A Model of Managerial Compensation, Firm Leverage and Credit Stimulus*

Rajdeep Chakraborti†, Sandeep Dahiya‡, Lei Ge§ and Pedro Gete¶

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Abstract

We study a model in which leverage and compensation are both choice variables for the firm and borrowing spreads are endogenous. First, we analyze the correlation between leverage and variable compensation. We show that allowing for endogenous compensation and leverage can explain the conflicting findings of the empirical literature. We uncover a new channel of complementarity between effort and leverage that induces a correlation sign opposite to what current theoretical models predict. Second, we study the dynamics of leverage and compensation design after a credit stimulus. We derive a set of new empirical predictions. For outward-shifts in credit supply, variable compensation is increasing in leverage growth. Moreover, variable compensation increases after the credit stimulus, especially for firms with low idiosyncratic risk.

Keywords: Compensation, Credit Policies, Executive Ownership, Leverage.

JEL Classification: E44, G28, G30, G32, G34

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†Durham University Business School. Email: rajdeep.chakraborti@durham.ac.uk.

‡**(Corresponding Author)** Georgetown University. Email: Sandeep.Dahiya@georgetown.edu. Phone: (+1) 202-687-3808. Address: 37th and O Sts., NW. Washington DC, 20057, USA.

§Renmin University of China. Email: lei.ge@live.com. Phone: (+1) 571-2740082. Address: 59 Zhongguancun St, Haidian District, Beijing 100872, China.

¶IE University. C. Maria de Molina 12, 28006 Madrid, Spain. Phone: (+34) 915689727. Email: pedro.gete@ie.edu.

1 Introduction

How much and in what form should a firm's owners pay a manager hired to run a firm? How will the compensation structure affect the manager's risk-taking through incurring debt to expand a firm's size? How will the CEO compensation structure affect a firm's sensitivity to government stimulus policies? These questions are central in corporate finance research. The literature so far has focused on models where at least one of the previous three elements is exogenous. This paper analyzes them in a model which is novel because CEO's compensation, firm's leverage (proxied by a firm's debt-to-asset ratio) and borrowing spreads are all endogenous.[1] In this regard our paper expands the work of Jaggia and Thakor (1994) who discussed the relation between CEO's actions, capital structure and firm's compensation design.

The model considers that a firm operates a project that generates risky cash flows. The risky cash flow is captured by incorporating a stochastic shock to the firm's productivity. The firm invests at the beginning of the period and the returns are realized only at the end of the period. The firm's cash flows are stochastic and increasing in the amount invested. Apart from the realized cash flow, the firm has no other assets. Thus, the final value of the firm equals the total cash flow generated by the project. This value is both observable and verifiable at the end of the period.

There are three agents of interest in this model: a shareholder, a CEO and a lender. The CEO is risk averse while the shareholder and the lender are risk neutral. The firm's cash flows are stochastic and increasing in the amount invested. The expected cash flow is also increasing in CEO's effort as well as in the invested amount. The CEO is averse to supplying effort as it is costly.

Following John and John (1993) and Carlson and Lazrak (2010), we assume that the shareholder is risk neutral and has an investment opportunity.[2] However, she lacks the managerial talent to exploit this opportunity. Thus, the shareholder hires an external CEO and provides

[1] Throughout the paper, firm leverage is proxied by it's debt-to-asset ratio.

[2] Chaigneau (2013) provides an interesting extension of the classic CEO compensation model for bank CEOs and shows that public guarantee of deposits can lead to excessive risk taking.

the necessary capital to the CEO for exploiting this investment opportunity. CEO effort is unobservable by the shareholder. This makes it impossible for the shareholder to write a compensation contract based on the CEO effort level. To motivate the CEO, the shareholder offers her a compensation contract featuring both fixed and variable components. The CEO receives the fixed component regardless of the final cash flow realized by the firm. Thus, the fixed component protects the financial interest of the CEO. The variable component is a fraction of the final cash flow realized by the firm. This component motivates the CEO to expand the scope of the firm's operations by borrowing more. A larger debt expands the scope of the firm and can potentially lead to a larger cash flow. However, the shareholder realizes that the CEO may increase the leverage to an undesirable level thus enhancing the default probability significantly. Thus, the shareholder needs to set the variable compensation at an optimal level. Our model endogenizes this variable compensation choice.

We follow Bernanke et al. (1999) to model the debt contract. The risk neutral lender prepares the debt contract and prices this debt by charging a spread over its own cost of funds. The cost of fund for the lender increases with the lending amount. The default risk is increasing in the lending amount, especially in high risk situations. To counter this default risk, the lending rates are increasing in risk levels for the same borrowing amount. Furthermore, when faced with a positive credit stimulus (e.g., a government subsidy), lender's cost of fund decreases. This allows an increase in credit supply to the market and the CEO finds it easier to borrow.

The CEO is assumed to be risk averse. The expected cash flow is increasing in CEO's effort. However, the effort is costly for the CEO. A larger variable component implies that the CEO compensation has a higher pay for performance sensitivity. The CEO receives a compensation offer from the shareholders. After accepting the contract, the CEO chooses her effort level as well as the debt amount. The CEO will put in effort only when she has a higher variable pay and/or has a lower cost of effort for a given level of variable compensation.

We obtain two sets of results. The first set relates to the relationship between executive compensation and capital structure in the cross-section of firms. John and John (1993) triggered a large literature studying the relationship between the level and structure of executive compensation and risk-taking. Benchmark models such as Carlson and Lazrak (2010) predict a negative correlation between CEO compensation structure and firm leverage that is driven by CEO's risk aversion. However, empirical studies have reported conflicting results. For example, Bryan et al. (2000), Lewellen (2006) and Coles et al. (2006) document a positive relationship between risk taking proxied by firm leverage and pay for performance sensitivity. In contrast, Berger et al. (1997) and Mehran (1992) report that higher pay for performance sensitivity is associated with lower firm leverage. To solve this puzzle, we add the shareholder's optimal compensation decision to our model. Our model provides a possible explanation for the existing conflict in empirical studies that investigate the relationship between executive compensation structure and firm leverage. The key is that we uncover a new channel of complementarity between CEO effort and firm leverage that works in opposite direction to CEO's risk aversion.[3] Chakraborti et al. (2022) study the 2008 Chinese credit stimulus and confirm our predictions. We note that the unique economic structure of the Chinese economy where many corporate decisions such as borrowing levels, executive compensation are heavily influenced by the state. This makes it difficult to generalize their empirical findings to another economy.

Our second set of results shows that maximizing the impact of credit policies requires combining them with policies that increase firms' willingness to borrow. For example, tax incentives that encourage higher managerial equity ownership may result in corporations reacting more to credit expansions if these incentives lead to greater managerial ownership.[4] This result complements papers such as Bebchuk and Goldstein (2011), who study economic policies in which banks abstain from lending to firms with good projects.

Most of the literature examining the impact of credit expansions has focused on how such policies influence banks' lending decisions, i.e., the "supply channel" of credit (Gambacorta and Shin, 2016). To the best of our knowledge, we are the first to show that the structure of

[3] To keep our model tractable, we do not consider stock options which may create different incentives and can potentially lead to other insights.

[4] Gorry et al. (2017) provide evidence that the structure of executive compensation is sensitive to taxation.

executive compensation can also affect the "demand" for borrowing. When the compensation structure makes a risk-averse CEO more exposed to her firm's risk then the CEO reduces firm leverage to lower her earnings risk. However, once we allow shareholders to optimally choose the CEO's compensation, there is a novel mechanism in the opposite direction that can explain the conflicting findings found in empirical literature.

The new mechanism requires that firm's leverage and CEO's effort are complementary to the shareholder. Greater CEO effort makes higher future cash flow more likely, and this allows the firm to sustain a higher level of leverage. This implies that shareholders desiring a higher debt level will include a larger variable component in the CEO compensation contract to encourage the CEO to exert more effort. Thus, the optimal action of shareholders can generate a positive cross-sectional relationship between the level of leverage and the degree of pay-for-performance sensitivity (i.e., the variable CEO compensation).

Hence, this paper shows that the relation between firm leverage and variable CEO compensation can be either positive or negative, depending on the channel that dominates. This is exactly what the empirical literature has found. We also make two novel predictions. First, total compensation is increasing in leverage; and second, leverage and the percentage of firm cash flow paid to the CEO as variable pay are positively correlated. That is, the optimal compensation contract requires increase in both fixed as well as variable CEO compensation components if the shareholder wants the CEO to increase effort and leverage at the same time (for example, to profit from better investment opportunities). However, the optimal variable pay grows faster than the fixed pay.

The paper proceeds as follows. Section 2 connects this paper to the existing literature. Section 3 presents the model. Section 4 provides the model mechanism. Section 5 studies the relationship between executive compensation and capital structure in the cross-section of firms. Section 6 studies the reaction to a credit stimulus. Section 7 compares between different CEO types. Section 8 discusses CEO effort and leverage complimentarity. Section 9 discusses CEO variable pay social welfare. Section 10 concludes.

2 Contribution to the literature

This paper connects two strands of theoretical literature on executive compensation and firm leverage.[5] The first group of models takes executive compensation as exogenous and studies a firm's leverage choices. Papers following this approach include John and John (1993), Carlson and Lazrak (2010) or Panousi and Papanikolaou (2012). The second group of models solves for the optimal compensation, but with exogenous leverage decisions with no default and no endogenous credit spreads. This group includes Dittmann et al. (2010, 2017), He (2011), Bolton et al. (2015) and Gete and Gomez (2017). We find that when compensation, leverage and CEO effort cost are all endogenous, we generate novel insights.

Jaggia and Thakor (1994) propose a model that also yields results similar to ours. However, in their model the highly-levered firms need to pay higher compensation in order to induce employees to invest in acquiring skills that are specific to that firm. Golan et al. (2015) show that greater product market competition can also impact compensation level. Since we want to focus primarily on the relationship between leverage and compensation, we exclude product market considerations in our model. Cheng et al. (2015) show that the total CEO compensation is increasing in the overall risk of the firm. However, the firm risk is exogenous in their model. In our model, the CEO chooses the induced risk associated with increased leverage.

Importantly, we also show how the CEO compensation structure affects a firm's response to credit supply expansions. This mechanism complements the large literature on the bank lending channel. Our results are closely related to Agarwal et al. (2018) who examine the response of retail (credit card) borrowers to the credit expansion in the U.S. They show that a consumer's propensity to borrow (i.e., demand for credit) is an important determinant in how much additional credit she obtains. We complement their study by focusing on the credit demand of corporate borrowers.

[5] Edmans and Gabaix (2016) is a recent survey.

3 Model

Our model considers a firm operating a project that generates risky cash flows. We model the cash flow risk by incorporating a stochastic shock to the firm's productivity. At the start of the period (date 0) the firm invests and the returns are realized at the end of the period (date 1). There are three agents: a shareholder, a CEO and a lender. The shareholder lacks the ability to operate the firm and must hire the CEO.

At date 0, the shareholder offers the CEO a compensation contract. Then, the CEO chooses to borrow an amount (B) and invests the newly borrowed amount in a project (the firm already has N of equity investment, made by the shareholder).[6] The lender prices this debt (B) by charging a spread over its own cost of funds. At date 1, the project generates a cash flow. Apart from the realized cash flow, the firm has no other assets. Thus, the final value of the firm (Y) equals the total cash flow generated by the project. This value is both observable and verifiable at date 1.

To operate the project, the CEO expends costly effort (p). CEO's effort increases the expected future cash flow for the firm. Following the typical setup employed in the compensation literature (e.g., Gayle et al., 2015), we assume that CEO effort is private information and the shareholder cannot observe it directly. Thus, it is impossible for the shareholder to write a compensation contract based on CEO effort level. The compensation contract has two components: a fixed component (A) and a variable component (v) that is a fraction of the realized cash flow of the firm at date 1. Figure 1 recapitulates our model's timeline.

Insert Figure 1 about here

3.1 The firm

At date 0, the firm has a pre-determined level of equity (N) and the CEO can borrow (B) to expand the size of the project:

$$K = B + N. \tag{1}$$

[6] We limit the new capital only to debt. This allows us to abstract away from issues of equity dilution as well as information frictions between different equity holders.

Capital (K) is the total investment of the firm. Conceptually, one can think of the equity (N) either in terms of cash investment or operating assets already in place originally contributed by the shareholder.

The firm's cash flow (Y) at date 1 is stochastic and depends both on the capital employed (K) and on the productivity shock (ω):

$$Y(\omega, K) = \omega R_k K,$$

where R_k is a parameter measuring the average return of capital, and ω is the productivity shock. The productivity shock (ω) follows a lognormal cumulative density function.[7] This setup mirrors the specification in Bernanke et al. (1999) where ω represents the idiosyncratic risk of a specific firm while R_k is the aggregate return to capital. We use the term idiosyncratic volatility to denote the total volatility of the productivity shock.

In our model, the CEO's effort (p) has an impact on the final realized value via the productivity shock (ω). The expected mean of the lognormal distribution of productivity shock (ω) is a function of CEO's effort[8]:

$$\omega \sim \ln \mathcal{N}(\omega; \mu(p), \sigma), \tag{2}$$

$$\mu(p) = \psi p^{\varepsilon} - \frac{\sigma^2}{2}, \tag{3}$$

where σ is the idiosyncratic uncertainty of the productivity shock, $\psi > 0$ and $\varepsilon < 1$ are respectively the level and the shape parameters controlling the effect of CEO's effort on the productivity shock (ω). We refer to σ as the productivity variance parameter.

From (2) and (3) it follows that the firm's expected productivity is increasing and concave in effort. That is,

$$\mathbb{E}[\omega] = e^{\mu(p)+\frac{\sigma^2}{2}} = e^{\psi p^{\varepsilon}}. \tag{4}$$

We denote the cumulative density function of ω by $F(\omega; p)$ to stress that the expected value of

[7]We provide a more detailed justification for choosing the lognormal distribution in the Online Appendix.
[8]see Page 60 of the Online Appendix for a detail discussion.

the productivity shock (ω) is a function of CEO's effort (p).

3.2 The lender

The lender faces a cost of funds $R_B(1-\tau)$. The parameter $\tau \geq 0$ is a government credit subsidy that shifts credit supply. There are several ways to interpret this parameter. For example, Jeske et al. (2013) refer to it as a loan guarantee. It is also interpreted as a monetary policy or government subsidy that lowers lender's cost of funds.

Following Bernanke et al. (1999), the credit contract can be modelled as a default threshold ($\hat{\omega}$) and a loan size (B) such that when the firm receives a shock ω above the threshold $\hat{\omega}$ then it pays $\hat{\omega} R_k K$ to the lender. When the shock ω is below the threshold $\hat{\omega}$ then the firm defaults and the lender seizes the firm's assets after paying a proportional foreclosure cost, $\gamma > 0$. The endogenous lending rate R_L is implicitly defined as:

$$R_L B = \hat{\omega} R_k K. \tag{5}$$

The lender's participation constraint requires that the lender must break even:

$$\int_0^{\hat{\omega}} (1-\gamma)\, \omega R_k K \, dF(\omega; p) + \int_{\hat{\omega}}^{\infty} R_L B \, dF(\omega; p) = R_B(1-\tau)B. \tag{6}$$

The first integral is the lender's expected revenue in the default scenario. That is, the value of the firm's assets net of foreclosure costs. The second integral in the left hand side of Equation (6) is the expected revenue for the lender when the firm repays (i.e., when ω is above the threshold $\hat{\omega}$). The right hand side of Equation (6) is the cost of funds for the lender.

Equation (6) determines the endogenous lending spreads. Since the firm's productivity shock (and the resulting cash flows) are not known ex-ante (at date 0), the lender needs to set the lending rate higher than her cost of funds to compensate for the default probability and for foreclosure costs. Using Equations (1), (5) and (6) we get:

$$\int_0^{\hat{\omega}} (1-\gamma)\, \omega R_k(B+N)\, dF(\omega;p) + \int_{\hat{\omega}}^{\infty} \hat{\omega} R_k(B+N)\, dF(\omega;p) = R_B(1-\tau)B. \tag{7}$$

3.3 The compensation contract

Similar to the approach of John and John (1993) and, Carlson and Lazrak (2010), we study compensation contracts with both a fixed component ($0 \leqslant A$) and a variable component denoted as a share, (v; $0 \leqslant v \leqslant 1$), of the firm's value at date 1. The total payoff for the CEO is $s(\omega)$,

$$s(\omega) = \begin{cases} A + v\left[Y(\omega, K) - R_L B\right] & \text{if} \quad \omega \geq \hat{\omega}, \\ A & \text{if} \quad \omega < \hat{\omega}. \end{cases} \tag{8}$$

That is, when the firm defaults (i.e., when $\omega < \hat{\omega}$) , the CEO only receives the fixed compensation (A). When the firm repays (i.e., when $\omega \geq \hat{\omega}$) , the CEO gets the fixed salary (A) and a share (v) of the firm's final cash flow net of payments to the lender.

In a default/foreclosure scenario, the CEO must receive the fixed component (A) of her salary. Thus, the lender includes the CEO fixed compensation (A) while calculating the foreclosure cost. Hence, the fixed CEO compensation (A) is captured through the foreclosure cost parameter (γ).

3.4 The CEO

The CEO bears the cost of effort denoted by $c(p)$,

$$c(p) = \phi p^{\rho}, \tag{9}$$

which we assume is increasing and convex. That is, $\phi > 0$ and $\rho > 1$.

Given the compensation contract, the CEO decides her effort (p) and the firms' borrowing contract (B, $\hat{\omega}$) to maximize her expected utility subject to the lender's participation constraint.[9] That is, the CEO solves:

$$\max_{\{\hat{\omega}, p, B\}} \int_{\hat{\omega}}^{\infty} u\left(A + v\left(Y\left(\omega, K\right) - R_L B\right) - c(p)\right) \, dF(\omega; p) + \int_{0}^{\hat{\omega}} u\left(A - c(p)\right) \, dF(\omega; p) \tag{10}$$

$$\text{subject to } (7).$$

We assume CEO effort (p) as a resource that is under the CEO's control. CEO effort and the firm's borrowing contract ($B, \hat{\omega}$) depend on the pre-determined compensation package that the CEO receives. Since, effort is a resource available to the CEO and she decides whether and what level of effort she will exert, we define CEO's cost of effort, $c(p)$, as a resource cost.

Hence, the board of directors must play an active role to protect shareholders' interests against the interests of long serving CEOs.

3.5 The shareholder

The shareholder makes a take it or leave it offer to the potential CEO taking into account that the compensation contract will affect the CEO's effort and borrowings.[10] Thus, the shareholder chooses the compensation contract (A, v) to maximize the firm's cash flow net of payments to the lender and to the CEO:

$$\max_{\{A, v\}} \int_{\hat{\omega}}^{\infty} \left[(1 - v)\left(Y\left(\omega, K\right) - R_L B\right) - A\right] \, dF(\omega; p) \tag{11}$$

subject to the CEO's effort, default threshold and borrowings determined by the FOCs of the CEO's problem defined by Equation (10).[11]

[9] In our model, the CEO's decision on leverage directly impacts the firm risk. While there other channels through which a CEO can increase the firm risk (e.g., increasing operating leverage or using off-balance sheet liabilities), to keep our model tractable, we focus exclusively on risk induced by increase in financial leverage.

[10] Following common practice, we assume that the CEO is risk-averse and the shareholder and lenders are risk-neutral. We note that there are instances where CEOs and shareholders display behavior that is not consistent with these assumptions. Such behavior can also be an alternative explanation for the relationship between firm leverage and CEO's variable compensation and may explain observed high leverage of some firms.

[11] In several instances, the majority shareholders might be driving the leverage decision more than the CEO does (for example, in many private equity owned firms). In those cases, the effects attributed to the CEOs compensation contract might actually be driven more by the shareholders' incentives.

3.6 Calibration

Our goal in this paper is to develop theoretical insights on CEO compensation and firm leverage. However, since the model has no closed form solutions, we used parameter values from existing literature to solve the model numerically. Then we illustrate how changing these parameters would change the results. Specifically, we show how the predictions of the model change by varying a) productivity variance parameter (σ) and, b) level parameter of effort (ψ). The rest of the model parameters come from the existing literature and changing them would not alter the main insights of the paper.

To solve the model numerically we assume that the CEO has the standard CRRA preferences:[12]

$$u(C) = \frac{C^{1-\eta}}{1-\eta}, \tag{12}$$

where the CEO's consumption C is the wage payments $s(\omega)$ defined in Equation 8 minus the cost of effort, i.e.,

$$C = s(\omega) - c(p). \tag{13}$$

The parameter η is the coefficient of risk aversion. For $\eta > 0$, $\eta \neq 1$ there is positive risk aversion. The risk-neutral case is $\eta = 0$.

We use the same coefficient of risk aversion (η) as Carlson and Lazrak (2010), the foreclosure cost parameter (γ) follows Bernanke et al. (1999), and the scale parameter (σ) of the lognormal productivity shocks is in the set of values common in papers that are based on the Bernanke et al. (1999) model. literature (see Gete and Melkadze, 2018 for example). We also analyze the impact of credit supply expansion on changes in leverage across firms with different CEO compensation contracts. For this purpose we use the monetary stimulation implemented by China as our test case.[13] For the cost of lenders' funds (R_b) we use a 2% rate, which is the average return on

[12] Calibration exercises with CRRA preferences include Dittmann et al. (2010) and, Hall and Murphy (2000) among others. We verified that the results also hold for constant absolute risk aversion (CARA) preferences. Given the strong intuition behind the theory, we believe that the results will also hold for other preference types such as Epstein-Zin.

[13] The Chinese government announced a $568 billion stimulus package combined with a dramatic easing of monetary policy as described by Deng et al. (2015). The announcement received extensive media coverage much

deposits between 2007 and 2010 in China. We select the credit stimulus parameter (τ) to match the decrease in interbank rates that the Chinese Central Bank implemented in 2008. Table 1 contains the parameters of the model and Table 2 reports the moments that we match.

Insert Tables 1 and 2 about here

4 How the model works

Equation (7) describes the lender's participation constraint when it is binding. The difference in lending rates across different uncertainty levels is higher at higher leverage levels (see Figure 2).[14]

Insert Figure 2 about here

Furthermore, the lender faces a cost of fund, $R_B(1-\tau)$, where τ ($\tau \geq 0$) represents the government credit stimulus that increases credit supply. Therefore, with increasing value of τ, lender's cost of fund decreases, and the CEO finds it easier to borrow. However, a risk averse CEO will be skeptical to borrow more as it increases her own financial risk. As a consequence, shareholders must offer the CEO a higher fixed compensation to offset her personal financial risk and to borrow. Thus, we expect the variable to fixed CEO compensation ratio to decrease in credit subsidy (τ). This is exactly what we find in Figure 3.

Insert Figure 3 about here

The CEO will put in effort only when she has a higher variable pay (see Figure 4) and/or has a lower cost of effort for a given percentage of firm cash flow paid as variable CEO pay (see Figure 5).

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of which was devoted to the large size of the Chinese stimulus.

[14] Firm leverage is proxied by debt-to-asset ratio across all figures.

Insert Figures 4 and 5 about here

Furthermore, to capture the sensitivity of borrowing under uncertainty, we select different productivity variance parameter (σ) values and capture the relationship between the percentage of firm cash flow paid as variable CEO pay and firm leverage.

In a situation when both a firm's debt-to-asset ratio and compensation are endogenous, to generate cross-sectional heterogeneity, the firms need to differ on some parameter. For this purpose, we focus on the idiosyncratic productivity variance parameter (σ). This approach is supported by Panousi and Papanikolau (2012), who show that higher productivity variance parameter (σ) (i.e., a higher risk level) lowers firm investment. Since both CEO effort and a firm's debt-to-asset ratio are positively associated with firm investment, we argue that the relationship between a firm's debt-to-asset ratio and the percentage of firm cash flow paid to the CEO as variable pay will depend on the productivity variance parameter (σ) values.

When we use the productivity variance parameter (σ) to generate heterogeneity across firms, there are two channels at play. First, volatility is bad for lenders because debt contracts imply concave payoffs. That is, high risk firms have higher default risk. Second, volatile firms encourage less effort from their risk-averse CEOs. Thus, all things being equal, less volatile firms face lower borrowing costs and, as a consequence, CEOs of such firms desire a higher debt-to-asset ratio level. Also, in a less volatile firm, the CEO faces a lower personal financial risk, so she is willing to exert more effort to grow the firm.

We classify the range of productivity variance parameter (σ) (which is a proxy for the firm volatility, firm risk or idiosyncratic uncertainty) into three categories, replicate our analysis for each of them and provide figures and relevant literature support for each scenario.

Category 1: Low productivity variance parameter ($\sigma = 0.10$)*:* The CEO variable compensation component is a function of the productivity shock parameter (ω) and firm capital (K). If the risk of productivity shock is low (i.e., when $\sigma = 0.10$), the CEO would increase firm capital (K) by borrowing more if the variable compensation component is low (i.e., when v is low). As the CEO's variable pay increases (i.e., when v increases), she decreases the optimal debt level to maintain the same pay-off. Note that when the risk of productivity shock is low (i.e., when $\sigma = 0.10$), the underlying cash flow generated by the firm is of low risk. Thus, the CEO feels confident about the size of the final cash flow. It is intuitive to see that adding debt increases the risk of this cash flow. Hence, when the CEO compensation has a large variable component, the CEO is reluctant to increase leverage. This is what is depicted in Panel A of Figure 6. In this figure, we see that higher variable pay is associated with lower debt-to-asset ratio. Note that this observation is valid only when the risk of productivity shock is low (i.e., when $\sigma = 0.10$). This finding is consistent with Berger et al. (1997) or Carlson and Lazrak (2010), who report that a higher percentage of firm cash flow paid to the CEO as variable pay is associated with low firm's debt-to-asset ratio.

Furthermore, as the lending rate is increasing in the borrowing amount, firms' borrowing costs are increasing as well. This higher borrowing cost makes the firms prone to loan defaults. When the CEO has no or very low variable pay (i.e., when v is zero or low), her financial interest is not affected much by default as most of her compensation is guaranteed. Thus, she is likely to borrow more when her variable compensation is low (i.e., when v is low).

On the contrary, when the variable pay is high, the CEO prefers less than optimal debt-to-asset ratio in order to shield herself from pressures associated with high debt volumes (e.g., Jensen, 1986; Berger et al., 1997; Carlson and Lazrak, 2010). Hence, the risk-averse CEO borrows less as her performance related variable pay increases in a low-risk scenario (i.e., when $\sigma = 0.10$) to increase her utility by reducing the borrowing cost. This is exactly what we find (see Panel A of Figure 6).

Category 2: Intermediate productivity variance parameter ($\sigma = 0.20$ and 0.40)*:* The CEO faces a trade-off between borrowing more and to protect her financial interest from loan default. A higher variable compensation component (v) incentivizes a higher firm capital (K). However, a higher firm capital (K) also increases the default probability. Independently, a higher productivity shock parameter (σ) also increases default risk. Thus, at low productivity shock parameter (i.e., when $\sigma = 0.10$), the CEO prefers a higher firm capital (K) only if the variable compensation component is low (i.e., when v is low) (see Panel A of figure 6).

In the intermediate range of productivity variance parameter values (i.e., when $\sigma = 0.20$ and 0.40) we have a critical value of variable compensation component (v), below which, the incentive to lower debt as v increases, dominates. Here the CEO sheds financial risk as the variable compensation component (v) increases. As the variable compensation component (v) increases, the higher productivity shock parameter (σ) has a non-linear impact on CEO's compensation. Note that with higher σ, the probability of productivity shock (ω) being less that the threshold productivity shock (ω^*) is higher. This represents that state of default. The CEO compensates this higher default risk by increasing the firm size (K) and borrows more. However, beyond a critical level of v (given by v^*), the compensation no longer increases with debt level as the risk of default overwhelms the benefit of larger firm. Beyond this critical level of v^*, the pay-off from higher variable compensation component (v) is more than enough to off-set the higher risk of default from higher debt. This is exactly what we find in Panels B and C of Figure 6.

Category 3: High productivity variance parameter ($\sigma = 0.70$)*:* A high debt-to-asset ratio is associated with a high fixed CEO compensation. In high-risk scenario, when productivity variance parameter (σ) value is high, the CEO can protect her financial interest against loan default through a higher fixed pay. This encourages the CEO to align her interests to those of the shareholders and she borrows more (e.g., Lewellen, 2006; Coles et al., 2006). However, the CEO maintains a high but steady borrowing level in this high-risk scenario (see Panel D of Figure 6).

However, in our model, the firm's productivity shock (ω) is a function of the CEO's effort (p) and the resulting cash flows are not known ex-ante (i.e., at date 0). Hence, the lender ensures the default compensation (considering the foreclosure cost) before allowing the CEO to borrow. Since a firm's debt-to-asset ratio increases with the percentage of firm cash flow paid to the CEO as variable pay, so is the firm's default probability. The CEO tends to borrow more in two scenarios. First, when default probability is low. Second, in the high-risk scenario when she is offered both a high fixed pay as well as a high variable pay. In this situation, the higher fixed pay protects the CEO's own financial interest from default risk and she borrows more. However, with a higher percentage of firm cash flow paid to the CEO as variable pay, lender's control on CEO borrowing becomes stricter. Hence, the CEO cannot borrow as she prefers. This is reflected through a negative relationship between a firm's debt-to-asset ratio and the percentage of firm cash flow paid to the CEO as variable pay in both low-risk and high-risk scenarios (see Panels A and D of Figure 6).

Furthermore, risk averse CEOs lower firm investment by borrowing less with increasing productivity variance parameter (σ) (Panousi and Papanikolau, 2012). However, we find that for high productivity variance parameter value (i.e., $\sigma = 0.70$), a firm's debt-to-asset ratio levels are very high and quite stable in the percentage of firm cash flow paid to the CEO as variable pay (see Panel D of Figure 6). In this situation, the CEO maintains a higher debt-to-asset ratio throughout different variable pay levels as the higher fixed pay protects her from default risk and she makes risky borrowings without affecting her own financial interest.

Insert Figure 6 about here

We also capture the change in the relationship between endogenous CEO effort and the percentage of firm cash flow paid as variable CEO pay for a lower ($\sigma = 0.10$) and a higher ($\sigma = 0.70$) productivity variance parameter (see Panels A and B of Figure 7 respectively).

We find that in low risk firms, i.e., when the productivity variance parameter value (σ) is low, the CEO effort is increasing in the percentage of firm cash flow paid as variable CEO pay (see Panel A of Figure 7). Low risk firms have a lower probability of default, thus the CEO feels encouraged to borrow more and she exerts more effort. On the other hand, for high risk firms, when the productivity variance parameter value (σ) is high, CEO effort has a negatively concave relationship with the percentage of firm cash flow paid as variable CEO pay (see Panel B of Figure 7). This occurs because the CEO does not feel motivated to exert more effort when faced with a stricter control on her borrowing level by the lender and the shareholder.

Insert Figure 7 about here

Existing empirical literature provides support to this conflicting relationship between firm risk and executive compensation. For example, Miller et al. (2002) propose a curvilinear relationship between firm risk and executive compensation. Furthermore, they also show that CEO total compensation increases with an increase in systematic firm risk. Other literature supporting this positive relationship include Lewellen et al. (1987), Core and Guay (2002), and Prendergast (2000). Another stream of literature shows no relation between idiosyncratic uncertainty and executive compensation (see Ittner et al., 1997; Conyon and Murphy, 1999). Finally, a negative relationship between idiosyncratic uncertainty and executive compensation is empirically shown in studies by Jin (2002) and Dee et al. (2005). Thus, existing empirical literature provide support to our argument that differences in CEO pay can be created by manipulating the productivity variance parameter (σ) (i.e., by varying the risk level).

A CEO with a long tenure will be more entrenched in a firm's decision making system and is more likely to pursue her own interests rather than those of the shareholders (Hill and Phan, 1991). A CEO with longer tenure can gain control over the board of directors and can consequently demand compensation packages that fulfill her own interests.

Several reasons exist to suggest that a CEO's influence over board will increase with the duration of her tenure. First, CEOs are actively involved in selecting new board members (Herman, 1981; Vance, 1983). Hence, a CEO can become more autocratic by replacing troublesome board members by the ones she prefers (Finkelstein and Hambrick, 1989). These newly elected board members will be loyal to the CEO rather than to the shareholders.

This level of control over the board members is highly improbable for a new CEO or a CEO with a shorter tenure. Since most board members are nominated by the predecessors of a new CEO, these members may not have any personal loyalty to the new CEO. Fredrickson et al. (1988) argue that new CEOs are extremely vulnerable early in their tenures. In fact, "CEOs gain power over time as they gain voting control, establish a patriarchal aura, or co-opt the board of directors" (Fredrickson et al., 1988: 258). Second, a CEO with long tenure will have influence over a firm's internal information system. This may restrict sharing of information "from compensation committees when that information would attribute poor firm performance to bad management" (Coughlan and Schmidt, 1985: 45). In addition, a long tenured CEO can use her control over information systems to select the agenda for the board meetings in a way that projects the CEO favorably (Hill and Phan, 1991).

A larger debt expands the scope of the firm and can potentially lead to a larger cash flow. Thus, the shareholders motivate the CEOs by increasing the variable compensation part of CEO's total compensation when firm leverage increases. This relationship remains valid both before and after a simulated credit stimulus. This is exactly what we find in Figure 8.

Insert Figure 8 about here

We show different productivity variance parameter (σ) values change the correlation between CEO effort and the percentage of firm cash flow paid as variable CEO pay. A low productivity variance parameter (σ) implies low risk. In a low risk scenario, the default probability is low. Consequently, the CEO feels more secured against any potential personal financial loss when she increases firm leverage. Hence, her effort to increase firm leverage is increasing in the percentage of firm cash flow paid as variable CEO pay for a low productivity variance parameter (σ). However, the rate of this increase is influenced by different CEO effort cost, $c(p)$, levels (see Figure 5).

On the contrary, in a high risk scenario (i.e., for high productivity variance parameter, σ), the default probability is high, and the CEO feels a threat of potential personal financial loss as increasing firm leverage may cause a default. Hence, the CEO exerts less effort to increase firm leverage. This is exactly what we find in Figure 9, where we show that CEO effort is decreasing in the percentage of firm cash flow paid as variable CEO pay for a high productivity variance parameter (σ) (see Figure 9).

Insert Figure 9 about here

Hence, Figures 5 and 9 suggest that the productivity variance parameter (σ) overpowers the CEO effort cost.[15]

5 Executive compensation and capital structure

First we analyze the sign of the correlation between leverage and variable compensation. Then we show some other predictions.

5.1 The sign of the correlation in the cross-section of firms

Figure 10 contains our key cross-sectional result. Panel A is a model with exogenous compensation, like Carlson and Lazrak (2010). Panel B is the model presented in Section 3 with endogenous compensation setup. Panel A shows a *negative* correlation between leverage and variable compensation. Panel B shows a *positive* correlation. Both cases are for a risk-averse CEO.

Insert Figure 10 about here

Panel A of Figure 10 shows that a compensation contract with a larger performance-based component discourages leverage for risk-averse CEOs. That is, the CEO trades off variable compensation and leverage because both increase the variance of her total compensation and her exposure to default risk. As discussed by Carlson and Lazrak (2010), this channel generates a *negative* cross-sectional correlation between leverage levels and variable compensation.

Panel B of Figure 10 shows that the cross-sectional correlation between leverage levels and variable compensation becomes *positive* when all variables are endogenous and optimally selected.[16]

[15] Results remain almost similar when other parameter values are varied.

[16] In the Panel A of Figure 10 compensation is exogenous and thus we could compare firms with different variable compensation. However, in Panel B of Figure 10 both leverage and compensation are endogenous. In this situation, to generate cross-sectional heterogeneity, the firms need to differ on some parameter. We focus on the productivity variance parameter (σ) to capture firm heterogeneity. This choice is motivated by the approach taken by Panousi and Papanikolau (2012). They show that higher firm risk lowers investment especially when a risk averse CEO has a high variable pay component.

Figure 11 shows that optimal compensation (represented by the solid red dot on the top of the surface) implies the use of both variable pay choice ($v > 0$) and fixed compensation ($A > 0$). The variable pay elicits the CEO's effort and increases the value of the firm. However, variable compensation makes the CEO more risk averse and encourages under-investment. The fixed pay makes the CEO less risk averse as there is a large guaranteed payout even if the firm suffers an adverse productivity shock. This encourages the CEO to increase leverage, which in turn also motivates her to supply greater effort to reduce the likelihood of bad shocks. Thus, the optimal compensation package with a risk averse CEO is a combination that provides enough motivation for the CEO to provide costly effort and enough insurance to encourage risk taking.

Insert Figure 11 about here

Figure 12 shows that low idiosyncratic risk (represented by the productivity variance parameter, σ) encourages the CEO to exert more effort (see Panel A), which, in turn, makes negative productivity shocks less likely. Thus, the CEO feels encouraged to increase firm leverage (see Panel B). Moreover the shareholders want higher variable compensation to motivate the CEO in firms with low idiosyncratic risk.

Insert Figure 12 about here

In this way, when we focus on firms with different productivity variance parameter (σ) values to generate cross-sectional heterogeneity, there are two channels at play. First, volatility is bad for lenders because debt contracts imply concave payoffs. That is, high risk firms have higher default risk. Second, volatile firms encourage less effort from their risk-averse CEOs. Thus, all things being equal, less volatile firms face lower borrowing costs and, as a consequence, CEOs of such firms will desire a higher level of leverage. Also, in a less volatile firm, the CEO faces less risk in his share of the firm's investment, so she is willing to exert more effort to the firm.

Thus, to recap, we just showed two channels that generate opposite predictions for the sign of the correlation between performance based compensation and firm leverage. Depending on what channel dominates the correlation can be positive or negative even if CEOs are risk-averse. This result explains why the empirical literature reports conflicting findings to explain the relationship between CEO compensation structure and firm leverage.

5.2 Other predictions

Figure 13 shows other novel predictions of the model: fixed compensation and total compensation are increasing in firm leverage (see Panels A and B respectively); and leverage and the ratio of variable-to-fixed compensation are positively correlated (see Panel C).

Insert Figure 13 about here

As we discussed before, firms with low productivity variance parameter (σ) will reward their CEOs with higher variable pay to motivate them to exert more effort (p). This is because the firms with low risk can get more low cost credit supply from the banks. As the leverage and CEO effort (p) are complementary, higher CEO effort will lead to an expansion of future cash flow for the firms. However, an increased variable pay can discourage a risk averse CEO from borrowing because of her personal financial concerns associated with the increased default probability. Thus, to encourage the CEO to borrow more, the shareholders of a low risk firm will also offer the CEO a higher fixed pay (see Panel A of Figure 13) to protect her financial interests. This will motivate the CEO to borrow more when the borrowing cost is low. In this way, the shareholders of a low risk firm will reward their CEO with both larger variable and fixed components and it will lead to larger total compensation (see Panel B of Figure 13). In addition, Panel C of Figure 13 shows that firm leverage is increasing in variable-to-fixed CEO compensation ratio for firms with low risk.

6 Credit stimulus, leverage and compensation

In this section, we show that the structure of executive compensation plays a critical role in how corporations choose to borrow when there is an outward shift in credit supply. Firms with a higher managerial equity ownership (i.e., stronger incentives) increase leverage more.[17] How the corporate sector responds to a large government-initiated credit stimulus is an important issue for economists as well as policymakers. After all, a major objective for expansionary credit policies is to induce greater borrowing by households as well as corporations.

6.1 Leverage growth during the credit stimulus

In our model we simulate the policy intervention by making the credit subsidy to lenders (τ) variable have a strictly positive value. This is consistent with Agarwal et al. (2018), who model credit expansions as changes in banks' cost of funds. The credit supply, which is the lender's participation constraint Equation 7, shifts right (Figure A3 of the Online Appendix) and the cost of leverage decreases when $\tau > 0$. Figure 14 illustrates the key cross-sectional implication of our model after the credit stimulus. The x-axis represents firms with different levels of CEO variable pay and the y-axis represents the growth of firm leverage after a credit stimulus.[18]

Insert Figure 14 about here

Figure 14 shows that firms whose CEOs have larger variable compensation react more to a credit supply shift. Thus, a CEO with high variable compensation will increase firm leverage more compared to another CEO with lower variable compensation. Intuitively, high variable pay implies that the CEO will share a larger portion of the rewards from leverage and is therefore more receptive to a credit stimulus. Thus, a higher variable compensation induces greater changes in firm leverage.

6.2 Optimal compensation after the credit stimulus

Now we study how the shareholders adjust the optimal CEO compensation structure after the government credit stimulus. When everything is endogenous, shareholders decide as in Figure

[17] To the extent that much of the variable compensation is in the form of equity, and the fact that higher leverage would lead to a higher ROE for the same ROA, there would be a natural incentive (just one of many, not the only one) for the CEO to increase leverage in such instances, especially in cases where the equity grants are rather large.

[18] We assume that the compensation structure is exogenous right after the credit stimulus. For example there are short-term frictions to alter the compensation.

11. As before, to generate cross-sectional differences, we study firms with different productivity variance parameter (σ). Figure 15 contains the results.

Insert Figure 15 about here

Figure 15 shows that the optimal compensation structure including the CEO's variable pay, fixed pay, total compensation and variable-to-fixed compensation ratio all will increase after the credit stimulus. In addition, low risk firms will increase the variable pay, fixed compensation, total compensation and variable to fixed compensation ratio more than the other firms. Empirical studies such as Gilchrist et al. (2014) and, Stock and Watson (2012) have also explored the relationship between firm risk level and firm leverage.

The first driver of Figure 15 is that the investment opportunities and the CEO effort are complementary. After the credit stimulus, firms with low firm risk face better investment opportunities, so shareholders would like to reward the CEO with higher variable pay to motivate CEO to exert more effort to increase the cash flow for the firms (see Panel A of Figure 15). However, higher variable pay makes the CEO more conservative in borrowing. So, the shareholders also give the CEO higher fixed pay to offset the CEO's risk aversion. In this way, CEOs of firms with low idiosyncratic risk will also get more fixed pay after the credit push (see Panel B of Figure 15). As both the variable and the fixed pay increase after the credit stimulus, the total CEO compensation also increases more for the firms with low idiosyncratic risk (see Panel C of Figure 15). Fourth, while both the variable and fixed pay increase after the credit stimulus, the increased variable pay motivates the CEO to borrow more, and the fixed pay serves an auxiliary role in offsetting the CEO's personal financial risks. Hence, the variable-to-fixed compensation ratio increase faster for low risk firms (see Panel D of Figure 15). So, the shareholders reward the CEO with bigger compensation package to motivate her to borrow more while protecting her financial interest. This effect is greater in firms with low idiosyncratic risk.

Our findings receive empirical support in the study by Chakraborti et al. (2022) who show the underlying mechanism for a positive relationship between executive compensation and firm leverage. They argue that this positive relationship is due to the fact that equity is a residual claim, while debt is a fixed claim.

Chakraborti et al. (2022) also argue that both leverage and CEO compensation are endogenous. For a shareholder, the firm's leverage and the executive's effort are complements. That is, greater effort makes higher future cash flow more likely, and this allows the firm to sustain a higher level of leverage. Hence, shareholders of firms desiring a higher level of debt will offer a larger variable pay component to the CEO to encourage her to exert more effort. Thus, the optimal action of shareholders can generate a positive cross-sectional relationship between firm leverage and the degree of pay for performance sensitivity (i.e., the variable component) of CEO compensation.

A credit stimulus increases the value of a firm as the subsidized credit allows the firm to become larger by borrowing more. The CEO has a strong incentive to increase leverage if she is promised a larger share of the firm. In addition, after the credit stimulus, the variable component of CEO compensation increases as shareholders encourage their executives to borrow more to increase the firm value. Consequently, the CEO with high equity stakes reaps the benefits of increase in firm value by borrowing more following a credit stimulus (Chakraborti et al., 2022). It is worth pointing out that compensation contracts that provide a CEO with incentives to borrow more may not be socially optimal. For example, Srivastav et al. (2018) show that equity based compensation can cause excessive risk taking by the CEO.

7 Empire-Building vs. Non Empire-Building CEO

For a non-empire building CEO, the payoffs are:

$$s(\omega) = \begin{cases} A + v\left[Y\left(\omega, K\right) - R_L B\right] & \text{if} \quad \omega \geq \hat{\omega}, \\ A & \text{if} \quad \omega < \hat{\omega}. \end{cases} \tag{14}$$

where, A is the fixed component and $0 \leq v \leq 1$ is the variable component of CEO compensation. However, for an empire building CEO, the payoffs are:

$$s(\omega) = \begin{cases} A + \varsigma(K) + \upsilon\left[Y(\omega, K) - R_L B\right] & \text{if} \quad \omega \geq \hat{\omega}, \\ A & \text{if} \quad \omega < \hat{\omega}. \end{cases} \tag{15}$$

where the CEO's empire building attitude is captured through $\varsigma(K)$, which is a concave function of the size of the firm. That is, the CEO enjoys leading a large firm:

$$\varsigma(K) = \nu K^{\kappa} \tag{16}$$

where, $\nu > 0$ and $0 < \kappa < 1$.

We compare the relationship between firm debt-to-asset ratio and the percentage of firm cash flow paid to the CEO as variable pay for empire building CEO and non-empire building CEO for low (i.e., $\sigma = 0.10$), low medium (i.e., $\sigma = 0.20$), medium (i.e., $\sigma = 0.40$) and high productivity variance parameter (i.e., $\sigma = 0.70$) values in Figure 16. We find that irrespective of the value of the productivity variance parameter (σ), the relationship between a firm's debt-to-asset ratio and the percentage of firm cash flow paid to the CEO as variable pay is always positively concave for the empire building CEO (see the dotted lines across all panels of Figure 16). However, the relationship between a firm's debt-to-asset ratio and the percentage of firm cash flow paid to the CEO as variable pay depends on the productivity variance parameter (σ) values for the non-empire building CEO (see the solid lines across all panels of Figure 16).

Insert Figure 16 Here

In Panel A of Figure 16 we observe a convex relationship between a firm's debt-to-asset ratio and the percentage of firm cash flow paid as variable pay for a non-empire building CEO when the productivity variance parameter value is low (i.e., when $\sigma = 0.10$). This convex relationship can be explained as follows. The CEO compensation contract outlined in Equation 14 shows that the CEO variable compensation component is a function of the productivity shock parameter (ω) and firm capital (K). If the risk of productivity shock is low (i.e., when $\sigma =$ 0.10), the CEO would increase firm capital (K) by borrowing more if the variable compensation component is low (i.e., when v is low). As the CEO's variable pay increases (i.e., when v increases), she decreases the optimal debt level to maintain the same pay-off. Note that when the risk of productivity shock is low (i.e., when $\sigma = 0.10$), the underlying cash flow generated by the firm is of low risk. Thus, the CEO feels confident about the size of the final cash flow. It is intuitive to see that adding debt increases the risk of this cash flow. Hence, when the CEO compensation has a large variable component, the CEO is reluctant to increase leverage. This is what is depicted by the solid line in Panel A of Figure 16. In this figure, we see that higher variable pay is associated with lower debt-to-asset ratio. Note that this observation is valid only when the risk of productivity shock is low (i.e., when $\sigma = 0.10$). This finding is consistent with Berger et al. (1997) or Carlson and Lazrak (2010), who report that a higher percentage of firm cash flow paid to the CEO as variable pay is associated with low firm's debt-to-asset ratio.

Furthermore, as the lending rate is increasing in the borrowing amount, firms' borrowing costs are increasing as well. This higher borrowing cost makes the firms prone to loan defaults. When the CEO has no or very low variable pay (i.e., when v is zero or low), her financial interest is not affected much by default as most of her compensation is guaranteed. Thus, she is likely to borrow more when her variable compensation is low (i.e., when v is low).

On the contrary, when the variable pay is high, the non-empire building CEO prefers less than optimal debt-to-asset ratio in order to shield herself from pressures associated with high debt volumes (e.g., Jensen, 1986; Berger et al., 1997; Carlson and Lazrak, 2010). Hence, the risk-averse, non-empire building CEO borrows less as her performance related variable pay increases in a low-risk scenario (i.e., when $\sigma = 0.10$) to increase her utility by reducing the borrowing cost. This is exactly what we find (see the solid line in Panel A of Figure 16).

The non-empire building CEO faces a trade-off between borrowing more and to protect her financial interest from loan default. A higher variable compensation component (v) incentivizes a higher firm capital (K). However, a higher firm capital (K) also increases the default probability. Independently, a higher productivity shock parameter (σ) also increases default risk.

Thus, at low productivity shock parameter (i.e., when $\sigma = 0.10$), the CEO prefers a higher firm capital (K) only if the variable compensation component is low (i.e., when v is low) (see the dotted line of Panel A of figure 16).

In the intermediate range of productivity variance parameter values (i.e., when $\sigma = 0.20$ and 0.40) we have a critical value of variable compensation component (v), below which, the incentive to lower debt as v increases, dominates. Here the CEO sheds financial risk as the variable compensation component (v) increases. As the variable compensation component (v) increases, the higher productivity shock parameter (σ) has a non-linear impact on CEO's compensation. Note that with higher σ the probability of productivity shock (ω) being less that the threshold productivity shock (ω^*) is higher. This represents that state of default. The CEO compensates this higher default risk by increasing the firm size (K) and borrows more. However, beyond a critical level of v (given by v^*), the compensation no longer increases with debt level as the risk of default overwhelms the benefit of larger firm. Beyond this critical level of v^*, the pay-off from higher variable compensation component (v) is more than enough to off-set the higher risk of default from higher debt (see the solid lines in Panels B and C of Figure 16).

Finally, Lewellen (2006) and Coles et al. (2006) document a positive relationship between risk taking proxied by firm leverage and the percentage of firm cash flow paid to the CEO as variable pay. A high debt-to-asset ratio is associated with a high fixed CEO compensation. In high-risk scenario, when productivity variance parameter (σ) value is high, the non-empire building CEO borrows more in order to protect her financial interest against loan default through a higher fixed pay. This encourages the non-empire building CEO to align her interests to those of the shareholders and she borrows more (e.g., Lewellen, 2006; Coles et al., 2006).

However, in our model, the firm's productivity shock (ω) is a function of the CEO's effort (p) and the resulting cash flows are not known ex-ante (i.e., at date 0). Hence, the lender ensures the default compensation (considering the foreclosure cost) before allowing the non-empire building CEO to borrow. Since a firm's debt-to-asset ratio increases with the percentage of firm cash flow paid to the non-empire building CEO as variable pay, so is the firm's default probability. The non-empire building CEO tends to borrow more in two scenarios. First, when default probability is low. Second, in the high-risk scenario when she is offered both a high fixed pay as well as a high variable pay. In this situation, the higher fixed pay protects the non-empire building CEO's own financial interest from default risk and she borrows more. However, with a higher percentage of firm cash flow paid to the non-empire building CEO as variable pay, lender's control on CEO borrowing becomes stricter. Hence, the non-empire building CEO cannot borrow as she prefers. Thus, the non-empire building CEO maintains a high but steady borrowing level in this high-risk scenario (see the solid line in Panel D of Figure 16).

Furthermore, risk averse, non-empire building CEOs lower firm investment by borrowing less with increasing productivity variance parameter (σ) (Panousi and Papanikolau, 2012). However, we find that for high productivity variance parameter value (i.e., $\sigma = 0.70$), a firm's debt-to-asset ratio levels are very high and quite stable in the percentage of firm cash flow paid to the non-empire building CEO as variable pay (see Panel D of Figure 16). In this situation, the non-empire building CEO maintains a higher debt-to-asset ratio throughout different variable pay levels as the higher fixed pay protects her from default risk and she makes risky borrowings without affecting her own financial interest. In other words, the non-empire building CEO is not entrenched in the context of endogenous effort and hence her borrowing decisions are optimized (see the solid line in Panel D of Figure 16).

8 CEO effort and firm leverage complementarity

To ensure optimum CEO effort, the shareholders must take into consideration individual risk factors that a CEO considers before exerting any effort to increase firm leverage. For example, a large, fixed CEO compensation, especially in a high-risk firm, may reduce the CEO's incentive to pursue strategies that maximize stock returns (Hill and Phan, 1991). On the contrary, offering a low fixed compensation may not be enough for the CEO to overcome her personal financial risks, leading to a lower than optimum firm leverage. To ensure the willingness of the

CEOs to put in more effort to increase shareholders' wealth, different strategies are utilized. For example, shareholders can create complementarity between CEO effort and firm leverage by offering a "signing bonus" or a "golden parachute" to the CEO along with a higher fixed pay (Singh and Harianto, 1989), especially after a credit stimulus (see Figure 17).

Insert Figure 17 Here

Figure 17 provides support to one of our original predictions that an optimal CEO compensation contract must contain a fixed component that is increasing in firm leverage. Figure 17 also shows that the fixed component of CEO compensation is higher after a credit stimulus (see the dotted line) relative to pre-credit stimulus scenario (see the solid line) irrespective of firm leverage level. This occurs because the borrowing cost decreases after a credit stimulus. Thus, the shareholders see the opportunity to grow and motivate the CEO to borrow more to enhance the scope of the firm's operations. To encourage the CEO to increase firm leverage, the shareholders must prepare a CEO contract that contains a higher level of fixed compensation component relative to the one offered in the absence of a credit stimulus. This protects the CEO against any personal financial loss in case of a default and she borrows more. This is exactly what Figure 17 shows.

Shareholders prefer a relatively a strong link between CEO variable compensation and firm performance, and a weak link between absolute compensation and risk (Hill and Phan, 1991). Linking CEO variable compensation to firm performance is beneficial for the shareholders as this gives CEOs an incentive to create wealth for shareholders (Grossman and Hart, 1983). We assume that from a shareholder's perspective, her wealth will increase only when the firm grows, and this firm growth depends on the amount of effort the CEO is willing to exert to borrow more.

Offering fixed incentives takes away the individual financial risk factors for a CEO and she aligns her own interests to those of the shareholders and consequently exerts more effort in order to ensure firm growth by borrowing more. This is exactly what we show in Figure 18.

Insert Figure 18 Here

As predicted, Figure 18 shows that CEO effort is increasing in firm leverage irrespective of the presence of a credit stimulus. However, Figure 18 also shows that the CEO has a higher effort level post-credit stimulus (see the dotted line) relative to her effort level before the credit stimulus (see the solid line) across different leverage levels. This occurs as after a credit stimulus the borrowing cost decreases. Thus, the CEO is more motivated to exert effort to increase borrowing in order to enhance the scope of the firm's operations after a credit stimulus.

9 CEO variable pay and social welfare

With positive credit shocks, like a credit stimuli, CEOs feel motivated to over-invest in excessively risky strategies due to lower borrowing costs. Strict monitoring by the lenders can prevent overinvestment in such risky strategies by eliminating CEO's pay for performance incentives (Kolm et al., 2015). To control for the risky CEO overinvestment, the lenders charge a higher lending rate that is increasing in both a firm's debt-to-asset ratio and in the productivity variance parameter (σ) (see Figure 2).

Insert Figure 2 Here

Furthermore, as the borrowing becomes more expensive with growing uncertainty, the CEO cannot borrow to grow the firm and hence does not exert her full effort (see Figure 19). Nevertheless, in presence of a credit stimulus, the CEO is more motivated to borrow than in the absence of such stimulus. Thus, the CEO effort level is always higher in the presence of a credit stimulus (see the dotted line in Figure 19) relative to the scenario when the credit stimulus is absent (see the solid line in Figure 19).

Insert Figure 19 Here

Therefore, optimal control on CEO decisions for firms combines strict monitoring and debt-to-asset ratio constraint.

10 Conclusions

This paper studies a model with endogenous compensation contracts and leverage choices. We show that multiple channels are at play and that cross-sectional links between leverage and variable compensation are ambiguous and much in line with the empirical findings.

Our model shows that the optimal compensation package is a combination of fixed and variable components that provides enough motivation for a CEO to exert costly effort and enough insurance to encourage risk-taking. From the perspective of the shareholder, leverage and the CEO's effort are complements. Thus, to encourage both of these two elements, optimal compensation packages need to have total pay increasing in leverage.

Finally, we show that the compensation structure of the CEO affects the demand for credit. A key cross-sectional implication arising from our model is that firms with high CEO ownership will react more (i.e., they will borrow more) in response to a credit supply expansion. Also, after the credit push, shareholders have the tendency to increase the size of the compensation package for the CEO. This increase is greater for these firms with low idiosyncratic risk. This increased compensation package also can make these firms more sensitive to future policy stimulus. This result uncovers a potential channel, which can play an important role in the effectiveness of credit policies.

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Tables

Table 1: **Parameters**

Exogenously Determined			
Parameter	Value	Description	Source
η	1.1	Coefficient of risk aversion	Carlson & Lazrak (2010)
σ	0.40	Productivity variance parameter	Gete & Melkadze (2018)
γ	0.12	Foreclosure cost	Bernanke et al. (1999)
τ	0.01	Credit subsidy to lenders	Drop in Chinese interbank rates in 2008
R_b	1.02	Cost of lenders' funds	Mean return on Chinese deposits from '07- '10
Endogenously Determined			
ψ	0.045	Level parameter of benefits from effort	
ε	0.315	Shape parameter of benefits from effort	
R_k	1.04	Parameter return of capital	
ϕ	0.0012	Level parameter of costs of effort	
ρ	2.2	Shape parameter of costs of effort	

Table 2: **Model Moments and Targets (annualized)**

Description	Targets	Model
Leverage	0.50	0.50
Default rate	5.1%	5.57%
Lender lending rate	3%–6%	3.44%
Net ROA	4-6%	4%
Net ROE	7%–9%	8.47%

Figures

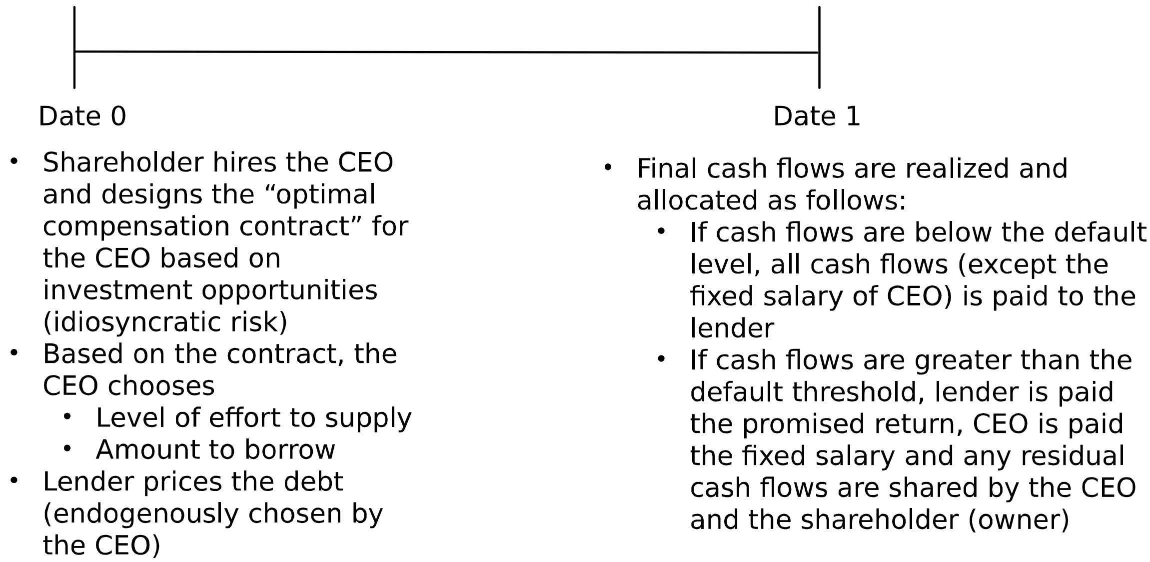

Figure 1. Time-line of the actions of shareholder, CEO and lender.

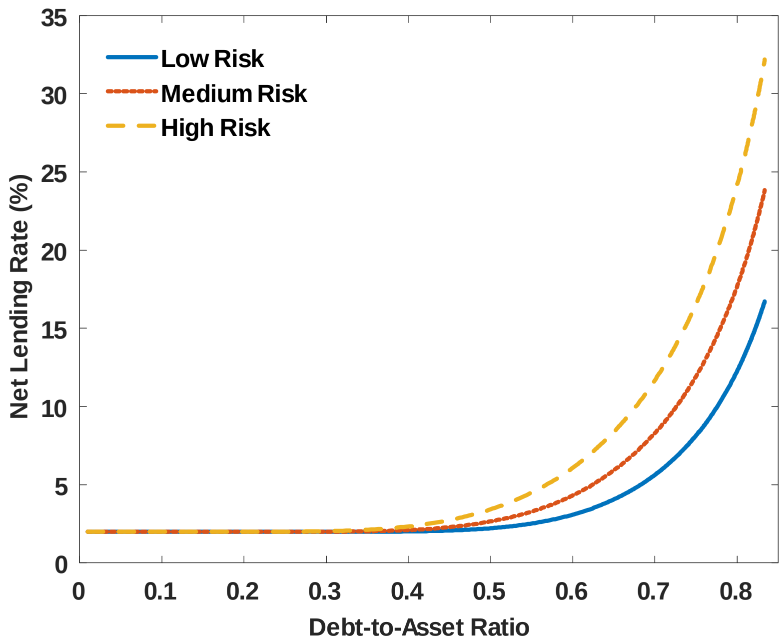

Figure 2. Lending rate and a firm's debt-to-asset ratio. This figure plots the relationship between the net lending rate offered by the lender $(R_L - 1)$ and a firm's debt-to-asset ratio $(\frac{B}{B+N})$ for different productivity variance parameter (σ) values that represent different risk levels. The solid line represents a low risk (i.e., $\sigma = 0.10$) scenario, the dotted line represents a medium risk (i.e., $\sigma = 0.40$) scenario while the dashed line represents a high risk (i.e., $\sigma = 0.70$) scenario.

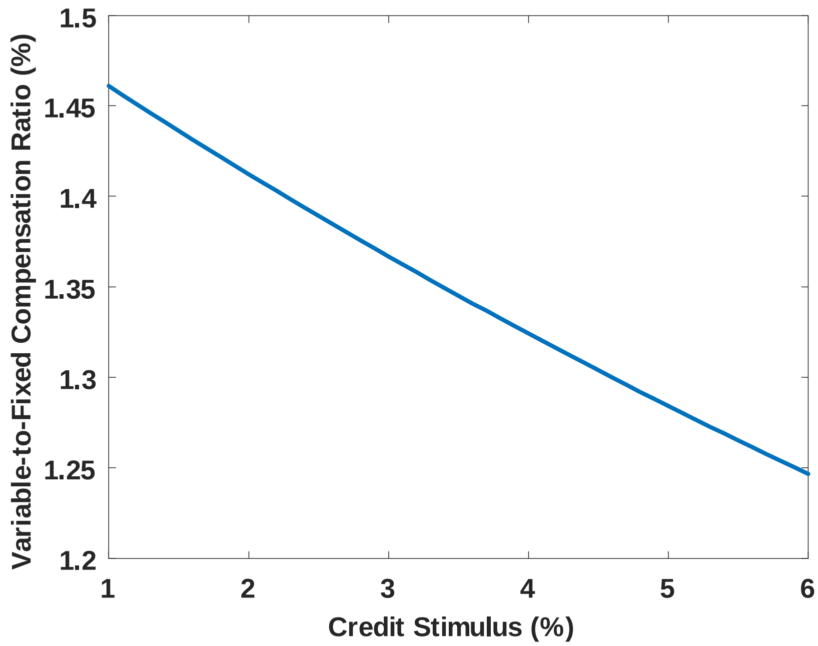

Figure 3. Ratio of variable-to-fixed CEO compensation and credit stimulus (τ). This figure plots the relationship between a simulated credit stimulus (τ) in percentage and the ratio of variable-to-fixed CEO compensation, $\frac{v(Y-R_LB)}{A}$. Where, v represents the percentage of firm's cash flow paid to the CEO, Y represents firm's cash flow and R_LB represents the payment to the lender. Hence, $v(Y-R_LB)$ represents the CEO variable pay while A represents the fixed CEO compensation.

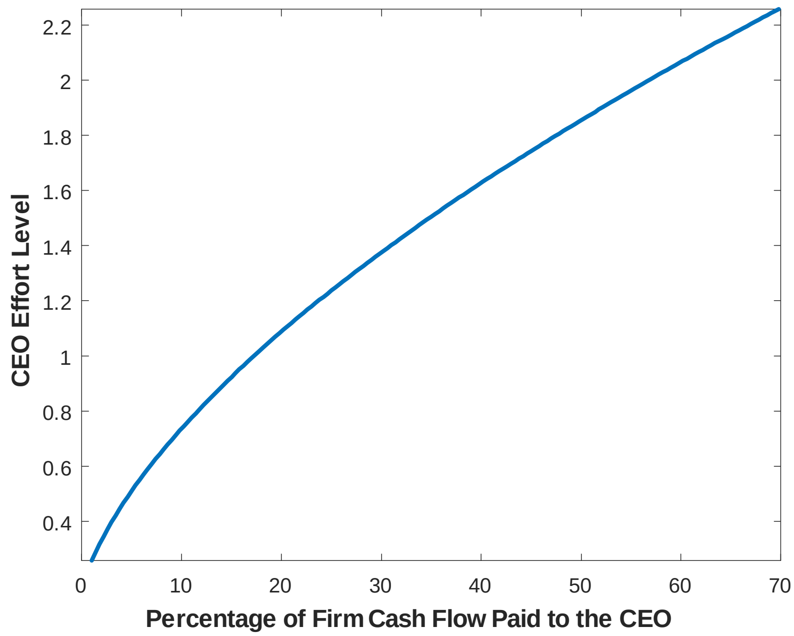

Figure 4. CEO effort and percentage of firm cash flow paid to the CEO. This figure plots the relationship between CEO effort level (p) and the percentage of firm cash flow paid to the CEO (v). For this figure, we keep the fixed CEO pay (A) as constant to show how CEO effort level (p) varies based only on the percentage of firm cash flow paid to the CEO (v).

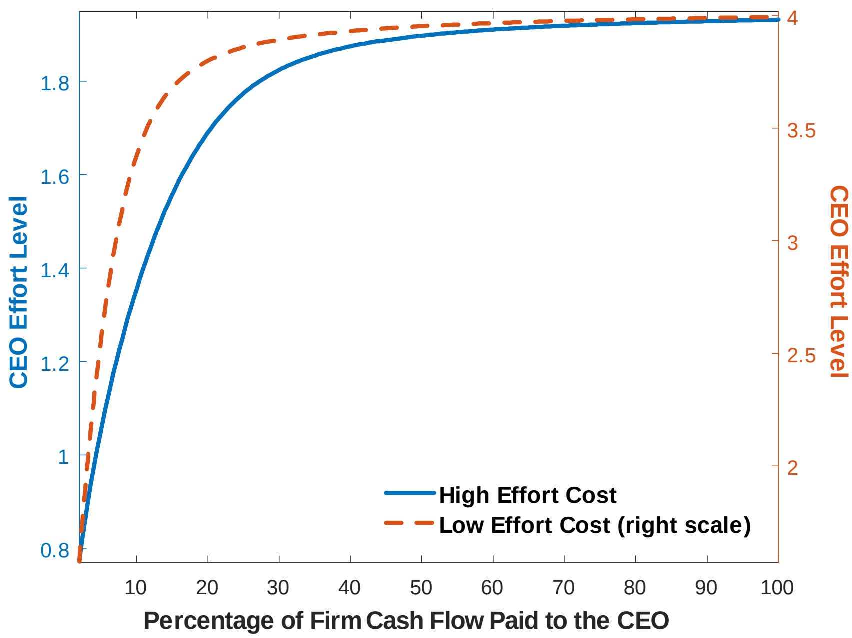

Figure 5. CEO effort and percentage of firm cash flow paid to the CEO for low and high effort costs. This figure replicates Figure 4 but for different CEO effort costs, $c(p)$. The dashed line represents low CEO effort cost (i.e., when $\phi = 0.0010$ and $\rho = 1.5$). The solid line represents high CEO effort cost (i.e., when $\phi = 0.0015$ and $\rho = 2.5$).

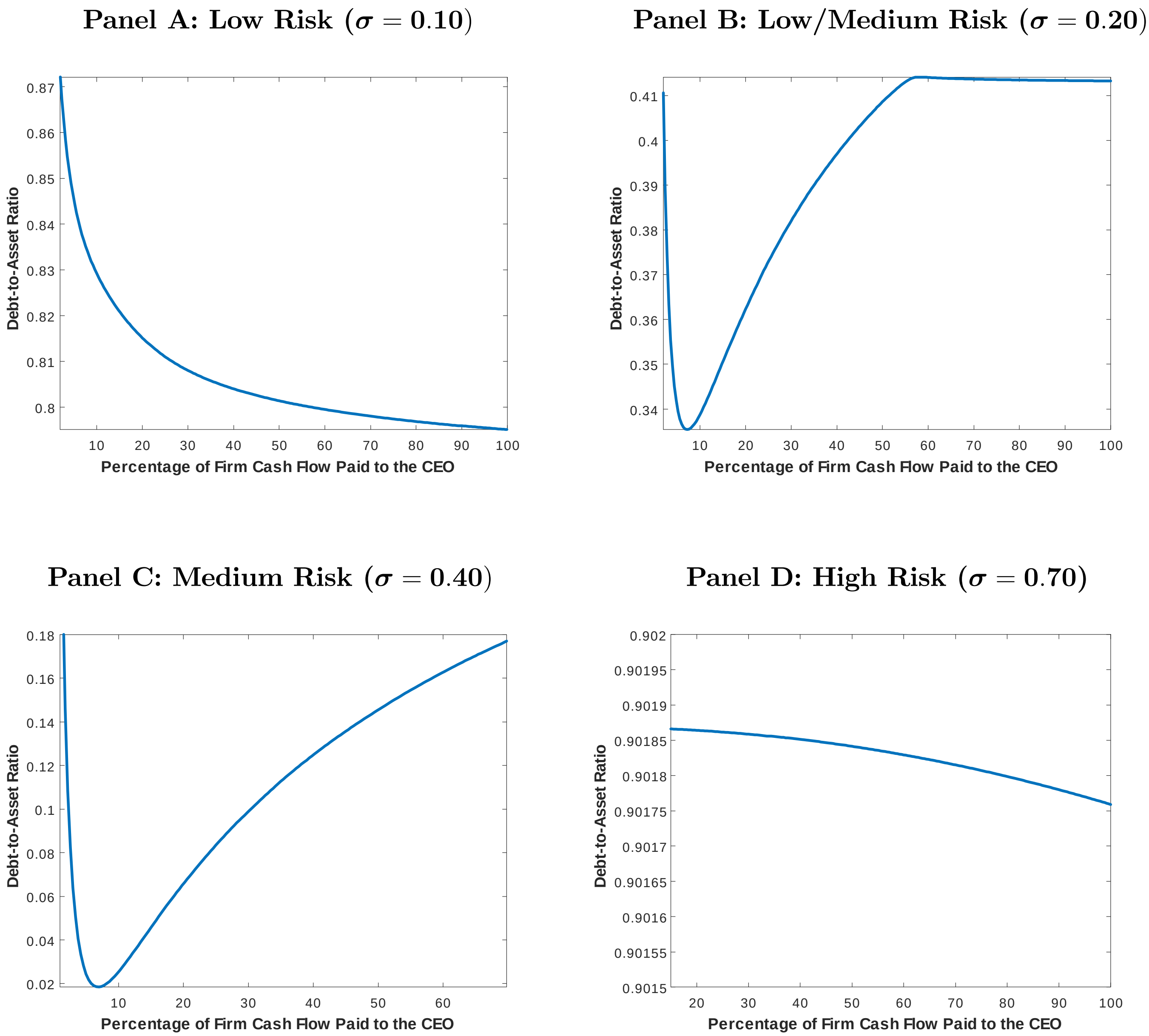

Figure 6. Debt-to-asset ratio and percentage of firm cash flow paid to the CEO for different productivity variance parameters (σ). This figure plots the relationship between the debt-to-asset ratio of a firm ($\frac{B}{B+N}$) and the percentage of firm cash flow paid to the CEO (v). We show this relationship across low (i.e., 0.10) (in Panel A), low/medium (i.e., 0.20) (in Panel B), medium (i.e., 0.40) (in Panel C), and high (i.e., 0.70) (in Panel D) productivity variance parameter (σ) values.

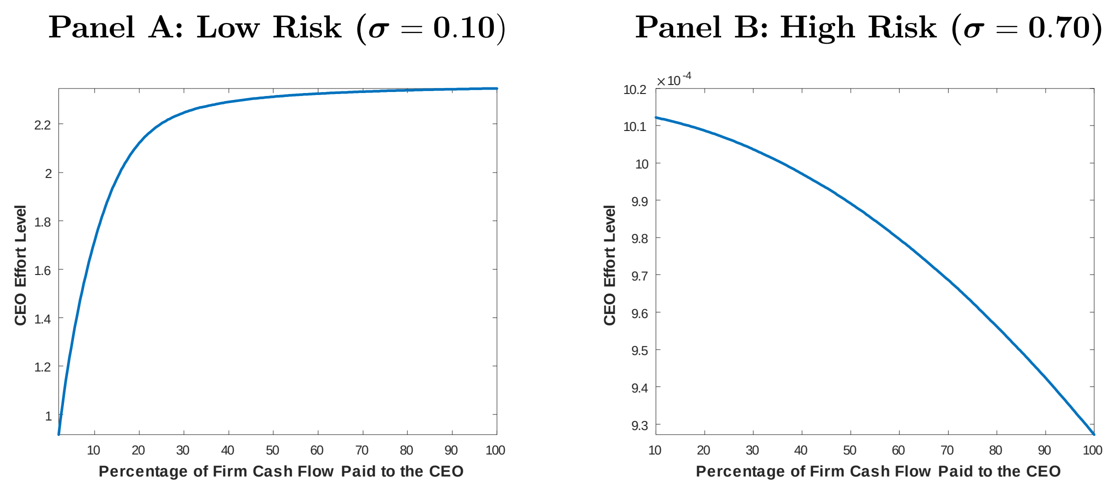

Figure 7. CEO effort and percentage of firm cash flow paid to the CEO for different productivity variance parameters ($\boldsymbol{\sigma}$). This figure plots the relationship between CEO effort level (p) and the percentage of firm cash flow paid to the CEO (v). We show this relationship for low (i.e., 0.10) (in Panel A), and high (i.e., 0.70) (in Panel B) productivity variance parameter (σ) values. For this figure, we keep the fixed CEO pay (A) constant to show how CEO effort level (p) varies based only on the percentage of firm cash flow paid to the CEO as her variable pay (v).

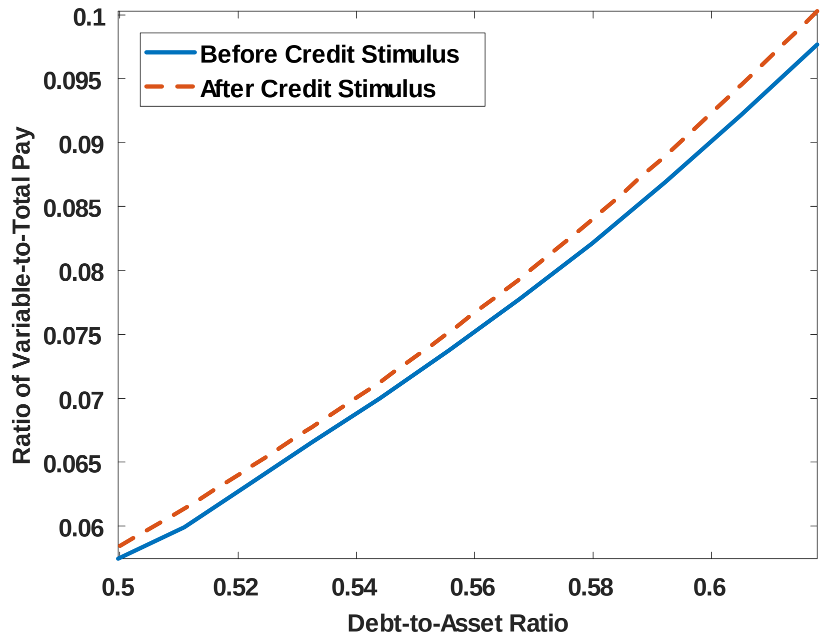

Figure 8. Debt-to-asset ratio and variable-to-total pay ratio before and after credit stimulus. This figure plots the ratio of variable-to-total CEO pay, $\frac{v(Y-R_LB)}{v(Y-R_LB)+A}$, as a function of firm's debt-to-asset ratio ($\frac{B}{B+N}$) before and after a simulated credit stimulus. Where, B represents firm's debt, N represents total equity, v represents the percentage of firm's cash flow paid to the CEO, Y represents firm's cash flow and R_LB represents the payment to the lender. The fixed CEO pay, A, is assumed to be exogenous that the CEO receives irrespective of the realized cash flow. The solid line represents this relationship before the simulated credit stimulus and the dashed line represents this relationship after the simulated credit stimulus.

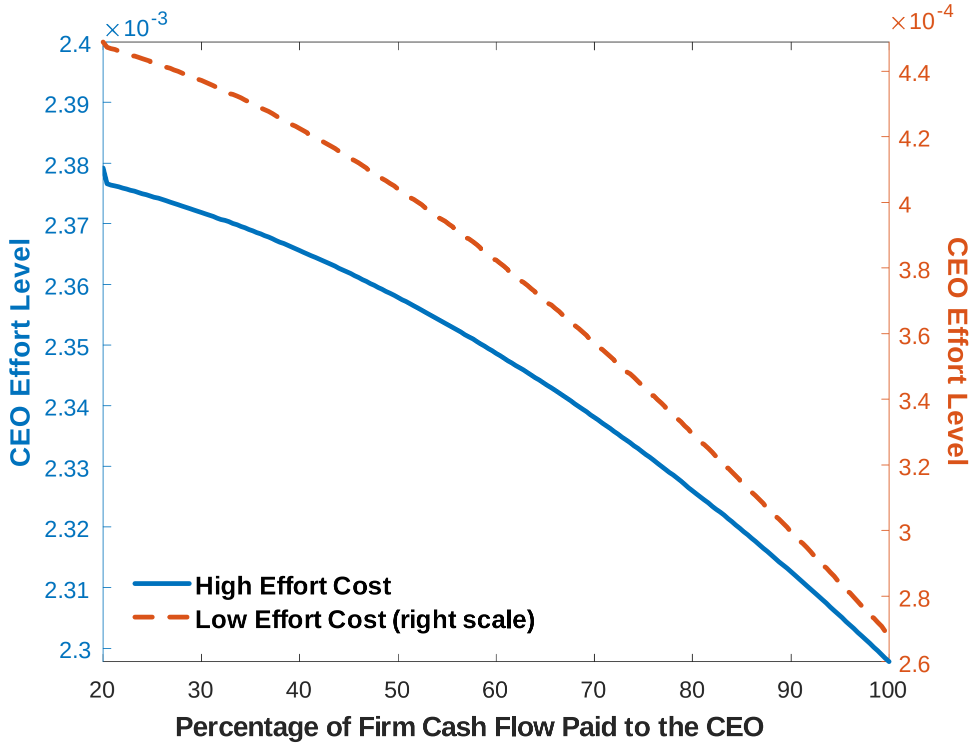

Figure 9. CEO effort and percentage of firm cash flow paid to the CEO for low and high effort costs. This figure plots the relationship between CEO effort level (p) and the percentage of firm's cash flow paid to the CEO (v). For this figure, we keep the fixed CEO pay (A) constant to show how CEO effort level (p) varies based only on the percentage of firm's cash flow paid to the CEO (v). The solid line represents low CEO effort cost, $c(p)$ (i.e., when $\phi = 0.0010$ and $\rho = 1.5$). The dashed line represents high CEO effort cost (i.e., when $\phi = 0.0015$ and $\rho = 2.5$). The firm has high productivity variance ($\sigma = 0.70$).

Panel A Panel B

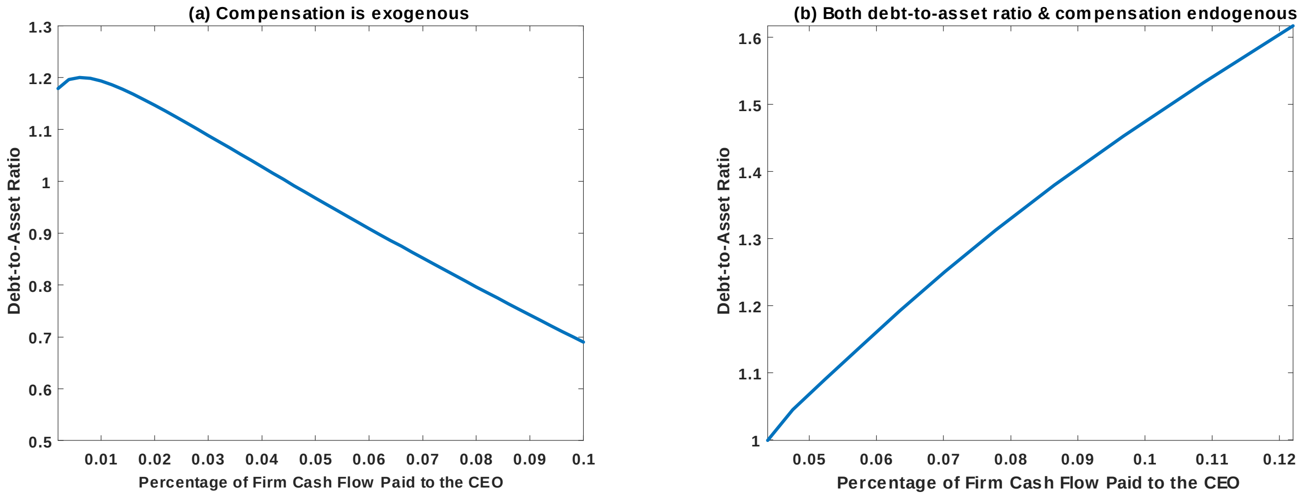

Figure 10. Debt-to-asset ratio and percentage of firm's cash flow paid to the CEO in models with exogenous or endogenous compensation. This figure plots firm's debt-to-asset ratio ($\frac{B}{B+N}$) as a function of shareholder's choice of the percentage of a firm's cash flow paid to the CEO (v). Where, B represents firm's debt, and N represents total equity. In Panel A, the compensation is exogenous, i.e., a firm's debt-to-asset ratio ($\frac{B}{B+N}$) is a function of only the percentage of a firm's cash flow paid to the CEO (v). In the exogenous compensation scenario, the relationship between a firm's debt-to-asset ratio ($\frac{B}{B+N}$) and the percentage of a firm's cash flow paid to the CEO as her variable pay (v) is independent of the productivity variance parameter (σ) across firms. In Panel B the compensation is endogenous as in Section 3.3. For the endogenous compensation scenario, the changes in a firm's debt-to-asset ratio ($\frac{B}{B+N}$) and the percentage of a firm's cash flow paid to the CEO (v) are induced by simultaneously altering the productivity variance parameter (σ) values across firms.

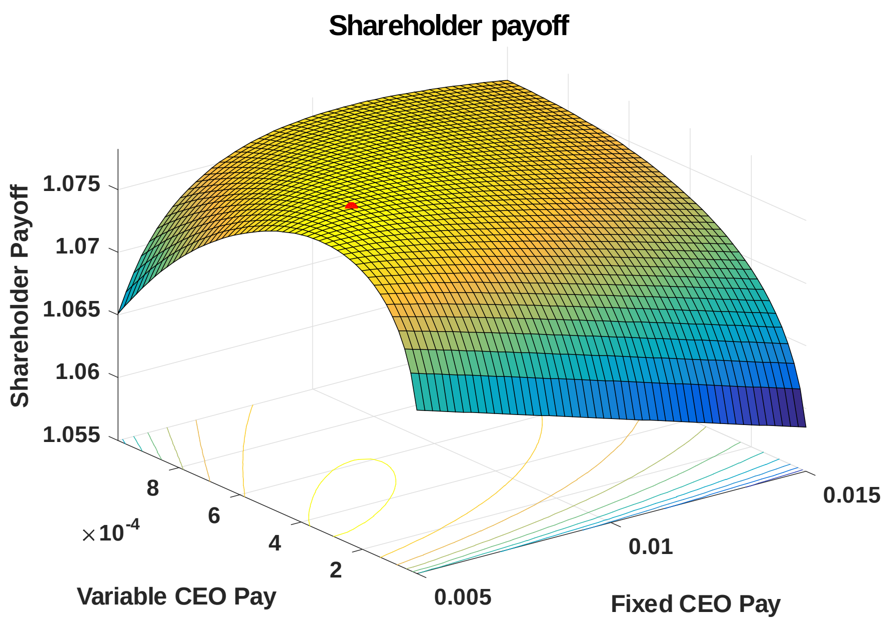

Figure 11. Shareholder payoff as a function of CEO compensation. This figure plots the shareholder's payoff based on her choice of the CEO variable pay, $v(Y - R_L B)$, and the fixed CEO compensation (A). Where, v represents the percentage of firm's cash flow paid to the CEO, Y represents firm's cash flow and $R_L B$ represents the payment to the lender. The optimal combination of the variable pay, $v(Y - R_L B)$, and fixed pay, A, is the dot on the top of the surface.

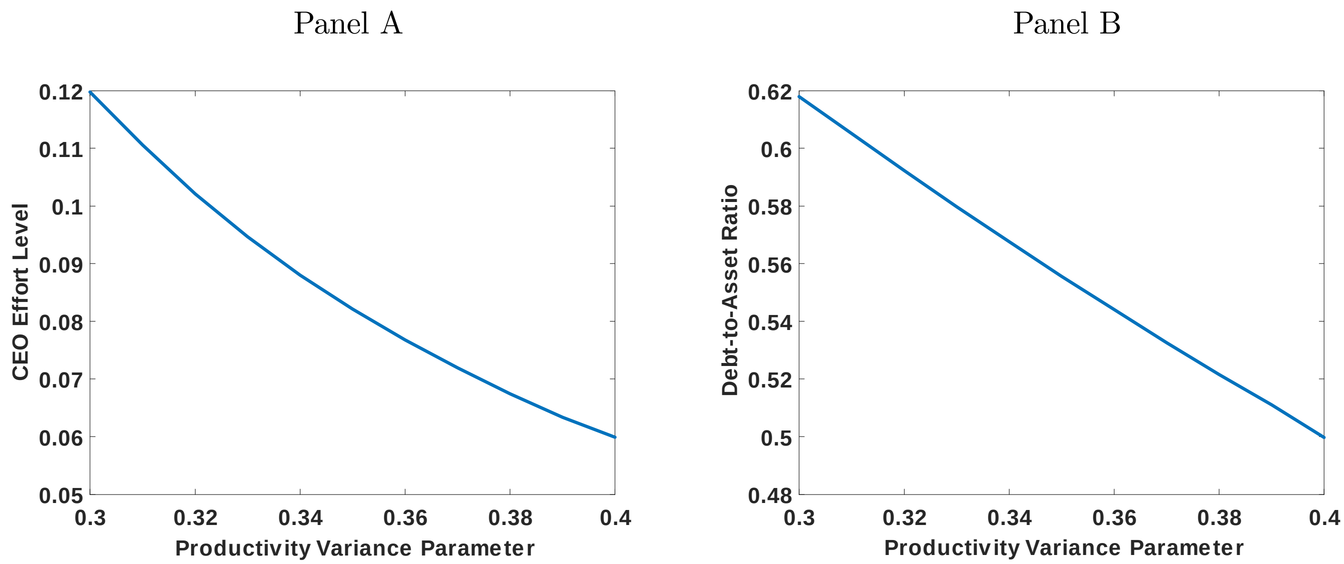

Figure 12. Debt-to-asset ratio and CEO effort as a function of firm's risk (σ).

This figure plots CEO's effort level (p) (in Panel A) and the firm's debt-to-asset ratio ($\frac{B}{B+N}$) (in Panel B) for firms with different levels of productivity variance parameter (σ). Where, B represents firm's debt, and N represents total equity.

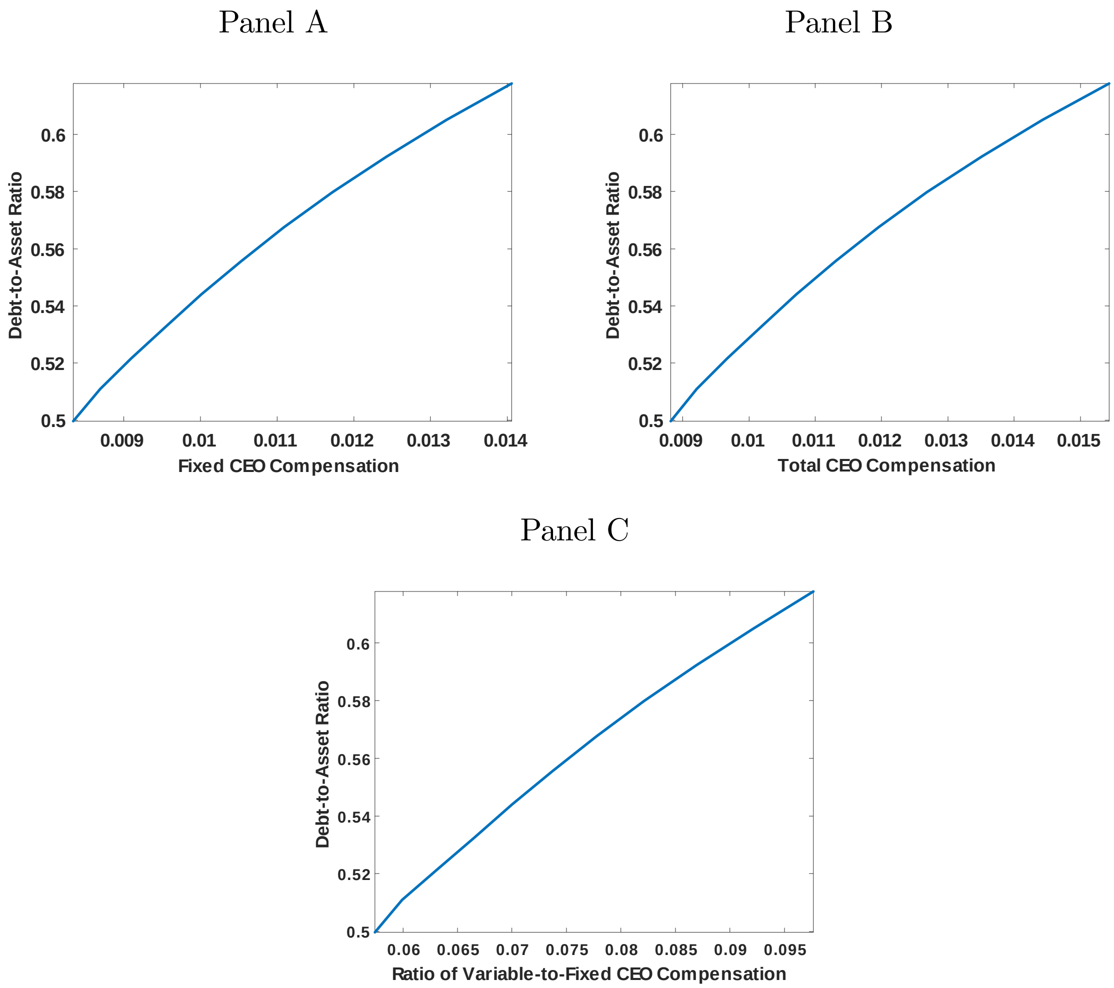

Figure 13. Compensation variables and debt-to-asset ratio in the cross-section of firms. This figure plots the compensation variables versus the debt-to-asset ratio of firms ($\frac{B}{B+N}$). The y-axis across all panels represents the debt-to-asset ratio of firms ($\frac{B}{B+N}$). Where, B represents firm's debt, and N represents total equity. The x-axis of Panel A represents the fixed CEO compensation (A). The x-axis of Panel B represents total CEO compensation represented by the sum of the CEO's variable compensation, $v(Y - R_L B)$ and her fixed compensation (A). Where, v represents the percentage of firm's cash flow paid to the CEO, Y represents firm's cash flow and $R_L B$ represents the payment to the lender. Finally, the x-axis of Panel C represents the ratio of a CEO's variable compensation, $v(Y - R_L B)$ to her fixed compensation (A). All variables listed across the panels of Figure 13 are endogenous as described in Section 3.

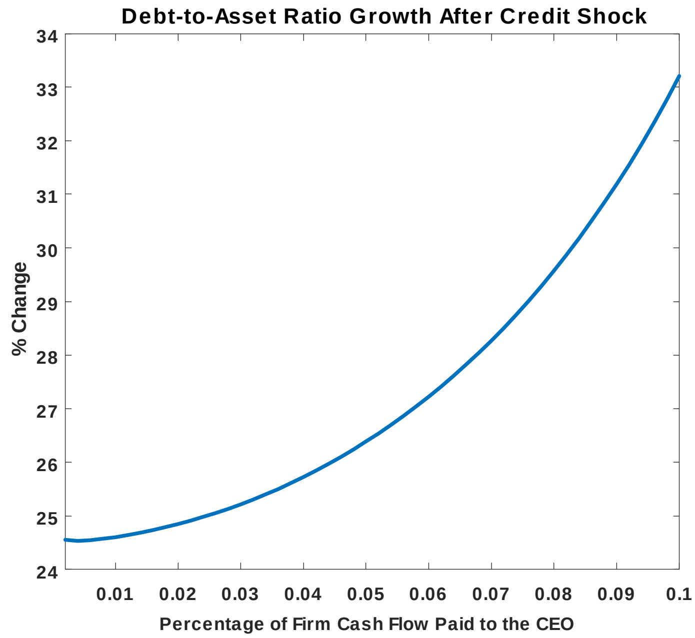

Figure 14. The effects of a credit stimulus on firm's debt-to-asset ratio. This figure plots the percentage change in debt-to-asset ratio for firms ($\frac{B}{B+N}$) across a range of the percentage of firm's cash flow paid to the CEO (v) after a simulated credit stimulus. Where, B represents firm's debt, and N represents total equity. Figure A8 of Online Appendix shows how a simulated credit stimulus changes the credit supply.

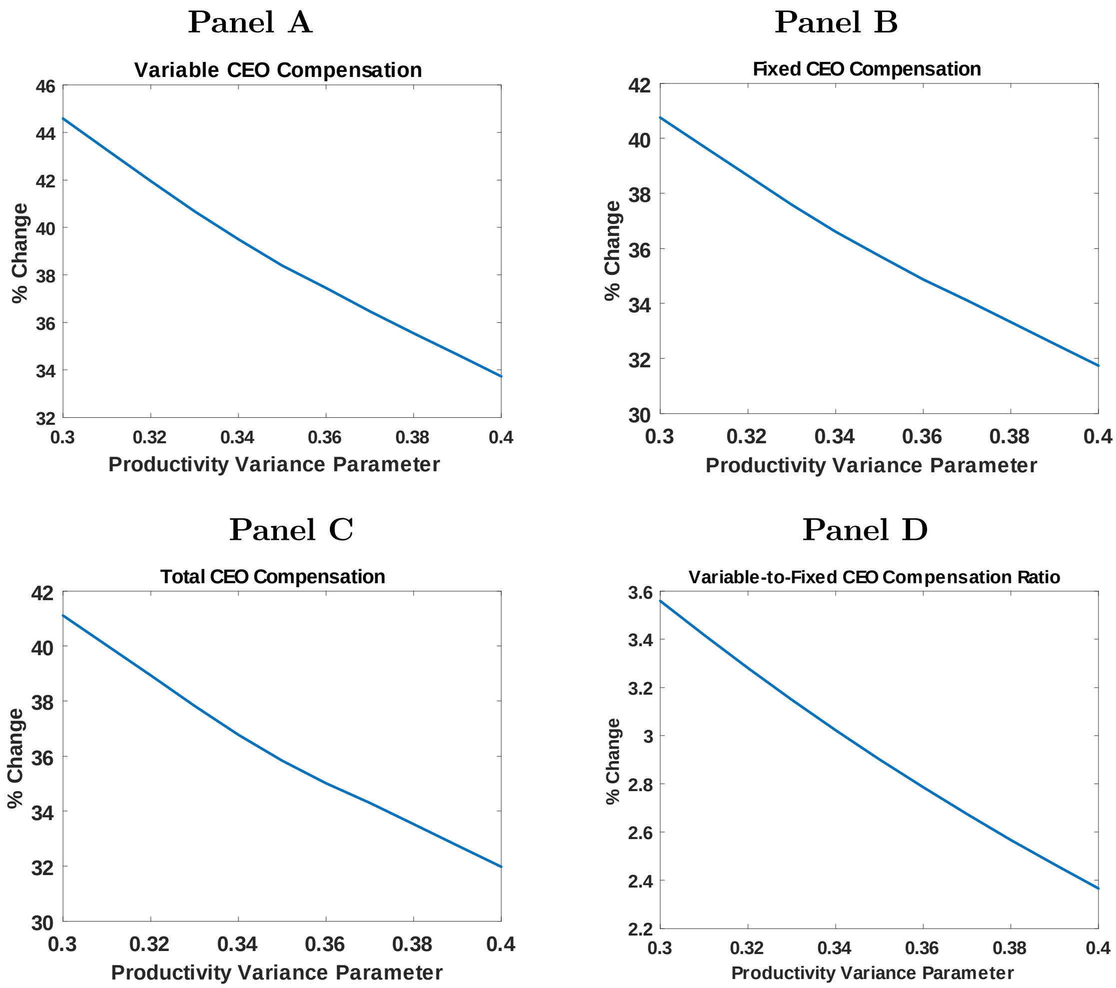

Figure 15. Change in compensation structure after the credit stimulus for different levels of firm risk (σ). This figure plots the compensation variables versus the productivity variance parameter (σ). The x-axis across all panels represents the productivity variance parameter (σ) range representing different firm risk levels. The y-axis of Panel A represents the percentage change in CEO's variable compensation, $v(Y - R_L B)$. Where, v represents the percentage of firm's cash flow paid to the CEO, Y represents firm's cash flow and $R_L B$ represents the payment to the lender. The y-axis of Panel B represents the percentage change in fixed CEO compensation (A). The y-axis of Panel C represents the percentage change in total CEO compensation represented by the sum of the CEO's variable compensation, $v(Y - R_L B)$ and her fixed compensation (A). Finally, the y-axis of Panel D represents the percentage change in the ratio of the CEO's variable compensation, $v(Y - R_L B)$ to her fixed compensation (A).

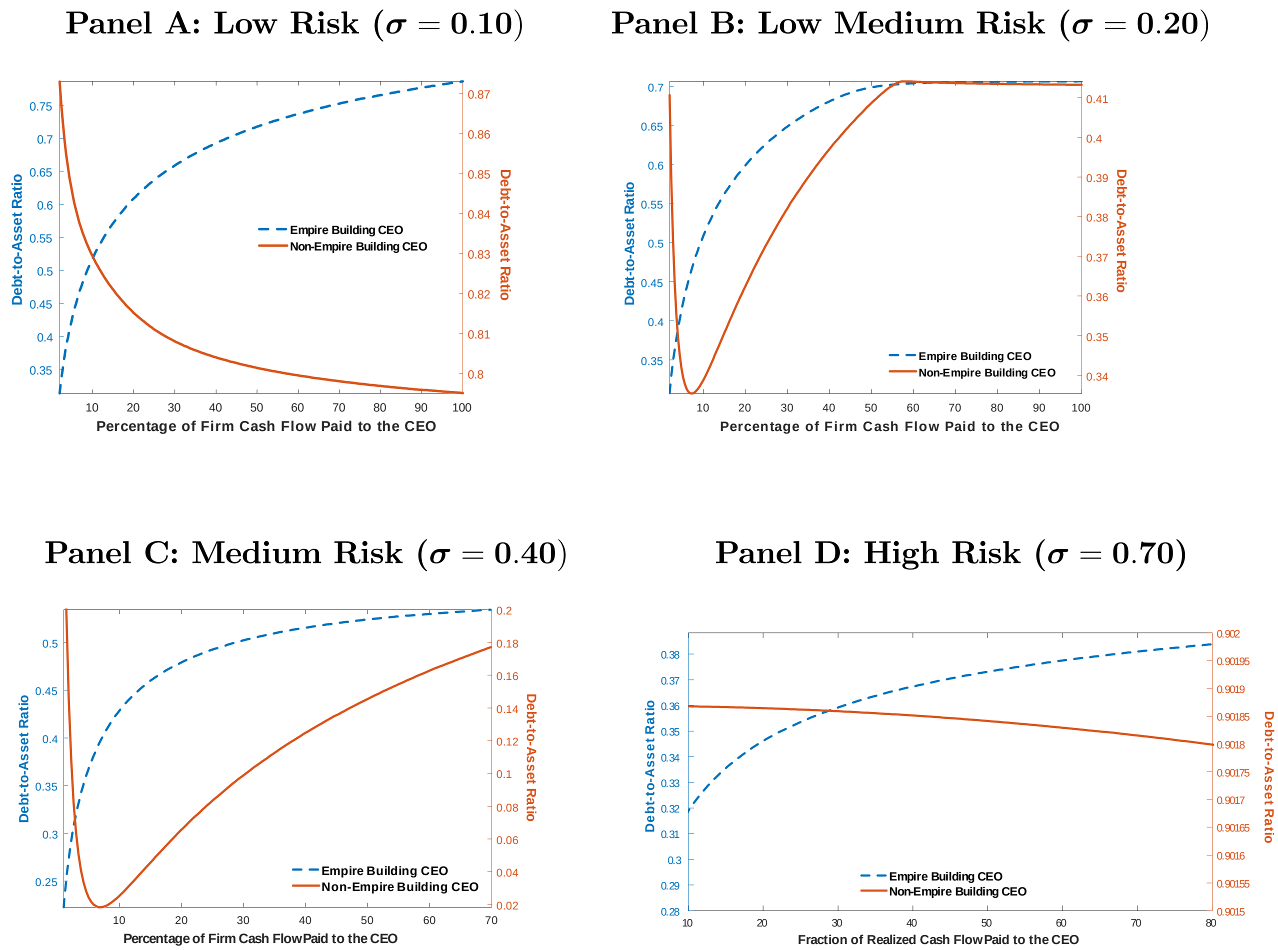

Figure 16. Debt-to-asset ratio and percentage of firm cash flow paid to the CEO for different CEO types and different levels of firm risk (σ). This figure plots the debt-to-asset ratio of the firm ($\frac{B}{B+N}$) and the percentage of firm's cash flow paid to the CEO (v) with low (i.e., 0.10) (Panel A), low medium (i.e., 0.20) (Panel B), medium (i.e., 0.40) (Panel C) and high (i.e., 0.70) (Panel D) productivity variance parameter (σ) values for different CEO types. Where, B represents firm's debt, and N represents total equity. The dashed line represents this relationship for an empire building CEO. The solid line represents the same relationship but for a non-empire building CEO.

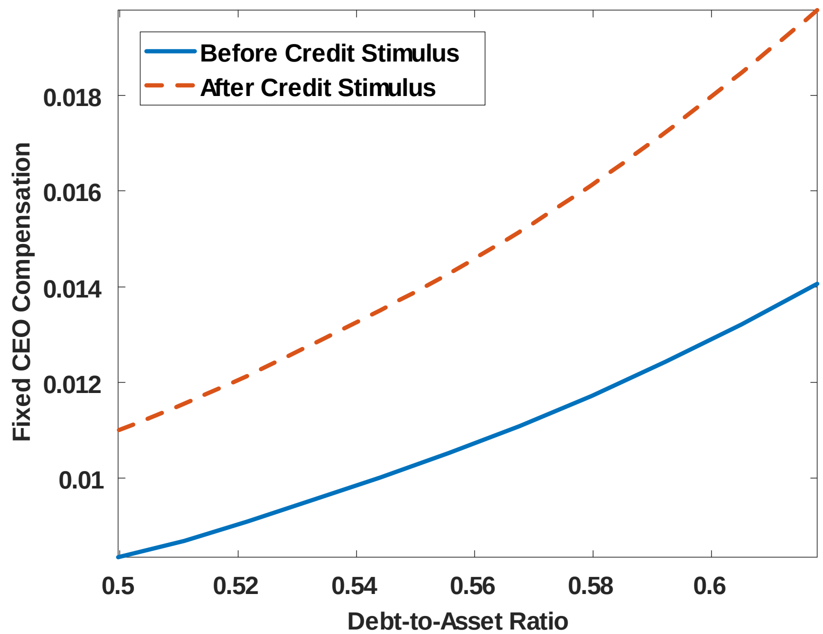

Figure 17. Debt-to-asset ratio and fixed CEO compensation. This figure plots the debt-to-asset ratio of a firm ($\frac{B}{B+N}$) and fixed CEO compensation (A) before and after a simulated credit stimulus. Where, B represents firm's debt, and N represents total equity. The solid line represents the relationship between the debt-to-asset ratio ($\frac{B}{B+N}$) and fixed CEO compensation (A) before the simulated credit stimulus when the borrowing cost for a firm is high. The dashed line represents the same relationship but after the simulated credit stimulus when the borrowing cost for a firm is low.

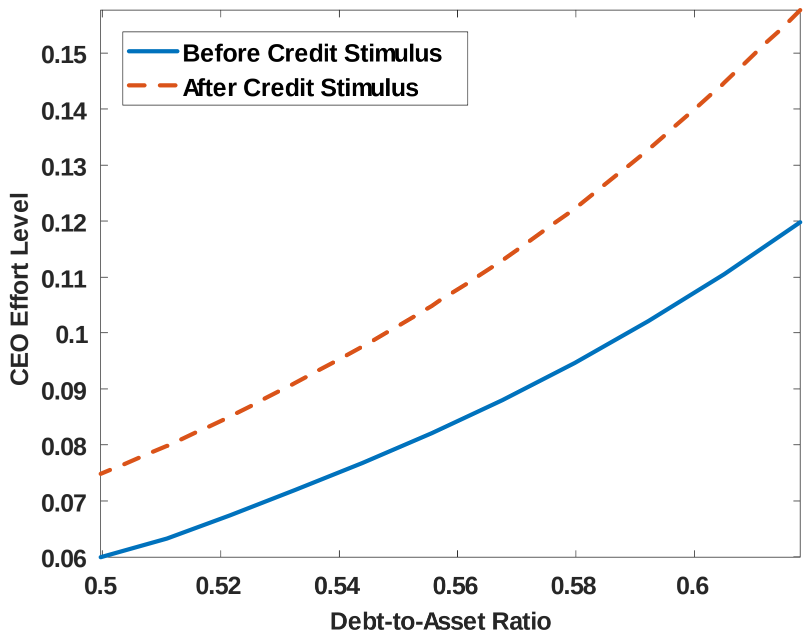

Figure 18. CEO effort and debt-to-asset ratio. This figure plots the relationship between a firm's debt-to-asset ratio ($\frac{B}{B+N}$) and CEO effort level (p) before and after a simulated credit stimulus. Where, B represents firm's debt, and N represents total equity. The solid line represents this relationship before the simulated credit stimulus when the borrowing cost for a firm is high. The dashed line represents the same relationship but after the simulated credit stimulus when the borrowing cost for a firm is low.

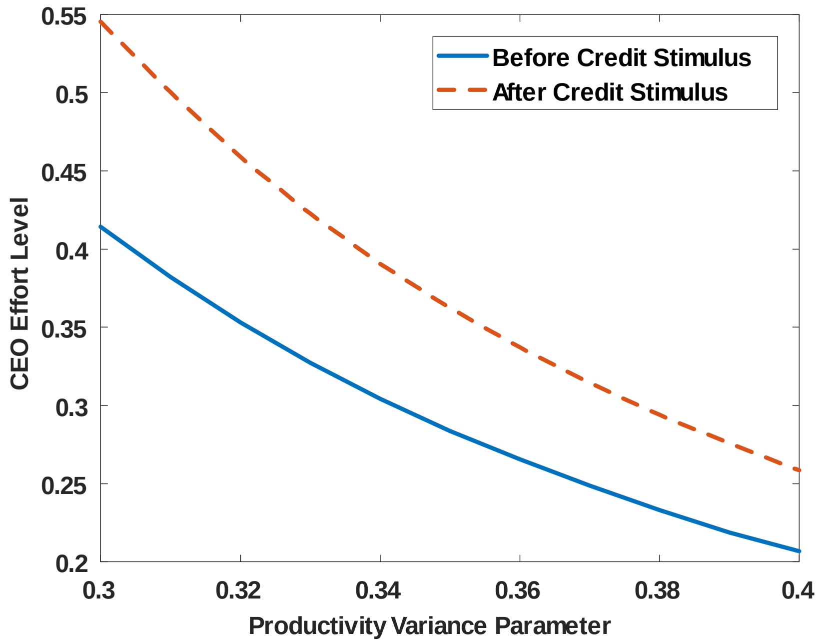

Figure 19. CEO effort and productivity variance parameter (σ). This figure plots CEO effort level (p) for different productivity variance parameter (σ) values that represent different risk levels before and after a simulated credit stimulus. The solid line represents this relationship before the simulated credit stimulus when the borrowing cost for a firm is high. The dashed line represents the same relationship but after the simulated credit stimulus when the borrowing cost for a firm is low.

ONLINE APPENDIX. NOT-FOR-PUBLICATION

The CEO problem

We denote the CEO's payoff when the firm is not in default as:

$$\Omega(\omega, \hat{\omega}, B, p) \equiv A + v\,(\omega - \hat{\omega})\,R^k(B+N) - c(p), \tag{A1}$$

and the CEO's payoffs when the firm is in default as:

$$\Psi(p) \equiv A - c(p). \tag{A2}$$

Using (A1) and (A2), the CEO's maximization problem (10) becomes:

$$\max_{\{\hat{\omega}, p, B\}} \int_{\hat{\omega}}^{\infty} u\left(\Omega(\omega, \hat{\omega}, B, p)\right) f(\omega; p)\, d\omega + u(\Psi(p))\, F(\hat{\omega}; p) \tag{A3}$$

s.t.

$$\int_0^{\hat{\omega}} (1-\gamma)\,\omega R^k(B+N) f(\omega; p)\, d\omega + \hat{\omega} R^k(B+N)\,(1 - F(\hat{\omega}; p)) = R^B(1-\tau)B. \tag{A4}$$

Denoting the Lagrangian multiplier by λ_m the Lagrangian is

$$\mathcal{L}_m(\hat{\omega}, p, B) = \left\{ \begin{array}{l} \int_{\hat{\omega}}^{\infty} u\left(\Omega(\omega, \hat{\omega}, B, p)\right) f(\omega; p)\, d\omega + u(\Psi(p))\, F(\hat{\omega}; p) + \\ +\lambda_m \left[\begin{array}{l} \int_0^{\hat{\omega}} (1-\gamma)\,\omega R^k(B+N) f(\omega; p)\, d\omega + \\ +\hat{\omega} R^k(B+N)\,(1 - F(\hat{\omega}; p)) - R^B(1-\tau)B \end{array} \right] \end{array} \right\},$$

and the FOCs are:

$$\frac{\partial \mathcal{L}_m(\hat{\omega}, p, B)}{\partial \hat{\omega}} = \left\{ \begin{array}{l} -\int_{\hat{\omega}}^{\infty} u'(\Omega) v R^k(B+N) f(\omega; p)\, d\omega + \\ +\lambda_m \left[-\gamma \hat{\omega} R^k(B+N) f(\hat{\omega}; p) + R^k(B+N)\,(1 - F(\hat{\omega}; p)) \right] \end{array} \right\} = 0. \tag{A5}$$

For effort:

$$\frac{\partial \mathcal{L}_m(\hat{\omega},p,B)}{\partial p} = \left\{ \begin{array}{l} \int_{\hat{\omega}}^{\infty} \left[-u'(\Omega)c'(p)f(\omega;p) + u(\Omega)\dfrac{\partial f(\omega;p)}{\partial p} \right] d\omega + \\ +u(\Psi)\dfrac{\partial F(\hat{\omega};p)}{\partial p} - u'(\Psi)c'(p)F(\hat{\omega};p) + \\ +\lambda_m \left[\begin{array}{l} \int_0^{\hat{\omega}} (1-\gamma)\omega R^k (B+N)\dfrac{\partial f(\omega;p)}{\partial p}\, d\omega + \\ -\hat{\omega} R^k (B+N) \dfrac{\partial F(\hat{\omega};p)}{\partial p} \end{array} \right] \end{array} \right\} = 0, \tag{A6}$$

and for debt level:

$$\frac{\partial \mathcal{L}_m(\hat{\omega},p,B)}{\partial B} = \left\{ \begin{array}{l} \int_{\hat{\omega}}^{\infty} u'(\Omega)(\omega-\hat{\omega})vR^k f(\omega;p)\, d\omega + \\ +\lambda_m \left[\begin{array}{l} \int_0^{\hat{\omega}} (1-\gamma)\,\omega R^k f(\omega;p)\, d\omega + \\ +\hat{\omega} R^k \left(1 - F(\hat{\omega};p)\right) - R^B(1-\tau) \end{array} \right] \end{array} \right\} = 0. \tag{A7}$$

The shareholder's problem

The shareholder proposes the compensation contract $\{v, A\}$ that maximizes

$$\max_{\{v,A\}} \int_{\hat{\omega}(v,A)}^{\infty} [(1-v)(\omega - \hat{\omega}(v,A))R_k(B(v,A)+N) - A]\, f(\omega; p(v,A))\, d\omega, \tag{A8}$$

subject to the CEO's decision allocations $\hat{\omega}(v, A)$, $p(v, A)$ and $B(v, A)$ implicitly defined in Section A1. That is, the shareholder solves:

$$\max_{\{v,F,\hat{\omega},p,B\}} \int_{\hat{\omega}}^{\infty} [(1-v)(\omega - \hat{\omega})R_k(B+N) - A]\, f(\omega; p)\, d\omega, \tag{A9}$$

subject to the first order conditions of the CEO's problem of functions (A5), (A6) and (A7). We use a numerical method to solve the shareholders' problem.

Lognormal distribution as the preferred choice

In our model, ω represents the productivity shock of a specific firm while R_K is the aggregate return to capital. The firm's cash flow (Y) at date 1 is stochastic and depends both on the capital employed (K) and on the productivity shock (ω). The firm's cash flow is given as:

$$Y(\omega; K) = \omega R_K K$$

Where, ω is the productivity shock and $R_K K$ is the ex-post aggregate return to a firm's capital. We assume that the productivity shock (ω) is idiosyncratic for firms over time. We also assume that the productivity shock (ω) has a continuous and once differentiable cumulative density function $F(\omega; p)$. We stress that the expected value of the productivity shock (ω) is a function of the CEO's effort (p) as given by Equation 4 and is reproduced below:

$$\mathbb{E}\,[\omega] = e^{\mu(p)+\frac{\sigma^2}{2}} = e^{\psi p^{\varepsilon}}$$

Further, we restrict the hazard rate, $h(\omega)$, for the productivity shock (ω) so that:

$$\frac{\partial(\omega h(\omega))}{\partial\omega} > 0$$

Where, $h(\omega) = \frac{F(\omega;p)}{1-F(\omega;p)}$. This regularity condition is a weak condition that satisfies almost all of the conventional distributions, including lognormal distribution.

Furthermore, since the expected value of the productivity shock (ω) is a function of the CEO's effort (p) (see Equation 4), the cumulative density function $F(\omega;p)$ is concave and increasing. This is also a characteristic of a lognormal distribution.

Hence, the use of lognormal distribution in our model assumptions is justified.[19]

CEO compensation in terms of share and cash

Equation 10, reproduced as Equation A10 below, captures how a non-empire building CEO wants to maximize her utility.

$$\max_{\{\hat{\omega},p,B\}} \int_{\hat{\omega}}^{\infty} u\left(A + v\left(Y\left(\omega,K\right) - R_L B\right) - c(p)\right)\, dF(\omega;p) + \int_{0}^{\hat{\omega}} u\left(A - c(p)\right)\, dF(\omega;p) \quad \text{(A10)}$$

subject to the lender's participation constraint that ensures that the CEO can borrow.

To address the concern of actual and immediate results in terms of cash rewards for the CEO's efforts, we modify Equation A10 slightly. We propose that while putting in effort, the CEO expects a certain percentage ($0 < \beta < 1$) as cash reward and the remaining percentage (i.e., $1-\beta$) in terms of improved equity values. Thus, the CEO wants to maximize her utility related to both cash reward and in terms of future equity values. Thus, we rewrite Equation A10 as:

$$\max_{\{\hat{\omega},p,B\}} [\beta[\int_{\hat{\omega}}^{\infty} u\left(A + v\left(Y\left(\omega,K\right) - R_L B\right) - c(p)\right)\, dF(\omega;p) + \int_{0}^{\hat{\omega}} u\left(A - c(p)\right)\, dF(\omega;p)] + \\ +(1-\beta)Y(\omega,K)] \quad \text{(A11)}$$

[19] Our approach is similar to the one by Bernanke et al. (1999) who assume that the productivity shock (ω) follows a lognormal distribution.

Using Equation A11, we investigate the relationship between CEO effort and the ratio of variable-to-total CEO pay and the results are given in Figure A1. We also investigate the relationship between the ratio of variable-to-total CEO pay and a firm's debt-to-asset ratio and the results are given in Figure A2.

Insert Figures A1 and A2 Here

We find that irrespective of the CEO's expected cash reward percentage (i.e., β), CEO effort is increasing in the ratio of variable-to-total CEO pay (see Figure A1). In both scenarios, the CEO is motivated to exert effort. When the cash reward percentage is low, the CEO exerts effort to increase the equity value of the firm. On the contrary, when the cash reward percentage is high, the CEO is protected from any credit default by the firm. Hence, the CEO puts in effort in order to increase her own financial interest by borrowing more. In this way, the CEO can get both a high cash reward as well as a high variable pay because of higher equity price of the firm. These findings are similar to our original findings (see Panel B of Figure A1 of the original draft).

We also find that irrespective of the CEO's expected cash reward percentage (i.e., β), a firm's debt-to-asset ratio has a negatively concave relationship with the ratio of variable-to-total CEO pay (see Figure A2). In this scenario, the CEO is reluctant to borrow more. When the cash reward percentage is low, a higher borrowing leaves the CEO exposed to risk to her own financial interest as it may lead to a loan default.

On the contrary, when the cash reward percentage is high, the CEO is protected from any credit default by the firm and wants to increase borrowing. However, the lender prepares the CEO compensation structure taking into account the probability of default and the foreclosure costs. Hence, the CEO cannot borrow as she prefers. In fact, with a higher variable pay, the control by the lender on the CEO borrowing amount becomes stricter, thus causing a negatively concave relationship between a firm's leverage and the percentage of firm cash flow paid as CEO's variable compensation These findings are similar to our original finding when CEO compensation is exogenous (see Panel A of Figure 2 of the original draft) but are contradictory to our original finding when CEO compensation is endogenous (see Panel B of Figure 2 of the original draft).

These findings suggest that CEO effort is increasing in expected cash reward percentage (i.e., β), but the lender and the shareholder use their control mechanism to restrict excessive borrowing by the CEO. However, we use a single period model in which the equality of a firm value and the final cash flow is a standard assumption (e.g., Liu et al., 2002).

Extra Figures

Panel A. Low Cash Reward ($\beta = 0.10$) **Panel B: High Cash Reward ($\beta = 0.70$)**

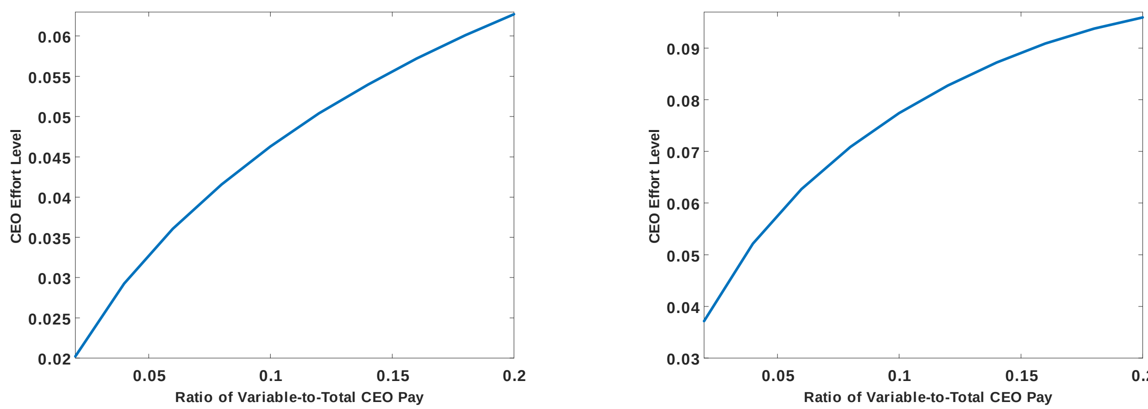

Figure A1. CEO effort and ratio of variable-to-total CEO compensation with different levels of cash reward expectations (β). This figure plots the relationship between CEO effort level (p) and the ratio of variable-to-total CEO pay, $\frac{v(Y-R_L B)}{v(Y-R_L B)+A}$ for different cash reward expectations. Panel A represents this relationship for a low (i.e., 0.10) expected cash reward (β) value. Panel B shows the same relationship but for a high (i.e., 0.70) expected cash reward (β) value.

Panel A: Low Cash Reward ($\beta = 0.10$) **Panel B: High Cash Reward ($\beta = 0.70$)**

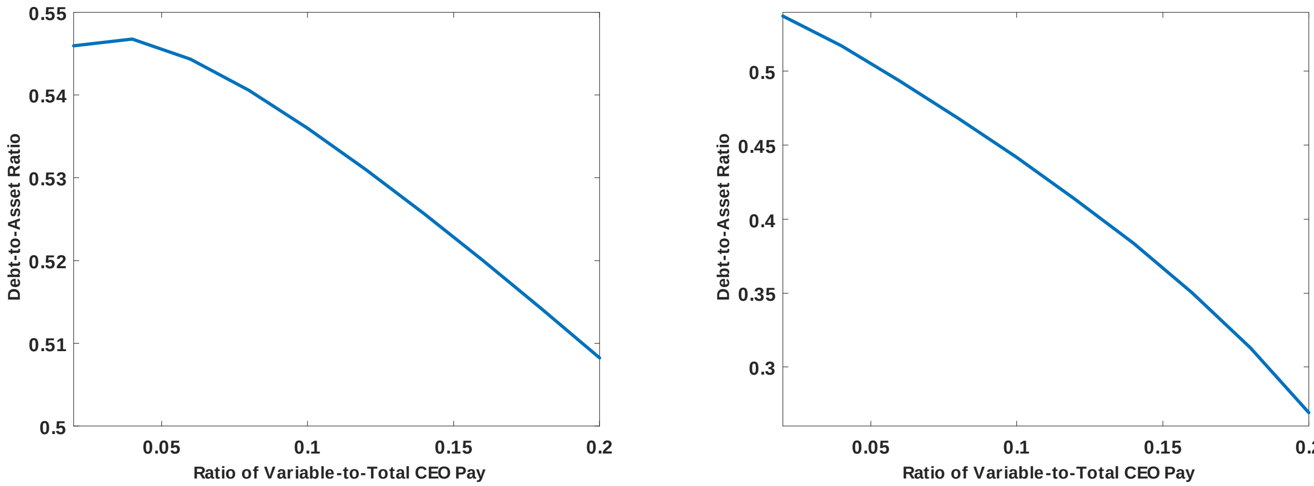

Figure A2. Debt-to asset ratio and ratio of variable-to-total CEO compensation with different levels of cash reward expectations (β). This figure plots the relationship between a firm's debt-to-asset ratio ($\frac{B}{B+N}$) and the ratio of variable-to-total CEO pay, $\frac{v(Y-R_L B)}{v(Y-R_L B)+A}$ for different cash reward expectations. Panel A represents this relationship for a low (i.e., 0.10) expected cash reward (β) value. Panel B shows the same relationship but for a high (i.e., 0.70) expected cash reward (β) value.

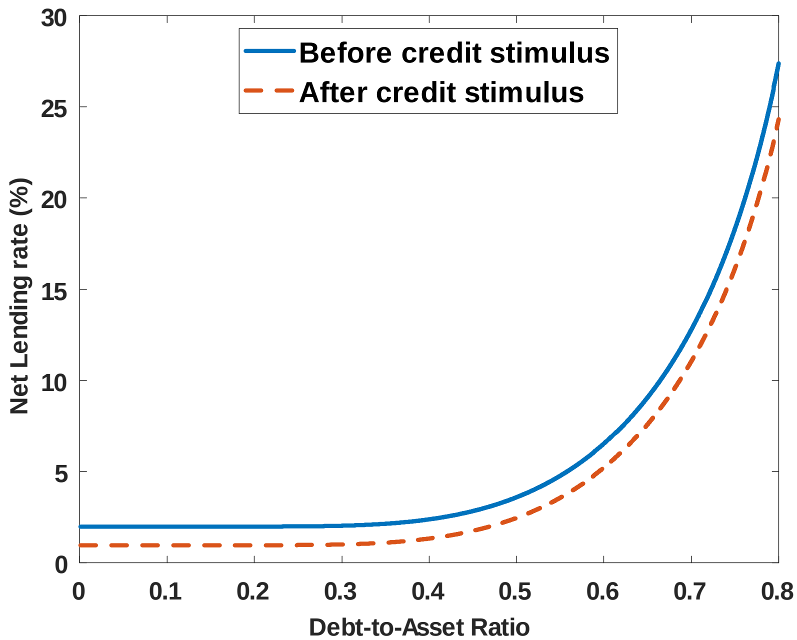

Figure A3. Effects of a credit stimulus on credit supply and firm's debt-to-asset ratio. This figure plots credit supply before and after a simulated credit stimulus to lenders' cost of funds. The x-axis represents credit supply proxied by the debt-to-asset ratio of a firm ($\frac{B}{B+N}$). Where, B represents firm's debt, and N represents total equity. The y-axis represents the lender's cost of funds in terms of net lending rate ($R_L - 1$). The solid line represents this relationship before the simulated credit stimulus when the borrowing cost for a firm is high. The dashed line represents the same relationship but after the simulated credit stimulus when the borrowing cost for a firm is low.