(K,\alpha_U))=0$, that is

$$\begin{aligned}\gamma(\theta^*(K,\alpha_U)) &= H\Big(\theta^*(K,\alpha_U)\Big)(1-c)K+\Big(1-H\Big(\theta^*(K,\alpha_U)\Big)\Big)\theta^*(K,\alpha_U)y(K)-(1-\alpha)K\\ &=0\end{aligned}$$

Next, using the implicit function theorem, we have $\frac{\partial\theta^*(K,\alpha_U)}{\partial\alpha}\gamma'\Big(\theta^*(K,\alpha_U)\Big)+K=0$, thus

$$\frac{\partial\theta^*(K,\alpha_U)}{\partial\alpha}=\frac{-K}{\gamma'(\theta^*(K,\alpha_U))}<0,$$

where the last inequality follows because $\gamma'(\ell)>0$ for $\theta^{opt}(K)<\ell<\tilde{\ell}$, finishing the proof. □

Proposition 3. *There exists a unique interior capital level $K^{opt}\in(0,\infty)$ that solves (9) and satisfies the first order condition*

$$1=(1-c)H\Big(\theta^{opt}(K^{opt})\Big)+y'(K^{opt})\int_{\theta^{opt}(K^{opt})}^{\infty}\theta\,dH(\theta). \tag{10}$$

Proof of Proposition 3. We prove it in two steps. We first show that K^{opt} exists. Then, we show that it is unique.

Step 1. (Existence) Taking a derivate w.r.t. K from (9) and dividing by $1-H\Big(\theta^{opt}(K)\Big)$

imply

$$y'(K)\mathbf{E}[\theta|\theta > \theta^{opt}(K)] - 1 - \frac{H\Big(\theta^{opt}(K)\Big)}{1 - H\Big(\theta^{opt}(K)\Big)}(1-c) \tag{16}$$

To show that the above equation has a solution we use continuity and the Rolle's theorem. We note that since $y(\cdot)$ (by assumption) is concave and increasing, thus $y'(K) \leq \frac{y(K)}{K}$. Next, recall that $\theta^{opt}(K) = \frac{(1-c)K}{y(K)}$. Therefore, since $y'(K) \leq \frac{y(K)}{K}$, thus $\theta^{opt}(K)$ is increasing in K. Moreover, since $y'(0) = \infty$, and $y'(\infty) = 0$, thus $\lim_{K\to 0} \theta^{opt}(K) = 0$ and $\lim_{K\to\infty} \theta^{opt}(K) = \infty$. Therefore,

$$\lim_{K\to 0} y'(K)\mathbf{E}\Big[\theta|\theta > \theta^{opt}(K)\Big] - 1 = \infty$$

and

$$\lim_{K\to 0} \frac{H\Big(\theta^{opt}(K)\Big)}{1 - H\Big(\theta^{opt}(K)\Big)}(1-c) = 0.$$

Thus,

$$\lim_{K\to 0} \left[y'(K)\mathbf{E}[\theta|\theta > \theta^{opt}(K)] - 1 - \frac{H\Big(\theta^{opt}(K)\Big)}{1 - H\Big(\theta^{opt}(K)\Big)}(1-c) \right] = \infty. \tag{17}$$

Next, we consider when $K \to \infty$. Recall that $y'(K) \leq \frac{y(K)}{K}$, thus $\theta^{opt}(K)y'(K) < 1 - c < 1$. Moreover, one can show that (using the assumption that $\ln h(\theta)$ is concave):

$$\frac{H\Big(\theta^{opt}(K)\Big)}{1 - H\Big(\theta^{opt}(K)\Big)} \left(\mathbf{E}\Big[\theta|\theta > \theta^{opt}(K)\Big] - \theta^{opt}(K) \right) \leq 1.$$

Thus, given that $\theta^{opt}(K) = \frac{(1-c)K}{y(K)}$, we must have

$$y'(K)\mathbf{E}\Big[\theta|\theta > \theta^{opt}(K)\Big] - 1 < \frac{y'(K)}{\frac{H\big(\theta^{opt}(K)\big)}{1-H\big(\theta^{opt}(K)\big)}}$$

Note that

$$\lim_{K\to\infty}\{\frac{y'(K)}{\frac{H\left(\theta^{opt}(K)\right)}{1-H\left(\theta^{opt}(K)\right)}}\}=0,$$

because $y'(\infty)=0$. Therefore, since $\lim_{K\to\infty}H\left(\theta^{opt}(K)\right)=1$, thus

$$\lim_{K\to\infty}\left[y'(K)\mathbf{E}\left[\theta|\theta>\theta^{opt}(K)\right]-1-\frac{H\left(\theta^{opt}(K)\right)}{1-H\left(\theta^{opt}(K)\right)}(1-c)\right]=-\infty. \tag{18}$$

Putting (17) and (18) together along with continuity of (16) imply that the solution K^{opt} exists.

Step 2. (Uniqueness) To prove the uniqueness we establish that

$$\frac{\partial}{\partial K}\left(y'(K)\mathbf{E}\left[\theta|\theta>\theta^{opt}(K)\right]-1-\frac{H\left(\theta^{opt}(K)\right)}{1-H\left(\theta^{opt}(K)\right)}(1-c)\right)<0.$$

Recall that $\frac{\partial\theta^{opt}(K)}{\partial K}>0$. Thus,

$$\frac{\partial}{\partial K}\left[\frac{H\left(\theta^{opt}(K)\right)}{1-H\left(\theta^{opt}(K)\right)}(1-c)\right]>0.$$

Therefore, to prove that above claim, we only need to show that

$$\frac{\partial\theta^{opt}(K)}{\partial K}\,y'(K)\frac{\partial\mathbf{E}[\theta|\theta>\theta^{opt}(K)]}{\partial\theta^{opt}(K)}+y''(K)\mathbf{E}\left[\theta|\theta>\theta^{opt}(K)\right]<0.$$

It is clear that

$$\frac{\partial\theta^{opt}(K)}{\partial K}\,y'(K)\frac{\partial\mathbf{E}[\theta|\theta>\theta^{opt}(K)]}{\partial\theta^{opt}(K)}>0$$

(because $\frac{\partial\theta^{opt}(K)}{\partial K}>0,\ y'(K)>0,\frac{\partial\mathbf{E}[\theta|\theta>\theta^{opt}(K)]}{\partial\theta^{opt}(K)}>0$) and

$$y''(K)\mathbf{E}\left[\theta|\theta>\theta^{opt}(K)\right]<0,$$

(because $y(\cdot)$ is concave).

Next, note that $\frac{\partial \theta^{opt}(K)}{\partial K} = \frac{1-c-\theta^{opt}(K)y'(K)}{y(K)} > 0$ and $0 \leq \frac{\partial \mathbf{E}[\theta|\theta>\theta^{opt}(K)]}{\partial \theta^{opt}(K)} \leq 1$, thus

$$\begin{aligned}
&\frac{\partial \theta^{opt}(K)}{\partial K} y'(K) \frac{\partial \mathbf{E}[\theta|\theta > \theta^{opt}(K)]}{\partial \theta^{opt}(K)} + y''(K)\mathbf{E}[\theta|\theta > \theta^{opt}(K)] \\
&< y''(K)\mathbf{E}[\theta|\theta > \theta^{opt}(K)] + (1-c)\frac{y'(K)}{y(K)} - \theta^{opt}(K)\frac{y'(K)^2}{y(K)} \\
&< (1-c)\frac{y'(K)}{y(K)} + \theta^{opt}(K)\left(y''(K) - \frac{y'(K)^2}{y(K)}\right) \\
&= (1-c)\left(\frac{y'(K)}{y(K)} + K[\frac{d}{dK}\left(\frac{y'(K)}{y(K)}\right)]\right)
\end{aligned}$$

Now, recall that $y'(\cdot)$ and $\frac{1}{y(K)}$ are convex and decreasing, and thus $\frac{y'(K)}{y(K)}$ is convex and decreasing.[17] As a result,

$$\frac{y'(K)}{y(K)} + K[\frac{d}{dK}\left(\frac{y'(K)}{y(K)}\right)] < 0$$

so the upper bound is negative, finishing the proof. □

Proposition 4. *If $\alpha_U > 1-c$, then $K^*(\alpha_U) < K^{opt}$.*

Proof of Proposition 4. When debt is high, due to Proposition 2, we have $\theta^*(K, \alpha_U) > \theta^{opt}(K)$. Thus, $K^*(\alpha_U)$ solves

$$K^*(\alpha_U) \in \arg\max_K \left\{ H\Big(\theta^{opt}(K)\Big)(1-c)K + \int_{\theta^{opt}(K)}^{\infty} \theta y(K) dH(\theta) - K - \mathsf{C}_{h.\ debt} \right\} \tag{19}$$

where the high debt **cost term** is

$$\mathsf{C}_{h.\ debt} \equiv \int_{\theta^{opt}(K)}^{\theta^*(K,\alpha_U)} K(\frac{\theta y(K)}{K} - (1-c))dH(\theta).$$

Clearly, the derivative of

$$H\Big(\theta^{opt}(K)\Big)(1-c)K + \int_{\theta^{opt}(K)}^{\infty} \theta y(K) dH(\theta) - K$$

evaluated at $K = K^{opt}$ is zero (by (10)). Hence, to prove the claim we only need to show

[17] Note that for any convex and decreasing function $\phi(x)$ we have $|\phi'(x)| > \frac{\phi(x)}{x}$.

that the derivative of the high debt **cost term** $\mathsf{C}_{h.\ debt}$ evaluated at $K = K^{opt}$ is positive.[18]

We prove this statement in several steps.

It observes that

$$\frac{d\mathsf{C}_{h.\ debt}}{dK} = \int_{\theta^{opt}(K)}^{\theta^*(K,\alpha_U)} \Big(\theta y'(K) - (1-c)\Big) dH(\theta) + \frac{\partial \theta^*(K,\alpha_U)}{\partial K} h\Big(\theta^*(K,\alpha_U)\Big)\Big(\theta^*(K,\alpha_U) y(K) - (1-c)K\Big).$$

Note that

$$(1-c)K = \theta^{opt}(K) y(K)$$

and

$$(1-c) = \frac{\partial \theta^{opt}(K)}{\partial K} y(K) + \theta^{opt}(K) y'(K).$$

Therefore,

$$\begin{aligned}\frac{d\mathsf{C}_{h.\ debt}}{dK} &\geq \frac{\partial \theta^{opt}(K)}{\partial K} y(K)\Big(H\Big(\theta^*(K,\alpha_U)\Big) - H(\theta^{opt}(K))\Big) + \frac{\partial \theta^*(K,\alpha_U)}{\partial K}\Big(\theta^*(K,\alpha_U) - \theta^{opt}(K)\Big) \\ &= y(K)\Big[-\frac{\partial \theta^{opt}(K)}{\partial K}\Big(\frac{\alpha_U}{1-c} - H(\theta^{opt}(K))\Big) + \frac{\partial \theta^*(K,\alpha_U)}{\partial K}\Big(1 - H\Big(\theta^*(K,\alpha_U)\Big)\Big)\Big],\end{aligned}$$

where the last equality follows from differentiating (4) with respect to K.

Next to finish the proof, we show that

$$-\frac{\partial \theta^{opt}(K)}{\partial K}\Big(\frac{\alpha_U}{1-c} - H(\theta^{opt}(K))\Big) + \frac{\partial \theta^*(K,\alpha_U)}{\partial K}\Big(1 - H\Big(\theta^*(K,\alpha_U)\Big)\Big) > 0. \tag{21}$$

Note that differentiating (4) with respect to K implies that

$$\begin{aligned}&\frac{\partial \theta^*(K,\alpha_U)}{\partial K}\Big[1 - H\Big(\theta^*(K,\alpha_U)\Big) - \Big(\theta^*(K,\alpha_U) - \theta^{opt}(K)\Big) h\Big(\theta^*(K,\alpha_U)\Big)\Big] \\ &= \frac{\partial \theta^{opt}(K)}{\partial K}\Big[\frac{\alpha_U}{1-c} - H(\theta^{opt}(K)) - \Big(H\Big(\theta^*(K,\alpha_U)\Big) - H(\theta^{opt}(K))\Big)\Big]\end{aligned}$$

[18] In more details, consider the F.O.C. of (19) w.r.t. K implying

$$0 = \Big(H(\theta^{opt}(K))(1-c) - 1 + \int_{\theta^{opt}(K)}^{\infty} \theta y'(K) dH(\theta)\Big) - \frac{d\mathsf{C}_{h.\ debt}}{dK}. \tag{20}$$

When K goes to zero, then $H(\theta^{opt}(K))(1-c) - 1 + \int_{\theta^{opt}(K)}^{\infty} \theta y'(K) dH(\theta)$ goes to infinity and $\frac{d\mathsf{C}_{h.\ debt}}{dK}$ goes to zero. Hence, the R.H.S. in (20) goes to infinity. Moreover, when $K = K^{opt}$ (using Proposition 3), then $H(\theta^{opt}(K))(1-c) - 1 + \int_{\theta^{opt}(K)}^{\infty} \theta y'(K) dH(\theta) = 0$. Hence, to prove the main result, we only need to show that $\frac{d\mathsf{C}_{h.\ debt}}{dK}|_{K=K^{opt}} > 0$, implying $K^*(\alpha_U) < K^{opt}$.

therefore, showing (21) is equivalent to show

$$\left(\frac{\alpha_U}{1-c} - H(\theta^{opt}(K))\right)\left(\theta^*(K,\alpha_U) - \theta^{opt}(K)\right)h\left(\theta^*(K,\alpha_U)\right)$$
$$> \left(1 - H\left(\theta^*(K,\alpha_U)\right)\right)\left(H\left(\theta^*(K,\alpha_U)\right) - H(\theta^{opt}(K))\right) \tag{22}$$

To show (22) we first note that since $\alpha_U > 1-c$ and $\theta^{opt}(K) < \theta^*(K,\alpha_U)$ thus

$$\frac{\alpha_U}{1-c} - H(\theta^{opt}(K)) > 1 - H(\theta^{opt}(K)) > 1 - H\left(\theta^*(K,\alpha_U)\right) \tag{23}$$

In addition, when $H(\cdot)$ is convex in the set $[\theta^{opt}(K), \theta^*(K,\alpha_U)]$ then

$$h\left(\theta^*(K,\alpha_U)\right) > \frac{H\left(\theta^*(K,\alpha_U)\right) - H(\theta^{opt}(K))}{\theta^*(K,\alpha_U) - \theta^{opt}(K)} \tag{24}$$

and (23) and (24) together show (22).

Similarly, when $G(\cdot)$ is concave in the set $[\theta^{opt}(K), \theta^*(K,\alpha_U)]$ then since $\frac{h(z)}{1-H(z)}$ is increasing in z (the monotone hazard rate assumption) and $\theta^{opt}(K) < \theta^*(K,\alpha_U)$ thus

$$\frac{1 - H\left(\theta^*(K,\alpha_U)\right)}{1 - H(\theta^{opt}(K))} \le \frac{h\left(\theta^*(K,\alpha_U)\right)}{h(\theta^*)} \le \left(\frac{\theta^*(K,\alpha_U) - \theta^{opt}(K)}{H\left(\theta^*(K,\alpha_U)\right) - H(\theta^{opt}(K))}\right)h\left(\theta^*(K,\alpha_U)\right)$$

and as a consequence,

$$\left(1 - H(\theta^{opt}(K))\right)\left(\theta^*(K,\alpha_U) - \theta^{opt}(K)\right)h\left(\theta^*(K,\alpha_U)\right)$$
$$\ge \left(1 - H\left(\theta^*(K,\alpha_U)\right)\right)\left(H\left(\theta^*(K,\alpha_U)\right) - H(\theta^{opt}(K))\right) \tag{25}$$

Replacing $1 - H(\theta^{opt}(K))$ with $\frac{\alpha_U}{1-c} - H(\theta^{opt}(K))$ in (25) and noting $\frac{\alpha_U}{1-c} - H(\theta^{opt}(K)) > 1 - H(\theta^{opt}(K))$ finish the proof.[19]

□

Lemma 2. *The termination threshold increases in the level of investment:* $\frac{\partial \theta^*(K,\alpha_U)}{\partial K} \ge 0$.

Proof of Lemma 2. To prove the claim, we need to consider two cases (high debt and low debt).

[19]Notice that in the case where $H(\cdot)$ is convex in $\theta^{opt}(K)$ and concave in $\theta^*(K,\alpha_U)$ similar analysis hold. In this case (due to the Rolle's theorem) there exists $\tilde{\theta} \in [\theta^{opt}(K), \theta^*(K,\alpha_U)]$ so that $H'(\tilde{\theta}) = \frac{H(\theta^*(K,\alpha_U)) - H(\theta^{opt}(K))}{\theta^*(K,\alpha_U) - \theta^{opt}(K)}$
.

Case1. Low debt $(1-c>\alpha_U)$. In this case depending on the size of the manager's private rent (managerial protection), G, the termination threshold satisfies $\theta^*(K,\alpha_U)y(K) = \max\{(1-c)K-G, \alpha_U K\} = \max\{(1-c)K-G, \alpha_U K\}$. Therefore, rearranging gives

$$\theta^*(K,\alpha_U) = \max\{\frac{(1-c)K-G}{y(K)}, \frac{\alpha_U K}{y(K)}\}.$$

Suppose $(1-c)K - G > \alpha_U K$. Then, $\theta^*(K,\alpha_U) = \frac{(1-c)K-G}{y(K)}$. Since $y(K)$ is increasing and concave thus $\frac{-1}{y(K)}$ and $\frac{K}{y(K)}$ are both increasing, thus $\theta^*(K,\alpha_U)$ is increasing in K. A similar argument holds when $\theta^*(K,\alpha_U) = \frac{(1-\alpha)K}{y(K)}$. Therefore, $\theta^*(K,\alpha_U)$ is increasing in K, i.e., $\frac{\partial\theta^*(K,\alpha_U)}{\partial K} \geq 0$.

Case2. High debt $(1-c<\alpha_U)$. For ease of notation let us denote the termination threshold by ℓ. In this case, the termination threshold satisfies the uninformed investor's IR constraint:

$$H(\ell)(1-c)K + (1-H(\ell))\ell y(K) = (1-\alpha)K = \alpha_U K.$$

We need to first show such threshold exists. Let us define for $\ell \geq \theta^{opt}(K) = \frac{(1-c)K}{y(K)}$,

$$\gamma(\ell) \equiv H(\ell)(1-c)K + \Big(1-H(\ell)\Big)\ell y(K) - \alpha_U K.$$

Thus, $\gamma(\frac{(1-c)K}{y(K)}) < 0$. As a result, the termination threshold is bigger that $\frac{(1-c)K}{y(K)}$. Taking derivative w.r.t. ℓ and substituting $(1-c)K$ by $\theta^{opt}(K)y(K)$ imply

$$\gamma'(\ell) = \left[y(K) + \Big(\theta^{opt}(K) - \ell\Big)\frac{y(K)h(\ell)}{1-H(\ell)}\right]\Big(1-H(\ell)\Big).$$

Clearly, $\lim_{\ell\uparrow\theta^{opt}(K)}\gamma'(\ell) > 0$. However, since (by the monotone hazard rate assumption) $\frac{h(\ell)}{1-H(\ell)}$ is increasing ℓ, thus

$$\lim_{\ell\to\infty}\left[y(K) + \Big(\theta^{opt}(K) - \ell\Big)\frac{y(K)h(\ell)}{1-H(\ell)}\right] = -\infty.$$

Moreover,

$$y(K) + \Big(\theta^{opt}(K) - \ell\Big)\frac{y(K)h(\ell)}{1-H(\ell)}$$

is decreasing in ℓ, thus, there exists a unique $\tilde{\ell}$ so that

$$\gamma'(\tilde{\ell}) = 0.$$

Hence, $\tilde{\ell}$ is the unique maximizer of $\gamma(\ell)$. Clearly, if $\gamma(\tilde{\ell}) \leq 0$ then the IR constraint is always violated (i.e., issuing debt is impossible). So, $\gamma(\tilde{\ell}) > 0$ and there exists $\theta^*(K, \alpha_U)$ (where $\theta^{opt}(K) < \theta^*(K, \alpha_U) < \tilde{\ell}$) so that $\gamma(\theta^*(K, \alpha_U)) = 0$, that is

$$\begin{aligned}\gamma(\theta^*(K, \alpha_U)) &= H\Big(\theta^*(K, \alpha_U)\Big)(1-c)K + \Big(1 - H\Big(\theta^*(K, \alpha_U)\Big)\Big)\theta^*(K, \alpha_U)y(K) - \alpha_U K \\ &= 0,\end{aligned}$$

and $\gamma'(\ell) > 0$ for $\theta^{opt}(K) < \ell < \tilde{\ell}$.

Next, by the implicit function theorem, we have

$$\frac{\partial \theta^*(K, \alpha_U)}{\partial K}\gamma'(\theta^*(K, \alpha_U)) + H\Big(\theta^*(K, \alpha_U)\Big)(1-c) + \Big(1 - H\Big(\theta^*(K, \alpha_U)\Big)\Big)\theta^*(K, \alpha_U)y'(K) - \alpha_U = 0.$$

Therefore,

$$\begin{aligned}\frac{\partial \theta^*(K, \alpha_U)}{\partial K} &= \frac{-1}{\gamma'\Big(\theta^*(K, \alpha_U)\Big)}\Big[H\Big(\theta^*(K, \alpha_U)\Big)(1-c) + \Big(1 - H\Big(\theta^*(K, \alpha_U)\Big)\Big)\theta^*(K, \alpha_U)y'(K) - \alpha_U\Big] \\ &> 0.\end{aligned}$$

The last equality follows, because $\gamma'\Big(\theta^*(K, \alpha_U)\Big) > 0$ and

$$H\Big(\theta^*(K, \alpha_U)\Big)(1-c) + \Big(1 - H(\theta^*(K, \alpha_U))\Big)\theta^*(K, \alpha_U)y'(K) - \alpha_U < 0,$$

because $y'(K) < \frac{y(K)}{K}$ and

$$\gamma\Big(\theta^*(K, \alpha_U)\Big) = H\Big(\theta^*(K, \alpha_U)\Big)(1-c)K + \Big(1 - H\Big(\theta^*(K, \alpha_U)\Big)\Big)\theta^*(K, \alpha_U)y(K) - \alpha_U K = 0,$$

finishing the proof. □

Proposition 5. *Suppose that the debt ratio is less than the efficient level, or $\alpha_U < 1 - c$. If there are no managerial protections, or $G = 0$, then the level of investment is equal to the first-best benchmark and there is no distortion:*

$$K^*(\alpha_U) = K^{opt} = K^*(1-c)$$

If there are managerial protections, or $G > 0$, then the conditionally efficient level of investment can in general be greater or less than the first-best benchmark. If the debt ratio is low enough, or $\alpha_U \leq 1 - c - \frac{G}{K^{opt}}$, and H is strictly concave then investment is distorted upwards, or $K^*(\alpha_U) >$

K^{opt}. *If the cdf for the return distribution H is weakly convex, then the conditionally efficient level of investment is distorted downwards, or $K^*(\alpha_U) \le K^{opt}$.*

Proof of Proposition 5. We prove the proposition in the following two parts.

Concave $H(\cdot)$ with low debt ratio capital structure. When $\alpha_U < 1 - c$ (i.e., low debt), due to Proposition 2, we have $\theta^*(K, \alpha_U) < \theta^{opt}(K)$. Thus, $K^*(\alpha_U)$ solves

$$K^*(\alpha_U) \in \arg\max_K \left\{ H\Big(\theta^{opt}(K)\Big)(1-c)K + \int_{\theta^{opt}(K)}^{\infty} \theta y(K) dH(\theta) - K - \mathsf{C}_{l.\ debt} \right\}$$

where the low debt **cost term** is

$$\mathsf{C}_{l.\ debt} \equiv \int_{\theta^*(K,\alpha_U)}^{\theta^{opt}} K\left(1 - c - \frac{\theta y(K)}{K}\right) dH(\theta).$$

Clearly, the derivative of

$$H\Big(\theta^{opt}(K)\Big)(1-c)K + \int_{\theta^{opt}(K)}^{\infty} \theta y(K) dH(\theta) - K$$

evaluated at $K = K^{opt}$ is zero (by (10)). Hence, to prove the claim we only need to show that the derivative of the low debt **cost term** $\mathsf{C}_{l.\ debt}$ evaluated at $K = K^{opt}$ is negative.

Moreover, when $\alpha_U < 1 - c$ then (due to (2))

$$\theta^*(K, \alpha_U) y(K) = \max\{(1-c)K - G, \alpha_U K\}.$$

Suppose that at $K = K^{opt}$ we have

$$\max\{(1-c)K^{opt} - G, \alpha_U K^{opt}\} = (1-c)K^{opt} - G$$

(which is ensured when $K^{opt} > \frac{G}{1-c-\alpha_U}$). Therefore,

$$\theta^*(K^{opt}, \alpha_U) y(K^{opt}) = (1-c)K^{opt} - G$$

and taking a derivative w.r.t. K implies

$$\frac{\partial \theta^*(K^{opt}, \alpha_U)}{\partial K} y(K^{opt}) + \theta^*(K^{opt}, \alpha_U) y'(K^{opt}) = 1 - c. \tag{26}$$

Next, to finish the proof, using (26), we show that the margin of the low debt **cost term** $\mathsf{C}_{l.\ debt}$ evaluated at $K = K^{opt}$ is negative.

$$
\begin{aligned}
\frac{d\mathsf{C}_{l.\ debt}}{dK} &= -\frac{\partial\theta^*(K,\alpha_U)}{\partial K} h(\theta^*(K,\alpha_U))\Big((1-c)K - \theta^*(K,\alpha_U)y(K)\Big) \\
&\qquad + \int_{\theta^*(K,\alpha_U)}^{\theta^{opt}(K)} (1-c-\theta y'(K))dH(\theta) \\
&\leq -\frac{\partial\theta^*(K,\alpha_U)}{\partial K} h(\theta^*(K,\alpha_U))\Big((1-c)K - \theta^*(K,\alpha_U)y(K)\Big) \\
&\qquad + \Big(H(\theta^{opt}(K)) - H(\theta^*(K,\alpha_U)\Big)\Big(1-c-\theta^*(K,\alpha_U)y'(K)\Big) \\
&= -\frac{\partial\theta^*(K,\alpha_U)}{\partial K} h(\theta^*(K,\alpha_U))\Big((1-c)K - \theta^*(K,\alpha_U)y(K)\Big) + \\
&\qquad \Big(H(\theta^{opt}(K)) - H(\theta^*(K,\alpha_U)\Big)\frac{\partial\theta^*(K,\alpha_U)}{\partial K} y(K) \\
&= \frac{\partial\theta^*(K,\alpha_U)}{\partial K} y(K)\Bigg(H(\theta^{opt}(K)) - H(\theta^*(K,\alpha_U)) - \Big(\theta^{opt}(K) - \theta^*(K,\alpha_U)\Big)h(\theta^*(K,\alpha_U))\Bigg) \\
&< 0,
\end{aligned}
$$

where the last inequality follows because $\frac{\partial\theta^*(K,\alpha_U)}{\partial K} \geq 0$ and

$$
H(\theta^{opt}(K)) - H(\theta^*(K,\alpha_U)) - \Big(\theta^{opt}(K) - \theta^*(K,\alpha_U)\Big)h(\theta^*(K,\alpha_U)) < 0,
$$

because $H(\cdot)$ is concave (using the Taylor expansions). As a consequence, the margin of the low debt cost term is negative at K^{opt}, implying that $K^*(\alpha_U) > K^{opt}$.

Convex and weakly convex (e.g., Uniform distribution) $H(\cdot)$ with low debt ratio capital structure. It is also possible to show that managerial protections can be associated with less investment for firms with low debt ratios, or $\alpha_U < 1-c$. In this section we show if the cdf for the return distribution H is weakly convex, then the conditionally efficient level of investment is less than the first-best benchmark, or $K^*(\alpha_U) \leq K^{opt}$.

Here we show when debt ratio is low and the distribution of θ is uniform (i.e., $\alpha_U < 1-c$ and $H(\cdot) \sim \text{Uniform}[a,b]$) then (similar to the high debt capital structure environment) we obtain $K^*(\alpha_U) \leq K^{opt}$. A similar result identically holds when the cdf $H(\cdot)$ is weakly convex on its compact support.

Recall that when $\alpha_U < 1-c$ (i.e., low debt), due to Proposition 2, we have $\theta^*(K,\alpha_U) < \theta^{opt}(K)$. Thus, then $K^*(\alpha_U)$ solves

$$
K^*(\alpha_U) \in \arg\max_K \left\{ H\Big(\theta^{opt}(K)\Big)(1-c)K + \int_{\theta^{opt}(K)}^{\infty} \theta y(K) dH(\theta) - K - \mathsf{C}_{l.\ debt} \right\}
$$

where the low debt **cost term** is

$$\mathsf{C}_{l.\ debt} \equiv \int_{\theta^*(K,\alpha_U)}^{\theta^{opt}} K\left(1 - c - \frac{\theta y(K)}{K}\right) dH(\theta).$$

Clearly, the derivative of

$$H\Big(\theta^{opt}(K)\Big)(1-c)K + \int_{\theta^{opt}(K)}^{\infty} \theta y(K) dH(\theta) - K$$

evaluated at $K = K^{opt}$ is zero (by (10)). Hence, to prove the claim that $K^*(\alpha_U) \leq K^{opt}$ we only need to show that the derivative of the low debt **cost term** $\mathsf{C}_{l.\ debt}$ evaluated at $K = K^{opt}$ is positive.

This claim follows because:

$$\begin{aligned}
\frac{d\mathsf{C}_{l.\ debt}}{dK} &= -\frac{\partial\theta^*(K,\alpha_U)}{\partial K} h(\theta^*(K,\alpha_U))\Big((1-c)K - \theta^*(K,\alpha_U)y(K)\Big) \\
&\qquad + \int_{\theta^*(K,\alpha_U)}^{\theta^{opt}(K)} (1 - c - \theta y'(K)) dH(\theta) \\
&\geq -\frac{\partial\theta^*(K,\alpha_U)}{\partial K} h(\theta^*(K,\alpha_U))\Big((1-c)K - \theta^*(K,\alpha_U)y(K)\Big) \\
&\qquad + \Big(H(\theta^{opt}(K)) - H(\theta^*(K,\alpha_U))\Big)\Big(1 - c - \theta^{opt}(K)y'(K)\Big) \\
&= -\frac{\partial\theta^*(K,\alpha_U)}{\partial K} h(\theta^*(K,\alpha_U))\Big((1-c)K - \theta^*(K,\alpha_U)y(K)\Big) \\
&\qquad + \Big(H(\theta^{opt}(K)) - H(\theta^*(K,\alpha_U))\Big)\frac{\partial\theta^{opt}(K)}{\partial K} y(K) \\
&\geq \frac{\partial\theta^*(K,\alpha_U)}{\partial K} y(K)\Big(H(\theta^{opt}(K)) - H(\theta^*(K,\alpha_U)) - \Big(\theta^{opt}(K) - \theta^*(K,\alpha_U)\Big)h(\theta^*(K,\alpha_U))\Big) \\
&= 0,
\end{aligned} \tag{27}$$

where the third relation follows because $(1-c)K = y(K)\theta^{opt}(K)$ and thus

$$1 - c = y'(K)\theta^{opt}(K) + \frac{\partial\theta^{opt}(K))}{\partial K} y(K);$$

the fourth relation follows because (due to supermodularity of the threshold $\theta^*(K,\alpha_U)$ in α_U and K) when $\theta^*(K,\alpha_U) < \theta^{opt}(K)$ we have

$$\frac{\partial\theta^*(K,\alpha_U)}{\partial K} < \frac{\partial\theta^*(K,1-c)}{\partial K} = \frac{\partial\theta^{opt}(K)}{\partial K}.$$

Finally, since the derivative of the low debt **cost term** $\mathsf{C}_{l.\ debt}$ evaluated at $K = K^{opt}$ is positive, thus $K^*(\alpha_U) \le K^{opt}$. Note that when $H(\cdot)$ is weakly convex on its compact support, then the last equality in (27) will be replaced by " $\ge$ " because for the convex C.D.F. $H(\cdot)$ we have

$$H(\theta^{opt}(K)) - H(\theta^*(K,\alpha_U)) - \Big(\theta^{opt}(K) - \theta^*(K,\alpha_U)\Big)h(\theta^*(K,\alpha_U)) \ge 0.$$

□

Proposition 6. *If there are no managerial protections, or $G = 0$, then the manager's preferred level of investment that maximizes his or her utility (equation (7)) for a given debt ratio α_U, $K_m(\alpha_U)$, is equal to the conditionally efficient level $K^*(\alpha_U)$. If there are managerial protections, or $G > 0$, then the manager's preferred level of investment is less than the conditionally efficient level, or $K_m(\alpha_U) < K^*(\alpha_U)$.*

Proof of Proposition 6. Suppose

$$K_m(\alpha_U) = \arg\max_K u_m = \arg\max_K \frac{\alpha_F}{1-\alpha_U} V\Big(K,\alpha_U\Big) + G\frac{\alpha_F}{1-\alpha_U}\Big(1 - H(\theta^*(K,\alpha_U))\Big).$$

Then, by the corresponding F.O.C. condition,

$$\frac{\partial u_m}{\partial K}\Big|_{K=K_m(\alpha_U)} = 0. \tag{28}$$

Moreover, as shown in section 2.4.2, we have

$$\frac{\partial V(K,\alpha_U)}{\partial K}\Big|_{K=K^*(\alpha_U)} = 0. \tag{29}$$

Then, evaluating $\frac{\partial u_m}{\partial K}$ at $K = K^*(\alpha_U)$ implies

$$\frac{\partial u_m}{\partial K}\Big|_{K=K^*(\alpha_U)} = \frac{\alpha_F}{1-\alpha_U}\left(\underbrace{\frac{\partial V(K,\alpha_U)}{\partial K}\Big|_{K=K^*(\alpha_U)}}_{=0,\text{ by (29)}} - G\, h\Big(\theta^*(K,\alpha_U)\Big)\underbrace{\frac{\partial \theta^*(K,\alpha_U)}{\partial K}\Big|_{K=K^*(\alpha_U)}}_{>0,\text{ by Lemma 2}}\right) < 0$$

the above inequality then shows that $\frac{\partial u_m}{\partial K}|_{K=K^*(\alpha_U)} < 0$, as a consequence, $K_m(\alpha_U) < K^*(\alpha_U)$ for all level of debt α_U. □

B Model: competitive equity market

The baseline model introduced in Section 2.1 assumes that informed investors obtain a fraction $\frac{\alpha_I}{1-\alpha_U}$ of the realized equity value. This section shows that Proposition 6, which broadly says that managerial protections can reduce a manager's preferred level of investment, is robust to alternatively assuming a competitive equity market in which the informed investors make zero rents, similar to the uninformed investors.

In that case, the individual rationality constraint for informed investors holds with equality, which implies

$$\lambda_I(K,\alpha_U) = \frac{\alpha_I K}{\int_{\theta^*(K,\alpha_U)}^{\infty} \theta y(K) dH(\theta) + H\Big(\theta^*(K,\alpha_U)\Big)(1-c)K - \alpha_U K} \tag{30}$$

where $\lambda_I(K,\alpha_U)$ is the *endogenous* shares from the realized equity value that goes to informed investors, contributing $\alpha_I K$ in investment. Note that $\lambda_I(K,\alpha_U)$ implies that the ex-ante individual rationality constraint for informed investors bind. Hence, informed investors and debt holders are ex-ante identical. Importantly, this complex object $\lambda_I(K,\alpha_U)$ does depend on K.

Given the competitive market for informed investors, the manager's problem, fixing α_F, is to solve

$$\max_{K_m,\alpha_U} u_m = \max_{K_m,\alpha_U} \underbrace{V(K,\alpha_U)}_{\text{ex-ante realized equity value}} + \underbrace{\Big(1-\lambda_I(K,\alpha_U)\Big)\, G\,\Big(1-H(\theta^*(K,\alpha_U))\Big)}_{\text{private benefit of control}} \tag{31}$$

where

$$V\Big(K,\alpha_U\Big) = H\Big(\theta^*(K,\alpha_U)\Big)\Big[((1-c)-\alpha_U)K\Big]^+ + \int_{\theta^*(K,\alpha_U)}^{\infty} \Big(\theta y(K) - p(K,\alpha_U)\Big) dH(\theta) - (1-\alpha_U)K$$

(see subsection 2.1) and $\Big(1-\lambda_I(K,\alpha_U)\Big)\, G\,\Big(1-H(\theta^*(K,\alpha_U))\Big)$ is the manager's private benefit of control given that the project is not terminated at $t=1$, which is proportional to multiplication of the manager's protection G and the manager's equity share $\Big(1-\lambda_I(K,\alpha_U)\Big)$, consistent with the logic in (1).

While $\lambda_I(K,\alpha_U)$ is endogenous and complex, the following proposition shows that we still have $K_m(\alpha_U) < K^*(\alpha_U)$. That is, even when informed investors, like debt-holders, are ex-ante in zero gain, i.e., their individual rationality constraint binds, the under-investment result in Proposition 6 still holds.

Proposition B.1. *Fix $\alpha_F < c$. Suppose the market for informed investors is competitive, i.e., informed investors' share from the realized equity value is*

$$\lambda_I(K, \alpha_U) = \frac{\alpha_I K}{\int_{\theta^*(K,\alpha_U)}^{\infty} \theta y(K) dH(\theta) + H\Big(\theta^*(K, \alpha_U)\Big)(1-c)K - \alpha_U K}.$$

Then, for all level of debt α_U, we have $K_m(\alpha_U) < K^*(\alpha_U)$.

Proof of Proposition B.1. The proof follows similar steps as in the proof of Proposition 6. To show that for all α_U, $K_m(\alpha_U) < K^*(\alpha_U)$, it is enough to prove that $\frac{\partial u_m}{\partial K}|_{K=K^*(\alpha_U)} < 0$. Note that since $\lambda_I(K, \alpha_U)$ depends on K, we first note that

$$\begin{aligned}
\frac{\partial \lambda_I(K, \alpha_U)}{\partial K}|_{K=K^*(\alpha_U)} &= \frac{\partial}{\partial K}\left\{\frac{\alpha_I K}{V(K, \alpha_U) + (1-\alpha_U)K}\right\}|_{K=K^*(\alpha_U)} \\
&= \left(\frac{V(K, \alpha_U) + (1-\alpha_U)K - K\Big(\frac{\partial V(K,\alpha_U)}{\partial K} + 1 - \alpha_U\Big)}{V(K, \alpha_U) + (1-\alpha_U)K}\right)\left(\frac{\alpha_I}{V(K, \alpha_U) + (1-\alpha_U)K}\right)|_{K=K^*(\alpha_U)} \\
&> 0 \qquad (32)
\end{aligned}$$

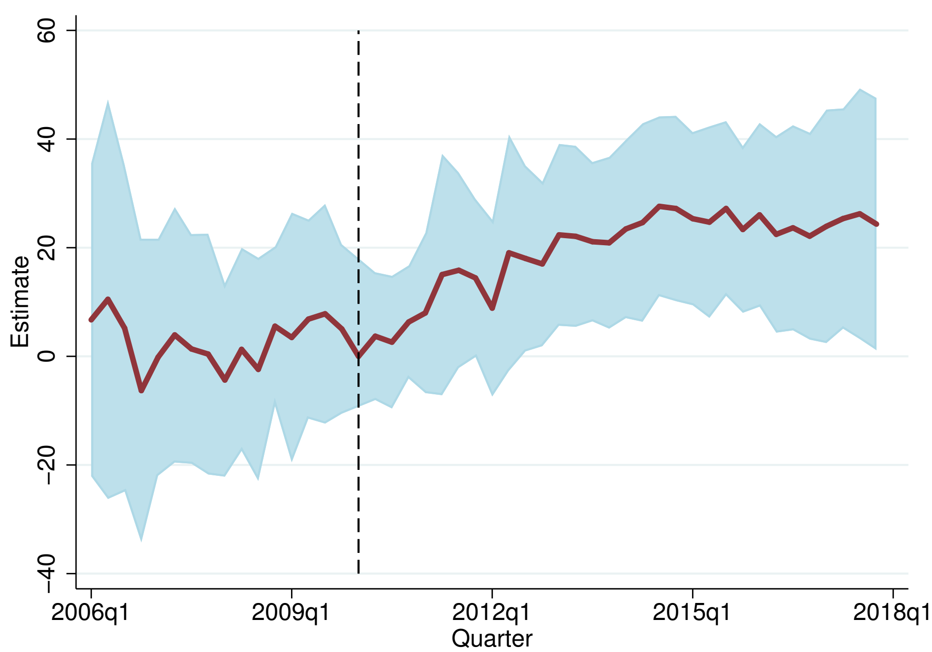
where that inequality follows by $\frac{\partial V(K,\alpha_U)}{\partial K}|_{K=K^*(\alpha_U)} = 0$, (as shown in section 2.4.2, see also (29). Using this result, next we have

$$\frac{\partial u_m}{\partial K}|_{K=K^*(\alpha_U)} = \underbrace{\frac{\partial V(K, \alpha_U)}{\partial K}|_{K=K^*(\alpha_U)}}_{=0, \text{ by } (29)} + \underbrace{\frac{\partial}{\partial K}\left(\Big(1 - \lambda_I(K, \alpha_U)\Big)\, G\,\Big(1 - H(\theta^*(K, \alpha_U))\Big)\right)|_{K=K^*(\alpha_U)}}_{<0, \text{ by } (32) \text{ and Lemma } 2} < 0,$$

(note that $\Big(1 - \lambda_I(K, \alpha_U)\Big)$ is decreasing in K, by (32), and $\Big(1 - H(\theta^*(K, \alpha_U))\Big)$ is decreasing in K by Lemma 2) finishing the proof. □

C Empirics: parallel trends

Figure 7: Difference-in-differences of loans on G-index for stress-tested bank holding companies (panel specification). This figure presents the estimates β_t from estimating the regression $Loans/assets_{it} = \sum_{t \neq 2010Q1} \beta_t highG_i \times STactive_t + \mathbf{X}'_{it-1}\gamma + \psi_i + \phi_t + \epsilon_{it}$, where $Loans/assets_{it}$ is the ratio of loans and unused commitments to assets for bank holding company (BHC) i at quarter t, $highG_i$ is an indicator for whether a BHC's 2006 G-index is above the median among the set of stress-tested BHCs, $STactive_t$ is an indicator for whether a quarter occurs on or after 2010Q1, ψ_i represents BHC fixed effects, ϕ_t represents year fixed effects, and $\mathbf{X}_{it-1}$ is a set of control variables that includes the fraction of tier 1 equity capital to assets, the fraction of non-performing loans, non-interest expenses to total assets, return on assets, the fraction of liquid assets, the difference between short-term assets and short-term liabilities divided by total assets, and the logarithm of total assets. Nominal variables are normalized to 2010Q4 dollars using the GDP deflator. The figure also presents 95% confidence intervals computed using BHC-clustered standard errors.



D Empirics: results

Table 3: Difference-in-differences regression of loans on G-index for stress-tested bank holding companies. This table presents results from estimating the regression $Loans/assets_{it} = \beta highG_i \times STactive_t + \mathbf{X}'_{it-1}\gamma + \psi_i + \phi_t + \epsilon_{it}$, where $Loans/assets_{it}$ is the ratio of loans and unused commitments to total assets for bank holding company (BHC) i at quarter t, $highG_i$ is an indicator for whether a BHC's 2006 G-index is greater than the median among the set of stress-tested BHCs, $STactive_t$ is an indicator for whether the quarter occurs on or after 2010Q1, ψ_i represents BHC fixed effects, ψ_t represents quarter fixed effects, and X_{it-1} is a set of control variables as described in Section 3.1. T-statistics computed using BHC-clustered standard errors are reported in parentheses. * indicates statistical significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level. Column (1) runs the estimation on the full sample. Column (2) runs the estimation on the subsample of BHCs with a dominantly concave return distribution. Column (3) runs the estimation on the subsample of BHCs with a dominantly convex return distribution.

	(1) Full sample	(2) Concave	(3) Convex
High G-index x stress tests active	16.002**	19.649***	-2.991
	(2.52)	(7.96)	(-0.69)
Observations	480	192	288
R^2	0.952	0.969	0.975
Controls	Yes	Yes	Yes
BHC FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes

E Empirics: firm earnings distribution concavity

This section describes a methodology for distinguishing bank holding companies (BHCs) with a relatively concave return distribution cdf. This methodology is motivated by Proposition 5, which shows that managerial protections cause a firm's conditionally efficient level of investment to be greater than the first-best benchmark if the debt ratio is low enough, or $\alpha_U \leq 1 - c - \frac{G}{K^{opt}}$, and the return distribution cdf H is strictly concave

First, we compute the empirical cdf of each BHC's return distribution using observations of return on assets during from the start of the sample 2006Q1 until the approximate start of the financial crisis in 2007Q3 (Bernanke (2009)). We think of the manager as responding to the stress tests based on the typical return distribution of the firm, so we omit the crisis because it may have caused uncharacteristic returns. Order the observed return on assets by θ_k, and let $H(\theta_k)$ denote the empirical cdf.

Second, we compute a numerical approximation of the second derivative of the cdf at each point by the formula

$$\frac{\frac{H(\theta_{k+1})-H(\theta_k)}{\theta_{k+1}-\theta_k} - \frac{H(\theta_k)-H(\theta_{k-1})}{\theta_k-\theta_{k-1}}}{\frac{(\theta_{k+1}-\theta_k)+(\theta_k-\theta_{k-1})}{2}}$$

BHCs for which the median second derivative is negative are identified as having a dominantly concave cdf, while BHCs for which the median second derivative is positive are identified as having a dominantly convex cdf.

Consistent with Proposition 5, Table 3 shows that, among the subset of BHCs with a dominantly concave return distribution, those with a higher degree of managerial protections experienced a relative increase in lending after the introduction of stress-testing.