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EMPIRE-BUILDERS AND SHIRKERS: INVESTMENT, FIRM PERFORMANCE, AND MANAGERIAL INCENTIVES

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ABSTRACT

Do firms systematically over- or underinvest as a result of agency problems? We develop a contracting model between shareholders and managers in which managers have private benefits or private costs of investment. Managers overinvest when they have private benefits and underinvest when they have private costs. Optimal incentive contracts mitigate the over- or underinvestment problem. We derive comparative static predictions for the equilibrium relationships between incentives from compensation, investment, and firm performance for both cases. The relationship between firm performance and managerial incentives, in isolation, is insufficient to identify whether managers have private benefits or private costs of investment. In order to identify whether managers have private benefits or costs, we estimate the joint relationships between incentives and firm performance *and* between incentives and investment. Our empirical results show that both firm performance and investment are increasing in managerial incentives. These results are consistent with managers having private costs of investment. We find no support for overinvestment based on private benefits.

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1. Introduction

In large corporations, owners delegate decisions such as investment, effort provision, and resource allocation to professional managers. These decisions are often unobservable or very costly for the owners to monitor. Owners provide managers with incentives to induce them to take actions that maximize the value of the firm. This separation of ownership and control is the classic principal-agent problem.

In this paper, we focus on the investment decisions of managers. Agency problems could lead managers either to overinvest or underinvest. For example, Jensen (1986, 1993) argues that managers take wasteful, negative net present value investment projects because they derive some benefit from controlling more assets. This is overinvestment or empire-building. Conversely, managers may forego some positive net present value investment projects. Investing requires the manager to oversee the investment. Because managers in general prefer to work less (i.e., they are inclined to shirk), managers will underinvest. The two different agency problems provide dramatically different characterizations of firm behavior.

This paper makes three principal contributions. First, we provide a flexible and tractable principal-agent model for analyzing investment decisions. We model managers as having either private benefits or private costs of investment. We show that the optimal provision of incentives through compensation can mitigate over- and underinvestment problems. The model delivers clear, testable implications that can be used to identify whether managers have private benefits or private costs of investment.

Second, we show that the existing evidence of overinvestment is not, in fact, sufficient to identify the agency problem as one of overinvestment. In an important paper, Morck, Shleifer, and Vishny (1988) find that over a range of incentives, firm performance is declining in incentives. They argue that this is because managers make investment decisions that serve to entrench them in their jobs. As a result, firms are overinvesting (see also Shleifer and Vishny (1989)). However, a finding that firm performance is declining in incentives does not imply that firms are overinvesting. Such a finding can also be consistent with firms that are underinvesting. In order to identify whether the agency problem is one of over- or underinvestment, we need to examine the relationship between investment and incentives in addition to the relationship between firm performance and incentives.

In general, it is not possible to associate changes in firm performance with changes in corporate governance mechanisms–takeovers, board size, capital structure, dividend policy, and incentives–unless there is also a relationship between changes in corporate governance and the actions taken by managers, such as investment decisions.

Third, we derive a unique equilibrium for our model and test its comparative static predictions. Empirically, we show that both firm performance *and* investment are increasing in incentives. These two results jointly imply that overinvestment is not a feature of the data. Instead, these findings are consistent with the presence of underinvestment that is mitigated through the use of optimal incentive contracts.

The idea that firms systematically overinvest originated with Jensen (1986), who argues that shareholders must find mechanisms to induce managers to disgorge free cash flow rather than to overinvest. Jensen focuses on the use of debt and dividends to force managers to pay out free cash flow and considers the threat of takeover as a disciplinary device. A number of authors, including Stulz (1990), Hart and Moore (1995), Zwiebel (1996), and Chang (1993), have formalized Jensen's argument.

The relationship between firm performance and managerial ownership has been used to support the overinvestment model. Morck, Shleifer, and Vishny (1988) estimate a nonmonotonic piecewise linear relationship between managerial ownership and firm performance. They find that firm performance is declining in ownership for ownership levels between 5 and 25 percent of the firm. They interpret their result as evidence that managers become entrenched in their positions for ownership in this range. As a result of entrenchment, managers consume perquisites or overinvest, lowering firm performance. Many subsequent papers (McConnell and Servaes (1990), Himmelberg, Hubbard, and Palia (1999), and Palia (1998)) have conducted similar analyses, with mixed results.

Other support for overinvestment comes from Jensen (1993), who provides illustrative calculations of the destruction of shareholder value at a number of the world's largest corporations. He argues that these firms would have generated much more value had they returned cash to their shareholders rather than invested in projects that turned out to be negative net present value. Kaplan (1989) analyzes changes in firm value, profitability and capital expenditures in a sample of seventy-six management buyouts at large public companies. He argues that management buyouts result in improved incentives. His results show that profitability increases and capital expenditures decrease after the buyouts. Other evidence of overinvestment is anecdotal in nature. For example, Burrough and Helyar (1990, p. 95) describe how managers at RJR Nabisco squandered shareholders' cash on corporate jet rides for dogs and celebrity golf tournaments.[1]

A number of models predict that firms will underinvest. Reasons for underinvestment include high leverage (Myers (1977)), dividend signaling (Miller and Rock (1985)), and more general asymmetric information between firms and capital markets (Myers and Majluf (1984)). Our underinvestment model is based on principal-agent considerations–investing may be personally costly for managers because managers have to oversee the investments that their firms make.

Existing empirical support for underinvestment comes from several sources. McConnell and Muscarella (1985) show that firm stock prices react positively to announcements of increases in capital expenditures. Poterba and Summers (1995) show that firms systematically evaluate investment projects using hurdle rates that exceed the firms' costs of capital. They argue that CEOs of firms in the U.S. have short capital budgeting time horizons. Poterba and Summers (1995) conclude that firms forego long-term, positive net present value investment projects. Both of these studies imply that firms could invest more and increase dollar returns to shareholders.[2]

We provide an alternative model of investment based on agency concerns. In our model, managers choose the level of investment and have either private benefits or private costs of investment. The first case we consider is that managers derive private benefits from investment, so that their utility is increasing in the level of investment. Managers are empire-builders and continue to choose investment projects even after all positive net present value investments have been taken. The second case is that investment is costly for managers. The disutility of investment comes from bearing oversight responsibilities for that investment. For example, when firms expand existing facilities or start new product lines, managers are required to do more work. Managers will forego some positive net present value investments in order to lessen the amount of work that they have to do. Given these assumptions, managers will overinvest in the first case and underinvest

1 A different strand of the empirical literature looks for evidence of overinvestment in corporate diversification and finds evidence of less diversification in firms with higher managerial equity ownership (see, for example, Denis, Denis, and Sarin (1997)).

2 The sensitivity of investment to cash flow, first documented by Fazzari, Hubbard, and Petersen (1988), also suggests that investment systematically differs from its optimal level. Hadlock (1998) demonstrates empirically that this sensitivity rises with ownership, which he argues is inconsistent with overinvestment.

in the second case. The two cases reflect very different perspectives on corporate investment and managerial behavior.

We focus on incentives provided by tying managers' compensation to the performance of their firms. The optimal contract for the manager ameliorates the overinvestment and underinvestment problems. We show how the optimal contract depends on the manager's risk aversion, the variance of firm performance, and the magnitude of the private benefits or costs associated with investment. We then estimate how performance and investment vary with changes in incentives, given changes in the underlying exogenous parameters.

In our model, we assume that the firm has sufficient funds to undertake all investment projects selected by the managers. In this sense, the firm is potentially subject to a free cash flow problem. Other studies have noted that debt, dividends, hostile takeovers, product and factor market competition, and board intervention are mechanisms that could be used to overcome a free cash flow problem. Compared to these other mechanisms, incentives can be adjusted frequently and inexpensively, and, when adjusted, they can be targeted precisely for the managers. Incentives from compensation should be the primary mechanism to influence managerial behavior.

Our results highlight the importance of investment. In order to differentiate between over- and underinvestment, we need to examine how both investment and firm performance respond to changes in incentives *in equilibrium*. If investment and firm performance both increase or both decrease in incentives, this supports the private costs model and rejects the private benefits model. If investment and firm performance move in opposite directions with changes in incentives, this supports the private benefits model and rejects the private costs model.

To conduct our empirical work, we use data on managerial incentives from Standard and Poor's ExecuComp dataset. Our sample consists of comprehensive data for the top five executives (ranked annually by salary and bonus) from the S&P 500, S&P MidCap 400, and S&P SmallCap 600 companies from 1993 to 1997. We use investment and firm performance data from Compustat.

Empirically, we find that both investment and firm performance are increasing in incentives. These findings are robust to the inclusion of firm-level fixed effects and other factors that could affect the level of investment and firm performance. These results support a model in which firms underinvest. Our results also suggest that the underlying sources of variation within and across firms are managerial risk aversion and the variance of firm performance. We find no support for models based on private benefits of investment. Intuitively, there cannot be an overinvestment problem due to agency concerns if greater incentives are associated with better firm performance *and* higher investment.

One of our empirical results is of independent interest from overinvestment and underinvestment problems. We find clear, systematic evidence that firm performance is increasing in incentives. This result is in contrast to the results in studies such as Morck, Shleifer, and Vishny (1988) and Himmelberg, Hubbard, and Palia (1999), which do not find a monotonically increasing relationship between performance and incentives. Although these studies do not draw this conclusion, their results reject standard principal-agent models such as Holmstrom (1979) and Holmstrom and Milgrom (1987), which predict that performance will be increasing in incentives in equilibrium. The standard principal-agent models are different from ours in that they focus on effort, not investment. Nonetheless, our finding that performance is increasing in incentives provides additional support for the standard models.

The remainder of the paper is organized as follows. In Section 2, we present the principal-agent model in which managers have either private benefits or costs of investment. In Section 3, we describe our data on incentives, firm performance, and investment. The econometric results are presented in Section 4. Section 5 concludes.

2. Theoretical Results and Predictions

In this section, we show how incentives are determined if managers have either private benefits or private costs of investment. We also show how incentives, investment, and firm performance are related in equilibrium. Changes in these equilibrium outcomes are driven by changes in the underlying parameters of the model–managerial risk aversion, the variance of firm performance, and the magnitude of private benefits or costs of investment. Our model illustrates two key points.

First, focusing only on the response of firm performance to incentives is insufficient to identify whether there is overinvestment or underinvestment. In equilibrium, firm performance could be declining in incentives even if the managers face private costs of investment and hence underinvest. Studies such as Morck, Shleifer, and Vishny (1988) have interpreted a declining relationship as evidence of overinvestment. Similarly, performance could be increasing in incentives even if the managers have private benefits of investment and hence overinvest.

Second, examining the joint response of firm performance and investment to incentives is sufficient to identify whether there is overinvestment or underinvestment. For example, if both performance and investment are increasing in incentives, then in equilibrium the firm is underinvesting. Similarly, if investment is increasing in incentives and firm performance is decreasing in incentives, then in equilibrium the firm is overinvesting. We derive a full set of results in a tractable principal-agent model of investment.

2.1 The Model

We consider a principal-agent setting in which managers choose investments. The firm is assumed to have sufficient free cash flow to fund all investment projects the manager wishes to undertake. We assume that firm profits net of the amount invested are:

$$\pi = mI - \frac{1}{2}I^2 + \varepsilon \tag{1}$$

where I is the level of investment, m parameterizes how productive the firm's investment is, and ε is a normally distributed shock to profits with a mean of zero and a variance of σ^2. Returns are concave in investment–there are diminishing returns to investing. In the absence of any principal-agent problem, the optimal level of investment is given by the first order condition to equation (1):

$$I^o = m. \tag{2}$$

The optimal level of investment is determined only by the productivity of investment–firms that are more productive invest more.

The principal employs an agent who chooses an unobservable level of investment, or a level of investment that is observable but not verifiable. While shareholders could potentially monitor managers' investment choices, doing so is costly. Monitoring is particularly costly in large, publicly traded corporations in which ownership is dispersed. An alternative interpretation is that the productivity of investment m is unobservable. In this case, investment is observable, but the principal does not know if the agent has chosen the right level of investment. The important point for our model is that we assume that investment is not contractible.

The agent has negative exponential utility with a coefficient of absolute risk aversion of r. The agent receives a wage contract that is linear in firm performance:

$$w = w_0 + \alpha\pi. \tag{3}$$

The agent receives a fixed wage component (salary) of w_0 and a performance-based component of $\alpha\pi$. In this setting, the agent's pay-performance sensitivity is α. We can also interpret the previous equation as a statement about the agent's wealth. If we assume, as is true of most executives, that a large fraction of their wealth is invested in their own firms, then w_0 is the component of wealth that is independent of the firm and $\alpha\pi$ is the component of wealth that depends on firm performance. In this case, α represents executive ownership in the firm.

We allow for either nonpecuniary private costs or benefits of investing for managers. Following Stulz (1990), we assume that the manager derives linearly increasing benefits or costs of the form BI from investing more. If $B > 0$, then every dollar of investment generates a marginal B dollars of utility for the manager. The manager enjoys private benefits from more investment or, equivalently, managing a larger firm (empire-building). If $B < 0$, then the manager incurs costs of investing. These take the form of oversight costs associated with greater investment. The more the manager invests, the more work the manager must do to actually manage the investment. Working is costly for the manager ($B < 0$), so the manager must be given incentives (α) in order to invest more.

The principal's problem is to maximize expected profits net of compensation for the agent, given that the agent will choose the level of investment to maximize her utility. The principal's program is:

$$\begin{aligned} &\max\nolimits_{\alpha} \quad E(\pi) - w \\ &s.t. \quad E\left[u(w + BI)\right] \geq \acute{u} \quad (IR) \\ &I^* \in \arg\max\nolimits_I \quad E\left[u(w + BI)\right] \quad (IC). \end{aligned} \tag{4}$$

The first constraint is the agent's individual rationality (IR) constraint where $\acute{u}$ is the agent's reservation utility. The second constraint is the agent's incentive compatibility constraint (IC), which requires that the agent choose the level of investment optimally (for her) given the compensation contract. The agent's certainty equivalent from a contract w is given by:

$$u = w_0 + \alpha\left(mI - \frac{1}{2}I^2\right) + BI - \frac{r}{2}\alpha^2\sigma^2, \tag{5}$$

where $\frac{r}{2}\alpha^2\sigma^2$ represents the cost of the agent's risk aversion.

The manager chooses the investment level to maximize her certainty equivalent (5). This level of investment is:

$$I^* = m + \frac{B}{\alpha}. \tag{6}$$

When compared to the optimal level of investment in the absence of agency problems ($I^o = m$), we notice two things. First, the level of investment chosen by the manager is distorted by B, her private benefits or costs of investment. If the manager has private benefits ($B > 0$), the manager will overinvest, $I^* > I^o$. If the manager has private costs ($B < 0$), the manager will underinvest, $I^* < I^o$. Second, the amount of over- or underinvestment is attenuated by incentives, α. The greater is α, the closer the manager's choice of investment will be to the level that is optimal in the absence of agency problems. This is true for both private benefits and private costs.

The principal's problem is to maximize net profits given the agent's choice of investment. Expected profits net of compensation for the agent are:

$$E[\pi] - w = mI - \frac{1}{2}I^2 + BI - \frac{r}{2}\alpha^2\sigma^2 - \acute{u}. \tag{7}$$

Here we assume that the managerial labor market is competitive, so that the agent is held to her reservation utility through the choice of w_0. Substituting the agent's choice of investment into the above expected net profit equation and maximizing with respect to α yields the following first order condition:

$$\frac{1}{\alpha^3}\left(-r\sigma^2\alpha^4 - B^2\alpha + B^2\right) = 0. \tag{8}$$

The first order condition defines an optimal contract α^* (the second order condition is satisfied as well). There exists a unique optimal contract, and this contract is on the interval $(0,1)$. To see this, note that because the function $-r\sigma^2\alpha^4 - B^2\alpha + B^2$ is polynomial, it is continuous in α. As $\alpha \to 0$, the function is positive. At $\alpha = 1$, the function is negative. Therefore, there exists a root on $(0,1)$. By Descartes' rule of signs, there is at most one real root to the equation $-r\sigma^2\alpha^4 - B^2\alpha + B^2 = 0$, thus proving uniqueness.

We obtain the following comparative statics by applying the implicit function theorem to equation (8):

$$\frac{\partial\alpha^*}{\partial r} = \frac{-\sigma^2\alpha^4}{4r\sigma^2\alpha^3 + B^2} < 0, \tag{9}$$

$$\frac{\partial \alpha^*}{\partial \sigma^2} = \frac{-r\alpha^4}{4r\sigma^2\alpha^3 + B^2} < 0, \tag{10}$$

$$\frac{\partial \alpha^*}{\partial B} = \frac{2B(1-\alpha)}{4r\sigma^2\alpha^3 + B^2} > 0, \text{ if } B > 0, \text{ or} \tag{11}$$

$$\frac{\partial \alpha^*}{\partial B} = \frac{2B(1-\alpha)}{4r\sigma^2\alpha^3 + B^2} < 0, \text{ if } B < 0.$$

Equations (9) and (10) are an immediate consequence of assuming that managers are risk averse. The optimal weight on firm performance, α^*, declines as risk aversion increases or the variance of the performance measure increases because shareholders must trade off incentives versus insurance for the managers. Equation (11) shows that α^* increases as a manager's private benefits become larger and that α^* decreases as a manager's private costs become smaller in magnitude. The intuition for these results is that incentives are used to counteract the manager's private benefits or costs. If private benefits or costs increase (in absolute value), the manager must be given more incentives. If private benefits or costs decrease (in absolute value), the manager can be given fewer incentives. Note that α^* does not depend on the productivity of investment, m. As a result, changes in m do not affect investment or profits through changes in incentives. As shown in equations (6) and (7), changes in m do have direct effects on investment and net profits, even though incentives are unaffected.

Aggarwal and Samwick (1999a, b) show that $\frac{\partial \alpha}{\partial \sigma^2} < 0$ is strongly supported empirically. This comparative static result shows that agents' will have weaker incentives the larger the variance of the performance measure. In those papers, we show that managers at firms with the largest variances of stock returns have pay-performance sensitivities that are an order of magnitude smaller than managers at firms with the smallest variances of stock returns. This result supports a general principal-agent framework, but the unanswered question is which principal-agent model–private benefits or private costs? Equation (10) points out that the finding $\frac{\partial \alpha}{\partial \sigma^2} < 0$ is consistent with both principal-agent models developed here. Because the manager is risk averse, greater variance of shocks will always lead to lower powered incentives. Therefore, our finding of $\frac{\partial \alpha}{\partial \sigma^2} < 0$ is insufficient to identify which of the two principal-agent models is generating the data (if either).

In order to distinguish the two models based on the determinants of α, we would need to observe whether B is positive. If managers have private benefits ($B > 0$) and we find that $\frac{\partial \alpha^*}{\partial B} > 0$, then this would constitute strong support for the models based on private benefits of investment. Conversely, if managers have private benefits and we find that $\frac{\partial \alpha^*}{\partial B} < 0$, then we know that the model, at least in its basic form, is wrong. Unfortunately, B is unobservable in a large cross-section of firms.

We can reliably observe π, I, and α in a large panel of firms. In order to test the theory, we therefore derive comparative static predictions of how these three outcomes will change as the underlying parameters r, B, and σ^2 vary across firms and over time. In our model, a larger B in absolute value means that the shareholders are confronted with a larger agency problem. Managers with larger values of B will require greater incentives to mitigate their agency behavior. For a given B, lower values of r or σ^2 will allow shareholders to provide higher powered incentives. We focus on how investment and firm performance are affected by these incentives in equilibrium. The predictions that we will test are summarized in Table 1. Testing these predictions allows us to infer whether managers have private benefits or private costs of investment; that is, we can infer the sign of B.

2.2 Investment and Incentives

We start with the investment predictions. The optimal α^* from equation (8) is a function of the exogenous parameters r, σ^2, and B. We take the derivative of I^* with respect to the exogenous parameters and then demonstrate how I^* varies with α^* given a change in the exogenous parameter. Consider first the manager's risk aversion. The optimal level of investment from equation (6) changes due to risk aversion only through the effect of risk aversion on incentives α^*:

$$\frac{\partial I^*}{\partial r} = -\frac{B}{(\alpha^*)^2}\frac{\partial \alpha^*}{\partial r}. \tag{12}$$

Because optimal incentives decrease as risk aversion increases ($\frac{\partial \alpha^*}{\partial r} < 0$), if the manager has private benefits of investment ($B > 0$), investment *increases* as risk aversion increases. The intuition is that increasing risk aversion lowers incentives so as to insulate the manager from risk. But incentives are what constrain the manager's overinvestment. As incentives decrease, the manager invests more. If the manager has private costs ($B < 0$), investment decreases as risk aversion increases. The manager again has lower incentives, but in this case lower incentives reduce investment. Fewer incentives induce the manager to underinvest even more.

Dividing both sides of equation (12) by $\frac{\partial \alpha^*}{\partial r}$ while holding σ^2 and B constant yields:

$$\frac{\partial I^*}{\partial \alpha^*} = -\frac{B}{(\alpha^*)^2}. \tag{13}$$

This expression relates the optimal level of investment to the optimal amount of incentives given a change in risk aversion. For $B > 0$, $\frac{\partial I^*}{\partial \alpha^*} < 0$. The manager is overinvesting and an increase in incentives due to a reduction in risk aversion lowers this overinvestment. For $B < 0$, $\frac{\partial I^*}{\partial \alpha^*} > 0$. The manager is underinvesting and an increase in incentives due to a reduction in risk aversion increases investment, thereby reducing underinvestment.

Next consider the variance of firm performance, σ^2. If we replace r with σ^2 in the above derivation (equations 12, 13) and hold r and B constant, we get similar results. The intuition is identical. Increasing the exogenous variance of firm performance lowers incentives so as to insulate the manager from risk. In the case of private benefits, lower incentives increase overinvestment. In the case of private costs, lower incentives decrease the level of investment, thereby increasing underinvestment. These predictions are reported in the second and fourth columns of the top row of Table 1.

Now consider the private benefits or costs of investment, B. The optimal level of investment changes due to private benefits or costs through two effects:

$$\frac{\partial I^*}{\partial B} = \frac{1}{\alpha^*} - \frac{B}{(\alpha^*)^2}\frac{\partial \alpha^*}{\partial B}. \tag{14}$$

The first effect in equation (14) is the direct effect of a change in private benefits on the level of investment itself. If the manager derives more benefits from investing, the manager will increase the level of investment. The second effect in equation (14) is due to the effect of private benefits on incentives. Shareholders will increase incentives to offset the manager's propensity to invest more. Because increasing incentives is costly for shareholders, the increase in incentives will not fully offset the higher investment due to the manager's greater private benefits. The intuition is the same for a change in the private costs of investment.

Dividing equation (14) through by $\frac{\partial \alpha^*}{\partial B}$ while holding σ^2 and r constant yields:

$$\frac{\partial I^*}{\partial \alpha^*} = \frac{1}{\alpha^*}\frac{1}{\frac{\partial \alpha^*}{\partial B}} - \frac{B}{(\alpha^*)^2} = \frac{1}{2}B\frac{2-\alpha^*}{(\alpha^*)^2(1-\alpha^*)}, \tag{15}$$

where we have used equations (8) and (11) to simplify the expression. This equation relates the optimal level of investment to the optimal amount of incentives given a change in private benefits or costs of investment. For $B > 0$, $\frac{\partial I^*}{\partial \alpha^*} > 0$. If there are private benefits, an increase in incentives is associated with an *increase* in investment. This result may seem paradoxical. The manager is overinvesting, and yet the increase in incentives seems to increase this overinvestment. However, incentives are not an exogenous variable that determine investment. The increases in incentives and investment are both equilibrium responses to the manager's higher private benefits. Although incentives increase in response to the increase in private benefits, incentives do not increase sufficiently to prevent the manager from overinvesting more. This prediction is exactly in line with the intuition from the entrenchment literature. In that literature, managers with higher incentives (ownership) engage in more wasteful activities (overinvest) because their ownership entrenches them. Here we give an optimal contracting and equilibrium interpretation to the entrenchment intuition.

For $B < 0$, $\frac{\partial I^*}{\partial \alpha^*} < 0$. If there are private costs, an increase in incentives is associated with a *decrease* in investment. The intuition is similar to the private benefits case. As B becomes more negative, the manager has more private costs and so the amount of incentives α that are optimally provided to the manager increases. Although incentives increase to offset the greater private costs, incentives do not increase sufficiently to prevent the manager from investing even less, thereby increasing underinvestment. These results are reported in the second and fourth columns of the bottom row of Table 1.

2.3 Firm Performance and Incentives

Now we turn to the profit predictions. Recall from equation (1) that $\pi = mI - \frac{1}{2}I^2 + \varepsilon$. It is clear that profits depend on the exogenous parameters r, σ^2, and B only through their impact on investment I. We take the derivative of π with respect to the exogenous parameters and then show how π varies with α^*, given a change in the exogenous parameter. For any exogenous parameter, x, where $x \in \{r, \sigma^2, B\}$:

$$\frac{\partial \pi}{\partial x} = (m - I^*)\frac{\partial I^*}{\partial x}. \tag{16}$$

Dividing both sides by $\frac{\partial \alpha^*}{\partial x}$ while holding the other parameters constant yields:

$$\frac{\partial \pi}{\partial \alpha^*} = (m - I^*)\frac{\partial I^*}{\partial \alpha^*} = -\frac{B}{\alpha^*}\frac{\partial I^*}{\partial \alpha^*}. \tag{17}$$

Equation (17) shows that the sign of $\frac{\partial \pi}{\partial \alpha^*}$ depends on the sign of B and the sign of $\frac{\partial I^*}{\partial \alpha^*}$. If managers have private benefits, B is positive and $\frac{\partial \pi}{\partial \alpha^*}$ will have the opposite sign of $\frac{\partial I^*}{\partial \alpha^*}$. If the firm is already overinvesting and investment increases, profits will decrease. If managers have private costs, B is negative and $\frac{\partial \pi}{\partial \alpha^*}$ will have the same sign as $\frac{\partial I^*}{\partial \alpha^*}$. If the firm is underinvesting and investment increases, profits will increase.

First, consider changes in r and σ^2. Increases in risk aversion or the variance of firm performance reduce incentives. If there are private benefits, reduced incentives increase investment, thereby reducing firm profits. Therefore, the reduction in incentives is associated with a reduction in profits, or $\frac{\partial \pi}{\partial \alpha^*} > 0$. If there are private costs, reduced incentives decrease investment, thereby reducing firm profits. Therefore, the reduction in incentives is associated with a reduction in profits, or $\frac{\partial \pi}{\partial \alpha^*} > 0$. Both the private benefits and private costs models yield the prediction that firm performance is increasing in incentives if the underlying source of exogenous variation is risk aversion or the variance of firm performance. These results are reported in the first and third columns of the top row of Table 1.

Next consider changes in the magnitude of private benefits or costs of investment. If there are private benefits of investment, an increase in those private benefits leads, in equilibrium, to an increase in incentives. However, the increase in incentives does not fully offset the higher investment due to higher private benefits, so the level of investment increases. Because the manager is overinvesting, the increase in investment decreases firm performance. Therefore, higher incentives will be associated with *lower* firm performance. This is the most prominent feature of stories of managerial entrenchment. Similarly, if there are private costs of investment, an increase in the absolute value of private costs leads, in equilibrium, to an increase in incentives and a reduction in investment. Because the manager is underinvesting, the decrease in investment decreases firm performance. Therefore, higher incentives will be associated with *lower* firm performance. Both the private benefits and private costs models yield the prediction that firm performance is decreasing in incentives if the underlying source of exogenous variation is the magnitude of the private benefits or costs. These results are reported in the first and third columns of the bottom row of Table 1.

Studies in the entrenchment literature typically focus on the reduced form relationship between firm performance and ownership. Morck, Shleifer, and Vishny (1988) find a negative relationship over an intermediate range of the data and view this result as support for the entrenchment hypothesis and overinvestment. Our comparative statics results show that this conclusion is not warranted. A finding that firm performance decreases in incentives is not sufficient to conclude that there are private benefits rather than private costs. Such a finding is also consistent with the private costs model (where there is no entrenchment) when the underlying source of variation is the magnitude of those private costs.

2.4 Summary

Table 1 summarizes the predictions between firm performance and investment and incentives, which are observable in our data. According to the theory, differences in firm performance, investment, and incentives must be the result of differences in the three underlying parameters–risk aversion, the variance of firm performance, or private benefits or costs.

First, consider the predictions for firm performance (the first and third columns). Finding that firm performance is increasing in incentives is consistent with both the private benefits and private costs models if the underlying source of variation is risk aversion or the variance of firm performance. Similarly, finding that firm performance is decreasing in incentives is consistent with both models if the underlying source of variation is in the magnitude of the private benefits or costs. Analyzing the relationship between firm performance and incentives in isolation is insufficient to determine whether managers face private benefits or private costs of investment.

Second, consider the predictions for investment (the second and fourth columns). Finding that investment increases with incentives would be consistent with the private costs model if the underlying source of variation is risk aversion or the variance of firm performance. A finding that investment increases with incentives would also be consistent with the private benefits model if the underlying source of variation is the magnitude of the private benefits. Conversely, a finding that investment decreases with incentives would be consistent with the private costs model if the underlying source of variation is the magnitude of the private costs. It would also be consistent with the private benefits model if the underlying source of variation is risk aversion or the variance of firm performance.

Using both the investment predictions and the firm performance predictions will allow us to identify which model is generating the data. Table 1 shows that each of the four possible combinations of the signs of the derivatives will identify a model and a source of exogenous variation. If performance and investment move in the same direction given a change in incentives, then the correct model is private costs. If performance and investment move in opposite directions given a change in incentives, then the correct model is private benefits. When we empirically examine these relationships, finding, for example, that investment increases with incentives and firm performance increases with incentives would rule out the private benefits model and suggest that either risk aversion or the variance of firm performance is the source of variation. These comparative static predictions are what we test.

3. Data

This section describes the data sources that we use to test the comparative static predictions of our principal-agent model. We use Standard and Poor's ExecuComp dataset to construct our measure of managerial incentives. ExecuComp contains data on all aspects of compensation for the top five executives (ranked annually by salary and bonus) at each of the firms in the S&P 500, S&P Midcap 400, and S&P SmallCap 600. Due to enhanced federal reporting requirements for fiscal years ending after December 15, 1992, we can measure incentives from 1993 to 1997.[3] Financial and operating data for the ExecuComp sample companies are drawn from the Compustat dataset. Monthly measures of stock returns from the Center for Research on Security Prices (CRSP) are utilized in calculations of the variance of returns.

Managers can receive pay-performance incentives from a variety of sources. The vast majority of these incentives are due to ownership of stock and stock options. Jensen and Murphy (1990) carefully aggregate pay-performance incentives into a single pay-performance sensitivity. They find that the typical CEO receives approximately $3.25 of compensation per thousand dollar increase in shareholder wealth. Of this amount, $2.50 is due to the median CEO's holdings of stock in the firm and $0.15 is due to ownership of stock options. Increases in the present value of current and future compensation and decreases in the probability of dismissal are responsible for $0.30 each. Hall and Liebman (1998) show that incentives from stock and particularly stock

3 The ExecuComp data are collected directly from the companies' proxy statements and related filings with the Securities Exchange Commission. Our analysis in this paper uses data from the October 1998 release of the data. See Standard and Poor's (1995) for further documentation.

options have grown substantially since the sample period used by Jensen and Murphy (1990). Aggarwal and Samwick (1999a) show that incentives from stock and options are roughly twenty times more important than annual compensation as a source of incentives for both CEOs and other top managers. Thus, our use of pay-performance sensitivities based on stock and option ownership captures the bulk of total incentives. Much of the managerial entrenchment literature has focused on incentives from stock ownership. Our measure of incentives is more inclusive in that it also covers options. For this reason, we call our explanatory variable "PPS" rather than "ownership." It is a more comprehensive measure of incentives.

ExecuComp contains precise data on executives' holdings of stock in their own companies and grants of options during the current year. For stock, the pay-performance sensitivity is simply the fraction of the firm that the executive owns. A CEO who holds 3 percent of the stock outstanding in her firm will receive $30 per thousand dollar change in shareholder wealth. For options, the pay-performance sensitivity is the fraction of the firm's stock on which the options are written multiplied by the options' deltas.

For options granted in the current year, companies must report the number of securities, the exercise price, and the exercise date. Following Standard and Poor's (1995), we assume that options will be exercised 80 percent (up to 1994) or 70 percent (1995 and later) through their term, which is usually 10 years. We use the corresponding 8 and 7 year zero-coupon Treasury bond rates as the risk-free rates of return. The risk-free interest rates used for 1992 through 1997 are 7.19, 5.86, 7.17, 6.50, 6.30, and 6.29 percent, respectively. In applying the Black-Scholes formula, we use the dividend yield for the company reported by ExecuComp and calculate the standard deviation of monthly stock returns for each company using data from CRSP. We use up to five years of prior monthly returns to compute variances. If a firm did not have at least twelve prior monthly returns for a given year, we impute the variance.[4] We multiply this value by $\sqrt{12}$ to get the standard deviation of continuously compounded annual returns (volatility).

For options granted in previous years, the proxy statement reports only the aggregate number of securities and the aggregate "intrinsic value" of the options that are in the money. The intrinsic value of each option is the stock price at the end of the fiscal year less the option's exercise price.

4 For firms that were missing data on variance for some years, we use the variance of the next available year's returns. For firms that had missing data on variance in all years, we use the sample's average variance in each year. Omitting these observations does not significantly change our results.

Following Murphy (1998), we treat all existing options as a single grant with a five year remaining term and an exercise price such that the intrinsic value of all options is equal to that reported on the proxy statement. Apart from having to impute the exercise price and years remaining until exercise, the methodology for options granted in previous years is the same as for current option grants.

We exploit ExecuComp's sampling frame and examine the incentives to the top management team. CEO status is reported directly in ExecuComp and pertains to the executive who held that position for the majority of the year. The pay-performance sensitivity for the top management team is defined as the PPS for the CEO plus four times the average PPS of the other executives at the firm whose information is reported in a given year. This convention standardizes the size of the team at five for all firms even if data are missing for some executives or more than five executives are reported in a given year.

The first two rows of Table 2 present descriptive statistics on the pay-performance sensitivities of the top management team and the CEO for the firms in our sample. The mean top management team has a combined pay-performance sensitivity equal to 6.76 percent of the firm. The interpretation of this number is that if the value of shareholder wealth increased by $1000 over the course of a year, then the value of the stock and option holdings of the top management team would increase by $67.60. The distribution of management incentives across firms is skewed to the right, with median incentives substantially lower at 2.93 percent. The CEO of each firm has incentives of 3.89 percent of the firm at the mean and 1.23 percent at the median. Other percentiles of the distributions are also reported, showing considerable variation in incentives in the ExecuComp sample.

The next two rows of Table 2 pertain to the two dependent variables that we use in our analysis, Tobin's Q and Investment, both of which are calculated from Compustat. Tobin's Q is equal to the ratio of the sum of the market value of equity and the book value of debt to the book value of assets. Q is commonly used as a measure of firm profitability and performance (Morck, Shleifer, and Vishny (1988), McConnell and Servaes (1990), and Himmelberg, Hubbard, and Palia (1999)). Our calculation reflects average Q and abstracts from the effect of taxes on firm value. In our sample, the mean and median values of Q are 2.00 and 1.57, respectively. The middle 80 percent of the firms have Q values between 1.06 and 3.34. Investment is equal to capital expenditures for property, plant, and equipment divided by the stock of net property, plant, and equipment. Investment rates are 24 percent at the mean and 20 percent at the median. Ten percent of the firms invest less than 7.8 percent and ten percent invest more than 46.5 percent.

The remainder of Table 2 presents the descriptive statistics for other variables that we control for in our econometric specifications for Q or Investment. We include the natural log of sales to account for differences in firm size. We also include the ratio of capital (net property, plant, and equipment) to sales to control for asset turnover. In the regressions presented below, we also include the squares of these two variables. We include the ratio of cash flow to capital because many studies based on the work of Fazzari, Hubbard, and Petersen (1988) have shown a relationship between cash flow and investment. The effect of leverage is captured by the ratio of long-term debt to assets. We include the standard deviation of dollar returns to shareholders (calculated from CRSP, as described above) to account for the effect of risk on profitability and investment. Finally, we include controls for the ratio of research and development to capital and advertising to capital.[5]

We restrict our sample to those firm-years in which team pay-performance sensitivity, investment, and Q can be constructed. Within that sample of 5665 firm-years for 1494 firms, the last four variables are missing for several hundred or more observations, as shown in the first column of Table 2. In the empirical work below, we set the values of these variables to zero for observations where they are missing and include a dummy variable for whether the data were originally missing.

4. Empirical Results

We begin by examining the effect of managerial incentives on both Tobin's Q and Investment. For ease of exposition, we first present our results without controlling for the full set of covariates found in Table 2.

4.1 Performance and Incentives–Initial Results

Our model predicts an equilibrium relationship between firm performance and managerial incentives. In the data, the observed relationship between performance and incentives need not be

[5] These variables are the same control variables used by Himmelberg, Hubbard, and Palia (1999).

linear or even monotonic. We choose an empirical specification that is flexible enough to allow for these possibilities. We estimate a piecewise linear specification in which the bendpoints correspond to the quartiles of the PPS distribution. Table 2 reports that the median PPS is 2.9281, with first and third quartiles of 1.0114 and 7.5885, respectively. The piecewise linear specification generates a continuous relationship between firm performance and managerial incentives that consists of four segments. Each segment can have a different slope, and the slope of any segment can be positive or negative. We estimate a spline regression of the following form:

$$Q_{it} = \beta_0 + \beta_1 PPS1_{it} + \beta_2 PPS2_{it} + \beta_3 PPS3_{it} + \beta_4 PPS4_{it} + \sum_{t=94}^{97} \theta_t + \lambda_i + \varepsilon_{it}. \qquad (18)$$

In this equation, the dependent variable is Tobin's Q. The four PPS terms are the increments to pay-performance incentives along each segment. The coefficients on the PPS terms correspond to the slopes of the segments in each of the four quartiles of the data.[6] The estimated relationship between Tobin's Q and managerial incentives will be monotonic only if all four coefficients on the PPS terms have the same sign. Therefore, this specification allows for nonmonotonicities to appear if they are in fact the best description of the data. The specification also includes year effects, denoted by θ_t, and firm level fixed effects, denoted by λ_i.

Table 3 presents the econometric estimates of the parameters in equation (18). The OLS estimates of the coefficients are presented in the first column. These results omit the fixed effects. The coefficients on the four PPS terms are estimated to be positive. The slopes are smaller in magnitude at higher levels of the PPS. The slopes of the first three segments, corresponding to the bottom 75 percent of the data, are significantly different from zero. The slope of the top segment is insignificantly different from zero. The second column of Table 3 presents the fixed effects results. As in the OLS regression, the coefficients on the four PPS terms are estimated to be positive, and the slopes are lower at higher levels of the PPS. In the fixed effects regression, the slopes of all segments are significantly different from zero at the 5 percent level. The bottom two rows of the table report the p-values for two tests. The first is that the four PPS coefficients

6 Denoting pay-performance incentives by α_{it}, the variables in the spline regression are defined as:

$$PPS1_{it} = \min(\alpha_{it}, 1.0114)$$
$$PPS2_{it} = \max(0, \min(\alpha_{it}, 2.9281) - 1.0114)$$
$$PPS3_{it} = \max(0, \min(\alpha_{it}, 7.5885) - 2.9281)$$
$$PPS4_{it} = \max(0, \alpha_{it} - 7.5885).$$

are jointly equal to zero. If the null hypothesis is not rejected, then Tobin's Q is unrelated to managerial incentives. The second is that the four PPS coefficients are jointly equal to each other. This is a test for linearity. If the null hypothesis is not rejected, then the relationship between Tobin's Q and managerial incentives is linear. Both null hypotheses are rejected for both the OLS and fixed effect specifications.

Observed changes in managerial incentives and firm performance are equilibrium responses to changes in exogenous parameters. Therefore, the coefficients on the PPS terms in Table 3 *do not* represent the marginal effect of an exogenous change in managerial incentives on firm performance. For example, the slope coefficient on the first segment in the fixed effect regression is 0.2387. Suppose that the top management team at a given firm is observed to have incentives of 0.25 percent in the form of stock and options. Increasing this team's incentives to 0.75 percent will not increase the value of Tobin's Q by $(0.75-0.25)*0.2387 = 0.1193$. Managerial incentives of 0.25 percent are set in equilibrium, based on the exogenous parameters r, σ^2, and B. Increasing managerial incentives from the optimal level of 0.25 percent will lower the returns to shareholders at this firm.[7] Instead, the coefficient of 0.2387 implies that at a firm in which it was optimal to set managerial incentives to 0.25 percent, Tobin's Q is expected to be 0.1193 lower than at a firm in which it was optimal to set managerial incentives to 0.75 percent. The values of exogenous parameters vary across firms and within firms over time. The firm in which managerial incentives of 0.75 percent are optimal either has lower variance of firm performance or has managers with lower risk aversion. Differences in the underlying parameters generate the observed variation in both incentives and firm performance.

The fixed effects regression provides a more robust test of the comparative statics predictions of the model. Including a dummy variable for each firm removes the effect of any firm-specific characteristic that may affect both performance and incentives in a way not specified by our model. The fixed effects regression establishes a relationship between performance and incentives based only on changes within firms over time. The OLS regression establishes a relationship between performance and incentives based on comparisons both within and across firms. If firms are not

[7] When incentives are set optimally, shareholders have traded off the benefits of reduced agency problems against the cost of compensating the manager. Higher-than-optimal incentives inefficiently expose managers to risk, deprive them of private benefits of investment, or force them to incur private costs of greater investment. Shareholders must then compensate managers for these added burdens, thereby lowering shareholders' returns relative to the optimum.

otherwise identical, the OLS regression will be biased by unobserved, firm-specific factors whereas the fixed effect regression will not. Comparing the R^2 from the two regressions, the inclusion of the fixed effects absorbs a substantial amount of the variation (increasing the proportion of variance explained from 0.0474 to 0.8475), but the fixed effects do not change the basic shape of the predicted relationship. The differences between the OLS and fixed effect regressions are shown in Figure 1. The plot consists of the predicted values for each regression using the intercept for the 1993 sample year. The values from the fixed effect regression have a higher intercept, a lower initial slope, but a more modest decline in slopes thereafter. Overall, the two graphs are quite similar. To the extent that there are unobserved, firm-specific factors that determine Tobin's Q, they do not appear to be highly correlated with managerial incentives in our data.

There are two important features of our findings on the relationship between Tobin's Q and managerial incentives. The first is that in neither regression do we find an intermediate range of incentives over which Tobin's Q decreases with higher levels of the PPS. This contrasts with the earliest papers that investigated this relationship (Morck, Shleifer, and Vishny (1988) and McConnell and Servaes (1990)). Recall that this negative relationship was the basis for the early literature's conclusion that managerial entrenchment and overinvestment are important features of large corporations. Our results, using more comprehensive data and including fixed effects, do not support this conclusion.

The second feature is that at all levels of incentives, greater incentives are associated with higher firm performance as measured by Tobin's Q. To date, there has been no general finding that performance is increasing in incentives. Our result contrasts with Himmelberg, Hubbard, and Palia (1999), who found essentially no relationship between Tobin's Q and managerial ownership in a fixed effects specification. Although they do not draw this conclusion, their results reject standard principal-agent models such as Holmstrom (1979) and Holmstrom and Milgrom (1987), which predict that performance will be increasing in incentives in equilibrium. Our finding of a positive relationship may therefore be viewed as support for standard principal-agent models, quite apart from the implications of this result for our models of over- or underinvestment.

We can also conclude from our estimate of a positive relationship that the underlying source of variation, both within and across firms, is risk aversion or the variance of firm performance (see Table 1). If risk aversion or variance decreases, then shareholders will increase incentives provided to managers. Greater incentives reduce the agency problem due to private costs or benefits of investment and thereby increase firm performance. In contrast, if the underlying source of variation were the magnitude of private costs or benefits, then higher incentives would reflect an attempt to offset the higher private benefits or costs. Higher private benefits or costs lower firm performance. Based on the positive relationship between performance and incentives, we conclude that any variations in the magnitude of B are small in comparison with the variation in risk aversion or the variance of firm performance.

4.2 Investment and Incentives–Initial Results

Our results on the relationship between Tobin's Q and managerial incentives enable us to identify the underlying source of variation but not the nature of the agency problem–private benefits or private costs. As shown in Table 1, we must also consider the relationship between investment and incentives in order to identify which model is generating the data. We estimate an analogous spline regression for investment:

$$(I/K)_{it} = \beta_0 + \beta_1 PPS1_{it} + \beta_2 PPS2_{it} + \beta_3 PPS3_{it} + \beta_4 PPS4_{it} + \sum_{t=94}^{97} \theta_t + \lambda_i + \varepsilon_{it}. \qquad (19)$$

In this equation, the dependent variable is firm investment divided by capital. Both investment and capital are defined in terms of net property, plant, and equipment. As in the Q regression, the PPS terms reflect the slopes of the segments in each of the four quartiles of the data, the year effects are denoted by θ_t, and the firm level fixed effects are λ_i.

Table 4 presents the results of the OLS and fixed effect estimates of the coefficients in equation (19). In the OLS regression, shown in the first column, the coefficients on the first three PPS terms are positive and significantly different from zero at the one percent level. The fourth PPS term, corresponding to the slope of the top segment, is negative and significant. However, as in the regressions for Tobin's Q in Table 3, the magnitude of the top segment's coefficient is extremely small and reflects an essentially flat relationship between investment and incentives. The fixed effect results in the second column show a different pattern. In this regression, the slopes of the first two segments are positive but insignificant. The slope of the third segment is negative but extremely small and statistically insignificant. The slope of the top segment is positive and statistically significant at the one percent level. The test for the joint significance of the four PPS terms rejects the null hypothesis that all coefficients are zero with a p-value of 0.0228. The PPS terms have significant explanatory power for investment. The p-value for the test that the coefficients on all four PPS terms are equal to each other is 0.6416, indicating that a linear specification would capture the relationship between investment and managerial incentives as well as the spline does. The predicted values for both regressions are graphed in Figure 2 using the intercepts for the 1993 sample year. Figure 2 shows that the relationship between investment and incentives is positive.

Combined with the positive slope of the relationship between Tobin's Q and incentives, the finding that investment is increasing in incentives allows us to identify which model, private costs or benefits of investment, is generating the data. Table 1 shows that if investment and firm performance move in the same direction when incentives change, then the model must be one of private costs of investment. The reason is intuitive: if risk aversion or the variance of firm performance declines, so that it is less expensive to compensate the manager through incentives, then shareholders will take advantage of the opportunity to increase incentives, thereby increasing investment toward its optimal level (in the absence of an agency problem) and raising the value of the firm. Our results do not support a model of overinvestment. If overinvestment were a feature of the data, then increases in firm performance associated with increases in incentives would also be associated with lower, not higher, levels of investment.

To summarize our results, we can uniquely identify the model that generates the data from the alternatives in the four cells of Table 1 based on two findings. Because the equilibrium values of Tobin's Q and investment move together in response to changes in incentives, the model must be one of private costs rather than private benefits of investment. Because this direction is positive, the underlying source of variation across the equilibrium outcomes must be risk aversion or the variance of firm performance rather than the magnitude of the private costs of investment.

4.3 Additional Specifications

Our initial regressions in Tables 3 and 4 focus on the relationships between managerial incentives and both Tobin's Q and investment. In principle, there may be other determinants of investment and firm performance that are not explicitly related to managerial incentives. The inclusion of fixed effects and year effects controls for a substantial amount of variation in these other factors. Firm-specific factors that do not vary over time are absorbed by the fixed effects. Firm-specific factors that change linearly over time are absorbed by the combination of the fixed effects and the year effects. Economy-wide factors that affect all firms equally but vary over time are absorbed by the year effects.

To futher demonstrate the robustness of our initial estimates, we augment our fixed effects specifications to include potential determinants of Tobin's Q and investment that vary both across firms and within firms over time. We use the full set of covariates described in Table 2 to estimate the following two regressions:

$$\begin{aligned} Q_{it} &= \beta_0 + \beta_1 PPS1_{it} + \beta_2 PPS2_{it} + \beta_3 PPS3_{it} + \beta_4 PPS4_{it} \\ &\quad + \sum_{k=1}^{K} \delta_k x_{it}^k + \sum_{t=94}^{97} \theta_t + \lambda_i + \varepsilon_{it}. \end{aligned} \tag{20}$$

$$\begin{aligned} (I/K)_{it} &= \beta_0 + \beta_1 PPS1_{it} + \beta_2 PPS2_{it} + \beta_3 PPS3_{it} + \beta_4 PPS4_{it} \\ &\quad + \sum_{k=1}^{K} \delta_k x_{it}^k + \sum_{t=94}^{97} \theta_t + \lambda_i + \varepsilon_{it}. \end{aligned} \tag{21}$$

In these regressions, the other covariates are denoted by x_{it}^k. The results are presented in Table 5.

The inclusion of the additional covariates does not change the pattern of the coefficients on the PPS terms in either regression. In the regression for Tobin's Q, all slopes are estimated to be positive and are somewhat smaller than the estimates in Table 3. The p-values for the statistical significance of the slope of each segment are 0.030, 0.058, 0.146, and 0.058. The p-value for their joint significance is 0.0001. In the regression for investment with the additional covariates, the estimated coefficient for the slope of the top segment is 0.0027 with a standard error of 0.0010. These match the coefficient and significance of the top segment in Table 4, which did not control for the additional covariates. The estimated coefficients for the bottom three slopes are slightly lower and of comparable significance to those in Table 4. The p-value for the joint significance of the PPS terms is now 0.0323. The p-value for the equality of the PPS coefficients is 0.6010, again suggesting a linear specification would be sufficient to capture the relationship between incentives and investment.

For the additional covariates, we find that greater variance of returns is associated with lower values of Tobin's Q and investment. All of the other variables in the investment regression are insignificant, including cash flow and leverage, which are often cited as determinants of investment. In the regressions for Tobin's Q, there are several significant results. Firm size, as measured by the logarithm of sales, has a decreasing then increasing effect on Tobin's Q. The same is true for the ratio of capital to sales. Higher leverage is associated with lower values of Tobin's Q. This result contradicts hypotheses that greater leverage improves firm performance, as in other private benefits models such as Jensen (1986), Stulz (1990), Hart and Moore (1995), and Zwiebel (1996). Firms with more advertising expenditures tend to have lower values of Tobin's Q. Dividend yield is not significantly related to either investment or Tobin's Q.

These regressions show that the increasing relationships between incentives and both firm performance and investment are robust features of the data. As an alternative specification, in Table 6, we estimate the fixed effect regressions with a single linear term in managerial incentives, denoted by α_{it}.

$$Q_{it} = \beta_0 + \beta_1 \alpha_{it} + \sum_{k=1}^{K} \delta_k x_{it}^k + \sum_{t=94}^{97} \theta_t + \lambda_i + \varepsilon_{it} \quad (22)$$

$$(I/K)_{it} = \beta_0 + \beta_1 \alpha_{it} + \sum_{k=1}^{K} \delta_k x_{it}^k + \sum_{t=94}^{97} \theta_t + \lambda_i + \varepsilon_{it}. \quad (23)$$

In effect, we are imposing the constraints that $\beta_1 = \beta_2 = \beta_3 = \beta_4$ in our original spline specifications.

For both Tobin's Q and investment, the coefficient on managerial incentives is positive and statistically significant. For Tobin's Q, the magnitude of the coefficient on incentives, 0.0121, is intermediate between the slopes of the third and fourth segments of the spline regression estimates in Table 5. For investment, the magnitude of the coefficient on incentives is very similar to that of the top segment in Table 5. In the linear specifications, both firm performance and investment are increasing in incentives, as predicted by the private costs of investment model.

4.4 Discussion

The results of our empirical estimates suggest a positive, concave relationship between Tobin's Q and incentives and a positive, linear relationship between investment and incentives. Based on the theoretical predictions detailed in Table 1, these results support a model in which managers face private costs of investment ($B < 0$) and the underlying source of variation across equilibrium outcomes is risk aversion or the variance of firm performance. The private costs model predicts that we will observe underinvestment.

Our results reject principal-agent models based on private benefits of investment (empire-building, managerial entrenchment, perquisites consumption). Both investment and firm performance move in the same direction in response to changes in incentives, not in opposite directions. We also show that earlier empirical findings, based solely on the relationship between firm performance and managerial ownership, are insufficient to identify whether the agency problem is one of private costs or private benefits of investment. While there is surely anecdotal evidence of overinvestment problems at individual firms, our results suggest that they are not, on average, significant problems at a broad cross-section of U.S. corporations.

Overinvestment problems have received extensive attention, starting with Jensen's (1986) discussion of overinvestment due to free cash flow. Jensen suggests that debt, dividends, takeovers, and board monitoring could all serve as mechanisms to curtail overinvestment. Our private benefits model shows that managerial incentives can serve the same purpose. Mechanisms such as takeovers and board intervention require substantial, disruptive change. Given the relative ease with which incentives from compensation can be adjusted, the compensation contract is the natural mechanism to alleviate agency problems.

Additionally, there is evidence to suggest that these alternative mechanisms are not effective. Bertrand and Mullainathan (1998) show that takeover activity has decreased markedly in response to antitakeover legislation. They also show that compensation incentives have partially offset the reduction in incentives from takeovers. Jensen (1993) and Yermack (1996) suggest that boards, and in particular larger boards, are ineffective at raising firm value. In our regressions from Tables 5 and 6, we include both debt and dividends as explanatory variables. The coefficients on dividends are insignificant in the regressions for both firm performance and investment. Although the coefficient on debt is negative and significant in the investment regression, the coefficient is also negative and significant in the Tobin's Q regression. This is inconsistent with debt constraining overinvestment problems.

In principle, our empirical results on underinvestment could be explained by factors other than the principal-agent concerns discussed here. To take one example, suppose that managers have private information about their own firms' quality. Then, in a dividend signaling model (Miller and Rock (1985)), managers will cut investment to pay a dividend that signals their firms' quality. In the Miller and Rock model, managers care about both the fundamental value of the firm and the short-term stock price. The higher dividend increases the short-term stock price. If greater management incentives cause managers to put greater weight on the fundamental value of the firm, then managers will be less inclined to signal. Investment will increase (underinvestment will decrease) and firm performance (fundamental value) will increase. As in our private costs model, greater incentives are associated with higher investment and higher firm performance. It is worth noting that, empirically, we find that both firm performance and investment are unrelated to dividends. Further, controlling for dividends, greater incentives are associated with higher firm performance and investment. These results cast doubt on the dividend signaling explanation.

Aggarwal and Samwick (1999a, b) provide further support for the general principal-agent framework by showing that incentives are declining in the variance of firm returns. While the dividend signaling model and other alternative explanations may predict underinvestment, they do not explain why incentives are declining in the variance of firm returns. Such a finding requires an incentives-insurance tradeoff. Our private costs model can reconcile all three empirical findings: investment is increasing in incentives; firm performance is increasing in incentives; and incentives are decreasing in the variance of firm returns.

Other models of the incentives-insurance tradeoff are also consistent with some of our findings. In the Holmstrom and Milgrom (1987) model, managers take actions such as exerting effort rather than choosing the level of investment. In equilibrium, firm performance is increasing in the level of incentives and incentives are decreasing in the variance of firm performance. Their model is not designed to study the relationship between investment and incentives. However, the interpretation of our underinvestment model is similar to that of their model if the private costs of investment come from managers needing to exert effort to monitor investment. Our three findings provide strong support for principal-agent models in which shareholders provide incentives for managers to choose higher values of the action, whether investment or effort. Although the Holmstrom and Milgrom (1987) model generates similar predictions to those of our underinvestment model, their model is not sufficient to study overinvestment problems, which is the other main focus of our study.

5. Conclusion

We examine how the separation of ownership and control affects investment and firm performance. We consider two variants of the principal-agent problem. In the first variant, managers have private benefits of investment and therefore overinvest. In the second variant, managers have private costs of investment and therefore underinvest. We show how compensation contracts will be designed to ameliorate over- or underinvestment problems. Given the optimal contracts we derive, we then test several implications of the theory.

For all specifications, we find that both investment and firm performance are increasing in incentives. These results are consistent with the presence of private costs and underinvestment. These results also suggest that the primary differences within and across firms are in risk aversion or the variance of firm performance. In our framework, incentives are an endogenous variable and our tests are based on the equilibrium predictions of the model. Increases in incentives come from decreases in risk aversion or the variance of firm performance. The equilibrium increase in incentives then yields higher investment and better performance. Without any change in the underlying exogenous variables (risk aversion, variance), an increase in incentives would lower net returns to shareholders and is therefore not optimal.

Overall, we find little support for the idea that managers systematically overinvest. Our main empirical contribution to the literature is to demonstrate that investment and performance increase in response to increases in incentives. The implications of this result are straightforward. How can there be an overinvestment problem due to agency concerns if greater incentives–the cure for agency concerns–results in greater investment *and* better firm performance? We find support for the idea that managers underinvest. To the extent that they do, the positive relationship between investment and incentives suggests that contracts are structured to address this problem. Therefore, our results support the idea that contracts are set in equilibrium to optimally address shirking problems in firms.

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Figure 1

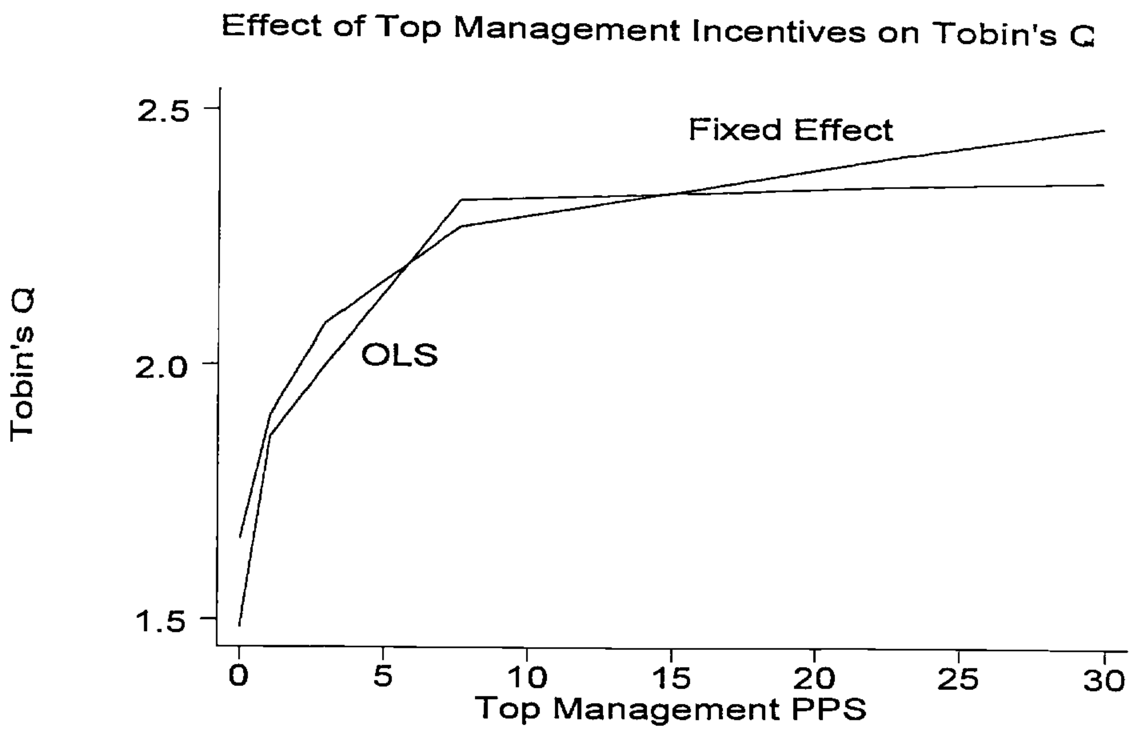
Effect of Top Management Incentives on Tobin's Q
Tobin's Q
2.5
2.0
1.5
Fixed Effect
OLS
0
5
10
15
20
25
30
Top Management PPS

Figure 2

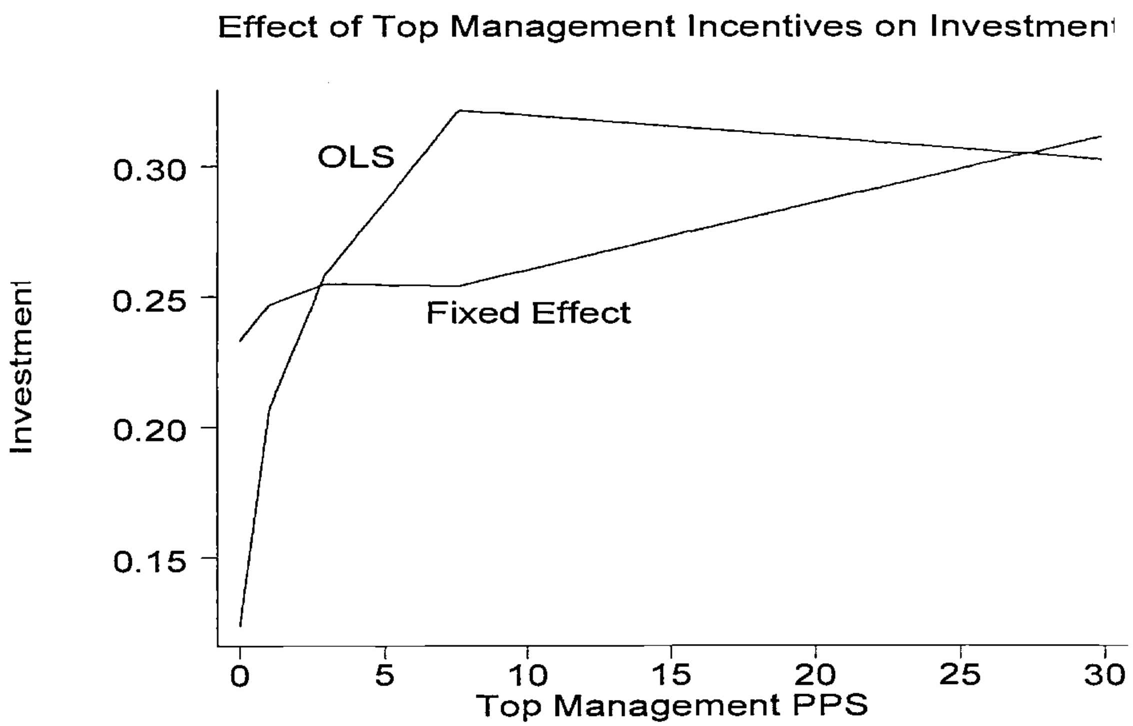
Effect of Top Management Incentives on Investment
OLS
Fixed Effect
Investment
0.30
0.25
0.20
0.15
0
5
10
15
20
25
30
Top Management PPS

Table 1
Comparative Static Predictions

Parameter Providing the Source of Variation	Private Benefits of Investment ($B > 0$) Sign of $\partial\pi/\partial\alpha$	Private Benefits of Investment ($B > 0$) Sign of $\partial I/\partial\alpha$	Private Costs of Investment ($B < 0$) Sign of $\partial\pi/\partial\alpha$	Private Costs of Investment ($B < 0$) Sign of $\partial I/\partial\alpha$
Risk Aversion (r) or Variance of Returns (σ^2)	+	-	+	+
Private Benefit or Cost of Investment (B)	-	+	-	-

Notes:

1) Each cell in the table represents the predicted sign of the change in profits or investment when managerial incentives change.
2) Each row specifies a different underlying (exogenous) parameter of the model in Section 2 that could be changing to generate the shifts in equilibrium incentives (α), investment (I), and profits (π).
3) See Section 2 for a discussion and derivation of the comparative static predictions.

Table 2

Descriptive Statistics for Variables Used in Econometric Analyses

Variable	Number of Observations	Mean	Standard Deviation	10^{th} Percentile	25^{th} Percentile	Median	75^{th} Percentile	90^{th} Percentile
Team PPS	5665	6.7580	10.4414	0.3786	1.0114	2.9281	7.5885	17.9307
CEO PPS	5665	3.8863	7.0932	0.1275	0.3980	1.2286	3.6608	10.5905
Tobin's Q	5665	2.0018	1.3877	1.0630	1.2281	1.5684	2.2087	3.3403
Investment/Capital	5665	0.2439	0.1716	0.0780	0.1305	0.2023	0.3136	0.4654
Dividend Yield	5665	1.6159	2.3086	0.0000	0.0000	1.0260	2.5010	4.3240
Ln(sales)	5665	6.9543	1.5994	5.0460	5.9504	6.9156	8.0332	9.0356
Capital/Sales	5665	0.6044	0.9595	0.0750	0.1471	0.2932	0.6792	1.6544
Cash Flow/Capital	5665	0.8521	3.0791	0.1369	0.2163	0.4482	0.8816	1.7413
Debt/Assets	5641	0.2399	0.1797	0.0071	0.0954	0.2329	0.3519	0.4550
Std Dev of Returns	5385	611.02	1314.05	57.68	98.83	214.62	555.05	1300.48
R & D/Capital	2920	0.3890	1.1606	0.0000	0.0254	0.1048	0.3663	0.9386
Advertising/Capital	1099	0.3439	0.9762	0.0213	0.0478	0.1140	0.3110	0.6497

Notes:

1) Pay-performance sensitivities (PPS) represent incentives provided by direct ownership of stock and stock options for each top management team or chief executive officer (CEO). They are expressed as percentages of the firm, from 0 to 100.
2) Pay-performance sensitivities are calculated from ExecuComp. The standard deviation of monthly returns is based on dollar returns calculated from CRSP, expressed in millions. All other variables are calculated from Compustat.
3) The PPS for the top management team includes the PPS for the CEO plus four times the average PPS for all other executives for whom data are available.
4) All dollar values are in millions of constant 1997 dollars.
5) The sample is comprised of 1494 firms observed annually from 1993 to 1997.

Table 3
Regressions of Tobin's Q on Top Management Incentives, by Estimation Method

Variable	OLS	Fixed Effect
Intercept	1.4846	1.6590
	(0.0499)	(0.0680)
PPS [0 – 1.0114]	0.3694	0.2387
	(0.0562)	(0.0700)
PPS [1.0114 – 2.9281]	0.0735	0.0943
	(0.0350)	(0.0352)
PPS [2.9281 – 7.5885]	0.0691	0.0406
	(0.0167)	(0.0196)
PPS [7.5885 and up]	0.0021	0.0093
	(0.0027)	(0.0046)
Year = 1994	-0.2329	-0.2113
	(0.0544)	(0.0314)
Year = 1995	-0.0541	-0.0654
	(0.0583)	(0.0322)
Year = 1996	0.0203	-0.0630
	(0.0599)	(0.0331)
Year = 1997	0.1983	-0.0036
	(0.0653)	(0.0371)
R-Squared	0.0474	0.8475
P-value for PPS terms:		
Joint Significance	0.0000	0.0000
Equality	0.0000	0.0000

Notes:
1) Each regression pertains to our sample of 1494 firms and 5665 firm-years.
2) The Fixed Effects specification includes a dummy variable for each sample firm.
3) Heteroskedasticity-robust standard errors are reported in parentheses beneath each coefficient.

Table 4

Regressions of Investment on Top Management Incentives, by Estimation Method

Variable	OLS	Fixed Effect
Intercept	0.1238	0.2331
	(0.0064)	(0.0118)
PPS [0 – 1.0114]	0.0822	0.0136
	(0.0070)	(0.0130)
PPS [1.0114 – 2.9281]	0.0268	0.0041
	(0.0039)	(0.0050)
PPS [2.9281 – 7.5885]	0.0135	-0.0002
	(0.0019)	(0.0027)
PPS [7.5885 and up]	-0.0008	0.0026
	(0.0003)	(0.0010)
Year = 1994	-0.0066	-0.0110
	(0.0068)	(0.0047)
Year = 1995	-0.0065	-0.0129
	(0.0068)	(0.0046)
Year = 1996	-0.0046	-0.0189
	(0.0073)	(0.0049)
Year = 1997	0.0037	-0.0217
	(0.0072)	(0.0052)
R-squared	0.1185	0.7582
P-value for PPS terms:		
Joint Significance	0.0000	0.0228
Equality	0.0000	0.6416

Notes:

1) Each regression pertains to our sample of 1494 firms and 5665 firm-years.
2) The Fixed Effects specification includes a dummy variable for each sample firm.
3) Heteroskedasticity-robust standard errors are reported in parentheses beneath each coefficient.

Table 5
Fixed Effect Regressions of Tobin's Q and Investment on Incentives, Spline Terms

Variable	Dep. Variable Is Tobin's Q	Dep. Variable Is Investment
Intercept	5.1210	0.3387
	(1.0319)	(0.1285)
PPS [0 – 1.0114]	0.1520	0.0108
	(0.0701)	(0.0133)
PPS [1.0114 – 2.9281]	0.0659	0.0016
	(0.0348)	(0.0052)
PPS [2.9281 – 7.5885]	0.0267	-0.0010
	(0.0183)	(0.0027)
PPS [7.5885 and up]	0.0086	0.0027
	(0.0045)	(0.0010)
Dividend Yield	-0.0089	-0.00003
	(0.0124)	(0.00066)
Ln(sales)	-0.6703	-0.0061
	(0.2576)	(0.0392)
$Ln(sales)^2$	0.0419	-0.0003
	(0.0170)	(0.0032)
Capital/Sales	-0.3040	0.0120
	(0.0736)	(0.0144)
$(Capital/Sales)^2$	0.0060	-0.0005
	(0.0022)	(0.0004)
Cash Flow/Capital	0.0589	0.0059
	(0.0204)	(0.0046)
Debt/Assets	-0.9206	-0.0744
	(0.1766)	(0.0265)
Missing D/A	-0.7729	-0.0013
	(0.5014)	(0.0373)
CDF of Std Dev	-1.1210	-0.0880
	(0.2599)	(0.0412)
Missing Std Dev	-0.3851	-0.0165
	(0.1887)	(0.0350)
R & D/Capital	0.0263	-0.0029
	(0.0751)	(0.0102)
Missing R&D/K	0.0536	0.0249
	(0.0906)	(0.0174)
Advertising/Capital	-0.1289	-0.0253
	(0.0628)	(0.0152)
Missing Adv/K	0.0673	-0.0124
	(0.0608)	(0.0083)
R-squared	0.8563	0.7617
P-value for PPS terms:		
Joint Significance	0.0001	0.0323
Equality	0.0222	0.6010

Notes:

1) Each regression pertains to our sample of 1494 firms and 5665 firm-years.
2) Heteroskedasticity-robust standard errors are reported in parentheses beneath each coefficient.
3) Each regression also includes year effects (not reported).

Table 6
Fixed Effect Regressions of Tobin's Q and Investment on Incentives, Linear Term

Variable	Dep. Variable Is Tobin's Q	Dep. Variable Is Investment
Intercept	5.4071	0.3346
	(1.0331)	(0.1279)
PPS [linear term]	0.0121	0.0023
	(0.0037)	(0.0007)
Dividend Yield	-0.0097	-0.00002
	(0.0127)	(0.00066)
Ln(sales)	-0.6802	-0.0052
	(0.2587)	(0.0394)
Ln(sales)^2	0.0418	-0.0003
	(0.0171)	(0.0032)
Capital/Sales	-0.3101	0.0121
	(0.0733)	(0.0144)
(Capital/Sales)^2	0.0062	-0.0005
	(0.0022)	(0.0004)
Cash Flow/Capital	0.0601	0.0058
	(0.0204)	(0.0046)
Debt/Assets	-0.9259	-0.0745
	(0.1764)	(0.0266)
Missing D/A	-0.7752	-0.0026
	(0.5012)	(0.0376)
CDF of Std Dev	-1.1607	-0.0850
	(0.2586)	(0.0404)
Missing Std Dev	-0.4234	-0.0141
	(0.1889)	(0.0345)
R & D/Capital	0.0246	-0.0028
	(0.0751)	(0.0101)
Missing R&D/K	0.0585	0.0247
	(0.0911)	(0.0174)
Advertising/Capital	-0.1347	-0.0250
	(0.0627)	(0.0152)
Missing Adv/K	0.0695	-0.0125
	(0.0610)	(0.0083)
R-squared	0.8560	0.7616

Notes:
1) Each regression pertains to our sample of 1494 firms and 5665 firm-years.
2) Heteroskedasticity-robust standard errors are reported in parentheses beneath each coefficient.
3) Each regression also includes year effects (not reported).