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

Sandeep Dahiya[†], Lei Ge[‡] and Pedro Gete[§]

This Draft: September 2018

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 both endogenous compensation and leverage fully rationalizes 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, greater CEO pay-performance sensitivity implies higher 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

---

*We appreciate the comments of Sumit Agarwal, Luca Anderlini, Axel Anderson, Sirio Aramonte, Jun Kyung Auh, Jennie Bai, Turan Bali, Chuqiao Bi, Mary Ann Bronson, Micheal Cichello, Behzad Diba, Dragon Yongjun Tang, Martin Evans, Douglas Gale, Garance Genicot, Limor Golan, Juan Pedro Gomez, Iftekhar Hasan, Kinda Hachem, Zhangkai Huang, Gazi Kara, Thomas Lemieux, David Marquez-Ibanez, Thomas Noe, Thorvardur Olafsson, Steven Ongena, Franco Peracchi, Yuliy Sannikov, Manuel Santos, Elod Takats, Anjan Thakor, David Valencia, Quan Wen, Maya Waisman, Wei Xiong, Eleanor Xu, Owen Zidar and seminar participants at Georgetown, George Washington, the 2017 Fordham-Bank of Finland conference and 2018 Eastern Finance. Pedro Gete gratefully acknowledges the financial support of the Bank of Spain.

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

[‡]Georgetown University. Email: lg669@georgetown.edu. Phone: (+1) 202-687-5582. Address: 37th and O Sts., NW. Washington DC, 20057, USA.

[§]IE Business School. Maria de Molina 12, 28006 Madrid, Spain. (+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 the firm? How will the compensation structure affect the manager's risk-taking through incurring debt to expand the firm's size? Furthermore, how the compensation structure of the firm will affect the 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 and borrowing spreads are all endogenous. In this regard our paper expands Jaggia and Thakor (1994) who discussed the relation between CEO's actions, capital structure and firm's compensation design.

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 as Carlson and Lazrak (2010) predict a *negative* correlation that is driven by CEO's risk aversion. However, the empirical studies have reported conflicting results. For example, Bryan, Hwang, and Lilien (2000), Lewellen (2006) and Coles, Deniel and Naveen (2006) document a *positive* relationship between risk-taking proxied by firm-leverage and pay-performance sensitivity. In contrast, Berger, Ofek, and Yermack (1997), Mehran (1992), Wiwattanakantang (1999) report that higher pay-performance sensitivity is associated with lower firm-leverage. To solve this puzzle, we add the shareholder's optimal compensation decision to our model. We show that allowing for endogenous compensation and endogenous leverage fully rationalizes the conflicting findings of the empirical literature. The key is that we uncover a new channel of complementarity between effort and leverage that works in opposite direction to CEO's risk aversion.

The second set of results shows how leverage and compensation react to a credit stimulus. Policy makers often try to stimulate economic activity by promoting growth in credit to the corporate sector. Most of the previous literature that has examined the impact of such credit expansions has focused on how this policy is transmitted through the banks' lending decisions, i.e. the "supply" of credit (Gambacorta and Shin 2016 provide a survey). To the best of our knowledge, we are the first to show that the structure of executive compensation can also affect the "demand" for borrowing.

We consider a firm owned by a shareholder who has access to an investment project but lacks the skills to exploit this opportunity. Thus, she hires a CEO possessing the required skills to manage the firm. The model also has a lender from whom the CEO can borrow. The CEO can be 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 the CEO's effort. The CEO is averse to effort, as it is costly.

Following John and John (1993) and Carlson and Lazrak (2010), the shareholder offers a compensation contract featuring two components. The first component is a fixed amount paid to the CEO regardless of the final cash flow realized by the firm. The second component is a share of the cash flow realized by the firm (hereafter "variable component"). A larger variable component implies that the CEO compensation has a higher pay-for-performance sensitivity. After accepting the contract, the CEO chooses her effort level as well as how much debt to take on. Larger debt expands the scope of the firm and can potentially lead to a larger cash flow.

We follow Bernanke, Gertler, and Gilchrist (1999) to model the debt contract. The lender is risk-neutral and charges a spread over her own cost of funds. This spread is determined endogenously and reflects the risk of default for the borrowing firm. The model assumes symmetric information among all players when the contracts (compensation and leverage) are written. However, the effort supplied by the CEO, is not verifiable by outsiders. This rules out the possibility of writing an explicit compensation contract conditioned on the effort of the CEO.

Concerning our first set of results, we start by showing that a CEO's risk aversion implies a *negative* relationship between leverage and the CEO's ownership of the firm.[1] This finding

[1] There are several factors in the model that can explain the observed differences in leverage and compensation across the cross-section of firms. These include different degrees of idiosyncratic risk of the firms as well as varying monitoring costs for the lender.

confirms the results of earlier theoretical models like Carlson and Lazrak (2010). 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, Carlson and Lazrak's (2010) result is based on a model with exogenous compensation. 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 of the empirical literature.

The new mechanism requires that both leverage and compensation are endogenous: for a shareholder, the firm's leverage and the CEO'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. This implies that the shareholders of firms desiring a higher level of debt 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. variable component) of CEO compensation.

Hence, this paper shows that empirically the relation between leverage and variable compensation can be either positive or negative, depending on what channel dominates. This is exactly what the empirical literature has found. We also make two novel predictions: total compensation is increasing in leverage; and leverage and the ratio of variable-to-fixed compensation are positively correlated. That is, the optimal compensation contract requires that both the compensation components, fixed as well as variable, need to be increased 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.

Concerning the reaction to a credit stimulus, the model predicts that the relationship between the *change* in leverage and variable compensation is unambiguously *positive*. This occurs because the variable component allows the CEO to capture a larger fraction of the cash flow generated by the firm. Since the government credit subsidy increases the value of the borrowing firm, its CEO will borrow more if she is promised a larger share of the firm. In addition, after the credit stimulus, variable compensation increases as shareholders want to encourage their CEOs to borrow. Dahiya, Ge, and Gete (2018) study the 2008 Chinese credit stimulus and confirm our predictions.

Our second set of results suggest 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 that tax incentives lead to greater managerial ownership.[2] This result complements papers such as Bebchuk and Goldstein (2011), who study policies for economies in which banks abstain from lending to firms with good projects.

The paper proceeds as follows. Section 2 connects this paper to the existing literature. Section 3 presents the model. Section 4 studies the relationship between executive compensation and capital structure in the cross-section of firms. Section 5 studies the reaction to a credit stimulus. Section 6 concludes.

2 Contribution to the literature

This paper connects two strands of theoretical literature on executive compensation and firm leverage.[3] 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, Maug, and Spalt (2010), Dittmann, Yu, and Zhang (2017), He (2011), Bolton, Mehran, and Shapiro (2015) and Gete and Gomez (2017). We find that when compensation, leverage and the cost of leverage are all endogenous, we generate novel insights.

[2]Gorry et al. (2017) provide evidence that the structure of executive compensation is sensitive to taxation.
[3]Edmans and Gabaix (2016) is a recent survey.

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, Parlour, and Rajan (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, Hong, and Scheinkman (2015) show that the total compensation will be higher if the overall risk of the firm increases. However, the firm-risk is exogenous in their model. In our model, the risk induced specifically by the increased leverage is chosen by the CEO.

Importantly, we also show how the compensation structure affects a firm's response to expansions of credit supply. 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 consumers' propensity to borrow (i.e. demand for credit) is an important determinant in how much additional credit is obtained by the consumer. We complement their study by focusing on the uptake of credit by corporate borrowers.

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 an outside CEO with the required skills.

At date 0, the shareholder offers the CEO a mutually acceptable compensation contract. After being hired, the CEO chooses to borrow an amount B and invests the newly borrowed amount in the project (the firm already has N of equity investment, made by the shareholder).[4]

[4]We limit the new capital to be in form of debt. This allows us to abstract away from issues related to equity

The lender prices this debt 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 of any value. Thus, the final value of the firm (denoted by 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 which we denote as p. The CEO's effort increases the expected future cash flow that will be generated by the firm. Following the typical setup employed in the compensation literature (see Gayle, Golan and Miller 2015 for example), we assume that the effort supplied by the CEO is private information and cannot be observed directly by the shareholder. This makes it impossible to write a compensation contract based on the level of effort supplied by the CEO. The compensation contract has two components: a fixed component (denoted by A) and a variable component (denoted by v) that is a fraction of the realized cash flow of the firm at date 1. Figure 1 recapitulates our model's time-line.

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,

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

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 contributed by the shareholder.

The firm's cash flow Y at date 1 is stochastic and depends both on the capital employed and on the shock to productivity,

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

dilution as well as information frictions between different equity holders.

where R_k is a constant and ω is the productivity shock. The productivity shock ω follows a lognormal cumulative density function. This setup mirrors the specification in Bernanke, Gertler, and Gilchrist (1999) where ω represents the idiosyncratic risk of a specific firm while R_k is the aggregate return to capital.

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

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

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

where σ is the idiosyncratic uncertainty of the productivity shock, $\psi > 0$ and $\varepsilon < 1$ are respectively the level and the shape parameters for the effect of the CEO's effort on the productivity shock.

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

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

We denote the cumulative density function of ω by $F(\omega; p)$ to stress that the expected value of the productivity shock (ω) is a function of the 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, as we explain in more detail below. There are several ways to interpret this parameter. For example, Jeske, Krueger, and Mitman (2013) refer to it as a loan guarantee. It can also be thought as a monetary policy or government's subsidies lowering the lender's cost of funds.

Following Bernanke, Gertler, and Gilchrist (1999), we model the financial contract 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 $\hat{\omega}R_kK$ 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

$$R_L B = \hat{\omega} R_k K. \tag{4}$$

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

$$\int_0^{\hat{\omega}} (1-\gamma)\, \omega R_k K \, dF(\omega; p) + \int_{\hat{\omega}}^{\infty} R_L B \, dF(\omega; p) = R_B(1-\tau)B. \tag{5}$$

The first integral is the lender's expected revenue in the case of the firm's default. That is, the value of the firm's assets net of foreclosure costs. The second integral in the left hand side of (5) is the expected revenue for the lender when the firm repays (the area where ω is above the threshold $\hat{\omega}$). The right hand side of (5) is the cost of funds for the lender.

Equation (5) 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 his cost of funds to compensate him for the probability of default and for the foreclosure costs. Using (1), (4) and (5) we get:

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

The equation (6) describes the lender's participation constraint when it is binding.

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 $0 \leqslant v \leqslant 1$ of the firm's value at date 1. The total payoff for the CEO is $s(\omega)$,

$$s(\omega) = \begin{cases} A + v\left[Y\left(\omega, K\right) - R_L B\right] & \text{if} \quad \omega \geq \hat{\omega}, \\ A & \text{if} \quad \omega < \hat{\omega}. \end{cases} \tag{7}$$

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

3.4 The CEO

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

$$c(p) = \phi p^{\rho}, \tag{8}$$

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. That is, the CEO solves:

$$\max_{\{\hat{\omega}, p, B\}} \int_{\hat{\omega}}^{\infty} u\left(A + v\left(Y\left(\omega, K\right) - R_L B\right) - c(p)\right)\, dF(\omega; p) + \int_{0}^{\hat{\omega}} u\left(A - c(p)\right)\, dF(\omega; p) \tag{9}$$

$$\text{subject to } \ (6)\,.$$

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. Thus, the shareholder chooses the compensation contract (A, v) to maximize the firm's cash flow net of payments to the lender and the CEO:

$$\max_{\{A,v\}} \int_{\hat{\omega}}^{\infty} \left[(1-v)\left(Y\left(\omega, K\right) - R_L B\right) - A\right] \, dF(\omega; p) \tag{10}$$

subject to the CEO's effort, default threshold and borrowings determined by the FOCs of the CEO's problem defined by (9).

3.6 Calibration

The model does not have closed-form solutions and we solve it numerically assuming that the CEO has the standard CRRA preferences:[5]

$$u(C) = \frac{C^{1-\eta}}{1-\eta}, \tag{11}$$

where the CEO's consumption C is the wage payments $s(\omega)$ defined in (7) minus the cost of effort,

$$C = s(\omega) - c(p). \tag{12}$$

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 (γ) follows Bernanke, Gertler, and Gilchrist (1999, BGG), and the scale parameter (σ) of the lognormal productivity shocks is in the set of values common in the BGG literature (see Gete and Melkadze 2018 for example). Since we also analyze the impact of credit supply expansion on changes in leverage across firms with different CEO compensation contracts, we use the monetary stimulation implemented by China as our test case.[6] For the cost of lenders'

[5]Calibration exercises with CRRA preferences include Dittmann, Maug, and Spalt (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.

[6]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

funds (R_b) we use a 2% rate, which is the average return on 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 Executive compensation and capital structure

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

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

Figure 2 contains our key cross-sectional result. The top panel is a model with exogenous compensation, like Carlson and Lazrak (2010). The bottom channel is the model presented in Section 3 with endogenous compensation setup. The top panel shows a *negative* correlation between leverage and variable compensation. The bottom panel shows a *positive* correlation. Both cases are for a risk-averse CEO.

Insert Figure 2 about here

The top panel in Figure 2 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.

The bottom panel in Figure 2 shows that the cross-sectional correlation between leverage

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

levels and variable compensation becomes *positive* when all variables are endogenous and optimally selected.[7] The reason is that from the shareholder's perspective, leverage and CEO's efforts are complementary as illustrated in Figure 4. To complement this result, Figure 3 shows how the shareholder of a particular firm chooses optimal executive compensation to maximize her own net revenue.

Insert Figures 3 and 4 about here

Figure 3 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.

Figure 4 shows that low idiosyncratic risk also encourages effort which, in turn, makes negative productivity shocks less likely. This increases the incentives to leverage from the view of the CEO. Moreover the shareholders want higher variable compensation to motivate the CEO in these firms with low idiosyncratic risk.

In this way, when we focus on firms heterogeneous in idiosyncratic volatility (σ) to generate cross-sectional heterogeneity, there are two channels at play: 1) Volatility is bad for lenders because debt contracts imply concave payoffs. That is, high risk firms have higher default risk; and 2) Volatile firms encourage less effort from their risk-averse CEOs. Thus, all things being

[7] In the top panel of Figure 2 compensation is exogenous and thus we could compare firms with different variable compensation. However, in the bottom panel 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 firms heterogeneous in idiosyncratic volatility (σ). This choice is motivated by the approach taken by Panousi and Papanikolau (2012). They show that higher idiosyncratic risk lowers investment especially when a risk-averse CEO holds a higher fraction of the firm's equity.

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 the less volatile firm, the CEO faces less risk in his share of the firm's investment, so he is willing to contribute 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 for that correlation.

4.2 Other predictions

Figure 5 shows other novel predictions of the model: *total compensation* is increasing in leverage; and leverage and the ratio of variable-to-fixed compensation are *positively* correlated.

Insert Figure 5 about here

As we discussed before, firms with low idiosyncratic uncertainty (σ) would like to reward the CEO more stock share to motive them to give more effort (p), because the firms with low risk can get more low cost credit supply from banks and, the leverage and the effort (p) are complementary. However, at the same time, the increased stock share can discourage the CEO from borrowing because their concerns of the increased default loss associated with his stock-holding. In this way, the shareholders in the firms with low uncertainty would also pay more fixed pay, as shown in Figure 5a, to make the CEO less risk averse and borrow more low cost debt from the lenders. In this way, the shareholders in the low idiosyncratic risk will reward their CEO both larger share of stock and fixed pay and it will lead to larger total compensation in Figure 5b. In addition, Figure 5c shows that variable-to-fixed ratio in the is also larger in the firms with low risk.

5 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. How the corporate sector responds to a large government-initiated credit stimulus is an important issue for economists as well as policy-makers. After all, a major objective for expansionary credit policies is to induce greater borrowing by households as well as corporations.

5.1 Leverage growth during the credit stimulus

In our model we simulate the policy intervention by making the 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 (6), shifts right (Figure A3 in the online appendix) and the cost of leverage decreases when $\tau > 0$. Figure 6 illustrates the key cross-sectional implication of our model after the credit stimulus. The x-axis represents firms with different levels of executive ownership and the y-axis represents the growth of the leverage after the credit stimulus.[8]

Insert Figure 6 about here

Figure 6 shows that firms whose CEOs have larger equity ownership react more to the credit supply shift. Thus, a CEO with high ownership is predicted to increase firm-leverage more compared to another CEO with lower firm ownership. Intuitively, high ownership implies that the CEO will share a larger portion of the rewards from leverage and is therefore more receptive to the credit stimulus. Thus, higher variable compensation induces greater changes in leverage.

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

5.2 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 3. As before, to generate cross-sectional differences, we study firms with different idiosyncratic uncertainty (σ). Figure 7 contains the results.

Insert Figure 7 about here

Figure 7 shows that the optimal compensation structure including the CEO's share of stock, fixed pay, total compensation and variable-to-fixed ratio all will become bigger after the stimulus. In addition, firms with low idiosyncratic volatility will increase variable pay choice, fixed compensation, the total compensation and variable to fixed compensation ratio, more than other firms.

The first driver of Figure 7 is that the investment opportunities and the CEO's effort are complementary. After the credit stimulus, the firms with low idiosyncratic risk face better investment opportunities, so shareholders would like to reward the CEO with more portion of stock to motivate CEO to give more effort to the firms (Figure 7a). Moreover, the shareholders know that when they give the CEO more stock reward, this tends to make them more risk-averse of borrowing. In the eyes of the shareholders, the CEO becomes conservative in borrowing. So, the shareholders, when they reward the CEO with more stock, at the same time will also give the CEO more fixed pay to offset the CEO's risk aversion. In this way, from the Figure 7b, the CEOs in the firms with low idiosyncratic risk will also get more fixed pay after the credit push.

In addition, both the portion of the stock and the fixed pay increased after the credit stimulus. So, Figure 7c shows that the total compensation increases more for the firms with low idiosyncratic risk. Fourth, while both the stock and fixed pay increase after the credit stimulus, the increased stock serves the main role in motivating the CEO, and the fixed pay serves an auxiliary role in offsetting the risk-aversion. In this way, the variable to fixed compensation ratio increased faster in these low idiosyncratic risk firms, as we have shown in Figure 7d. So, the shareholders tend to reward the CEO with bigger compensation package to motivate the CEO. This effect is greater in the firms with low idiosyncratic risk.

6 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.

References

Agarwal, S., Chomsisengphet, S., Mahoney, N. and Stroebel, J.: 2018, Do banks pass through credit expansions to consumers who want to borrow?, *The Quarterly Journal of Economics* **133**(1), 129–190.

Bebchuk, L. A. and Goldstein, I.: 2011, Self-fulfilling credit market freezes, *Review of Financial Studies* **24**(11), 3519–3555.

Berger, P. G., Ofek, E. and Yermack, D. L.: 1997, Managerial entrenchment and capital structure decisions, *The Journal of Finance* **52**(4), 1411–1438.

Bernanke, B. S., Gertler, M. and Gilchrist, S.: 1999, The financial accelerator in a quantitative business cycle framework, *Handbook of Macroeconomics* **1**, 1341–1393.

Bolton, P., Mehran, H. and Shapiro, J.: 2015, Executive compensation and risk taking, *Review of Finance* **19**(6), 2139–2181.

Bryan, S., Hwang, L. and Lilien, S.: 2000, CEO stock-based compensation: An empirical analysis of incentive-intensity, relative mix, and economic determinants, *The Journal of Business* **73**(4), 661–693.

Carlson, M. and Lazrak, A.: 2010, Leverage choice and credit spreads when managers risk shift, *The Journal of Finance* **65**(6), 2323–2362.

Cheng, I.-H., Hong, H. and Scheinkman, J. A.: 2015, Yesterday's heroes: compensation and risk at financial firms, *The Journal of Finance* **70**(2), 839–879.

Coles, J. L., Daniel, N. D. and Naveen, L.: 2006, Managerial incentives and risk-taking, *Journal of Financial Economics* **79**(2), 431–468.

Dahiya, S., Ge, L. and Gete, P.: 2018, Credit stimulus, executive ownership, and firm leverage.

Deng, Y., Morck, R., Wu, J. and Yeung, B.: 2015, China's pseudo-monetary policy, *Review of Finance* **19**(1), 55–93.

Dittmann, I., Maug, E. and Spalt, O.: 2010, Sticks or carrots? Optimal CEO compensation when managers are loss averse, *The Journal of Finance* **65**(6), 2015–2050.

Dittmann, I., Yu, K.-C. and Zhang, D.: 2017, How important are risk-taking incentives in executive compensation?, *Review of Finance* **21**(5), 1805–1846.

Edmans, A. and Gabaix, X.: 2016, Executive compensation: A modern primer, *Journal of Economic Literature* **54**(4), 1232–1287.

Gambacorta, L. and Shin, H. S.: 2016, Why bank capital matters for monetary policy, *Journal of Financial Intermediation* .

Gayle, G.-L., Golan, L. and Miller, R. A.: 2015, Promotion, turnover, and compensation in the executive labor market, *Econometrica* **83**(6), 2293–2369.

Gete, P. and Gómez, J.-P.: 2017, Dealing with overleverage: Restricting leverage vs. restricting variable compensation, *Quarterly Journal of Finance* p. 1850001.

Gete, P. and Melkadze, G.: 2018, A quantitative model of international lending of last resort.

Golan, L., Parlour, C. A. and Rajan, U.: 2015, Competition, managerial slack, and corporate governance, *Review of Corporate Finance Studies* **4**(1), 43–68.

Gorry, A., Hassett, K. A., Hubbard, R. G. and Mathur, A.: 2017, The response of deferred executive compensation to changes in tax rates, *Journal of Public Economics* **151**, 28–40.

Hall, B. J. and Murphy, K. J.: 2000, Optimal exercise prices for executive stock options, *The American Economic Review* **90**(2), 209–209.

He, Z.: 2011, A model of dynamic compensation and capital structure, *Journal of Financial Economics* **100**(2), 351–366.

Jaggia, P. B. and Thakor, A. V.: 1994, Firm-specific human capital and optimal capital structure, *International Economic Review* **35**(2), 283–308.

Jeske, K., Krueger, D. and Mitman, K.: 2013, Housing, mortgage bailout guarantees and the macro economy, *Journal of Monetary Economics* **60**(8), 917–935.

John, T. A. and John, K.: 1993, Top-management compensation and capital structure, *The Journal of Finance* **48**(3), 949–974.

Lewellen, K.: 2006, Financing decisions when managers are risk averse, *Journal of Financial Economics* **82**(3), 551–589.

Mehran, H.: 1992, Executive incentive plans, corporate control, and capital structure, *Journal of Financial and Quantitative analysis* **27**(4), 539–560.

Panousi, V. and Papanikolaou, D.: 2012, Investment, idiosyncratic risk, and ownership, *The Journal of Finance* **67**(3), 1113–1148.

Tables

Table 1. Parameters

Parameter	Value	Description
Exogenously Determined		
Parameter	Value	Description
η	1.1	Coefficient of risk aversion
σ	0.40	Scale parameter productivity shock
γ	0.12	Foreclosure cost
τ	0.01	Credit subsidy to lenders
R_b	1.02	Cost of lenders' funds
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

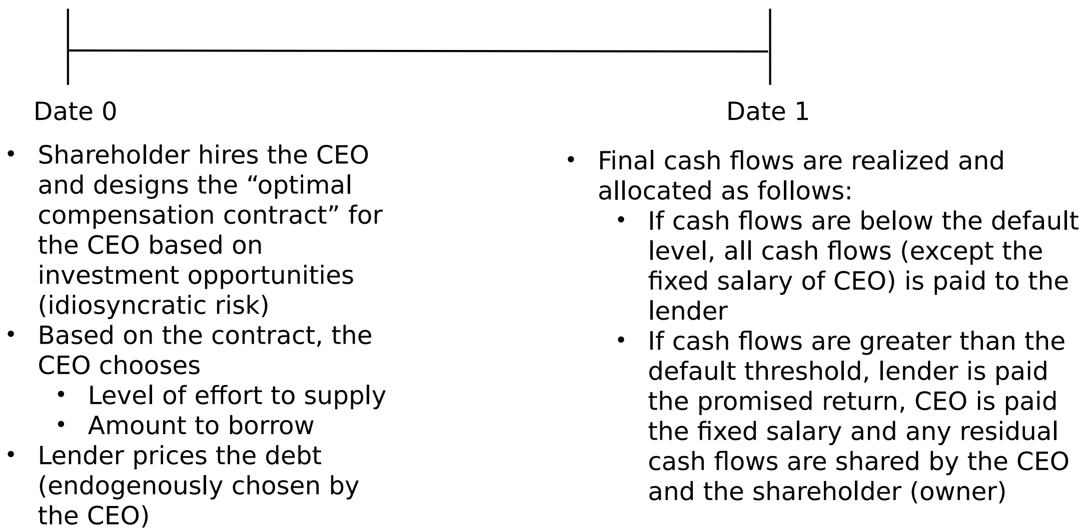

Figure 1. Time-line of the actions of shareholder, CEO and lender.

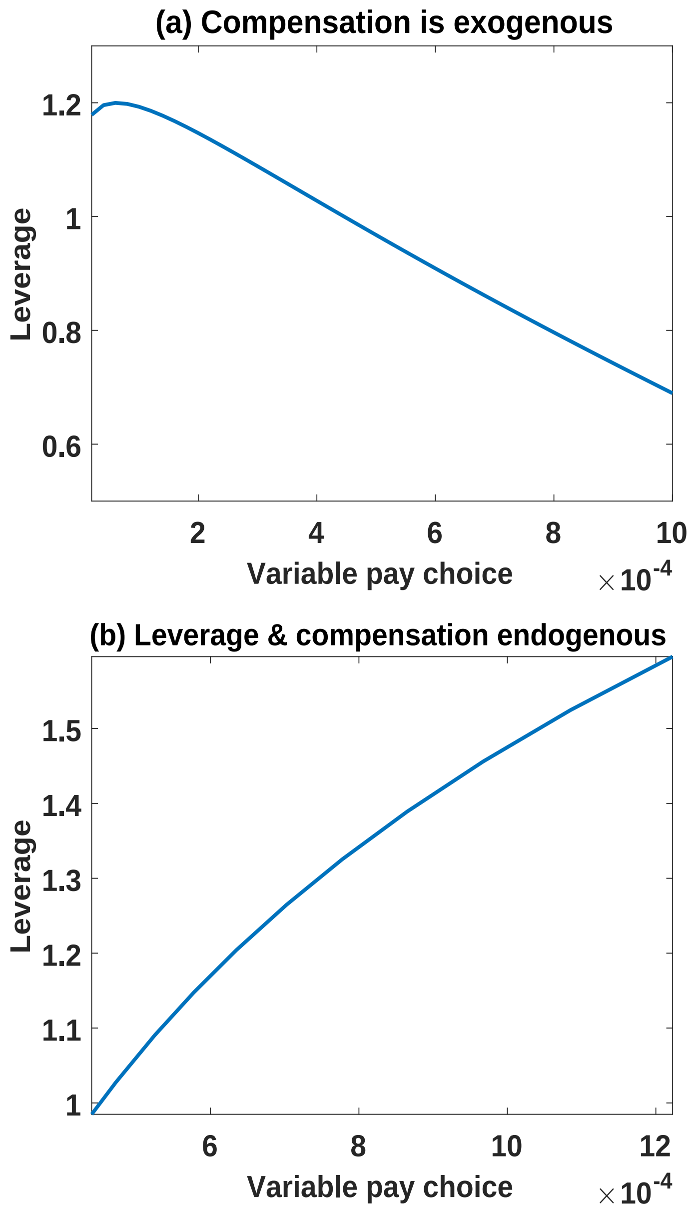

Figure 2. Leverage and variable compensation in models with exogenous or endogenous compensation. This figure plots firm's leverage as a function of shareholder's choice of CEO's variable pay choice (v). In the top panel, the compensation is exogenous. In the bottom panel the compensation is endogenous as in section 3.3. For the endogenous compensation case, all variables change because the degree of idiosyncratic uncertainty (σ) is different across firms. Leverage is defined as debt-to-equity ($\frac{B}{N}$).

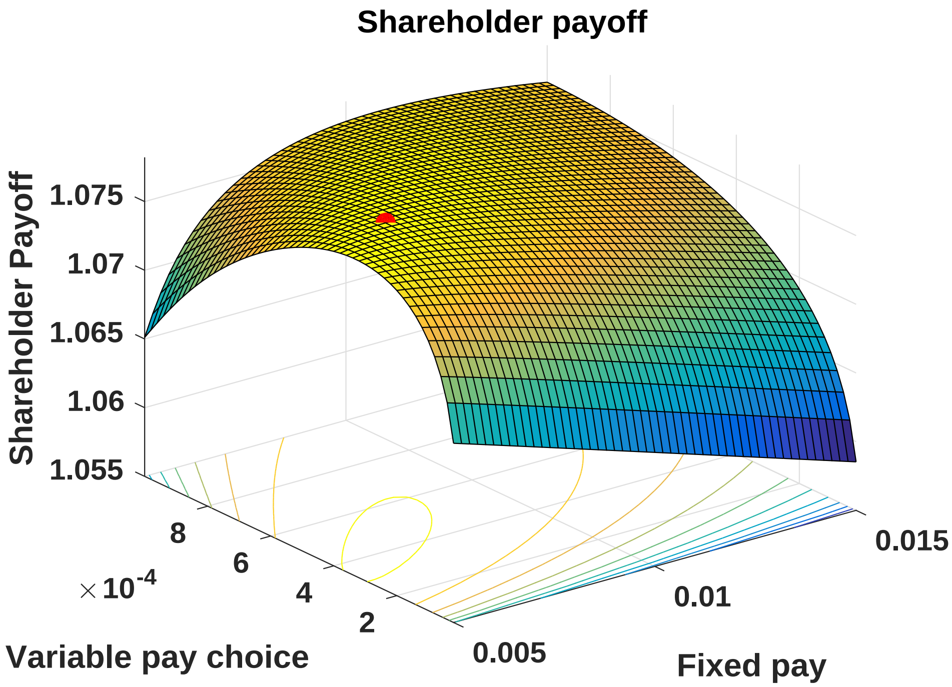

Figure 3. Shareholder payoff as a function of CEO compensation. This figure plots the shareholder's payoff (equation 10) as a function of the variable (v) and fixed (A) compensation paid to CEO. All parameters are as in Table 1. The optimal combination (v, A) is the dot on the top of the surface.

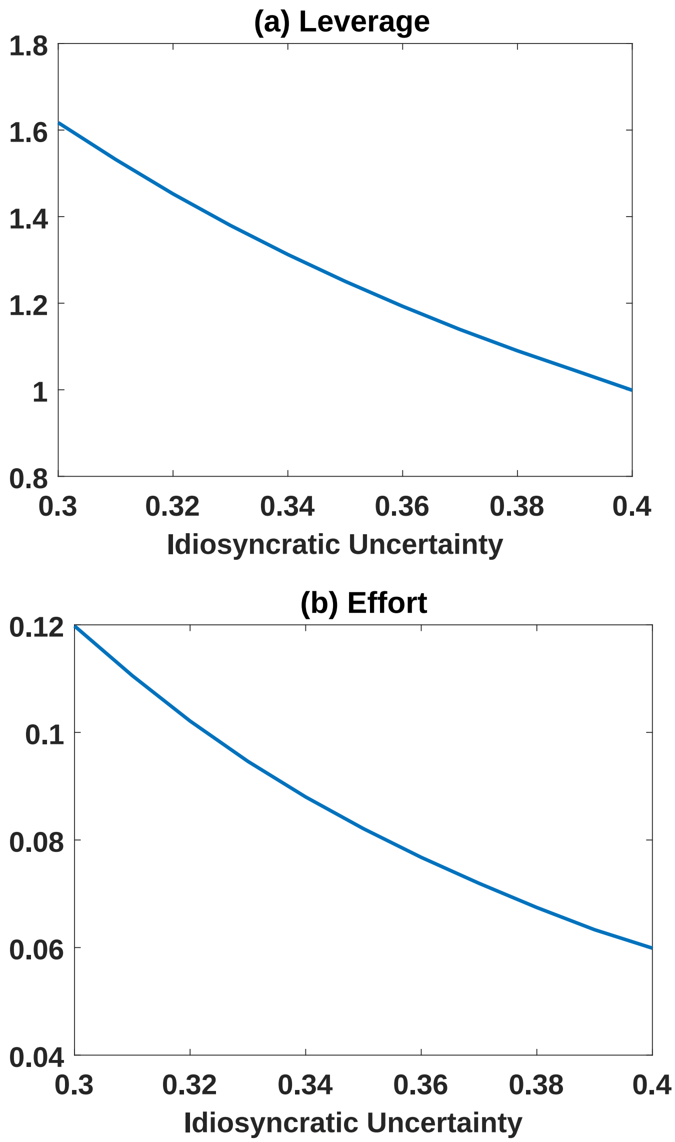

Figure 4. Leverage and CEO's effort as a function of firm's risk. This figure plots leverage and CEO's effort for firms with different levels of idiosyncratic uncertainty (σ).

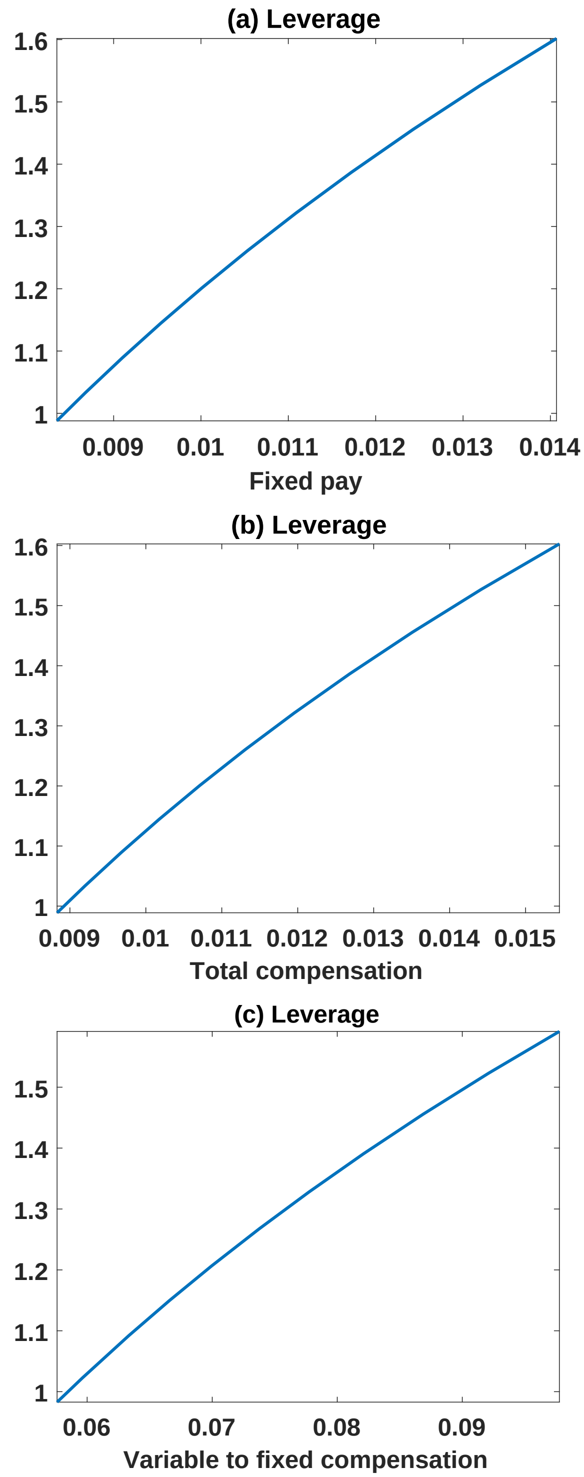

Figure 5. Compensation variables and leverage in the cross-section of firms. This figure plots the compensation variables versus the firm's leverage. All variables listed in the Figure are endogenous as in section 3. All variables change because the degree of idiosyncratic uncertainty

(σ) is different across firms.

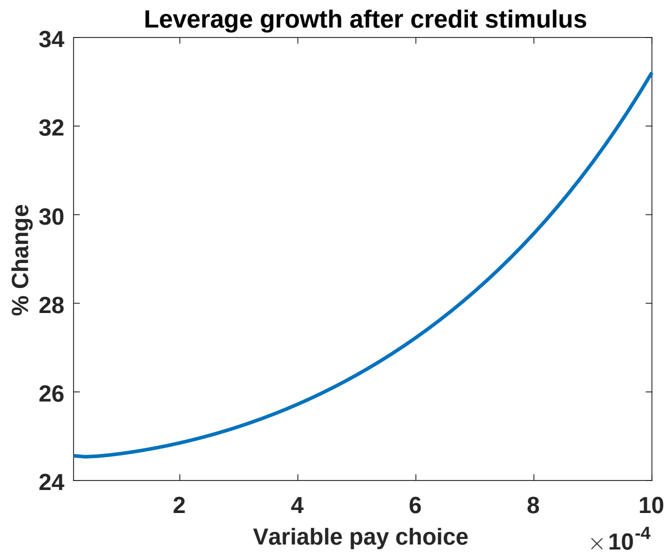

Figure 6. The effects of a credit stimulus on firm's leverage. This figure plots the % change in firm's leverage for firms with different level of variable compensation (v) after the simulated credit stimulus. Figure A3 in the online appendix shows how the credit stimulus change the credit supply.

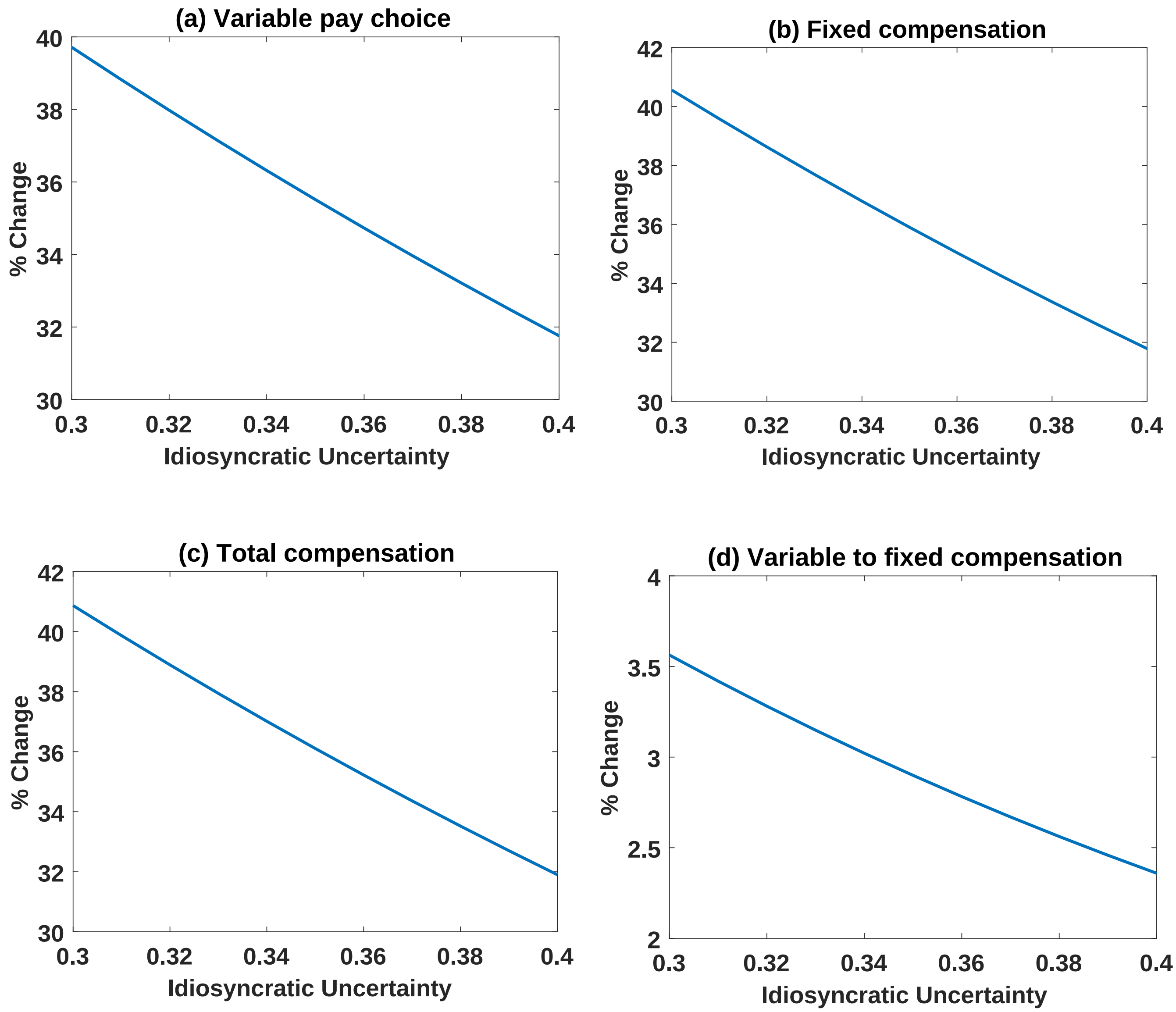

Figure 7. Change in compensation structure after the credit stimulus for firms with different risk levels. This figure plots the % change in compensation variables and leverage after the credit stimulus for firms with different levels of idiosyncratic uncertainty.

ON-LINE APPENDIX. NOT-FOR-PUBLICATION

The CEO problem

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

$$\Omega(\omega, \hat{\omega}, B, p) \equiv A + v\,(\omega - \hat{\omega})\, R^k(B + N) - c(p), \tag{1}$$

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

$$\Psi(p) \equiv A - c(p). \tag{2}$$

Using (1) and (2), the CEO's maximization problem (9) becomes:

$$\max_{\{\hat{\omega}, p, B\}} \int_{\hat{\omega}}^{\infty} u\left(\Omega(\omega, \hat{\omega}, B, p)\right) f(\omega; p)\, d\omega + u(\Psi(p))\, F(\hat{\omega}; p) \tag{3}$$

s.t.

$$\int_0^{\hat{\omega}} (1-\gamma)\, \omega R^k(B+N) f(\omega; p)\, d\omega + \hat{\omega} R^k(B+N)\left(1 - F(\hat{\omega}; p)\right) = R^B(1-\tau)B. \tag{4}$$

Denoting the Lagrangian multiplier by λ_m the Lagrangian is

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

and the FOCs are:

$$\frac{\partial \mathcal{L}_m(\hat{\omega}, p, B)}{\partial \hat{\omega}} = \left\{ \begin{array}{l} -\int_{\hat{\omega}}^{\infty} u'(\Omega) v R^k(B+N) f(\omega; p)\, d\omega + \\ +\lambda_m \left[-\gamma \hat{\omega} R^k(B+N) f(\hat{\omega}; p) + R^k(B+N)\left(1 - F(\hat{\omega}; p)\right) \right] \end{array} \right\} = 0. \tag{5}$$

For effort:

$$\frac{\partial \mathcal{L}_m(\hat{\omega},p,B)}{\partial p}=\left\{\begin{array}{l} \int_{\hat{\omega}}^{\infty}\left[-u'(\Omega)c'(p)f(\omega;p)+u(\Omega)\dfrac{\partial f(\omega;p)}{\partial p}\right]d\omega+ \\ +u(\Psi)\dfrac{\partial F(\hat{\omega};p)}{\partial p}-u'(\Psi)c'(p)F(\hat{\omega};p)+ \\ +\lambda_m\left[\begin{array}{l} \int_0^{\hat{\omega}}(1-\gamma)\omega R^k(B+N)\dfrac{\partial f(\omega;p)}{\partial p}\,d\omega+ \\ -\hat{\omega}R^k(B+N)\dfrac{\partial F(\hat{\omega};p)}{\partial p} \end{array}\right] \end{array}\right\}=0, \tag{6}$$

and for debt level:

$$\frac{\partial \mathcal{L}_m(\hat{\omega},p,B)}{\partial B}=\left\{\begin{array}{l} \int_{\hat{\omega}}^{\infty}u'(\Omega)(\omega-\hat{\omega})vR^kf(\omega;p)\,d\omega+ \\ +\lambda_m\left[\begin{array}{l} \int_0^{\hat{\omega}}(1-\gamma)\,\omega R^kf(\omega;p)\,d\omega+ \\ +\hat{\omega}R^k\,(1-F(\hat{\omega};p))-R^B(1-\tau) \end{array}\right] \end{array}\right\}=0. \tag{7}$$

The shareholder's problem

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

$$\max_{\{v,A\}}\int_{\hat{\omega}(v,A)}^{\infty}\left[(1-v)(\omega-\hat{\omega}(v,A))R_k(B(v,A)+N)-A\right]f(\omega;p(v,A))\,d\omega, \tag{8}$$

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:

$$\max_{\{v,F,\hat{\omega},p,B\}}\int_{\hat{\omega}}^{\infty}\left[(1-v)(\omega-\hat{\omega})R_k(B+N)-A\right]f(\omega;p)\,d\omega, \tag{9}$$

subject to the first order conditions of the CEO's problem of functions (5), (6) and (7). We use a numerical method to solve the shareholders' problem.

Extra Figures

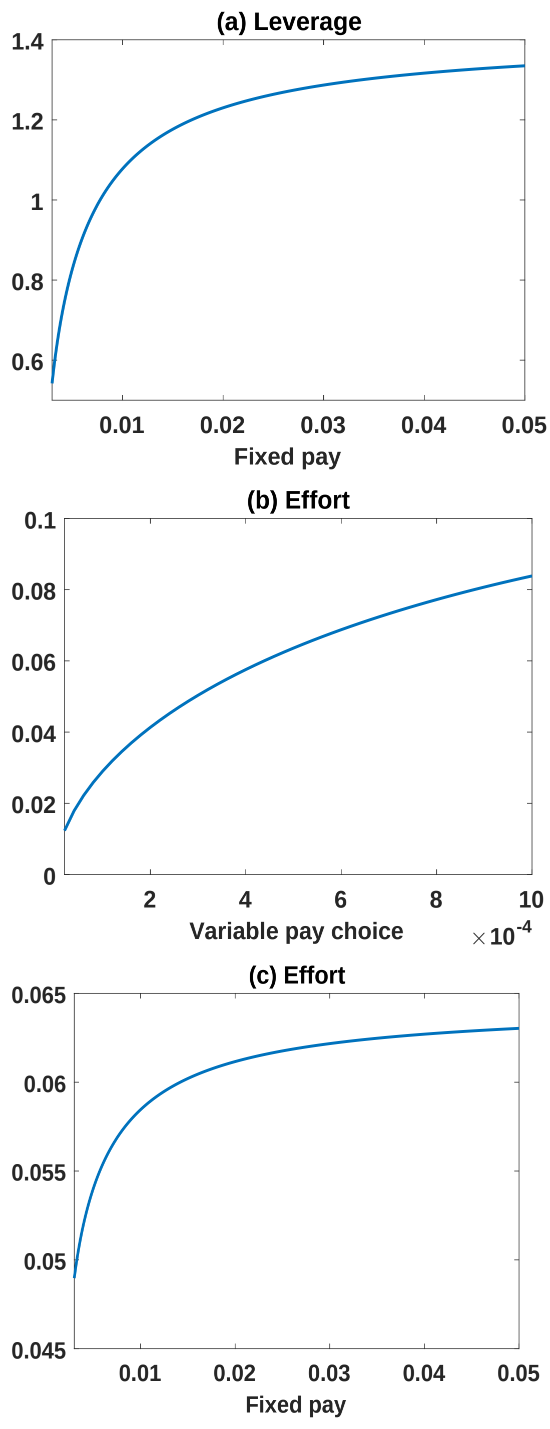

Figure A1. Leverage and CEO's effort as a function of CEO risk aversion and exogenous CEO compensation. This figure plots firm's leverage and CEO's effort as a function of CEO's variable (v) and fixed compensation (A) when the CEO is risk-averse and when her compensation structure is exogenous. Leverage is defined as debt-to-equity ($\frac{B}{N}$).

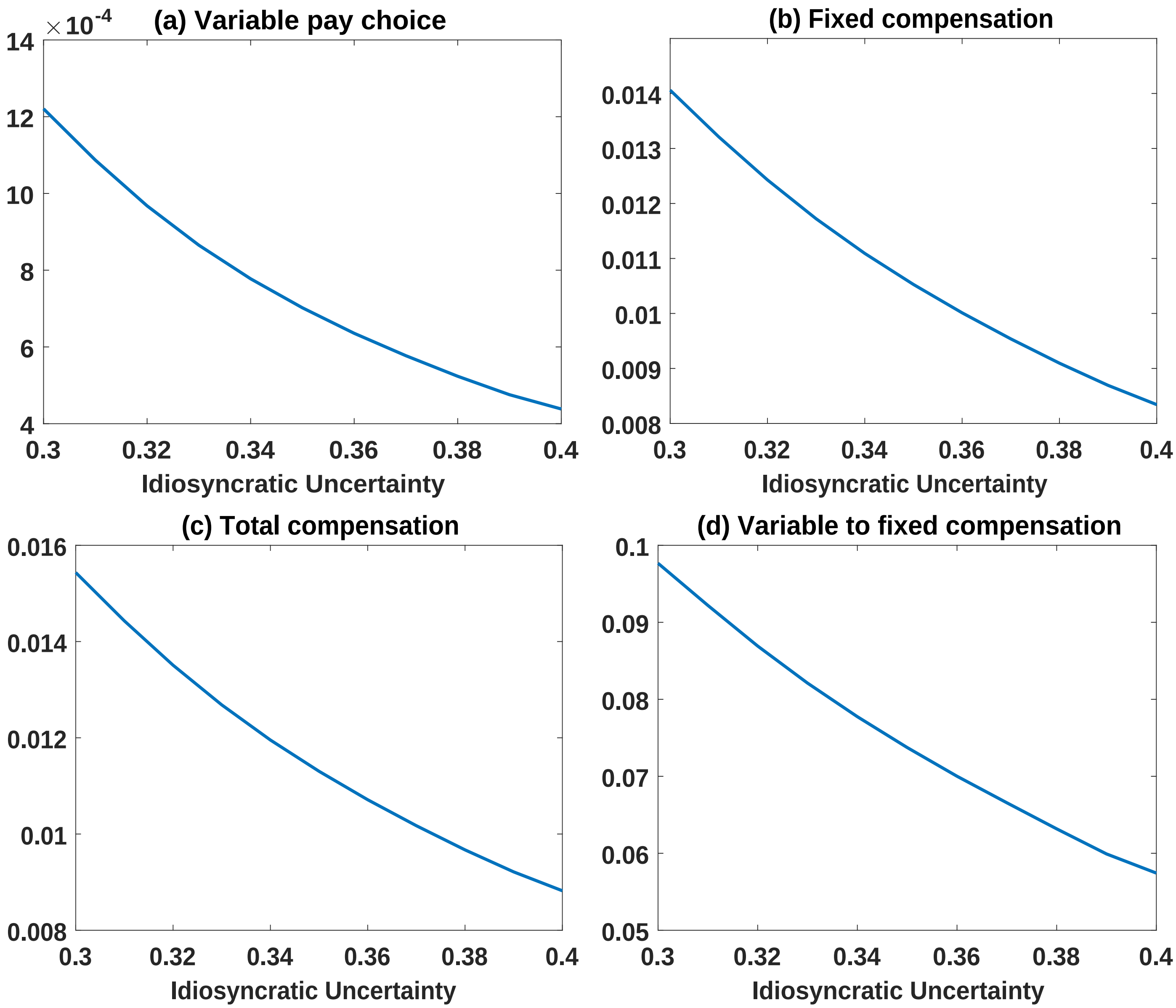

Figure A2. Compensation variables for firms heterogeneous in risk. This figure plots the compensation variables for firms with different levels of idiosyncratic uncertainty (σ).

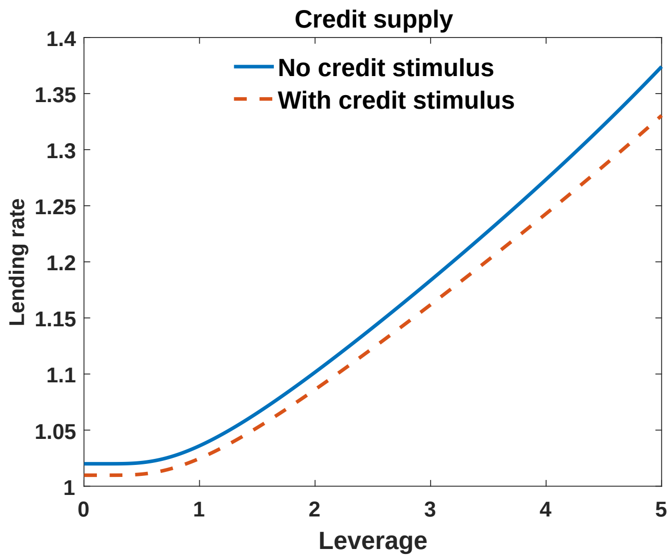

Figure A3. The effects of a credit stimulus on credit supply and firm's leverage. The top panel plots credit supply (equation 5) before and after a government subsidy to lenders' cost of funds. The bottom panel plots the change in firm's leverage for firms with different level of variable compensation (v) after the credit supply shift reported in the top panel.