Idiosyncratic Risk and the Manager

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PRELIMINARY

Abstract

Compensating a manager with their own firm’s equity induces effort but also exposes the manager to firm-specific risk. Consequently, the discount rate of the undiversified manager differs from that of a diversified shareholder, resulting in a distortion in the optimal investment and financing policies chosen by the manager. We embed an agency conflict in a neoclassical model of the firm to investigate the quantitative effects of this distortion. In the calibrated model, the risk averse manager significantly underinvests, resulting in a long-run capital stock 7-12% below the shareholder’s optimal level. This represents a loss to shareholders of 1-2% of total firm value. Alternatively, this loss resulting from suboptimal investment policy can be viewed as the cost of inducing effort from the manager. Additionally, this friction helps to explain features of firm-level investment, such as the positive skewness seen in the data.

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1 Introduction

A nearly universal feature of executive compensation contracts is that they are based largely on firm-level performance. Linking an executive’s compensation to her firm’s performance is usually viewed as an effective way to induce unobservable effort that is personally costly for the manager but increases shareholder value. However, such a contract also exposes the manager to firm-specific idiosyncratic risk that cannot be diversified without undoing the incentive to exert effort. Consequently, while a performance-based contract induces effort, it also drives a wedge between the discount rates of diversified shareholders and undiversified managers. The result is that optimal investment, financing, and payout policies of the manager are not aligned with those of the shareholders. If shareholders are unable to directly contract on the manager’s policy decisions, the manager can be expected to select her own utility-maximizing policies for the firm, which are suboptimal from the viewpoint of diversified shareholders. Thus, a performance-based contract imposes a cost on shareholders.

This paper studies the distortions to optimal firm policy choices, and the cost to shareholders of these distortions, resulting from the manager’s undiversifiable idiosyncratic risk imposed by performance-based compensation contracts. We embed an agency conflict between manager and shareholders in a neoclassical model of firm investment and financing decisions. The fact that the manager has control over firm-level policy decisions and shareholders are not able to contract upon the manager’s selected policies results in a moral hazard problem in the manager’s policy choices as well as her effort. Using the quantitative model, we investigate these policy distortions and their effect on shareholder value.

We find that compensating a risk averse manager with her own firm’s equity leads to significant distortions in the manager’s chosen policies for the firm. That is, the undiversified manager’s optimal policies differ from the policies that would be chosen by a diversified shareholder. Even for modest levels of manager risk aversion, the manager’s exposure to firm-specific risk results in long-term underinvestment by the manager. Specifically, the undiversified, risk averse manager’s long-run optimal capital stock in the simulated model is 7% to 12% lower than the capital stock that would be chosen by a diversified agent. From the
viewpoint of the diversified shareholder, this underinvestment by the manager represents a loss of 1-2% of firm value. This cost is balanced against the compensation contract’s benefit of inducing managerial effort, which has a positive effect on shareholder value. As such, one can view our calculated loss in value as the cost of inducing effort from the manager. If the firm’s board and shareholders are maximizing value in setting the incentive-based compensation contract, this also gives an implied valuation of the manager’s effort.

Additionally, our results suggest that the investment distortion is asymmetric with respect to the firm’s productivity shock. In particular, the difference in manager and shareholder optimal policies is larger following a negative innovation to firm productivity. This suggests that the friction we study is exacerbated when the firm nears failure. A consequence of this asymmetry is that it induces positive skewness in the manager’s optimally chosen investment rate. This positive skewness is consistent with firm-level data and can be generated in the model even without irreversibility or asymmetric adjustment costs.\(^1\)

These results have important implications for executive compensation, firm investment and financing decisions, and corporate governance. First, corporate boards and shareholders face a tradeoff in choosing the degree to which their manager’s compensation is tied to firm performance. The benefits of inducing managerial effort must be weighed against the costs of distorting the manager’s discount rate, and consequently her optimal policy decisions. When the policy decisions cannot be contracted upon, the manager can be expected to choose the policies that maximize her own utility. Such policies need not, and generally will not, coincide with the diversified shareholders’ optimal policies. Our results show that this divergence can result in a significant loss to shareholders compared to a case where the manager selects the policies that would be chosen by a diversified shareholder.

Our paper lies at the intersection of the literature on executive compensation and firm investment and financing decisions. The former is an extensive literature that examines the problem of compensating a manager when effort is unobservable to shareholders. For the most part, the effect of a manager’s compensation contract on her chosen investment and

\(^1\) For evidence of positive skewness in firm-level investment, see Dangl and Wu (2010).
financing policies is not considered in this literature. The latter literature in most cases assumes that there does not exist an agency problem between the manager and outside shareholders. Instead, this literature studies the optimal investment and financing policies of a well-diversified manager whose discount rate is identical to that of diversified shareholders.

The idea that incentivizing executives with their own company’s equity and options results in undiversified managers has been previously recognized in the executive compensation literature. Meulbroek (2001) notes that undiversified managers value their own company’s stock and options less than the market value determined by diversified investors. She estimates that executives value their option-based compensation between 53% and 70% of its cost to the firm. Hall and Murphy (2002) study the cost, value, and pay/performance sensitivity of executive stock options when these options are held by undiversified, risk averse executives. Similar to Meulbroek (2001), they argue that the distinction between the compensation package’s cost to the company and value to the manager is significant. Additionally, Hall and Murphy (2003) note that stock and options are distributed to managers below the top-level executives. Thus, the distortions we study are likely to be present throughout the firm, not just for a handful of individuals.

While the executive compensation literature has noted the costs to a manager of being undiversified, the implications for the manager’s policy choices has been mostly unexplored. There are a couple of notable exceptions, however. Lewellen (2006) notes that a manager’s exposure to firm-specific risk drives a wedge between the optimal financing policy of the manager and a diversified shareholder. She finds empirically that the volatility costs induced by debt can be significant and help to explain the observed leverage ratios for U.S. firms. Panousi and Papanikolaou (2011) documents empirically that firm investment falls in response to a rise in idiosyncratic risk and this effect is increasing in the fraction of the firm owned by the manager. They attribute this effect to the undiversified idiosyncratic risk borne by managers that have incentive-based compensation packages. Danthine and Donaldson (2010) study the optimal contract in a general equilibrium setting where firms are run by risk averse managers and owned by risk averse shareholders. They derive a contract
that maintains the incentive for managerial effort while still keeping the manager’s pricing kernel in line with that of the diversified shareholders. To achieve this, the manager holds a portion of her own firm’s equity as well as a salary that depends on the aggregate wage bill and aggregate dividend. Chen et al. (2010) study the effects of nondiversifiable risk in the context of entrepreneurial firms.

The remainder of the paper is organized as follows. In Section 2 we present a quantitative model of the firm featuring an agency conflict between manager and shareholders. In Section 3 we present results from the simulated model and quantify the impact of the policy distortions and shareholder losses associated with the wedge between the discount rates of undiversified managers and diversified shareholders. Section 4 concludes.

2 Model

We develop a neoclassical production model of the firm that features agency conflicts between the manager running the firm and outside equity holders. We assume that a manager’s effort increases firm value but is personally costly for the manager to exert. Furthermore, the manager’s effort and policy decisions for firm investment and financing are unobservable to the outside shareholders. This gives rise to agency conflicts in two dimensions: the manager’s choice of effort and her choice of firm policies for investment and financing. We do not explicitly model effort but assume the contract is chosen by the board to induce effort at the second-best optimal level. That effort is valuable is implicit in the board’s choice of equity-based compensation.

The economy is populated with a cross-section of heterogenous firms and two types of agents: managers and shareholders. Each firm is run by a manager who makes the policy decisions of the firm. Time is discrete and firms and shareholders have infinite horizons. Managers are finitely lived. We adopt recursive notation throughout where the ’ superscripts denote next period values.
2.1 Firm Production and Investment

Firms are infinitely lived and produce using physical capital, $k$, subject to idiosyncratic productivity shocks, $z$. The firm’s profits are given by

$$
\pi(k, z) = zk^\alpha - f
$$

where $f$ represents a fixed operating cost. We assume decreasing returns to scale in production, which implies $\alpha < 1$. A firm’s idiosyncratic productivity, $z$, evolves according to

$$
\log(z') = \rho \log(z) + \sigma z' \epsilon'
$$

where $\epsilon$ is drawn from the standard normal distribution. Each firm is able to scale its operations through changes in its capital stock, $k$. This physical investment expenditure, $i$, obeys the capital accumulation constraint

$$
i = k' - (1-\delta)k
$$

where $\delta > 0$ represents the per period depreciation rate of capital. Investment is subject to adjustment costs of a quadratic form given by

$$
\Phi(i, k) = b \left( \frac{i}{k} - \delta \right)^2 k.
$$

2.2 Financing

Each firm’s capital investment as well as any distributions to shareholders can be financed from two sources: internal funds resulting from operating profits or by raising additional external equity. Consistent with the existing literature, we assume that raising external equity entails a cost that may contain both a fixed and variable component. Specifically, we follow Gomes (2001) and assume that raising external equity, $e$, is subject to an issuance cost of the form

$$
\Lambda(e) = \lambda_0 + \lambda_1 e
$$
where $\lambda_0, \lambda_1 \geq 0$.

Firms pay the corporate tax rate $\tau_c$ on their profits, net of their depreciated capital and fixed payments to the manager, both of which are tax deductible under the U.S. tax code. Thus, the firm’s taxable income is given by

$$\pi(k, z) - \delta k - F$$

where $F$ is the fixed component of compensation paid to the manager. The equity-based portion of compensation is discussed below.

### 2.3 The Manager

The manager of a firm has full control over all investment, financing, and distribution decisions. Managers are self-interested, meaning that a manager selects firm policies with the objective of maximizing her own lifetime utility, taking the form of her compensation contract as given. The manager’s wealth is tied to her firm’s performance through the compensation contract and we assume this exposure cannot be undone by trading in other securities.\(^2\) Consequently, the manager’s optimally chosen consumption stream will be affected by shocks to firm productivity. We assume the manager is risk averse with concave utility over consumption, resulting in the standard desire to smooth her consumption path.

Outside shareholders are assumed to be unable to perfectly observe or contract on the manager’s effort choice and policy decisions, giving rise to a moral hazard problem in both effort and policy decisions. Most of the executive compensation literature has studied the former moral hazard problem while ignoring the latter. In this paper, we focus on the latter moral hazard problem, which results directly from shareholders attempting to mitigate the former.\(^3\)

\(^2\)Note that allowing the manager to undo her exposure to idiosyncratic risk of the firm would effectively undo the incentive to exert effort that the exposure is meant to induce.

\(^3\)We do not explicitly model the friction that prevents shareholders from contracting on the manager’s policy decisions. However, the inability to contract on these decisions can be viewed as the manager having private information that is not observed by shareholders. Similarly, although outside the model, managers may have the ability to choose the volatility of the projects they invest in, so even if investment size was contractible, managers could potentially “shield” assets from risk by choosing low-risk projects.
2.3.1 Manager’s Compensation

One aspect of the firm not directly controlled by the manager is her own compensation, which is composed of a fixed cash salary $F$ and shares of firm equity representing a constant fraction $\theta$ of the firm. Because we assume the manager cannot unwind or sell this position, we can view this incentive pay as unvested shares in the firm. For tractability, we exogenously fix the manager’s contract and examine the effect of the manager’s exposure to firm-specific idiosyncratic risk on her policy choices for the firm. We compare the manager’s policy choices with what would have been chosen by the diversified shareholders.

Each period, the manager receives a fixed salary payment, and dividends proportional to their unvested equity holdings. Simultaneously, the manager makes a consumption decision for that period, which may be funded out of existing cash wealth $W$ or from current compensation. Any cash wealth this is held between periods is invested at the risk-free rate. Because $W$ affects the manager’s policy decisions and thus firm value, firm value is a function of $W$.

Each period there is some probability that the manager separates from the firm. A manager’s separation from the firm is a random event that follows a Poisson arrival with constant intensity parameter $\kappa$. Upon separation, the manager sells her equity holding in the firm and receives utility over final period wealth. We assume that upon separation, a new manager is installed with initial wealth $W_0$, and that this information is revealed to the market prior to the incumbent manager being able to sell her shares. In effect, each period a manager faces a probability $\kappa$ of receiving terminal payoff $\theta V(k, z, W_0)$. This ties the manager’s compensation to the value of the firm.

The compensation contract is fixed and is not chosen by the manager. However, the firm’s net distribution to shareholders, $d(k, z, W, k')$, is chosen by the manager. Thus, the manager is able to influence her compensation through her choice of firm policies. The manager is also able to indirectly affect her compensation through her policy decisions.

\footnote{We assume, however, that the manager is unable to privately divert funds from the firm. That is, $\theta$ is fixed and $d$, while chosen by the manager, is observed by the shareholders.}
2.3.2 Manager’s Optimization Problem

The manager is responsible for making all investment and financing decisions of the firm. Each period the manager faces a probability $\kappa$ of being forced to separate from the firm. That is, a manager’s exit follows a Poisson arrival with a constant intensity parameter $\kappa$. Conditional on not exiting at the start of a period, the manager makes a joint investment and financing decision for the firm. For a manager who hasn’t separated from the firm in the current period, the manager’s lifetime utility is given by

$$U(k, z, W) = \max_{c, k'} \left\{ u(c) + \beta \mathbb{E} \left[ \chi \nu \left( W' + \theta V(k', z', W_0) \right) + (1 - \chi) U(k', z', W') \mid z \right] \right\} \quad (7)$$

s.t.

$$W' = (1 + (1 - \tau_i) r)(W + \theta d(k, z, k') + F - c) \quad (8)$$
$$W \geq 0 \quad (9)$$

where $u(\cdot)$ is per period utility over consumption, $\nu(\cdot) \equiv Au(\cdot)$ is the utility derived from total wealth at separation, $\chi$ is a binary function indicating separation from the firm, $\tau_i$ is the personal income tax rate the manager faces on interest income, and $d(\cdot)$ is the dividend defined below. Throughout we assume the manager’s utility is power with constant relative risk aversion equal to $\gamma$:

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}. \quad (10)$$

The manager’s budget constraint is given by (8). We rule out borrowing by the manager in (9). Solving the recursive problem given by (7)-(9) gives an optimal policy function for investment, $k'(k, z, W)$.

2.4 Shareholders and Firm Valuation

We assume that there is no aggregate risk in the economy. In contrast to managers, who are exposed to their own firm’s idiosyncratic risk, shareholders are optimally diversified such that they require no risk premium for holding equity. The firm’s equity value is priced in the market by diversified equity holders who, in the absence of systematic risk, discount future
equity distributions at the risk-free rate. The firm’s equity distributions are chosen by the manager to maximize her own lifetime utility. We assume that shareholders are unable to contract upon the manager’s policy choices and instead take the manager’s policy functions as given. Because there is a lump-sum payment to the manager at separation to fulfill her equity-based portion of compensation, the value of the firm drops when a manager exit shock hits. Thus, the shareholder value of the firm is given by two Bellman equations, one for when the manager remains with the firm and one for when she separates:

\[
V(k, z, W) = \max \left\{ 0, \ (1 - \theta) \ d(k, z, k'(k, z, W)) \right. \\
\left. + \beta \mathbb{E} \left[ \chi V_{\chi}(k', z', W_0) + (1 - \chi) V(k', z', W') \right| z \right\} \tag{11}
\]

\[
V_{\chi}(k, z, W) = \max \left\{ 0, \ (1 - \theta) \left\{ (1 - \theta) \ d(k, z, k'(k, z, W)) \right. \\
\left. + \beta \mathbb{E} \left[ \chi V_{\chi}(k', z', W_0) + (1 - \chi) V(k', z', W') \right| z \right\} \right. \\
\left. + (1 - \chi) V(k, z, W) \right\} \tag{12}
\]

where

\[
d(k, z, k') = \left( 1 + (1 - \phi_d) \lambda_1 - \phi_d \tau_d \right) \times \\
\left[ (1 - \tau_c)(\pi(k, z) - F) + \delta \tau_c k - i - \Phi(k, k') - (1 - \phi_d) \lambda_0 \right]. \tag{13}
\]

and \( \phi_d \) is an indicator for positive distributions to shareholders. The market value of the firm conditional on having not received an exit shock from the manager is given by \( V(k, z, W) \) in (11). With probability \( \kappa \) the manager separates from the firm and the market value of the firm becomes \( V_{\chi}(k, z, W) \) defined in (12). This formulation implies that \( V_{\chi}(k, z, W) \) is simply \( V(k, z, W) \) scaled by a constant:

\[
V_{\chi}(k, z, W) \equiv (1 - \theta) V(k, z, W) . \tag{14}
\]

Shareholders have limited liability, which gives the outer max on the optimization problem in (11) and (12): shareholders have the option and sole discretion to walk away and receive zero.
As a benchmark, we also define the shareholder value of the firm with the conflict between shareholder and manager is shut down. In this case the manager follows the first best optimal investment policy that would be chosen by a shareholder, just as in a standard neoclassical model of firm production. However, to keep this benchmark comparable in outflows due to cost of management, we assume there is a passive manager which receives the same compensation contract as in the the previous version. This benchmark is given by

\[ V_0(k, z) = \max \left[ 0, \max_{k'} \left\{ (1 - \theta) d(k, z, k') + \beta \mathbb{E} \left[ \chi V_{0,\chi}(k', z') + (1 - \chi) V_0(k', z') | z \right] \right\} \right] \]  

(15)

\[ V_{0,\chi}(k, z) \equiv (1 - \theta) V_0(k, z). \]  

(16)

The primary reason to solve this benchmark is in order to simplify computation of \( U(k, z, W) \) and \( V(k, z, W) \). We use the benchmark to approximate the manager’s terminal compensation \( \theta V(k, z, W) \) by \( \theta V_0(k, z, W) \). This eliminates solving the fixed point problem defined by equations (7) and (11). This is a reasonable approximation because \( \text{corr}(V, V_0) \) is very close to one and the magnitude of the distortion in total firm value caused by agency costs is small. However, it is critical that any approximation error does not drive the results. To avoid problems resulting from approximation error, we use firm value and policy implied by (11) and (12) for the risk neutral manager as the relevant comparison for distortions arising from agency conflict. Our results can therefore be interpreted as distortions resulting from the fact that managers are risk averse, rather than the fact that shareholders are unable to make policy decisions directly.

### 2.5 Calibration

The calibrated model parameters are shown in Table I. All values are at an annual frequency. For the production and financing parameters, we follow the literature that studies a similar class of model. Specifically, the capital depreciation rate, \( \delta \), is close to the value reported in Cooley and Prescott (1995) and the returns to scale parameter \( \alpha \) is consistent with the evidence in Cooper and Ejarque (2003). The parameterization of the capital adjustment costs
follows Caballero et al. (1995) and Caballero and Engel (1999). The equity issuance costs λ is consistent with values in Gomes (2001) and Hennessy and Whited (2007). Additionally, it is consistent with the estimates reported in Altinkilic and Hansen (2000). The persistence and volatility of firm productivity (ρz, σz), and the time preference (β) are in line with the parameters used in other neoclassical models of firm investment.\footnote{See, for example, Gomes (2001), Hennessy and Whited (2005), or Hennessy and Whited (2007).}

Parameters that have readily observable counterparts in the data are set using empirical guidance. For example, we choose tax parameters that are in line with the current U.S. tax code. The manager’s ownership stake in the firm θ and fixed pay F are chosen to approximate the average ownership stake and fraction of total compensation which comes from salary observed in the data. The per-period probability of manager separation, κ, is set to 1/7 to generate an average tenure length of 7 years which is seen in the data.

Finally, the ratio of utility of terminal period wealth to utility of per-period consumption, A, is chosen such that the manager’s expected wealth at separation time τ is equal to the manager’s initial wealth: \( E_0[W_τ] = W_0 \). This value of A implies that managers neither have a strong motive to save nor spend down their wealth during their tenure. Because we do not observe the trend in manager’s wealth, we assume the manager’s savings (cash wealth) is near its long-run mean when the manager is hired. As risk aversion affects the value of wealth in a consumption-savings problem, the calibrated value for A is a function of γ.\footnote{The calibrated values for A are 1.1, 9.3, and 650 for risk neutral utility, log utility, and power utility with gamma equal to 3, respectively.}

\section*{3 Model Results}

In this section we investigate the results produced from solving and simulating the calibrated model. In particular, we are interested in the effect of managerial risk aversion, coupled with the manager’s inability to fully diversify her firm-specific exposure, on a firm’s optimal policy choices. To this end, we solve and simulate the model for a risk-neutral manager, a log utility manager, and a power utility manager with γ = 3. Throughout, we take the risk-neutral
manager as a benchmark in the sense that the nondiversifiable risk does not affect her firm policy choices. In other words, the optimal policies chosen by the risk-neutral manager coincide with the policies that would be selected by a diversified shareholder. In the case of a risk averse manager, however, the manager’s chosen policies differ, at times significantly, from what is optimal for a diversified shareholder.

The optimal investment policy that would be chosen by a risk neutral manager is also the policy that would be optimally chosen if a diversified shareholder were running the firm. Therefore, the difference between the optimal policy of a risk-averse and risk-neutral manager represents the difference between policies of risk averse manager and diversified shareholders.

We find that the difference in the manager and shareholder optimal policies is increasing in the degree of the manager’s risk aversion. Intuitively, this result is to be expected. Fixing the compensation contract, as a manager’s risk aversion increases, the price of risk she assigns to the idiosyncratic shocks of the firm increase as well. This increases the discount rate the manager applies to a firm’s cash flows, however the idiosyncratic shocks have no effect on the risk neutral manager or diversified shareholders’ pricing. Consequently, a higher level of managerial risk aversion, for a given compensation contract and level of exposure to firm-specific risk, drives a greater wedge between the optimal policy choices of the undiversified manager and diversified shareholders.

3.1 Model Simulation Results

While the policy functions give some qualitative intuition for the difference in manager and shareholder policies, we are primarily interested in the dynamics of these effects. To study the quantitative implications of the model, we now turn to the simulation results. We run three separate simulations, one for each level of manager risk aversion: risk-neutral, log utility, and power utility with $\gamma = 3$. Because the model is stationary, we initialize the firm values in the initial period and then simulate for 10,000 periods, discarding the first 1,000 periods. Should the firm exit, another is born in its place, resetting the state variables for the new firm. We then take time series averages of the moments of interest.
Table III displays moments from the simulated model for the three different values of the manager’s risk aversion that we consider. First, we note that the mean investment rate does not change with changes in the manager’s risk aversion. While the investment policies are not the same, a risk-neutral and risk-averse manager have the same average investment rate. This implies that the average investment rate for the risk averse, undiversified shareholder is consistent with the average investment rate that would be selected by a diversified shareholder.

Similar to the mean investment rates, we see that the volatility of the optimal investment rate does not change with the manager’s risk aversion. Furthermore, the investment rate has a relatively low volatility due to the presence of adjustment costs in physical capital. The higher moments of investment do, however, vary with the manager’s risk aversion. The row labeled ‘Skew(i/k)’ displays the skewness of the investment rate of the manager for the three different levels of risk aversion. The risk-neutral manager has a negative skewness in the chosen investment policy. However, we observe a positive skewness for the investment rate of a risk-averse manager and this skewness is increasing in the degree of risk aversion, with a value of 0.26 for a manager with $\gamma = 3$. In contrast, the optimal investment policy chosen by a risk-neutral manager, which is also the policy that would be chosen by a diversified shareholder, has a skewness of -0.15.

In addition, we compute the kurtosis of the investment rates for each case of manager risk aversion. We can see that the kurtosis of the manager’s investment rate is higher for the risk averse manager. For a risk averse manager with log utility, the kurtosis of $i/k$ is 3.82, significantly higher than the kurtosis of 2.81 for the risk-neutral manager’s investment policy. Thus, while the mean investment rates of the risk-neutral and risk-averse manager are not very different, there are significant differences in the distribution of the investment rates.

In Figure 1, we display histograms of the investment policy for the three levels of manager risk aversion. These histograms plot the distribution of the investment rate for the simulated time series of a single firm. Comparing Panels A and B to Panel C, we can see the
positive skewness of the risk-averse manager’s investment policy versus the negative skew-
ness of the risk-neutral manager’s optimal policy. More generally, Figure 1 indicates that 
the distribution of a manager’s investment rate varies with the degree of risk aversion.

Additionally, we note that while the levels and volatility of the risk-averse and risk-neutral 
manager’s chosen investment rates are similar, the correlation is not perfect. In Table III 
the row labeled ‘$\text{Corr}((i/k),(i/k)_{RN})$’ displays the correlation of the investment policies 
chosen by the risk-averse and risk neutral manager. By construction, the first column is 
equal to one. However, the second and third columns show that the risk averse manager’s 
optimal investment policy is less than perfectly correlated with the policy of the risk-neutral 
manager. Furthermore, comparing column two to three, we see that as the manager’s risk 
aversion increases, the correlation of these investment rates drops. For a manager with 
power utility and $\gamma = 3$, the optimal investment policy has a correlation of 0.79 with the 
risk-neutral manager’s policy. Note that the risk-neutral manager’s policy is consistent with 
what would be chosen by diversified shareholders. Thus, even for relatively low levels of 
manager risk aversion, the model generates a nontrivial wedge between the optimal policy 
choices of a risk-averse manager and a diversified shareholder.

A natural question is whether this difference in preferred investment policy of the risk-
averse, undiversified manager and diversified shareholder is time-varying. From Table III, we 
can see that the wedge in policies of manager and shareholder is larger when the firm is hit 
with a bad shock. Namely, the row labeled “Good shocks: $\text{Corr}((i/k),(i/k)_{RN})$” displays 
the correlation of the risk-averse and risk-neutral manager’s investment policies following a 
positive innovation in firm productivity. The row labeled “Bad shocks” provides an analogous 
correlation measure following negative innovations to firm productivity. Comparing these 
rows, we see that the difference in investment policies is greater following negative shocks 
and the magnitude of this difference is increasing in the manager’s level of risk aversion.

From Table III we see that the investment policies of the undiversified manager and diver-
sified shareholder are not perfectly correlated. Holding the contract fixed, the correlation of 
these optimal investment policies is decreasing in the level of manager risk aversion. At the
same time, the correlation of risk-neutral and risk-averse manager’s investment rate with the firm productivity shock are nearly identical and this correlation is unaffected by a change in the manager’s risk aversion. However, the manager’s optimal investment policy depends on her level of personal wealth, \( W \), as well as the current level of capital stock, \( k \), and the firm productivity, \( z \). The results in the correlation tables presented in Table IV help to illustrate this point.

Table IV reports pairwise correlations of a few variables of interest from the simulated model for the case of a risk averse manager with log utility and one with power utility with \( \gamma = 3 \). We present pairwise correlations for the firm productivity shock, \( z \), the risk-averse manager’s optimal investment rate, \( (i/k) \), the investment rate that would be optimally chosen by a risk-neutral manager, \( (i/k)_{RN} \), and the manager’s wealth, \( W \). As previously noted, increasing manager risk aversion does not change the correlation between the manager’s optimal investment policy and the firm’s productivity shock, \( z \). However, the correlation between the manager’s wealth, \( W \), and the firm productivity, \( z \), does change with the manager’s risk aversion.

Additionally, in Table IV we see that both the risk-averse and risk-neutral manager’s optimal investment policies have a nontrivial correlation with the manager’s level of wealth. For the case of a power utility manager with \( \gamma = 3 \), the correlation of a risk-neutral manager’s investment rate with the manager’s wealth is -0.35. The correlation of the manager’s wealth and her investment policy for this case is -0.47. Intuitively, for a risk averse manager, the investment policy will depend on the level of wealth. The correlation of the risk-neutral manager’s investment policy with wealth is perhaps less clear. While the wealth should not explicitly affect the risk-neutral manager’s policy function, the manager’s wealth is correlated with the level of the firm’s capital stock, which does affect the risk-neutral manager’s policy choice.

Table IV also compares the level of capital stock that would be chosen for the simulated firm under the risk-averse and risk-neutral manager policies. In the simulation, we compare the capital stock chosen by the risk-averse manager to the level of capital stock that the
firm would have if a risk-neutral manager with the same compensation contract had been running the firm from the beginning of the simulation. We compute this ratio for each date in our simulation and report the time series mean and standard deviation of this ratio in Table III. The table shows that a risk-averse manager’s optimally chosen level of capital stock is on average lower than what would be chosen by a risk-neutral manager. Since the risk-neutral manager’s optimal policy coincides with that of the diversified shareholder, this result means that a risk-averse manager selects a level of capital stock that is suboptimal from the viewpoint of a diversified shareholder. Furthermore, comparing the second and third columns, we see that the ratio of manager to shareholder optimal capital stock is decreasing in manager risk aversion. For the log utility case, the manager’s capital stock is, on average, 93% of what would be chosen by a diversified shareholder. When the manager has power utility with $\gamma = 3$, this average ratio drops to 0.88.

The difference in levels of optimal capital stock chosen by risk-averse and risk-neutral managers can also be seen in the plots provided in Figure 3. Here we plot the simulated paths of capital stock under the optimal risk-averse and risk-neutral manager investment policies. In Panels A and B of Figure 3, we plot the level of capital stock under the optimal policy of a risk averse manager (solid line) and risk-neutral manager (dashed line). In Panel A, the risk-averse manager has log utility while in Panel B she has power utility with $\gamma = 3$. Going from Panel A to B, we see that the difference in the levels of capital chosen increases with the level of manager risk aversion. The simulated path of productivity shocks, $z$, which is held fixed across these three cases, is plotted in Panel C.

The simulated paths for the capital stock in Figure 3 clearly illustrates the point that a risk averse manager optimally chooses a lower capital stock than what would be selected by a risk-neutral manager, as well as a diversified shareholder. This result is in stark contrast to what would be predicted for a manager with an empire-building motive. In that case, the manager has utility over the size of the firm she manages and consequently overinvests relative to the optimal level that would be selected by a shareholder without such a motive.

In Figures 4 and 5 we present impulse responses for the investment policy of a risk-averse
and risk-neutral manager following a shock to the firm's productivity, $z$. A firm is simulated over a long horizon (100,000 years) and these shocks are identified within the sample path. The “High to High” event occurs when the firm is in a high $z$ state, identified as a specific point on the grid for $z$, and the next period innovation to $z$ is such that $z' > z$. All such events are identified in the sample path, and a 16 year event window, 6 years prior and 10 years subsequent to the event, is constructed around the event. The figures show the cross-sectional average of these investment rates in event time. This process in repeated for events where $z' < z$ conditional $z$ being a high state, giving “High to Low.” This is repeated for the cases when the firm is initially in a low $z$ state to give “Low to High” and “Low to Low.” These results are also displayed in Table V. This table shows the average spread between the risk neutral manager and the risk averse manager at event date 1, i.e. when the shock is realized.

### 3.2 Shareholder Losses and the Value of Effort

Ultimately, the underinvestment by the risk averse manager results in a value loss to shareholders. A diversified shareholder’s optimal firm size is larger than what is optimally chosen by the risk-averse, undiversified manager and this difference is a loss borne by the shareholders. In Table III, the row labeled “Value Loss” presents the computed value loss to shareholders for the three levels of risk aversion considered. In all three cases, the manager is undiversified, however, the value loss to shareholders only occurs for the cases where the manager is risk averse. In these cases (columns two and three of the table), exposure to firm-specific risk distorts the manager’s optimal policy and this distortion results in a value loss to shareholders.

For the case of a log utility manager, the distortion in optimal policy choices results in a loss of 1% of firm value. Comparing this value to column three, we see that the loss to shareholders is increasing in the level of manager risk aversion. For a manager with power utility and $\gamma = 3$, the loss increases to 2.3% of shareholder value. That is, if the manager selected the policies that are optimal from the viewpoint of a diversified shareholder, the
value of the firm to the shareholders would increase by 2.3%. This is a significant cost to the firm, even for a case where the manager’s risk aversion is relatively low. While there isn’t a consensus on the degree of risk aversion among corporate executives, a value of $\gamma = 3$ is certainly on the lower end of values used in the asset pricing literature. This substantial value loss is interesting in its own right, but it also gives insight into the value of a manager’s effort.

The previous discussion of value loss holds fixed the manager’s effort, which presumably has a positive effect on shareholder value. Thus, compensating a manager with her own firm’s equity has the benefit of inducing effort but the cost of driving a wedge between the discount rates, and therefore the optimal investment and financing policies, of manager and shareholder. Thus, the loss in shareholder value discussed above can be viewed as the cost of inducing effort by the manager. From this view, our results suggest that, assuming shareholders and boards of directors are maximizing shareholder value, the value of managerial effort is significant. In particular, it ought to be the case that the benefits of inducing effort are at least as large as the cost, which we find to be of an economically important magnitude.

4 Conclusion

This paper studies the impact of incentive-based executive compensation contracts on firm investment and financing policies. Contracts that compensate a manager with her own company’s stock or options expose the manager to firm-specific risk that is not priced by diversified investors in equilibrium. Allowing a manager to diversify away this firm-specific risk would eliminate the effort-inducing incentive effects that such contracts are meant to produce. The effect of this undiversified idiosyncratic risk on an executive’s valuation of her own company stock and options has been previously identified and studied in the executive compensation literature as a cost of this type of contract. However, our paper is the first to study the effects of these contracts on the investment and financing decisions that an undiversified manager makes for the firm.

We find that an incentive-based contract can significantly distort the firm policy choices
of a risk averse manager. From the calibrated model we see that the capital stock chosen by
the undiversified manager is 7-14% below the level that would be selected by a diversified
shareholder. This underinvestment by the manager represents a 1-3% loss in firm value to
shareholders. Alternatively, this value loss can be viewed as the cost of inducing the firm
value-maximizing level of effort from the manager.
References


This table reports parameter choices for the model. The model is calibrated at an annual frequency. For more details, see Section 2.5.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.10</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.70</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.96</td>
</tr>
<tr>
<td>$f$</td>
<td>0.20</td>
</tr>
<tr>
<td>$\lambda_0$</td>
<td>0.00</td>
</tr>
<tr>
<td>$\lambda_1$</td>
<td>0.02</td>
</tr>
<tr>
<td>$b$</td>
<td>0.20</td>
</tr>
<tr>
<td>$\rho_z$</td>
<td>0.90</td>
</tr>
<tr>
<td>$\sigma_z$</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>Manager</strong></td>
<td></td>
</tr>
<tr>
<td>$F$</td>
<td>0.004</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.01</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Taxes</strong></td>
<td></td>
</tr>
<tr>
<td>$\tau_c$</td>
<td>0.35</td>
</tr>
<tr>
<td>$\tau_d$</td>
<td>0.20</td>
</tr>
<tr>
<td>$\tau_i$</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Table II: Empirical Distribution of Firm Moments

This table reports statistics from the cross-sectional distribution of firm-level moments from the data. The values presented in the table are the cross-sectional mean, median, and standard deviation of the firm level moment in each row. Where applicable, values reported are for a quarterly frequency.

Panel A: Distribution of Empirical Firm Moments

<table>
<thead>
<tr>
<th></th>
<th>δ</th>
<th>α</th>
<th>ρ_z</th>
<th>σ_z</th>
<th>F/k (%)</th>
<th>θ (%)</th>
<th>β^E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.025</td>
<td>0.53</td>
<td>0.63</td>
<td>0.23</td>
<td>0.21</td>
<td>2.05</td>
<td>1.09</td>
</tr>
<tr>
<td>Std</td>
<td>0.015</td>
<td>0.15</td>
<td>0.28</td>
<td>0.22</td>
<td>0.34</td>
<td>3.74</td>
<td>0.38</td>
</tr>
<tr>
<td>P5</td>
<td>0.009</td>
<td>0.26</td>
<td>0.03</td>
<td>0.03</td>
<td>0.01</td>
<td>0.03</td>
<td>0.54</td>
</tr>
<tr>
<td>P25</td>
<td>0.016</td>
<td>0.45</td>
<td>0.47</td>
<td>0.08</td>
<td>0.03</td>
<td>0.16</td>
<td>0.83</td>
</tr>
<tr>
<td>Median</td>
<td>0.021</td>
<td>0.55</td>
<td>0.69</td>
<td>0.16</td>
<td>0.08</td>
<td>0.50</td>
<td>1.04</td>
</tr>
<tr>
<td>P75</td>
<td>0.030</td>
<td>0.64</td>
<td>0.85</td>
<td>0.31</td>
<td>0.24</td>
<td>1.65</td>
<td>1.30</td>
</tr>
<tr>
<td>P95</td>
<td>0.061</td>
<td>0.75</td>
<td>0.95</td>
<td>0.72</td>
<td>0.85</td>
<td>11.36</td>
<td>1.85</td>
</tr>
</tbody>
</table>
Table III: Simulated Moments for Different Values of Managerial Risk Aversion

This table reports moments from the simulated model for the three different levels of manager risk aversion. The first column displays values for the case of a risk-neutral manager. The second and third columns present values for a risk averse manager with log utility and power utility with $\gamma = 3$, respectively. All moments are for the simulation of a single firm over 10,000 periods, with the first 1,000 periods discarded. The model is simulated at an annual frequency with the parameters given in Table I. The subscript ‘RN’ denotes investment rates or levels of capital stock that are optimally chosen by the risk-neutral manager. These coincide with the policies that would be chosen by diversified shareholders.

<table>
<thead>
<tr>
<th></th>
<th>Risk Neutral</th>
<th>Log Utility</th>
<th>Power $\gamma = 3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean $(i/k)$</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Std $(i/k)$</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Skew $(i/k)$</td>
<td>-0.15</td>
<td>0.22</td>
<td>0.26</td>
</tr>
<tr>
<td>Kurtosis $(i/k)$</td>
<td>2.81</td>
<td>3.82</td>
<td>3.71</td>
</tr>
<tr>
<td>Value loss</td>
<td>0</td>
<td>0.010</td>
<td>0.023</td>
</tr>
<tr>
<td>Corr($z,(i/k)$)</td>
<td>0.57</td>
<td>0.58</td>
<td>0.57</td>
</tr>
<tr>
<td>Mean $k/k_{RN}$</td>
<td>1</td>
<td>0.93</td>
<td>0.88</td>
</tr>
<tr>
<td>Std $k/k_{RN}$</td>
<td>0</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Corr($(i/k), (i/k)_{RN}$)</td>
<td>1</td>
<td>0.86</td>
<td>0.79</td>
</tr>
<tr>
<td>Good shocks: Corr($(i/k), (i/k)_{RN}$)</td>
<td>1</td>
<td>0.78</td>
<td>0.68</td>
</tr>
<tr>
<td>Bad shocks: Corr($(i/k), (i/k)_{RN}$)</td>
<td>1</td>
<td>0.76</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Table IV: Correlations from the Simulated Model

This table reports the pairwise correlations of the firm productivity shock, $z$, the risk-averse manager’s optimal investment rate, $i/k$, the risk-neutral manager’s optimal investment rate, $i/k_{RN}$, and the manager’s wealth, $W$, for three levels of risk aversion. The first table reports the correlation results for the case of a risk averse manager with log utility and the second is for a manager with power utility with $\gamma = 3$. The correlations displayed are for a single firm with a simulated time series of 10,000 periods where the first 1,000 periods are discarded. The time series path of the shocks is fixed across the three cases. The value $i/k_{RN}$ coincides with the investment rate that would be chosen if a diversified shareholder were to choose the firm policies for the entire simulation period, starting at date 0. The model is simulated at an annual frequency using the parameters displayed in Table I.

<table>
<thead>
<tr>
<th></th>
<th>$z$</th>
<th>$i/k$</th>
<th>$(i/k)_{RN}$</th>
<th>$W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log utility manager</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$z$</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i/k$</td>
<td>0.55</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(i/k)_{RN}$</td>
<td>0.52</td>
<td>0.86</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$W$</td>
<td>-0.29</td>
<td>-0.49</td>
<td>-0.42</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$z$</th>
<th>$i/k$</th>
<th>$(i/k)_{RN}$</th>
<th>$W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power utility manager with $\gamma = 3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$z$</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i/k$</td>
<td>0.54</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(i/k)_{RN}$</td>
<td>0.52</td>
<td>0.79</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$W$</td>
<td>-0.27</td>
<td>-0.47</td>
<td>-0.35</td>
<td>1</td>
</tr>
</tbody>
</table>
Table V: Investment Impulse Response

This table presents the difference in investment policy chosen by a risk averse and risk neutral manager following a shock to the firm’s level of productivity, $z$. In each column we report the difference in the investment rate of a risk averse manager and a risk neutral manager: $(i/k) - (i/k)_{RN}$ for the period immediately following the date of the shock. Column (1) presents the case of a risk averse manager with log utility and column (2) presents the case of a risk averse manager with power utility with $\gamma = 3$.

\[
(i/k) - (i/k)_{RN}
\]

<table>
<thead>
<tr>
<th></th>
<th>(1) Log Utility</th>
<th>(2) $\gamma = 3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>High to High</td>
<td>0.78%</td>
<td>-0.36%</td>
</tr>
<tr>
<td>Low to High</td>
<td>-1.91%</td>
<td>-2.44%</td>
</tr>
<tr>
<td>High to Low</td>
<td>0.50%</td>
<td>-0.52%</td>
</tr>
<tr>
<td>Low to Low</td>
<td>0.49%</td>
<td>1.23%</td>
</tr>
</tbody>
</table>
Figure 1: This figure plots the histograms of the investment rate in the simulated model under three cases of a manager’s risk aversion. Panels A and B display histograms of the optimally chosen investment rate in the simulated model for a manager with log utility and power utility with $\gamma = 3$, respectively. Panel C displays a histogram of the investment rate for a risk-neutral manager with the same compensation contract. The simulation is performed at an annual frequency.
Figure 2: **Time series of investment.** This figure plots the time series of investment rates \((i/k)\) from the simulated model for different levels of manager risk aversion against the policy that would be chosen by a risk-neutral manager. Panel A compares the investment rate of a risk-averse manager with log utility (solid line) to the investment rate of a risk-neutral manager (dashed line). Panel B is analogous for the case where the risk-averse manager has power utility with \(\gamma = 3\). The series of shocks is fixed for all of these cases and the plots represent a single firm’s simulated sample path for 100 periods. Panel C plots the series of productivity shocks, \(z\), from the simulation.
Figure 3: Time series paths of the capital stock. This figure plots the time series of the capital stock \( k \) from the simulated model as well as the simulated firm productivity shock, \( z \). Panels A and B plot the simulated time series of the level of capital stock, \( k \), under a risk averse manager’s policy (solid line) and a risk neutral manager’s policy (dashed line). The risk averse manager has log utility in Panel A and power utility with \( \gamma = 3 \) in Panel B. The series of firm productivity shocks, which is the same across all cases, is plotted in Panel C. The values displayed are of a single firm’s simulated sample path for 100 periods.
Figure 4: Investment Impulse Response Following a High Shock. This figure displays impulse response functions for investment under different levels of a manager’s risk aversion. In each panel, the solid line represents the policy decision of a risk averse manager while the dashed line represents the decision of a risk-neutral manager. Panels A and C display the case for a log utility manager, while in Panels B and D the risk averse manager has power utility with $\gamma = 3$. In each panel, at date 0, the firm is hit with a high productivity shock. In the top two panels, the firm has a high level of productivity prior to the shock. In the bottom two panels the prior level of productivity is low.
Figure 5: **Investment Impulse Response Following a Low Shock.** This figure displays impulse response functions for investment under different levels of a manager’s risk aversion. In each panel, the solid line represents the policy decision of a risk averse manager while the dashed line represents the decision of a risk-neutral manager. Panels A and C display the case for a log utility manager, while in Panels B and D the risk averse manager has power utility with $\gamma = 3$. In each panel, at date 0, the firm is hit with a low productivity shock. In the top two panels, the firm has a high level of productivity prior to the shock. In the bottom two panels the prior level of productivity is low.