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# FIRM VALUE AND CORPORATE GOVERNANCE: HOW THE FORMER DETERMINES THE LATTER\*

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## ABSTRACT

A model of corporate governance must explain (i) why governance matters; (ii) variation in governance across firms (*i.e.*, be responsive to the Demsetz and Lehn, 1985, critique); and (iii) the positive correlations found empirically between quality of corporate governance and corporate performance. The model presented here satisfies these three criteria. Moreover, the model explains the correlation between firm size and executive compensation and why empirical estimates of managerial incentives seem too low, among other phenomena.

*Keywords:* corporate governance, executive compensation, firm heterogeneity, trends in governance.

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## 1 INTRODUCTION

As a rule, people choose more security or protection the more they have at stake. Observations of homeowners, merchants, and institutions support this view: those with more at stake typically have greater security. The same rule should apply to firm owners when they must rely on others to manage their firms. A concern, dating at least as far back as Adam Smith, is that managers will abuse, misuse, or even misappropriate the resources of the firm.<sup>1</sup> Corporate governance is the security that owners put in place to protect their interests against such agency problems. It is well-documented that the strength of governance varies across firms; and one might ask which firms will have stronger governance than others? The answer, I will argue, are those in which more is at stake.

Which firms have more at stake? To an extent, those with the most resources (*e.g.*, capital, assets, etc.). But also those that possess the greatest potential return to those resources. Specifically, consider two firms, A and B, with B having the greater marginal return to resources. The marginal cost to B's owners of an abused, misused, or misappropriated dollar of resources is, thus, greater than it is for A's. Consequently, the marginal return to B's owners of investing in greater security—that is, stronger corporate governance—is greater than it is for A's. In equilibrium, firm B will have stronger governance than firm A. Furthermore, if the factors that give firm B greater marginal returns also directly increase its returns, then firm B will be more profitable than firm A in equilibrium. Profits and strength of governance will, therefore, be positively correlated. Observe that this correlation follows not because better governance leads to greater profitability. Rather it follows because potential profitability leads to better governance.<sup>2</sup>

This view satisfies the three requirements necessary of theory in this area: (i) it must allow governance to matter; (ii) it must explain why there is *variation* in governance across firms; and (iii) it must also explain why we observe the empirical results we do; in particular, that in many studies—but not all—there is a positive correlation between stronger governance and firm performance (profitability or value).<sup>3</sup> The idea that A's profit potential is worse than B's is particularly attractive with respect to these last two criteria because it readily explains both why A's owners choose weaker governance than B's and why the level of governance and firm performance are positively correlated.

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<sup>1</sup>“The directors of companies, however, being the managers rather of other people's money than of their own, it cannot well be expected, that they should watch over it with the same anxious vigilance . . . negligence and profusion, therefore, must always prevail, more or less, in the management of the affairs of such a company.” — Smith (1776).

<sup>2</sup>Causality is an important, but vexing, issue in the study of corporate governance. Demsetz and Lehn (1985) were among the first to make this point. Others who have raised it include Himmelberg et al. (1999), Palia (2001), Hermalin and Wallace (2001), and Coles et al. (2007). The point has also been discussed in various surveys of the literature; consider, *e.g.*, Bhagat and Jefferis (2002), Becht et al. (2003), and Hermalin and Weisbach (2003) among others.

<sup>3</sup>See the literature surveys by Becht et al. and Hermalin and Weisbach for examples and discussion.

The more-to-protect view developed here is an alternative to the more prevalent views in the literature, which tend to be cost-based. For instance, variation in the noisiness of a firm's environment affects contracting costs, which in turn determine the degree to which agency problems are ameliorated, thus finally determining performance (Demsetz and Lehn; Himmelberg et al.; Palia; and Hermalin and Wallace); or variation in the complexity and size of a firm's operations affect contracting costs and, hence, agency amelioration and firm performance (Demsetz and Lehn; Himmelberg et al.; and Hermalin and Wallace).

The two views can be summarized as (i) firms vary in their profit potential so that firms with greater potential *ceteris paribus* have a higher marginal return to governance; or (ii) firms vary on the cost side so that firms with lower marginal costs of governance have more of it and, therefore, higher profits.<sup>4</sup> At one level, as discussed in Section 5.2 below, a similar logic is behind both stories. Ultimately, whether it is heterogeneity on the profit-side or the cost-side that is more important is an empirical question. As discussed in Sections 5.2 and 6, the trend toward stronger governance over the past quarter century or so would suggest it is primarily the profit-side that is critical given that the empirical evidence suggests that the marginal cost of governance has, if anything, risen over this period.

Another reason to consider the profit-potential side is that one might expect firms in the same industry to face similar agency costs. Yet, *intra*-industry heterogeneity in governance is large (see, *e.g.*, Hermalin, 1994, and Hermalin and Wallace, 2001, for discussion and evidence). Although within-industry competition itself can account for some of this heterogeneity (Hermalin, 1994), the fact that different firms have different profit potentials (*e.g.*, as a consequence of valuable intellectual property, superior location, advantageous supplier relations, etc.) offers another explanation.

Yet another reason to consider the profit-side perspective is that firm size, which is often taken to be a cost determinant, is itself endogenous. As discussed below, heterogeneity on the profit-side can explain both firm size and the level of governance.

One paper that can be seen as also considering the profit-side is the contemporaneous work of Coles et al. Although their paper is primarily empirical, it does contain a brief model of optimal managerial ownership in which the firm's productivity, among other factors, influences the amount of managerial ownership. They do not, however, analyze the general relation between profit potential and governance; nor do they distinguish between marginal and level effects.

In what follows, Section 2 presents the model. The key assumption is that firms vary in their marginal returns from resources utilized for the owners' benefit (*i.e.*, total resources less those diverted by the manager). It is shown that

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<sup>4</sup>It is worth noting that the cited articles, which provide primarily verbal models, do not distinguish between total and marginal costs of governance. For a variety of reasons (see, *e.g.*, Grossman and Hart, 1983 or Hermalin, 1994), comparative statics on the cost side can often be quite subtle or counter-intuitive; in particular, a factor that raises total cost might not everywhere shift the marginal-cost schedule in the same direction.

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firms with higher marginal returns—*higher-type firms*—will have stronger governance than those with lower marginal returns—*lower-type firms*. If type also directly and positively affects profits, then there will be a positive correlation between profits and the level of governance; however, the correlation is essentially spurious in that both variables are positively correlated with firm type (profit potential).

Section 2 also considers the situation in which firms are homogeneous in type, but vary with respect to total resources. The more-to-protect rule is shown to apply here too: firms with more resources will tend to have stronger governance and greater profits. Again, governance and profits are positively correlated, but also again the correlation is spurious—both variables are a function of total resources.

In Section 2, a firm's total resources are fixed exogenously. In many contexts, it is better to think of them as endogenously determined, with the necessary funds coming from the capital markets. Section 3 extends the basic model to allow the firm's owners to also determine how much capital is to be raised. Higher-type firms will raise more capital, have stronger governance, and generate greater profits than will lower-type firms. To the extent the amount of capital raised or profits are indicators of firm size or correlated with other measures of size, the results from this section predict a positive correlation between firm size and the strength of governance. It is also shown that the level of governance could well be independent of a firm's capital structure.

A particularly important form of governance is incentive compensation. Section 4 explores the implications of the model for compensation. It is shown there that higher-type firms pay more in expectation than lower-type firms; that is, executives are paid more not only as a function of how their firms *actually* do, but also as a function of how they are *expected* to do. Given that profits are correlated with standard measures of firm size, this insight offers a novel explanation for the positive correlation between firm size and executive pay commonly found in the data.

Much of Section 4 concerns the standard cross-sectional regression of pay on performance. It is shown that equation is almost always misspecified. Importantly, this misspecification leads to the coefficient on performance (profit) being biased downward so that it understates the true strength of the incentives executives have. This finding sheds light on the debate over whether real-life executives are given sufficiently strong incentives.

Section 5 considers two alternative formulations of the model. One, as discussed above, considers heterogeneity on the cost side of governance. The other, considered in Section 5.1, addresses the degree to which the analysis of the earlier sections continues to hold if governance is a multi-dimensional variable. That is, in that section, the fact the governance can vary simultaneously across firms on many dimensions, such as board structure, incentive compensation, shareholder activism, and so forth, is explicitly considered. It is readily shown that firms with better profit potentials will spend more on governance than firms with weaker profit potentials. This does not, however, mean that higher-type firms have stronger governance on all dimensions. Such a result follows, however, if

it is assumed that there is complementarity in governance.

Section 6 contains a brief discussion of how the analysis in this paper sheds light on trends in corporate governance over the past twenty to thirty years. Section 7 is a brief conclusion, which focuses on the implications of the analysis for future empirical work in the area.

Because much of the analysis involves a reduced-form model, it is important to note that the model in question can be derived from first principles. An earlier version of this paper developed two models from first principles that correspond to the reduced-form model used in the main part of the paper (details available from author). Moreover, as will become clear, the examination of compensation in Section 4 builds a model from first principles that satisfies the assumptions of the reduced-form model. Proofs not given in the text can be found in Appendix A.

## 2 THE BASIC MODEL

Consider a firm's manager, who has utility

$$u = S + v(Y - S, g),$$

where  $Y$  is a source of funds or pool of assets from which the manager can divert  $S$  to his private use and  $g$  is a measure of the strength of corporate governance. Private use is meant to encompass a wide range of possible behaviors such as allocating funds or assets to pet projects not in the owners' interest, using funds for empire building, acquiring perks, or misusing assets for private benefit.<sup>5</sup> The variable  $g$  could represent the percentage of independent directors on the board or on key board committees, a measure of the directors' diligence, a measure of the effectiveness of the monitoring and auditing systems in place, some measure of the strength of the incentives given the manager, or perhaps some index of governance strength.<sup>6</sup>

One interpretation, in particular, is worth considering: given the many dimensions of governance, think of  $g$  as the firm's total expenditure on governance. Provided the owners set the dimensions of governance optimally, spending more on governance must correspond to better governance. Section 5.1 explores this interpretation in greater depth.

The function  $v : \mathbb{R}^2 \rightarrow \mathbb{R}$  represents the monetary equivalent of the benefit the manager derives from behaving in a manner desired by the firm's owners (*i.e.*, not diverting funds or assets for private benefit). Equivalently, it could

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<sup>5</sup>Another interpretation is that  $S$  represents resources that are wasted through managerial neglect, inefficiency of operations, or in other ways. Under this interpretation, the more attentive is the manager or the harder he works to improve operations—that is, the lower is  $S$ —the greater the disutility he suffers; hence, the lower his utility (ignoring the  $v(Y - S, g)$  term).

<sup>6</sup>The conclusions of the paper would not change if the manager's utility were  $b(S) + v(Y - S, g)$ , where  $b(\cdot)$  is an increasing and, at least weakly, concave function. Nor would the conclusions of this section and the next section change if the specification were  $U(b(S) + v(Y - S, g))$ ,  $U(\cdot)$  an increasing function.

be reexpressed—with a suitable change in sign—as the cost, in monetary units, the manager incurs from his efforts to divert  $S$ .<sup>7</sup> The function  $v(\cdot, \cdot)$ , like all functions in this paper, is assumed to be at least twice differentiable in each of its arguments. Throughout, the convention  $f_n$  is used to denote the derivative with respect to the  $n$ th argument of function  $f$  and  $f_{nm}$  to denote the second derivative with respect to the  $n$ th and  $m$ th arguments. Assume that

$$v_1(\cdot, g) > 0 \quad \forall g, \quad (1)$$

$$v_{11}(\cdot, g) < 0 \quad \forall g, \quad (2)$$

$$v_1(0, g) > 1 > \lim_{x \rightarrow \infty} v_1(x, g) \quad \forall g > 0, \quad (3)$$

$$v_{12}(\cdot, \cdot) > 0, \quad (4)$$

and

$$\forall x \exists g < \infty \text{ such that } v_1(x, g) \geq 1. \quad (5)$$

Expression (1) reflects that, due to governance, a component of the manager's utility is increasing in the amount of undiverted resources. Expression (2) implies that there is a unique value of  $S$  that maximizes the manager's utility. Expression (3) implies that the manager never finds it personally optimal to divert all resources (all  $Y$ ) to himself, but will divert some if the amount of resources is great enough. Expression (4) implies that the manager's marginal utility from not diverting resources increases with the level of governance,  $g$ . Finally, (5) implies that for any level of resources, there exists a sufficiently tough level of governance such that the manager's optimal response is to divert no resources.<sup>8</sup>

Although expressed in reduced form, these assumptions are meant to capture the idea that, through the governance system, the manager benefits the better managed the firm is. This could reflect the direct impact on his compensation, the benefit of keeping his job, the utility from less interference from the directors and owners, etc. Equivalently, the manager's cost of diverting resources to his own use depends on the level of governance. The concavity-of-benefits assumption, expression (2)—equivalently, a convexity assumption about the cost of diverting resources—could reflect assumptions that the marginal increase in the probability of being retained or other benefits rise at a slower rate the better the manager performs. It could also reflect an assumption about the technology of diverting resources, namely that it shows decreasing returns to scale—the first dollar is likely easier to divert than the second. Alternatively, the risk of detection or the penalty if detected or both accelerate in the amount diverted.

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<sup>7</sup>In this second interpretation, the manager's marginal cost of diverting funds falls with the total amount,  $Y$ , potentially available. This is consistent with the idea that diverting the marginal dollar is easier, less subject to detection, or less penalized when taken from a large pool than a small pool. For example, it could be easier for a manager to get away with trips on the company jet when the firm has lots of resources than when it is strapped for cash.

<sup>8</sup>Observe, as one of many examples, that the function  $v(Y - S, g) = 2g\sqrt{Y - S}$  satisfies all these assumptions.

Assumption (3) assumes it is never in the manager's interest to divert all resources, at least given positive levels of governance. Finally, assumptions (4) and (5) simply say that governance matters—the better governed the firm, the less the marginal benefit (the greater the marginal cost) to the manager from diverting resources; and, in fact, the marginal benefit can be made so low that the manager prefers to divert no resources.

In this paper, the focus is on  $Y$  and  $S$ 's being monetary amounts; that is, the manager diverts  $S$  dollars from a total pool of  $Y$  dollars. The analysis, in this section at least, also applies, however, if  $Y$  is the total amount of some asset measured in non-monetary terms (*e.g.*, managerial time; so  $S$  is, *e.g.*, on-the-job leisure or time devoted to activities that benefit the manager but not the company, etc.). In this sense, this basic model encompasses the standard principal-agent model.

A consequence of assumptions (1)–(4) is

**Lemma 1.** *For all governance levels,  $g \in \mathbb{R}_+$ , there exists an amount  $Y(g)$ , such that, in equilibrium, the manager diverts a positive amount if and only if total resources exceed  $Y(g)$  (*i.e.*, iff  $Y > Y(g)$ ). The equilibrium amount of diversion is  $S = \max\{Y - Y(g), 0\}$ . Moreover,  $Y(g)$  is strictly increasing and differentiable in  $g$ .*

To avoid dealing with corner solutions in the level of governance, assume  $v_1(0, 0) = 1$ ; this implies  $Y(0) = 0$ —in the absence of governance, the manager will divert all available funds to his private use. Because the function  $Y(\cdot)$  is monotone, it is invertible. Let  $G(\cdot)$  denote its inverse.

Much of the analysis in this paper relies on the following well-known revealed-preference result, which is worth stating once, at a general level, for the sake of completeness and to avoid unnecessary repetition.

**Lemma 2.** *Let  $f(\cdot, \cdot) : \mathbb{R}^2 \rightarrow \mathbb{R}$  be a function at least twice differentiable in its arguments. Suppose that  $f_{12}(\cdot, \cdot) > 0$ . Let  $\hat{x}$  maximize  $f(x, z)$  and let  $\hat{x}'$  maximize  $f(x, z')$ , where  $z > z'$ . Then  $\hat{x} \geq \hat{x}'$ . Moreover, if  $\hat{x}'$  is an interior maximum, then  $\hat{x} > \hat{x}'$ .*

The owners of the firm have a payoff given by

$$B(Y - S, \tau) - C(g),$$

where  $\tau \in \mathcal{T} \subset \mathbb{R}$  is an index of the firm's type. The amount  $C(g)$  is the cost of implementing governance level  $g$ ; it is, for instance, the cost of establishing and maintaining auditing and monitoring procedures, the cost of incentive pay, etc. It could also include the cost owners incur overcoming managerial resistance to more oversight. The amount  $B(Y - S, \tau)$  is the benefit a type- $\tau$  firm's owners realize when the net resources utilized are  $Y - S$ . The function  $C(\cdot)$  is increasing. To avoid corner solutions at zero governance, assume  $C'(0) = 0$ .<sup>9</sup> Assume that

<sup>9</sup>This assumption is not critical. There are other assumptions that could be made to avoid corner solutions at  $g = 0$ . Moreover, corner solutions only mean that some of the strict comparative static results below become weak comparative static results.

$B_1(\cdot, \tau) > 0$ ; that is, the more net resources utilized, the more the owners' benefit. As a definition of type, assume:

$$B_{12}(\cdot, \cdot) > 0; \quad (6)$$

that is, the marginal benefit of more net resources is greater for higher-index types than for lower-index types.

There are numerous possible underlying assumptions for  $B(\cdot, \cdot)$ . For instance,  $B(x, \tau) = \tau\psi(x)$ , where  $\psi(\cdot)$  is an increasing function that relates the net amount invested to expected production and  $\tau$  is the average price margin. Alternatively,  $\psi(\cdot)$  could be the probability of a successful R&D innovation and  $\tau$  the profit from such an innovation. As yet one more example,  $\psi(\cdot)$  is realized cash flow and  $\tau$  is the owners' claim on that cash flow (*i.e.*, excluding (i) the shares held by management and (ii) after taxes).<sup>10</sup>

The timing of the model is that the owners choose the level of governance,  $g$ , then the manager chooses how much to divert,  $S$ . Assume for the moment that  $Y$  is fixed exogenously. From Lemma 1, net resources will be  $Y(g)$  if  $Y(g) < Y$  (the manager diverts  $Y - Y(g)$ ); or  $Y$  if  $Y(g) \geq Y$ . Given that raising  $g$  is costly and  $Y(\cdot)$  is strictly increasing, the owners will never choose a level of  $g$  such that  $Y(g) > Y$ . Define  $\bar{g}$  as the solution to  $Y(g) = Y$ ; that is,  $\bar{g} = G(Y)$ .<sup>11</sup> The owners' problem is, thus,

$$\max_{g \in [0, \bar{g}]} B(Y(g), \tau) - C(g).$$

Because  $[0, \bar{g}]$  is compact and all functions are continuous, at least one solution must exist. Let  $g(\tau)$  be the solution adopted by a type- $\tau$  firm.

There is variance in the level of governance across firms. Specifically,

**Proposition 1.** *Higher-type firms adopt at least as great a level of governance as lower-type firms (*i.e.*, if  $\tau > \tau'$ , then  $g(\tau) \geq g(\tau')$ ). Moreover, if a lower-type firm has not adopted the maximum level of governance (*i.e.*,  $g(\tau') < \bar{g}$ ), then a higher-type firm will have a strictly greater level of governance (*i.e.*,  $g(\tau) > g(\tau')$ ).*

**Proof:** Given Lemma 2, the proposition follows if the cross-partial derivative of

$$B(Y(g), \tau) - C(g)$$

with respect to  $\tau$  and  $g$  is positive everywhere. That cross-partial derivative is  $B_{12}(Y(g), \tau)Y'(g)$ , which is positive by Lemma 1 and expression (6). ■

<sup>10</sup>Alternatively, if because of free-rider issues, only some shareholders act to shape governance (*e.g.*, large blockholders such as institutional investors take an active role), then  $\tau$  could be the proportion held by these active shareholders.

<sup>11</sup>The equation  $Y(g) = Y$  has a solution; this follows from the assumption that  $v_1(0, 0) \geq 1$  (*i.e.*,  $Y(0) = 0$ ), condition (5), and the continuity of  $Y(\cdot)$  as established by Lemma 1.

If we assume that total benefit—and not just the marginal benefit of resources—is increasing in type—that is,<sup>12</sup>

$$B_2(y, \tau) > 0 \text{ for all } y > 0 \quad (7)$$

—then we get the following relationship between firm profits and governance.

**Proposition 2.** *Under the assumptions of the basic model and assuming a common level of resources,  $Y$ , a firm that will be more profitable in equilibrium than another has at least as high a level of governance as the other firm.*

**Proof:** Equilibrium profits are

$$\pi(\tau) \equiv B\left(Y(g(\tau)), \tau\right) - C(g(\tau)).$$

By the envelope theorem,

$$\pi'(\tau) = B_2\left(Y(g(\tau)), \tau\right) > 0.$$

So  $\tau > \tau'$  implies  $\pi(\tau) > \pi(\tau')$ . From Proposition 1,  $\tau > \tau'$  implies  $g(\tau) \geq g(\tau')$ .

■

In other words, profitability potential (type) causes better governance and, of course, it also directly causes better profits. Consequently, profits and governance end up positively correlated (consistent with many studies). The correlation is, however, spurious, not causal (both are a function of type).

Suppose that  $\tau$  were invariant across firms. Suppose, however, that firms differed in terms of the gross resources,  $Y$ , available to them. Each firm's owners would solve

$$\max_{g \in [0, G(Y)]} B(Y(g)) - C(g), \quad (8)$$

where  $\tau$  has been suppressed because it is assumed constant across firms. Let  $\hat{g}(Y)$  denote the solution to (8). Because  $G(\cdot)$  is an increasing function,  $\hat{g}(\cdot)$  is non-decreasing. Moreover, a higher- $Y$  firm has more options than a lower- $Y$  firm (*i.e.*,  $[0, G(Y')] \subset [0, G(Y)]$  if  $Y' < Y$ ), which means its profits are weakly greater as well.<sup>13</sup> Hence,

**Proposition 3.** *Assume all firms are the same type, but they differ as to the gross resources,  $Y$ , available to them. Then a firm with more resources will have at least as great a level of governance as a firm with fewer resources. It will also have at least as much profits as a firm with fewer resources. That is,*

<sup>12</sup>Note, in light of (6), assumption (7) is equivalent to assuming  $B_2(0, \tau) \geq 0$  because  $B_2(y, \tau) = B_2(0, \tau) + \int_0^y B_{12}(z, \tau) dz$ .

<sup>13</sup>One has to be careful about how these resources are accounted for. If, as assumed here, they are sunk, then they are not directly a component of (economic) profits and the statement in Proposition 3 is valid. If the accounting system, nevertheless, treats them as an expense, then the correlation between governance and accounting profits could prove ambiguous.

*under these assumptions, gross resources and the level of governance are non-negatively correlated and profits and the level of governance are non-negatively correlated. The correlation between profits and the level of governance will, therefore, be non-negative.*

Adopting any of a myriad of possible assumptions that guarantee interior solutions would allow one to rewrite Proposition 3 so “non-negative” is replaced with “positive.”

### 3 ENDOGENOUS INVESTMENT

To this point, gross resources,  $Y$ , were fixed exogenously. Now consider a model in which resources must be funded from the capital market. Let  $I$  denote funds raised from the market. The resources potentially available for productive investment are  $Y = I - C(g)$ . Of these,  $S$  will be diverted, leaving  $N = I - C(g) - S$  available to be actually utilized. Normalize the model so the marginal opportunity cost of funds is 1.

Denote financial returns by  $r$ . Assume  $r \sim F(\cdot|N, \tau)$ . Assume the expectation

$$B(N, \tau) \equiv \int_{-\infty}^{\infty} r dF(r|N, \tau)$$

exists. Maintain the previously made assumptions about  $B(\cdot, \cdot)$ .<sup>14</sup> To these, add the assumption that, for all  $\tau$ ,

$$B_1(0, \tau) > 1 > B_1(n, \tau) \tag{9}$$

for  $n > \bar{n}$ , where  $\bar{n}$  is finite. The first inequality in (9) implies it is profitable to invest in firms; the second inequality rules out infinite investment as being optimal. The second inequality implies that we are free to act as if the set of possible investment levels is bounded; this will insure interior maxima for the optimization programs below.

Initially, assume that the owners self finance. Because every dollar provided over  $Y(g) + C(g)$  will be diverted by the manager, the owners will never provide funding in excess of  $Y(g) + C(g)$ . The owners problem can, thus, be stated as

$$\max_Y \int_{-\infty}^{\infty} r dF(r|Y, \tau) - C(G(Y)) - Y, \tag{10}$$

where, recall,  $G(\cdot)$  is the inverse function of  $Y(\cdot)$ .

**Proposition 4.** *Under the above assumptions, there will be a strictly positive correlation between the amount the owners invest in a firm and its level of governance. Furthermore, if financial return is increasing in firm type (i.e.,  $B_2(N, \tau) > 0$ ), then there will be a strictly positive correlation between firm profit and level of governance.*

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<sup>14</sup>Those assumptions would hold, for instance, if  $r = \tau\sqrt{N} + \eta$ , where  $\eta$  is a random variable drawn independently of  $N$  and  $\tau$ .

**Proof:** Let  $y^*(\tau)$  denote a solution to (10). By the assumptions above,  $0 < y^*(\tau) < \infty$  for all  $\tau$ ; that is, it is an interior solution. The first part of the proposition follows immediately from Lemma 2 provided the cross-partial derivative of

$$B(Y, \tau) - C(G(Y)) - Y$$

with respect to  $Y$  and  $\tau$  is positive everywhere. That it follows from assumption (6).

The “furthermore” part follows from the envelope theorem, which establishes that equilibrium profits are increasing in type, and from the first part of the proposition, which established that investment is increasing in type. ■

One imagines that firm size is positively correlated with the amount invested in it. Indeed, the amount invested—firm capitalization—could be a definition of size. Hence,

**Corollary 1.** *If investment in a firm is positively correlated with its size, then firm size and level of governance are positively correlated.*

What if the firm owners must raise capital? Consider two timing possibilities: first, the owners can wait to set  $g$  until they have received outside capital; second, they must set it and expend the money to do so prior to seeking capital. In the latter case, it follows that  $g \leq C^{-1}(I_0)$ , where  $I_0$  is the owners’ available capital. A firm’s type is taken to be common knowledge; in particular, it is known to would-be investors.

Consider the first possibility. Because every dollar of capital over  $Y(g)+C(g)$  will be diverted by the manager, total capital invested will be  $Y + C(G(Y))$ . Let  $I \in [0, I_0]$  be the amount of capital the owners self finance and  $Y + C(G(Y)) - I$ , therefore, be the amount they must raise from outside investors. Let  $Z(\cdot)$  denote the financial contract; that is, the owners repay the outside investors  $Z(r)$  when the firm’s gross profit is  $r$ .<sup>15</sup> Observe, this encompasses standard forms of financing such as debt, equity, a combination of debt and equity, or more exotic securities. Given the owners are the residual claimants, they get the cash left in the firm at the end,  $r$ , less what the outside investors are due. Hence, their problem is

$$\max_{\{Y, I, Z(\cdot)\}} \int_{-\infty}^{\infty} (r - Z(r)) dF(r|Y, \tau) - I \tag{11}$$

subject to

$$\int_{-\infty}^{\infty} Z(r) dF(r|Y, \tau) = Y + C(G(Y)) - I, \tag{12}$$

where (12) is the condition for investors to be willing to provide the required capital. Using (12) to substitute out  $I$  in (11) and, then, simplifying yields (10); hence, the total amount invested is unaffected by the need to raise funds and

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<sup>15</sup>An alternative, but ultimately equivalent, accounting would be to define profit as  $r - C(G(Y))$ . What is relevant for the owners is the cash left in the firm less what they must repay outside investors.

the financial structure of the firm (*i.e.*, the  $Z(\cdot)$  function) is indeterminate. This establishes

**Proposition 5.** *If a firm's owners are not obligated to fund the level of governance before raising capital from the market, then the level of governance will be the same as if the owners could self finance. Moreover, there is not necessarily any correlation between the firm's capital structure and its level of governance.*

This result is, in essence, a simple version of Modigliani and Miller (1958). Like Modigliani and Miller, Proposition 5 can be criticized insofar as capital-structure indeterminacy may fail to hold in a richer model. Nevertheless, it indicates that governance need not be a driver of capital structure nor even correlated with it.

A further potential criticism is there is a significant literature that argues that the capital structure is itself part of the governance structure; that is, because  $g$  has entered the model in reduced form, the analysis could be overlooking the possibility that  $g$  is a function of the capital structure. For instance, it has been argued that debt can be used to force managers not to divert funds (see, *e.g.*, Grossman and Hart, 1982, Jensen, 1986, Hart and Moore, 1998). While this literature offers many insights, it remains true that there are a number of other governance instruments, such as incentive schemes, board oversight, and outside auditing, that have nothing to do with the capital structure. Moreover, because of access to these other governance mechanisms, one wonders to what extent firms would utilize capital structure for this purpose. After all, there could be competing motives (*e.g.*, the tax advantage of debt) affecting capital structure; and it could be difficult or costly to adjust capital structure with sufficient precision to deal with governance issues.

A related concern is that agency issues can lead managers to distort a firm's capital structure (see, *e.g.*, Jensen and Meckling, 1976, Harris and Raviv, 1988, Stulz, 1988; for an empirical examination see Berger et al., 1997). In particular, weak governance could mean more agency problems, which could mean a preference for one form of financing over another; that is, a correlation exists between governance and capital structure. To an extent, this issue can be captured within the framework of the previous section and the interpretation of the agency problem spelled out in the next section: Interpret  $S$  as the funds raised via one form of financing and  $Y - S = Y(g)$  the funds raised via another. In light of Lemma 1, stronger governance would be positively correlated with the use of the other form of financing. On the other hand, one might question why the manager is not simply barred contractually from changing the capital structure.

What if the owners must fix and pay for the level of governance before seeking outside capital? Because the owners can subsequently acquire capital from the market at the same rate that their own investments in the market would earn, there is no loss in generality in assuming that, beyond the funding of the governance level, the owners invest none of their own money in the firm.

The owners' problem is, therefore,

$$\max_{\{g, Z(\cdot)\}} \int_{-\infty}^{\infty} (r - Z(r)) dF(r|Y(g), \tau) - C(g) \quad (13)$$

subject to

$$C(g) \leq I_0 \text{ and} \quad (14)$$

$$\int_{-\infty}^{\infty} Z(r) dF(r|Y(g), \tau) = Y(g), \quad (15)$$

where, recall,  $I_0$  equals the owners' available funds. Using (15) to substitute out  $\int Z dF$  in (13), the owners' problem becomes

$$\max_g B(Y(g), \tau) - C(g) - Y(g) \quad (16)$$

subject to (14). Expression (16) is equivalent to (10); hence, if  $I_0 > C(G(y^*(\tau)))$ , then the solution is the same as in Proposition 4. If, instead, the constraint binds, then the equilibrium level of governance is less than the unconstrained optimum. The basic conclusion of Proposition 5 continues, however, to hold.

**Corollary 2.** *Suppose a firm's owners are obligated to set and pay for the level of governance before raising capital from the market. Then the level of governance they choose is independent of the firm's capital structure.*

#### 4 MANAGERIAL COMPENSATION

In this section, the focus is on the use of managerial compensation as a governance mechanism. To that end a model of compensation consistent with the reduced-form model used above needs to be constructed. Assume, as is customary in agency models, the manager's utility is additively separable in income,  $w$ , and action (*i.e.*, choice of  $S$ ). Specifically, assume it is  $S + V(w)$ , where  $V(\cdot)$  is increasing and strictly concave.<sup>16</sup> Suppose that there are two possible outcomes, success and failure, upon which the manager's compensation can be based. Let  $w_s$  and  $w_f$  be compensation for success and failure, respectively. Let the probability of success be  $P(Y - S)$ , where  $P'(\cdot) > 0$  and  $P''(\cdot) < 0$ . Assume  $P(0) = 0$ . Define  $g = V(w_s) - V(w_f)$ . Observe  $g$  is a measure of the strength of the incentives.

$$v(Y - S, g) = P(Y - S)g + V(w_f).$$

Observe  $v_{11} = P''(Y - S)g < 0$  and  $v_{12} = P'(Y - S) > 0$ , as required.

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<sup>16</sup>If  $S$  and  $w$  are both money, one might ask why utility isn't  $V(S+w)$ . One possible answer is that diverted funds are consumed in kind (*e.g.*, as trips on the company jet, lavish offices, etc.) so  $w$  and  $S$  are not perfect substitutes. A second answer is that  $V(w) = w$ —so  $S$  and  $w$  are perfect substitutes—but, due to limited liability on the part of the manager, his expected compensation is increasing in the strength of his incentives. An earlier version of this paper, in fact, pursued this latter approach and reached the same conclusions.

Here,  $C(g)$ , the cost of governance, must be determined as part of the analysis. To keep the analysis straightforward, assume  $Y$  is sufficiently big that the constraint  $S \leq Y$  never binds in equilibrium. Given  $g$ , the manager will choose  $S$  to solve

$$-P'(Y - S)g + 1 = 0$$

if a solution exists for  $S \in [0, Y)$ ; and he chooses  $S = Y$  otherwise. Observe if  $g = 0$ , the manager will choose  $S = Y$ . In that case, because  $P(0) = 0$ , it is irrelevant what  $w_s$  is because the manager will be paid  $w_f$  with certainty.

The manager chooses  $S$  such that

$$P'(Y - S) = P'(\hat{N}(g)) = \frac{1}{g};$$

note the implicit definition of  $\hat{N}(\cdot)$ . Because  $P(\cdot)$  is concave,  $\hat{N}(\cdot)$  is an increasing function.

To close the model, assume that the manager has, as an alternative to working for the firm in question, an opportunity that would yield him utility  $\underline{U}$ . Normalize this reservation utility to zero (*i.e.*,  $\underline{U} = 0$ ). Conditional on  $V(w_s) - V(w_f) = g$ , the firm will set  $w_s$  and  $w_f$  as low as possible, which means the manager's participation constraint,

$$P(\hat{N}(g)) \underbrace{(V(w_s) - V(w_f))}_g + V(w_f) \geq 0,$$

is binding. It follows that

$$w_f(g) = V^{-1} \left( -P(\hat{N}(g))g \right) \text{ and, thus}$$

$$w_s(g) = V^{-1} \left( \left( 1 - P(\hat{N}(g)) \right) g \right).$$

The expected cost of providing  $g$  in incentives is, therefore,

$$C(g) = P(\hat{N}(g)) (w_s(g) - w_f(g)) + w_f(g).$$

**Lemma 3.** *The function  $C(\cdot)$  is increasing.*

By the choice of functional forms, one can insure that  $C'(0) = 0$ .<sup>17</sup> For example, if  $P(N) = \sqrt{1 - (N - 1)^2}$  (a quarter-circle function with center  $(1, 0)$ ) and  $V(w) = \log(w)$ , then it can be shown  $\lim_{g \rightarrow 0} C'(g) = 0$ .

Finally, suppose that owners get  $\tau$  if the manager is successful and 0 if he fails. The benefit function is, thus,  $B(N, \tau) = \tau P(N)$ . Let  $c(N)$  denote the minimum cost to the owners of inducing the manager to divert only  $S = Y - N$ . Note  $c(N)$  is the manager's expected compensation, which by Lemma 3 is an increasing function of  $N$ . Because  $\hat{N}(g)$  is increasing in  $g$  it is invertible, so a

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<sup>17</sup>Of course, since this assumption was made primarily for convenience, it is not essential that it hold.

higher  $N$  also means the manager has more high-powered incentives. Given that  $B_{12}(\cdot, \cdot) > 0$  and  $B_2(\cdot, \cdot) > 0$  when  $B(N, \tau) = \tau P(N)$ , it follows that  $N$ , and thus expected compensation and the power of the manager's incentives will (i) be non-decreasing in  $\tau$  by Lemma 2; and (ii) that therefore there will be a non-negative correlation between firm profits and managers' expected compensation and between profits and strength of incentives. By Lemma 2 "non-decreasing" and "non-negative" can be replaced by "increasing" and "positive" if the owners' problem always admits an interior solution (for instance, if  $c(\cdot)$  is convex and  $c'(0) < \tau P'(0)$  for almost every  $\tau \in \mathcal{T}$ ). To summarize:

**Proposition 6.** *Under the agency model presented here and assuming the owners get profits  $\tau$  if the manager is successful and 0 if he fails, an increase in the relative value of success (i.e.,  $\tau$ ) causes*

- (i) *net resources,  $N$ , not to decrease;*
- (ii) *the manager's expected compensation,  $c(N)$ , not to decrease; and*
- (iii) *the power of the manager's incentives,  $g$ , not to decrease.*

*If the owners' problem has an interior solution for all  $\tau \in \mathcal{T}$ , then "not to decrease" can be replaced by "to increase." Furthermore, the following correlations will hold:*

- (iv) *Firm profits and managerial compensation will be non-negatively correlated; and*
- (v) *Firm profits and the power of managerial incentives will be non-negatively correlated.*

*If the owners' problem has an interior solution for all  $\tau \in \mathcal{T}$ , then "non-negatively" can be replaced by "positively."*

Proposition 6 holds two important implications for empirical analysis. One concerns the cross-sectional relation between pay and performance, the other the cross-sectional relation between pay and firm size. With respect to the first, the proposition predicts that there will be a positive correlation between managerial pay and the financial performance of the firm. Firms that are likely to be more profitable (e.g., higher  $\tau$  firms) will have both a higher level of  $g$  and a higher probability of paying it. Consequently, if one estimated the regression

$$\text{Pay}_i = \delta_0 + \delta_1 \text{Profit}_i + \eta_i, \quad (17)$$

where  $i$  indexes firms, the  $\delta$ s are coefficients to be estimated, and  $\eta_i$  is an error term, then one's estimate of  $\delta_1$  would be positive.<sup>18</sup>

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<sup>18</sup>For simplicity, any other controls in (17) have been omitted. For purpose of this discussion  $\text{Pay}_i$  and  $\text{Profit}_i$  are in levels. As will become clear, a specification in logs would not change the conclusions of this analysis.

How should such a finding be interpreted? Observe that the manager of a more profitable firm has greater expected compensation than the manager of a less profitable firm solely because he was employed by a firm that anticipated being more profitable. In other words, his expected compensation is due to the inherent profitability of the firm that employs him.

Another issue this analysis points out is that because different type firms will have different values of  $\delta_0$  and  $\delta_1$ , heterogeneity across firms could make (17) a questionable specification. To appreciate this point, for each firm, its  $\delta_0$  is  $w_f(g)$  and its  $\delta_1$  is  $(w_s(g) - w_f(g))/\tau$ . Because  $g$  varies with  $\tau$  (Proposition 6(iii)), the coefficients are varying with  $\tau$  and are not constants as specification (17) assumes.

This last discussion leads to a final comment about (17). There has been a lengthy debate about whether executive compensation is sufficiently sensitive to firm performance (see, *e.g.*, Jensen and Murphy, 1990, Haubrich, 1994, Hall and Liebman, 1998, Hermalin and Wallace, 2001). A rough summary of the debate is that it is concerned with whether  $\delta_1$  is big enough. But  $\delta_1$  could be the wrong measure on which to focus: The strength of the manager's incentives are reflected by  $g$ , not  $\delta_1$ . Moreover, the estimated  $\delta_1$  will likely be biased.<sup>19</sup>

To illustrate the problems with specification (17), the following simulation was done using the specification  $P(N) = \frac{N}{N+1}$  and  $V(w) = \log(w)$ . Data were created for 10,000 firms as follows. For each firm, its  $\tau$  was a random draw from the Pareto distribution  $\tau \sim 1 - (6/\tau)^3 : [6, \infty)$ . Gabaix and Landier (2008) provide evidence for why a Pareto distribution reflects reality. Then, for each firm, the optimal contract was calculated, as was the  $N$  its manager would choose in equilibrium. Whether that firm was successful or not was determined by whether a uniformly distributed random variable on the unit interval was less than  $P(N)$ —successful—or was above  $P(N)$ —failure. Once the data were constructed, equation (17) was estimated. The results are shown in Table 1.<sup>20</sup>

The estimated  $\delta_1$ , while estimated with great accuracy, is a poor measure of actual incentives in this sample. For any given firm, the true coefficients solve

$$w_f = \delta_0 + \delta_1 \times 0 \quad \text{and} \quad w_s = \delta_0 + \delta_1 \tau .$$

Hence a firm's true  $\delta_1$  is given by

$$\delta_1 = \frac{w_s - w_f}{\tau} .$$

In the sample, the range of  $\tau$  proved to be from 6.0010 to 132.32. The corresponding firm-specific  $\delta_1$ s are falling in  $\tau$  from .670 to .147. This is considerable variation. Moreover, the estimated cross-section  $\delta_1$  is the true  $\delta_1$  of a firm with

<sup>19</sup>Hermalin and Wallace also present reasons, different than those discussed here, for why the  $\delta_1$  estimated from (17) using cross-sectional data could be a biased-downward measure of incentive strength.

<sup>20</sup>The Mathematica program used to generate the data is available from the author upon request.

Coefficient	Estimate
$\delta_0$	.884 (72.7)
$\delta_1$	.366 (209.)
$R^2$	.813

**Table 1:** Estimation of equation (17) using data generated as described in this appendix. Dependent variable is realized pay. Independent variable is profit (gross of compensation), its coefficient is  $\delta_1$ . The coefficient  $\delta_0$  is the intercept. Numbers in parentheses are t-statistics.

a  $\tau \approx 18.6$ . This implies that 96.6% of the firms have true  $\delta_1$ s greater than the estimated  $\delta_1$ !<sup>21</sup>

Let one suspect that these results are an artifact of a two-outcome model, Appendix B shows that expression (17) is similarly problematic with a continuum of outcomes and, in particular, that the  $\delta_1$  estimated cross-sectionally is biased downward due to firm heterogeneity.

A second cross-sectional relation implied by Proposition 6 is the following. Suppose firm size is positively correlated with firm profits.<sup>22</sup> Given firms that will be more profitable (higher  $\tau$  firms) pay more than their counterparts (Proposition 6), the following result obtains.

**Corollary 3.** *If firm size is positively correlated with firm profits, then there will be a positive correlation between firm size and managerial compensation under the assumptions of Proposition 6.*

That there is a positive correlation between firm size and executive compensation is a well-documented phenomenon (see, among others, Baker et al., 1988, Rose and Shepard, 1997, and Frydman and Saks; Gabaix and Landier, 2008, provide a brief survey of the literature). Corollary 3 offers a potential explanation for this phenomenon.<sup>23</sup>

<sup>21</sup>Even if one dropped outliers from the data, a considerable majority of firms would have true  $\delta_1$ s greater than the estimated  $\delta_1$ . For example, if the  $\tau$ s were distributed uniformly on  $[6, 16]$ , then the estimated  $\delta_1$  corresponds to a  $\tau \approx 12.8$ ; that is, 68% of the firms have true  $\delta_1$ s greater than the estimated  $\delta_1$ .

<sup>22</sup>In empirical analyses, firm size is often measured as market value (see, *e.g.*, Frydman and Saks, 2007), which, as the present discounted value of profits, should be correlated with profits.

<sup>23</sup>As such, Corollary 3 complements other explanations that have been offered in the literature. Two such explanations are models based on the distribution of managerial talent (Terviö, 2007, and Gabaix and Landier); and the correlation between firm size, hierarchical depth, and pay at the top of the hierarchy (Calvo and Wellisz, 1979). It is worth noting that both these explanations rely, in part, on heterogeneity in managerial ability whereas Corollary 3 does not.

The amount of firm resources,  $Y$ , is an alternative measure of size. The following proposition provides comparative statics when  $Y$  varies, but  $\tau$  is fixed (to improve readability,  $\tau$  is, thus, suppressed in the following).

**Proposition 7.** *Assume firms don't vary in type, but have different levels of resources,  $Y$ . A manager of firm with a higher value of  $Y$  is paid at least as much in expectation as a manager of a firm with a lower value of  $Y$ ; moreover, there is an interval of  $Y$ , starting at 0, such that the manager's expected compensation is strictly increasing with  $Y$ .*

**Proof:** A firm's profit can be written as

$$\hat{\pi} = B(\hat{N}(g)) - C(g). \quad (18)$$

Because  $\hat{N}(\cdot)$  is strictly increasing, it is invertible and, hence, (18) can be rewritten as

$$\hat{\pi} = B(N) - c(N), \quad (19)$$

where  $c(N) = C(\hat{N}^{-1}(N))$ . The firm's objective is to maximize (19) with respect to  $N$  subject to the boundary constraint  $N \leq Y$ . For  $Y$  small, the constraint binds, so relaxing it means a larger  $N$ , which in turn means a larger  $g$ , which in turn means higher expected compensation,  $C(g)$ . ■

**Corollary 4.** *Under the assumptions of Proposition 7, there is a positive correlation between firm size, measured as available resources (assets), and managerial compensation.*

## 5 ALTERNATIVE FORMULATIONS

### 5.1 GOVERNANCE AS A MULTI-DIMENSIONAL PROBLEM

There are multiple dimensions to governance. There is board structure, compensation, shareholder activism, and so forth. Heretofore, however, governance has been treated as a scalar,  $g$ . In this section, the model is extended to allow governance to be a vector,  $\mathbf{g} \in \mathbb{R}_+^n$ ,  $n > 1$ .

Return to the model of Section 2 and let the manager's utility be

$$u = S + v(Y - S, \mathbf{g}).$$

Assume that  $v(\cdot, \cdot)$  continues to satisfy conditions (1)–(3), with  $\mathbf{g}$  substituted for  $g$ . In lieu of (4), assume

$$v_{1j}(\cdot, \cdot) > 0 \text{ for all } 1 < j < n; \quad (4')$$

that is, an increase in any dimension of governance lowers the marginal benefit of diverting resources (equivalently, raises the marginal cost of doing so).

**Lemma 1'.** *For all governance levels,  $\mathbf{g} \in \mathbb{R}_+^n$ , there exists an amount  $Y(\mathbf{g})$ , such that, in equilibrium, the manager diverts a positive amount if and only if*

total resources exceed  $Y(\mathbf{g})$  (i.e., iff  $Y > Y(\mathbf{g})$ ). The equilibrium amount of diversion is  $S = \max\{Y - Y(\mathbf{g}), 0\}$ . Moreover,  $Y(\cdot)$  is strictly increasing and differentiable in each argument (i.e.,  $\partial Y/\partial g_j$  exists and is positive).

Assume  $v_1(0, \mathbf{0}) = 1$ , so  $Y(\mathbf{0}) = 0$ .

In lieu of (5), assume

$$\forall x \exists \mathbf{g} = (g_1, \dots, g_n) \text{ such that } g_j < \infty \forall j \text{ and } v_1(x, \mathbf{g}) \geq 1. \quad (5')$$

Let the owners' profits be

$$B(Y - S, \tau) - C(\mathbf{g}),$$

where the previous assumptions hold and  $C(\cdot)$  is strictly increasing in each of its arguments. Because increasing  $\mathbf{g}$  along any dimension is costly, the owners will never choose a  $\mathbf{g}$  such that  $Y(\mathbf{g}) > Y$ . Define

$$\mathcal{G}(Y) = \{\mathbf{g} | Y(\mathbf{g}) \leq Y\}.$$

In light of the assumption that  $v_1(0, \mathbf{0}) = 1$ , condition (5'), and the continuity of  $Y(\cdot)$  as established by Lemma 1',  $\mathcal{G}(Y)$  is compact. The owners problem is, thus,

$$\max_{\mathbf{g} \in \mathcal{G}(Y)} B(Y(\mathbf{g}), \tau) - C(\mathbf{g}).$$

Because  $\mathcal{G}(Y)$  is compact and all functions are continuous, at least one solution must exist. Let  $\mathbf{g}(\tau)$  be the solution adopted by a type- $\tau$  firm.

The main comparative static result is the following:

**Proposition 8.** *Higher-type firms spend at least as much on governance as do lower-type firms (i.e., if  $\tau > \tau'$ , then  $C(\mathbf{g}(\tau)) \geq C(\mathbf{g}(\tau'))$ ). Moreover, if a lower-type firm has not blocked all resource diversion (i.e.,  $Y(\mathbf{g}(\tau')) < Y$ ), then the higher-type firm spends strictly more (i.e.,  $C(\mathbf{g}(\tau)) > C(\mathbf{g}(\tau'))$ ).*

Recall the interpretation set forth in Section 2 that  $g$  be thought of as the expenditure on governance; that is,  $g = C(\mathbf{g})$ . In light of Proposition 8, one is free to view the owners as solving a two-step process: first, for each  $y$  solve the problem

$$\min_{\mathbf{g}} C(\mathbf{g}) \text{ subject to } Y(\mathbf{g}) = y.$$

Let  $\mathbf{g}(y)$  denote the solution. Then associate to each  $y$  a  $g \equiv C(\mathbf{g}(y))$ ; this yields a one-to-one strictly monotonic mapping. This mapping can be inverted to yield a function mapping  $g$  into  $y$ . By construction, that function is equivalent to the  $Y(g)$  function used in Section 2. Observe, in this case, the cost of  $g$  is just  $g$ .<sup>24</sup>

A related question is whether higher-type firms employ stronger governance on all dimensions than lower-type firms; that is, does  $\tau > \tau'$  imply  $\mathbf{g}(\tau) \geq \mathbf{g}(\tau')$ ,

<sup>24</sup>To rule out corner solutions at no governance (i.e.,  $g = 0$ ) it was assumed in Section 2 that  $C'(0) = 0$ . Under the interpretation here,  $C'(g) \equiv 1$ . Hence, an alternative solution is needed to rule out solutions; one such assumption would be  $B_1(0, \tau) > 1$  for all  $\tau$ .

where the order over vectors is the usually piecewise ordering? It is readily shown this implication cannot be true generally. For instance, suppose  $n = 2$ ,  $v(Y - S, \mathbf{g}) = v(Y - S, \max\{g_1, g_2\})$ , and

$$C(\mathbf{g}) = g_1 + \frac{1}{2}g_2 + \frac{3}{2} \left( g_2 - \min \left\{ g_2, \frac{2}{3} \right\} \right),$$

then the optimal  $\mathbf{g}$  to achieve effective governance level  $g = \max\{g_1, g_2\}$  is  $(0, g)$  for  $g \leq 1$  and  $(g, 0)$  for  $g > 1$ . Hence, if  $g(\tau') < 1 < g(\tau)$ , then  $\mathbf{g}(\tau')$  and  $\mathbf{g}(\tau)$  cannot be compared (*i.e.*, neither  $\mathbf{g}(\tau) \geq \mathbf{g}(\tau')$  nor  $\mathbf{g}(\tau') \geq \mathbf{g}(\tau)$  are true).

In the preceding example, the two dimensions of governance are perfect substitutes. If the dimensions of governance are complements, then the desired implication,  $\tau > \tau' \Rightarrow \mathbf{g}(\tau) \geq \mathbf{g}(\tau')$ , follows from Topkis's Monotonicity Theorem (Milgrom and Roberts, 1990, p. 1262):

**Proposition 9.** *Suppose that the manager's marginal benefit from behaving in a manner desired by the owners,  $v_1(y, \mathbf{g})$ , exhibits complementarities in governance; specifically, assume it is supermodular in  $\mathbf{g}$ . Suppose it also exhibits increasing differences; that is, if  $y > y'$  and  $\mathbf{g} \geq \mathbf{g}'$ , then*

$$v_1(y, \mathbf{g}) - v_1(y', \mathbf{g}) > v_1(y, \mathbf{g}') - v_1(y', \mathbf{g}').$$

Finally suppose that the marginal cost of governance in one dimension is non-increasing in any other dimension (*i.e.*,  $\partial^2 C(\mathbf{g}) / (\partial g_i \partial g_j) \leq 0$ ,  $i \neq j$ ).<sup>25</sup> Then the governance of a higher-type firm on any given dimension is no less than that of a lower-type firm on that dimension; that is,  $\tau > \tau'$  implies  $\mathbf{g}(\tau) \geq \mathbf{g}(\tau')$ .

Observe that if (i)  $v(y, \mathbf{g})$  has the form

$$v(y, \mathbf{g}) = \gamma(\mathbf{g})v(y) \tag{20}$$

plus, possibly, additional terms with zero cross-partial derivatives in  $g_i$  and  $y$  for all  $i$ ; if (ii)  $\gamma(\cdot)$  is increasing in its arguments, with positive cross-partial derivatives; and if (iii)  $v(\cdot)$  is increasing, then the conditions on  $v_1(y, \mathbf{g})$  set forth in Proposition 9 all hold. Observe further that (20) has the following interpretation: given a choice of  $\mathbf{g}$ , the firm has an "effective" level of governance  $\gamma(\mathbf{g})$ .<sup>26</sup> The owners' problem can, thus, be seen as choosing, for each effective level of governance  $\gamma$ , the cost-minimizing vector  $\mathbf{g}(\gamma)$ . The cost of such an effective level is  $C(\mathbf{g}(\gamma)) \equiv \hat{C}(\gamma)$ . Viewing  $\gamma$  as the equivalent of  $g$  in Sections 2

<sup>25</sup>Observe this condition would hold if  $C(\mathbf{g})$  were additive across the dimensions; that is, if

$$C(\mathbf{g}) = \sum_{i=1}^n c_i(g_i),$$

where  $c_i(\cdot)$  is strictly increasing for all  $i$ .

<sup>26</sup>The effective level of governance is increasing in each dimension of governance and the marginal effective level in any one dimension is increasing in any other dimension (*e.g.*,  $\gamma(\cdot)$  exhibits complementarities).

and 3, the analysis in those earlier sections can be seen as short-hand for a more elaborate model in which the owners set governance on many dimensions in a cost-minimizing way to achieve an effective level of governance (the  $g$  in those sections).

Whether different dimensions of governance are complements or substitutes is an empirical question. This question does not seem to have attracted much attention. A partial exception is Hermalin and Wallace (2001), which studies, *inter alia*, whether firms base incentive compensation on the same measures or different measures. They find evidence that if a firm heavily weights one measure, it will tend not to weight another; whereas if a firm heavily weights the other, it will tend not to weight the one. With respect to compensation, these findings support a view that dimensions of governance are substitutes. On the other hand, they neglect many other dimensions, so the overall issue of complements versus substitutes must be seen as open.

## 5.2 HETEROGENEITY IN COST OF GOVERNANCE

An alternative to assuming heterogeneity in the benefit function,  $B(\cdot, \cdot)$ , is to assume heterogeneity in the cost-of-governance function. To explore this, consider the model of Section 2, except write the owners' payoff as  $B(Y - S) - C(g, \theta)$ , where  $\theta$  denotes firm type in this alternative specification. As a definition of type, assume

$$C_{12}(\cdot, \cdot) < 0; \tag{6'}$$

that is, higher-type firms have lower marginal costs of governance. A straightforward modification of the proof of Proposition 1 shows that

**Proposition 1'.** *In a heterogeneous costs model, higher-type firms adopt at least as great a level of governance as lower-type firms (i.e., if  $\theta > \theta'$ , then  $g(\theta) \geq g(\theta')$ ). Moreover, if a lower-type firm has not adopted the maximum level of governance (i.e.,  $g(\theta') < \bar{g}$ ),<sup>27</sup> then a higher-type firm will have a strictly greater level of governance (i.e.,  $g(\theta) > g(\theta')$ ).*

If  $C_2(0, \theta) \leq 0$  for all  $\theta$ , then it also follows that

**Proposition 2'.** *Under the assumptions of the heterogenous costs model and assuming a common level of resources,  $Y$ , a firm that will be more profitable in equilibrium than another has at least as high a level of governance as the other firm.*

and

**Proposition 4'.** *Assuming (6') and endogenous investment, there will be a strictly positive correlation between the amount the owners invest in a firm and its level of governance. Furthermore, if governance cost is decreasing in firm type (i.e.,  $C_2(g, \theta) < 0$ ), then there will be a strictly positive, but non-causal, correlation between firm profit and level of governance.*

<sup>27</sup>Recall  $\bar{g}$  is the solution to  $Y(g) = Y$ .

In short, the model operates the same whether it is assumed that heterogeneity stems from different profit potentials or it is assumed that heterogeneity stems from different marginal costs of governance across firms.

There are numerous reasons firms could have different marginal costs of achieving a given level of effective governance (*i.e.*, a level that deters a given amount of agency behavior). Monitoring in some settings could be more difficult than in others (Demsetz and Lehn, 1985, among others make this point). For example, it could be more difficult to determine what is going on with firms in fast-changing or highly innovative industries than with firms in staid and predictable industries. Or for instance, it could be more difficult to monitor a conglomerate operating in many industries than a firm operating in a single industry. Variation in laws and regulations across time or place could lead to differences in governance costs across time or space.

Although there is no reason to think that heterogeneity is solely on the benefit or cost side, one might ask which is more relevant. This is, obviously, an empirical question. One piece of evidence that points to the benefit side is the trend towards increased use of outside directors on the board in the United States and other countries over the past quarter decade or more (see, for instance, Borokhovich et al., 1996, Dahya et al., 2002, and Huson et al., 2001). It is difficult to see this trend as reflecting a drop in the marginal cost of outside directors. If anything, the evidence suggests the marginal cost of outside directors has increased; certainly, outside director compensation has increased (see, *e.g.*, Huson et al.). Another piece of evidence is the increased payout to executives, particularly from incentive pay (Hall and Liebman report a nearly seven-fold increase in the amount of options granted managers from 1980 to 1994). It is unclear what, if anything, has changed over the past thirty years to make the marginal cost of incentive pay decrease.

## 6 TRENDS IN GOVERNANCE

There have been numerous trends in corporate governance over the past twenty to thirty years (see, *e.g.*, Becht et al. and Holmstrom and Kaplan, 2001, for surveys). As noted above, the proportion of outside directors on boards has steadily increased in the United States and other countries (Borokhovich et al.; Dahya et al.; and Huson et al.). There has been growing use of stock-based incentives for directors over the period 1989 to 1997 (Huson et al.). Kaplan and Minton (2006) find evidence that CEO turnover rates in the period 1998–2005 are significantly greater than in the period 1992–1998; and the rate in that period is greater than found in studies for the pre-1992 period. They interpret this as evidence of better monitoring by boards of directors. Consistent with this interpretation is the finding of Huson et al. that firings, as a percentage of all CEO successions, were trending upward in the period 1971 to 1994. These trends can all be interpreted as evidence that governance has been getting stronger over the past twenty to thirty years.

At the same time, there is evidence that firms' profit potential and resources have been increasing during this period. As Gabaix and Landier note, there

has been a six-fold increase in the market value of the top 500 US firms between 1980 and 2003. From 1973 to 2003, there has been a three-fold increase in patents granted in the US; and, since the late 1980s, evidence of increased productivity in R&D (Hall, 2004). Technological progress has been remarkable in this period, especially with respect to information technology and telecommunications. Since the mid-1990s, there has been a growth in productivity that has not resulted in a significant increase in wages (DeLong, 2003).

The analysis in Sections 2–4 offers a way of tying these two trends together. As the potential profitability and resources of firms increased, the value of improved governance also rose. Consequently, governance got stronger (on average—the model does not predict any kind of convergence across firms).

This is not to say the process was necessarily smooth. As noted by many authors, one might expect management to resist improved governance. This resistance could have led to more aggressive forms of change, such as the takeovers, leveraged buyouts, and proxy fights that characterized the 1980s. It could also have motivated shareholders to seek change through legislation or changes in the listing requirements of exchanges. But over time, as suggested by Holmstrom and Kaplan, a new equilibrium with stronger governance has emerged.

Tying the change in governance to changes in the resources and potential of firms also serves to explain why changes in governance occurred when they did. After all, commentators have been complaining about the state of governance for a long time (consider, *e.g.*, Berle and Means, 1932), so presumably something had to occur to motivate action. Until the point that the payoff from improved governance made imposing it worthwhile, investors were not willing to walk the talk.

The model set forth above offers a broader explanation for change than that set forth by Terviö or Gabaix and Landier, which are concerned with executive compensation only; moreover, their models suggest a relatively smooth process in which growth in firm size increases executive compensation.<sup>28</sup> Like the model here, Hermalin (2005) offers an explanation for improvements, broadly, in governance, but his explanation is based on the rise of institutional investors.<sup>29</sup> His explanation can be seen as complementary to the one set forth here insofar as greater institutional holding could reduce the free-riding problem among equity holders with respect to taking action; hence, greater institutional holding could serve to reduce the owners' marginal cost of governance, which, following Proposition 1', would yield higher levels of governance. Alternatively, an increase in holdings by institutional investors can be seen as a rise in  $\tau$ —as a larger proportion of profits accrue to these investors, their incentive to push for stronger governance increases.

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<sup>28</sup>Another explanation primarily focused on executive compensation is the model of Murphy and Zábojník (2003), which argues that changes in the CEO labor market, specifically a greater emphasis on general versus firm-specific knowledge, explains the rise in CEO compensation.

<sup>29</sup>Huson et al. report that the percentage of US equity held by institutional investors has increased from 20% in 1971 to 45% in 1994. Gompers and Metrick (2001) report a similar doubling from 1980 to 1996.

## 7 CONCLUSIONS

This paper has sought to make the case that firms are not profitable because they have good corporate governance, rather they have good corporate governance because they are profitable. This is not to say, of course, that corporate governance is irrelevant, but instead to say that the observed variation in governance across firms is not the cause of observed variation in their profits.

This insight holds important implications for empirical work in corporate governance and, to an extent, in the study of organizations generally. The endogenous characteristics of an organization are, presumably, chosen to facilitate the organization's objectives. If organizations are behaving optimally, then variation in how well they do cannot be explained by variation in their characteristics. However, as shown here, the variation in their characteristics could well be a tied to variation in the potentials they have to do well.

To be sure, real-life optimizing is often a trial-and-error process. Hence, at any moment in time, organizations could be making errors and, thus, some variation in chosen characteristics is explaining some of the variation in performance. But if the variation in characteristics persists over time, then the weight one can place on cross-sectional regressions' representing evidence of causation is *de minimus*.

What might these insights hold for empirical work? One course suggested by this paper is to consider exogenous firm attributes that plausibly predict profitability and see whether they predict patterns in governance (somewhat analogous to earlier work that looks for attributes that plausibly predict the costs of ameliorating agency problems and their ability to predict patterns in governance). A second course is, for some aspects of governance such as compensation, to make greater use of panel data and employ random-coefficient or similar models to estimate firm-specific coefficients. For instance, in the pay-for-performance regression (17), estimate the coefficients  $\delta_0$  and  $\delta_1$  on a firm-by-firm basis.<sup>30</sup> A third course is to examine the consequences of regulated changes that are binding on some firms (*e.g.*, those resulting from the Sarbanes-Oxley Act). If firms were optimizing prior to the regulated change, then those firms for which the regulations are binding should suffer poorer performance subsequent to the regulations than firms for which the regulations were not binding (*i.e.*, than firms that were meeting the regulations prior to their enactment).

Beyond empirical work, future research may wish to model the dynamics of governance change. Although some sense of how the model might be extended to a dynamic setting was given in Section 6, this is far from a complete analysis. Moreover, in a dynamic setting, many models presume managers can entrench themselves or otherwise gain influence over how they are governed (surveys by Becht et al. and Hermalin and Weisbach discuss such models). In terms of the model presented above, this suggests that the cost of governance (*i.e.*,  $C(g)$ ) could rise over time if the same management team remains in office.

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<sup>30</sup>Hermalin and Wallace essentially employ this approach in their study of pay for performance; they find evidence for a much stronger pay-for-performance relationship using this approach than suggested by a cross-sectional analysis of the same data.

Particularly if the *marginal* cost increases, then governance strength will decline and, consequently, so will profits.

To an extent, entrenchment and managerial influence are, themselves, a product of the initial governance system, which suggests that, when a dynamic perspective is taken, initial governance might be overly strong when viewed at that point in time, but is optimal *vis-à-vis* the dynamic game. Other factors that influence the play of a dynamic game would be adjustment costs related to governance. In short, numerous issues will arise when this analysis is extended to a dynamic framework. Nonetheless, the basic messages of the paper concerning causality and the importance of firm heterogeneity are unlikely to be overturned by such an extension.

## APPENDIX A: PROOFS

**Proof of Lemma 1:** Fix a  $g$ . From (3) and the continuity and monotonicity of  $v_1(\cdot, g)$ , there exists a  $Y(g) < \infty$  such that

$$v_1(Y(g), g) = 1. \quad (21)$$

The manager's problem is

$$\max_{S \geq 0} S + v(Y - S, g). \quad (22)$$

$$\text{The derivative} = 1 - v_1(Y - S, g) \begin{cases} < 0, & \text{if } Y - S < Y(g) \\ > 0, & \text{if } Y - S > Y(g) \end{cases},$$

where the inequalities follow from (21) because (22) is strictly concave. It follows the manager does best to set  $S = 0$  if  $Y < Y(g)$  and  $S > 0$  if  $Y > Y(g)$ . In the latter case, it is readily seen the manager's optimal  $S = Y - Y(g)$ . The moreover part follows because raising  $g$  increases the left-hand side of (21) by (4), hence, by concavity,  $Y(g)$  must increase to restore equality. That  $Y(\cdot)$  is differentiable follows from the implicit function theorem. ■

**Proof of Lemma 2:** By the definition of an optimum (revealed preference):

$$f(\hat{x}, z) \geq f(\hat{x}', z) \text{ and} \quad (23)$$

$$f(\hat{x}', z') \geq f(\hat{x}, z'). \quad (24)$$

Expressions (23) and (24) imply

$$\begin{aligned} 0 &\leq (f(\hat{x}, z) - f(\hat{x}', z)) - (f(\hat{x}, z') - f(\hat{x}', z')) \\ &= \int_{\hat{x}'}^{\hat{x}} (f_1(x, z) - f_1(x, z')) dx = \int_{\hat{x}'}^{\hat{x}} \left( \int_{z'}^z f_{12}(x, \zeta) d\zeta \right) dx, \end{aligned}$$

where the integrals follow from the fundamental theorem of calculus. The inner integral in the rightmost term is positive because  $f_{12}(\cdot, \cdot) > 0$  and the direction of integration is left to right. It follows that the direction of integration in the outer integral must be weakly left to right; that is,  $\hat{x}' \leq \hat{x}$ . To establish the moreover part, because  $f_1(\cdot, \zeta)$  is a differentiable function for all  $\zeta$ , if  $\hat{x}'$  is an interior maximum, then it must satisfy the first-order condition

$$0 = f_1(\hat{x}', z').$$

Because  $f_{12}(\cdot, \cdot) > 0$  implies  $f_1(\hat{x}', z) > f_1(\hat{x}', z')$ , it follows that  $\hat{x}'$  does not satisfy the necessary first-order condition for maximizing  $f_1(x, z)$ . Therefore  $\hat{x}' \neq \hat{x}$ ; so, by the first half of the lemma,  $\hat{x}' < \hat{x}$ . ■

**Proof of Lemma 3:** Given that  $\hat{N}(\cdot)$  is increasing, it is sufficient to show that the standard agency problem of implementing  $N$  at minimum cost yields a cost function  $c(N)$  that is increasing in  $N$ . The standard problem is

$$\min_{\{v_s, v_f\}} P(N)V^{-1}(v_s) + (1 - P(N))V^{-1}(v_f) \quad (P)$$

subject to

$$P'(N)(v_s - v_f) - 1 = 0 \text{ and} \quad (\text{IC})$$

$$P(N)v_s + (1 - P(N))v_f \geq 0. \quad (\text{IR})$$

The solution is readily shown to be

$$v_f = -\frac{P(N)}{P'(N)} \text{ and } v_s = \frac{1 - P(N)}{P'(N)}.$$

Hence,

$$c(N) = P(N)V^{-1} \left( \frac{1 - P(N)}{P'(N)} \right) + (1 - P(N))V^{-1} \left( -\frac{P(N)}{P'(N)} \right).$$

Observe that  $c(N)$  is the expected value of a convex function over a two-point distribution that has a mean of zero for all  $N$ ; that is,

$$P(N)v_s + (1 - P(N))v_f = \frac{P(N)(1 - P(N))}{P'(N)} - \frac{P(N)(1 - P(N))}{P'(N)} = 0.$$

Because the left point of the distribution is falling in  $N$  (*i.e.*,  $dv_f/dN < 0$ ) and the right point is increasing in  $N$  (*i.e.*,  $dv_s/dN > 0$ ), an increase in  $N$  represents a mean-preserving spread. From Jensen's inequality, it follows that  $c(N)$  must be increasing in  $N$ . ■

**Proof of Lemma 1':** The proof up to the “moreover” part mimics that of Lemma 1 and is omitted for the sake of brevity. The moreover part follows because raising any element of  $\mathbf{g}$  increases the left-hand side of (21) by (4'), hence, by concavity,  $Y(\mathbf{g})$  must increase to restore equality. That  $Y(\cdot)$  is differentiable follows from the implicit function theorem. ■

**Proof of Proposition 8:** Let  $\tau > \tau'$ . To reduce notational clutter, let  $\mathbf{g} = \mathbf{g}(\tau)$  and  $\mathbf{g}' = \mathbf{g}(\tau')$ . To prove the first part of the proposition it is sufficient to show that  $Y(\mathbf{g}) \geq Y(\mathbf{g}')$ ; because, if  $Y(\mathbf{g}) \geq Y(\mathbf{g}')$  but  $C(\mathbf{g}) < C(\mathbf{g}')$ , then the  $\tau'$ -type firm cannot be optimizing—it could weakly increase its benefit and strictly lower its costs by switching to  $\mathbf{g}$ . By revealed preference:

$$B(Y(\mathbf{g}), \tau) - C(\mathbf{g}) \geq B(Y(\mathbf{g}'), \tau) - C(\mathbf{g}') \text{ and} \quad (25)$$

$$B(Y(\mathbf{g}'), \tau') - C(\mathbf{g}') \geq B(Y(\mathbf{g}), \tau') - C(\mathbf{g}). \quad (26)$$

Expressions (25) and (26) can be combined to yield

$$B(Y(\mathbf{g}), \tau) - B(Y(\mathbf{g}'), \tau) \geq B(Y(\mathbf{g}), \tau') - B(Y(\mathbf{g}'), \tau').$$

Twice applying the fundamental theorem of calculus, this last expression can be rewritten as

$$\int_{\tau'}^{\tau} \int_{Y(\mathbf{g}')}^{Y(\mathbf{g})} B_{12}(y, t) dy dt \geq 0. \quad (27)$$

Because  $B_{12}(\cdot, \cdot) > 0$  and  $\tau > \tau'$ , (27) can be non-negative only if the direction of integration for the inner integral is left to right; that is, only if  $Y(\mathbf{g}) \geq Y(\mathbf{g}')$ . As noted, this implies  $C(\mathbf{g}) \geq C(\mathbf{g}')$ , as was to be shown.

Turning to the moreover part, the goal is to show  $Y(\mathbf{g}) > Y(\mathbf{g}')$ . Suppose, instead, that  $Y(\mathbf{g}) = Y(\mathbf{g}')$ . One of the types would, therefore, have to be playing non-optimally if  $C(\mathbf{g}) \neq C(\mathbf{g}')$ ; hence, this supposition implies  $C(\mathbf{g}) = C(\mathbf{g}')$ . The  $\tau'$ -type firm is at an interior solution, so there must be at least one  $g'_j$  such that

$$B_1(Y(\mathbf{g}'), \tau') Y_j(\mathbf{g}') - C_j(\mathbf{g}') = 0.$$

Because  $B_{12}(\cdot, \cdot) > 0$ , this implies

$$B_1(Y(\mathbf{g}'), \tau) Y_j(\mathbf{g}') - C_j(\mathbf{g}') > 0.$$

It follows there exists a governance vector  $\tilde{\mathbf{g}}$  that has slightly more on the  $j$ th dimension such that

$$B(Y(\tilde{\mathbf{g}}), \tau) - C(\tilde{\mathbf{g}}) > B(Y(\mathbf{g}'), \tau) - C(\mathbf{g}') = B(Y(\mathbf{g}), \tau) - C(\mathbf{g}),$$

where the equality follows because  $Y(\mathbf{g}) = Y(\mathbf{g}')$  and  $C(\mathbf{g}) = C(\mathbf{g}')$ . But then,  $\mathbf{g}$  was not optimal for the  $\tau$ -type firm, a contradiction. By contradiction,  $Y(\mathbf{g}) \neq Y(\mathbf{g}')$ , which, given the first part of the proposition, entails  $Y(\mathbf{g}) > Y(\mathbf{g}')$ . It must then be that  $C(\mathbf{g}) > C(\mathbf{g}')$  because otherwise the  $\tau'$ -type firm is not behaving optimally. ■

**Proof of Proposition 9:** In light of Proposition 8, define

$$\tilde{C}(y) = \min_{\mathbf{g} \in \mathcal{G}(Y)} C(\mathbf{g}) \quad \text{subject to } y = Y(\mathbf{g}). \quad (28)$$

The cost,  $C(\mathbf{g})$ , is increasing in each dimension and so is  $Y(\mathbf{g})$  (the latter follows from Lemma 1'). Consequently,  $\tilde{C}(\cdot)$  is an increasing function. The owners' problem can be reexpressed as

$$\max_{y \leq Y} B(y, \tau) - \tilde{C}(y). \quad (29)$$

Let  $y(\tau)$  be the solution to (29) selected by a type- $\tau$  firm. Utilizing Lemma 2, it is readily shown that  $\tau > \tau'$  implies  $y(\tau) \geq y(\tau')$ . The proposition follows if it can be shown that  $y(\tau) \geq y(\tau')$  implies  $\mathbf{g}(\tau) \geq \mathbf{g}(\tau')$ .

To that end, observe that minimization program in (28) is equivalent to the program

$$\max_{\mathbf{g} \in \mathcal{G}(Y)} -C(\mathbf{g}) \quad \text{subject to} \quad (30)$$

$$v_1(y, \mathbf{g}) = 1 \quad (31)$$

Let  $\lambda$  be the Lagrange multiplier on (31). The program given by (30) is, thus, equivalent to

$$\max_{\mathbf{g}, \lambda} -C(\mathbf{g}) + \lambda(v_1(y, \mathbf{g}) - 1). \quad (32)$$

This expression is supermodular in  $(\mathbf{g}, \lambda)$  in light of Topkis's characterization theorem (Milgrom and Roberts, 1990, p. 1261) because  $v_{1i}(y, \mathbf{g}) > 0$  by (4') and  $v_{1ij}(y, \mathbf{g}) \geq 0$  and  $-C_{ij}(\mathbf{g}) \geq 0$  by the assumptions of the proposition.<sup>31</sup> By the increasing-differences assumption of the proposition, (32) exhibits increasing differences in  $y$  and  $g_i$  for any  $i$ . Let  $\mathbf{g}(y)$  denote the solution to (32). It follows, therefore, from Topkis's monotonicity theorem (Milgrom and Roberts, p. 1262) that  $y > y'$  implies the  $\mathbf{g}(y) \geq \mathbf{g}(y')$ . ■

## APPENDIX B: ISSUES IN THE ESTIMATION OF THE PAY-FOR-PERFORMANCE RELATION

Consider the following agency model. The manager's utility is

$$\frac{-1}{\exp(\underbrace{Y - N}_S + \delta_0 + \delta_1 \pi)},$$

where his compensation contract is  $\delta_0 + \delta_1 \pi$ ,  $\pi$  being realized profits gross of compensation. Assume that<sup>32</sup>

$$\pi \sim \mathcal{N}(\tau \log(N), \sigma^2),$$

In what follows, assume  $Y$  is sufficiently large that the constraint  $N \leq Y$  never binds.

Using the formula for the moment-generating function of a normal random variable, the manager's expected utility is

$$\frac{-1}{\exp(Y - N + \delta_0 + \delta_1 \tau \log(N) - \frac{1}{2} \delta_1^2 \sigma^2)}.$$

A monotonic transformation is

$$Y - N + \delta_0 + \delta_1 \tau \log(N) - \frac{1}{2} \delta_1^2 \sigma^2. \quad (33)$$

Given  $\delta_0$  and  $\delta_1$ , the manager maximizes (33) with respect to  $N$ . This yields

$$N = \delta_1 \tau.$$

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<sup>31</sup> $v_{1ij}$  denotes the third partial derivative of  $v$  with respect to  $y$ ,  $g_i$ , and  $g_j$ .

<sup>32</sup>Note the assumed compensation contract is not second-best optimal under these assumptions (see Mirrlees, 1974). A reformulation of this simple model along the lines of Holmstrom and Milgrom (1987)—in particular, assuming the manager decides how much to divert on a continuous basis with the resulting net funds controlling the drift of a Brownian motion—would, however, yield an optimal compensation contract of this form. One can thus view the model here as a simple approximation of that more complex model. In any case, given the issue is the econometric consequences of heterogeneity, the optimality of the contract is not essential to the analysis.

Hence, if the owners want to induce a particular  $N$ , they must set  $\delta_1$  to satisfy

$$\delta_1 = \frac{N}{\tau}. \quad (34)$$

Assume, as an alternative to working for the firm, the manager could get a job that paid a flat wage of  $\underline{w}$ . Hence, the owners must set  $\delta_0$  to satisfy

$$Y - N + \delta_0 + \underbrace{\frac{N}{\tau}}_{\delta_1} \tau \log(N) - \frac{1}{2} \underbrace{\frac{N^2}{\tau^2}}_{\delta_1^2} \sigma^2 \geq \underline{w}.$$

Given the owners' profit is decreasing in  $\delta_0$ , the constraint will bind and, thus,

$$\delta_0 = \underline{w} - Y + N - N \log(N) + \frac{1}{2} N^2 \frac{\sigma^2}{\tau^2}. \quad (35)$$

The owners seek to choose  $N$  to maximize their expected profits. Using (34) and (35), their expected profits can be written as

$$\tau \log(N) - \underline{w} + Y - N - \frac{1}{2} N^2 \frac{\sigma^2}{\tau^2}.$$

The first-order condition is

$$\frac{\tau}{N} - 1 - N \frac{\sigma^2}{\tau^2} = 0.$$

Solving for the root that satisfies the second-order condition yields

$$N = \frac{\tau^{3/2} \sqrt{4\sigma^2 + \tau} - \tau^2}{2\sigma^2}. \quad (36)$$

Plugging (36) into (34) and (35) yields expressions for  $\delta_1$  and  $\delta_0$ , respectively, in terms of the model's primitives ( $\tau$ ,  $\sigma^2$ ,  $Y$ , and  $\underline{w}$ ).

Data were created for 10,000 firms as follows. For each firm, its  $\tau$  was a random draw from the uniform distribution  $\tau \sim \mathcal{U} : [10, 20]$ . To insure that  $N \leq Y$  was never binding,  $Y = 400$ . The reservation wage,  $\underline{w}$ , was set to zero. Then, for each firm, the optimal contract was calculated, as was the  $N$  its manager would choose in equilibrium. Profits gross of compensation,  $\pi$ , were then generated for that firm as a draw from  $\mathcal{N}(\tau \log(N), 1)$  and the resulting compensation for the manager calculated. Once the data were constructed, equation (17) was estimated with  $\pi$  as the independent variable. The results are shown in Table 2.<sup>33</sup>

The true  $\delta_1$ s for firms with  $\tau \in [10, 20]$  ranges from [.916, .954]; hence, the estimate  $\delta_1$  is less than the true  $\delta_1$  for 100% of the firms. The reason why

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<sup>33</sup>The Mathematica program used to generate the data is available from the author upon request.

Coefficient	Estimate
$\hat{\delta}_0$	-396.46 (-15321.)
$\hat{\delta}_1$	.27568 (440.69)
$R^2$	.95104

**Table 2:** Estimation of equation (17) using data generated as described in this appendix. Dependent variable is realized pay. Independent variable is profit (gross of compensation), its coefficient is  $\delta_1$ . The coefficient  $\delta_0$  is the intercept. Numbers in parentheses are t-statistics.

(17) does so poorly is that while the true  $\delta_1$ s are fairly constant across  $\tau$ , the intercepts—the true  $\delta_0$ s—vary considerably. Because low  $\tau$  firms have greater  $\delta_0$ s and tend to have lower  $\pi$ s, while high  $\tau$  firms have lower  $\delta_0$ s and tend to have higher  $\pi$ s, the estimated slope between pay and profits is flattened. Consequently, the estimated  $\delta_1$  is biased downward.

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