Executive Pay, Talent and Firm Size*

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Abstract

We present an integrated agency model of career concerns and labor market equilibrium. Unlike the existing literature, our managerial reservation utility levels and thus their pay levels are endogenously determined, and managers with high expected talent levels are not necessarily hired by large firms. A number of our theoretical results are supported by our panel data for 1992-2006 exclusive of time factors, which strikingly suggest that the average talent level of small firm CEOs is only slightly lower than that of large firm CEOs, but the talent variability of small firm CEOs is far greater than that of large firms. Moreover, a remarkable 55% of CEO-years indicate negative (real) productivity; and a sizeable portion of the increased real CEO pay levels in terms of higher productivity is attributable to both firm size and compensation for risk.

Key words: executive pay, firm size, career concern, CEO talent, principal-agent, optimal contract.

JEL Classification: G34, J41, J44, L25

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1. Introduction

A strong positive correlation between firm size and executive pay has become one of the most highly documented facts in the area of executive compensation for many decades over many countries.[1] In particular, executive pay increases in the size of the firm with approximately a one-third higher pay level for each doubling of firm size. However, the reasons for this are not well understood. One of our aims is to help explain these peculiar findings.

In this paper, we present an integrated agency model of career concerns and labor market equilibrium, in which both executive pay levels and incentive contracts are endogenously determined. Then, we provide empirical results supporting our model by using panel data for 1992-2006 exclusive of time factors.

It is well known in the existing agency literature that the expected pay of an agent is the sum of the agent reservation certainty equivalent wealth and compensation for effort production. However, the literature typically assumes the agent's reservation utility as an exogenous parameter, and thus it does not provide a model that can be used to compare different executive pay levels across firms with different sizes. We build a principal-agent model with reservation utility levels endogenously determined though labor market competition.

[1] See, for example, Roberts (1956), Lewellen and Huntsman (1970), Cosh (1975), Murphy (1985), Baker, Jensen, and Murphy (1988), Kostiuk (1990), Barro and Barro (1990), Rosen (1992), Joskow et al (1993), Rose and Shepard (1997), and Frydman and Saks (2007). Their findings suggest that a 100 percent larger firm will pay its CEO about thirty-three percent more. Zhou (1999) finds a positive correlation between executive pay and firm size for Canadian firms. Kaplan (1997), Kato (1997) and Kato and Kubo (2006) find a similar result for Japanese firms; Cosh and Hughes (1997) and Conyon (1997), McKnight, and Tomkins (1999) and Conyon and Murphy (2000) for British firms; and Merhabi, Pattenden, Swan and Zhou (2006) for Australian firms.

Our model is based on a two-period economy consisting of two firms of different sizes and two agents with unknown talent levels drawn from two different distributions. In each period, the two firms compete with each other to hire the better of the two agents, and consequently, agent reservation utility/pay levels are endogenously determined. For each period, each firm signs a contract with one agent chosen from two candidates with unknown abilities. After the first period, each firm again makes its hiring decision for the second period. The hiring decision will be made with each agent's past performance record taken into account. His past record would provide each agent with differing negotiating power for second-period contracting, and thus a different reservation utility level. In our framework we would expect to see quite different pay outcomes depending on firm size and "manager reputation" based on track record.

We argue that in executive labor-market equilibrium, reservation wealth is made up of compensation for wealth creation due to the agent's effort and talent had he been hired by the small (reference) firm plus compensation for any future job-market disadvantages he may face because of his working for the current firm. We believe ours to be the first estimable agency model to explicitly include managerial talent.

The endogenous reservation wealth levels enable us to characterize hiring decisions by the firms, and to explicitly compute the managerial pay differential between the small and large firms. Recall that the matching literature (e.g., Gabaix and Landier (2008)) *a priori* assumes that large firms (or firms with better production technologies) hire managers with superior abilities, and argues that there should be a positive relationship between pay and firm size because large firms hire managers with superior talent who thus "deserve" higher pay (e.g., Rosen (1982)). However, in our agency world, a large firm (with better production technology) may not always be willing to hire a high expected ability manager if there is too high a level of uncertainty in ability, because this uncertainty hurts work incentives. We argue that even when a large firm hires a low-ability manager, the expected pay for the low-ability manager can be higher than that for a high-ability manager who is hired by a small firm, if the large firm's productivity and size are sufficiently higher and larger than those of the small firm. Thus large firms can in equilibrium hire low-ability CEOs but pay them as if they were high-ability CEOs. Our empirical findings support this hypothesis. In fact, we find that on average the CEOs of large firms are of only slightly higher ability than those of small firms, holding the technology of the two firm types the same, yet are paid far more. Augmenting the higher mean ability of large firm managers is reduced talent dispersion which in turn is particularly advantageous for large firms.

In order to empirically test our theoretical result, we estimate the stochastic CEO production function measuring the ability of CEOs to convert total assets under management at the beginning of each year into total claimant wealth at the end. Approximately 19,000 CEO-years from a sample of S&P 1500 firms over the period, 1992-2006, are evaluated on the basis of their performance when subjected to moral hazard. All performance measures are recorded in the dollars of 2006 and are thus in real terms. These "internal" wealth creation measures are based on both stock market and accounting numbers. Surprisingly, in 55% of CEO-years based on the market measure (59% based on the accounting measure), these internal contributions to productivity are negative in real terms; indicating that poor productivity performance is the norm and that much apparent company growth is externally funded.

The plan of the paper is as follows: Section 2 reviews the literature, the model is developed in Section 3 and the empirical estimation is in Section 4. Section 5 concludes.

2. Literature Review

Our paper is most closely related to the agency literature on pay-size relationship, pay sensitivity, and career concerns. Recently, Gabaix and Landier (2008) develop a calculable competitive assignment model of CEO pay, under the assumption that the best managers are paired with the largest firms. Based on the extreme value theory, the authors argue that a negligible difference in managerial talent of only 0.016% between the CEO ranked number 250 and the top CEO accounts for pay for the top manager that is 500% higher than for manager number 250. This raises the quandary as to why the market for executive talent does not appear to clear. In particular, if the alternative for the most talented executive assigned to the largest firm is to be employed by a smaller firm, say # 250, why does not the largest firm offer (say) just $1 more than firm #250 for a manager of almost precisely the same ability, rather than pay 500% more? Contrary to Gabaix and Landier, we find that the distribution of CEO ability is significant and for the large firms lower than for of small firms such that the risk-adjusted mean (equivalent of the Sharpe ratio) is considerably higher.

Giannetti (2007) develops a theoretical model in which the growth in job hopping opportunities for risk-neutral CEOs leads to higher CEO pay. While we model the CEO labor market, job hopping *per se* does not affect the level of pay in our model.

Moreover, within our dataset of nearly 20,000 CEO years, job movements are surprisingly few at 125, inclusive of multiple movers.[2]

In contrast to recent decades, Frydman and Saks (2007) find only a weak relationship between compensation and firm size from the late 1940s to the mid-1970s. These findings for the earlier period suggest that technological advances in the last 35 years such as computers have increased the ability of able executives to manage very large companies successfully. Scale economies in effort and talent that we identify have most likely been augmented by the technological revolution and in particular the introduction of computers.

The pay sensitivity issue has emerged as an important issue in the agency literature since Jensen and Murphy (1990) argued that there is a negative relationship between sensitivity and firm size. The Jensen and Murphy (1990) finding is modeled by Schaefer (1998) taking into account larger team sizes in bigger firms. More recently, Edmans, Gabaix and Landier (2007) have introduced a multiplicative specification for an agency model with both incentives and talent assignment that can explain why equity incentives fall with firm size.

Our model explicitly accounts for firm size effects on contracting and our empirical estimates show that pay-performance sensitivity optimally falls with size. Moreover, our modeling tells us how sensitivities are affected by executives' career paths. Given

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[2] There have been several other attempts to try and reconcile the pay-size premium with patial explanations of the phenomena put down to effects, such as, compensating differentials by Dunn (1986), union status by Lewis (1986), and efficiency wages by Krueger and Summers (1988). Idson and Oi (1999) and Bayard and Troske (1999) both find that workers in larger firms achieve higher labor productivity, based on some restrictive measures of labor productivity. Bebchuk and Grinstien (2006) find that there is an economically and statistically significant positive relationship between CEO compensation and the CEO's past decisions to increase firm size, by means of increasing the number of shares on issue.

our estimated elasticities, our model predicts that a manager recruited from a small to a large firm will be given a lower pay-performance sensitivity that a manager recruited from a firm of the same size. This is because the large firm's performance provides a more reliable signal of the manager's ability with less risk being borne by the CEO and thus warrants the use of higher-powered incentives.

Baker and Hall (2004) estimate a form of a production function of CEO effort, and document that CEO effort increases in pay-performance sensitivity of the manager, but their production function ignores impact of managerial talent on the output. Their estimated effort elasticity based on market value ranges from as low as 37 percent up to 66 percent and thus overlaps with our estimate for large firms of 46%, after controlling for managerial ability.

Our third focus, apart from the estimation of pay sensitivity, and the pay-size relationship, is executive career concern. Fama (1980) provocatively argued in the absence of formal modeling that the managerial labor market could provide a perfect substitute for incentive pay by rewarding managers with high reputations for talent even though there is a moral hazard problem due to the unobserved nature of the manager's actions. Holmstrom (1999) formally modeled such career concern issues. He showed that the less is known about managerial ability the greater the incentive for the manager to supply effort. Gibbons and Murphy (1992) also model career concern issues to argue that explicit contracts should provide stronger incentives as executives approach retirement as the impact of the implicit incentives provided by the labor market decline with the prospect of retirement. As far as career concerns are concerned, our paper is closely related to Gibbons and Murphy. We argue that CEO career concerns not only affect the sensitivity but their negotiating power in the future labor market and thus the current pay size.

3. The Two-Period Career Concerns Model

There are two firms, S (small) and L (large), and two agents a and b with unknown abilities, θ^a and θ^b, respectively. The firms are risk neutral and both agents are risk averse with the same constant absolute risk aversion (CARA) coefficient, r. We assume that $\theta^{\hat{a}}$, for $\hat{a} \in \{a,b\}$, is normally distributed with a mean of $m_{\theta^{\hat{a}}}$ and a variance of $\sigma^2_{\theta^{\hat{a}}}$, and that θ^a and θ^b are independent of each other. There are thus two dimensions to managerial talent, namely, the mean and variance. One may say that agent $\hat{a}$ is more talented if his talent is drawn from a distribution with a higher mean, $m_{\theta^{\hat{a}}} > m_{\theta^{\hat{b}}}$, or a tighter distribution, $\sigma^2_{\theta^{\hat{a}}} < \sigma^2_{\theta^{\hat{b}}}$. The initial signal enabling expected ability levels to differ between the candidates could be résumés' indicating that one candidate has better educational attainments or track-record to date.

There are two periods with three dates, 0, 1, and 2. Contracting between the two firms and two agents occurs at time 0 and 1. At time $t-1$, for $t \in \{1,2\}$, firm i $i \in \{S,L\}$ hires agent $\hat{a}$, and the agent exerts effort $e^{\hat{a}}_{t-1}$ to produce outcome $Y^i_t(\hat{a})$, where the production function for CEO output takes the additively separable form:

$$Y^i_t(\hat{a}) = e^{\hat{a}}_{t-1} f(K^i) + \theta^{\hat{a}} g(K^i) + h(K^i)\varepsilon^i_t, \qquad (1)$$

and $K^S < K^L$ where $K^i > 0$ indicates the *i*th's firm's capital stock and thus size; and ε^i_t, for $t \in \{1,2\}$ and $i \in \{S,L\}$, are independent normal random variables, each of which are distributed with a mean of zero and a standard deviation of σ. The ability (or talent) $\theta^{\hat{a}}$ may represent agent $\hat{a}$'s decision-making competency or information-gathering ability to identify better investment opportunities.

The functions $f(K^i)$ and $g(K^i)$, respectively, describe how firm size and scale economies affect the agent's marginal productivity of effort and ability, and $h(K^i)$ signifies the way risk (dollar volatility) varies with firm size. We assume that $f(K) = K^{\gamma_f}$, $g(K) = K^{\gamma_g}$, and $h(K) = K^{\gamma_h}$, for some $\gamma_f, \gamma_g, \gamma_h > 0$. Then, the first two terms of equation (1) imply that the expected outcome is given as the sum of two Cobb-Douglas production functions: the first in labor effort, $e_{t-1}^{\hat{a}}$, and capital, K, and the other in expected ability, $m_{\theta^{\hat{a}}}$, and capital K, reflecting the manner in which talent reaps scale economies in assets under management distinctively from effort. The last term of the equation captures the random element in the productive process with its volatility increasing in K.

At time $t \in \{0,1\}$, agent $\hat{a}$ exerts effort $e_t^{\hat{a}}$, incurring a personal (monetary) cost of $c(e) = (\kappa/2)e^2$ for some $\kappa > 0$. Hence the shadow cost of effort is independent of either ability or career profile. At time $t \in \{1,2\}$, agent $\hat{a}$ working for firm i is compensated by an amount $S_t^i(Y_t^i(\hat{a}))$, and the utility of the agent takes the form $-\exp\left(-r\sum_{t=1}^{2}\left\{S_t^i(\hat{a}) - c(e_{t-1}^{\hat{a}})\right\}\right)$. Without loss of generality and in the spirit of Holmstrom and Milgrom (1987) and Schattler and Sung (1993), we assume, for $t \in \{1,2\}$, that there is a linear pay schedule with a fixed and a performance component:[3]

$$S_t^i(Y_t^i(\hat{a})) = \alpha_{t-1}^i(\hat{a}) + \beta_{t-1}^i(\hat{a})Y_t^i(\hat{a})$$

[3] In fact, one can show by using Kaman-Bucy filtering technique that in an analogous continuous-time setting with incomplete information, the optimal contract is linear as in this paper. Thus, all results in this paper can be interpreted as those in the continuous-time model.

At time 0, agent $\hat{a}$'s reservation utility is $-\exp\left(-rW_0^{\hat{a}}\right)$, where $W_0^{\hat{a}}$ is called the certainty equivalent reservation wealth. At time 1, since outcomes of agents' effort are realized, and provide better information about agents' abilities, firms compete for better agents, and as a consequence, the certainty equivalent wealth level of agent $\hat{a}$ who previously worked for firm k changes to $W_1^{\hat{a}}(Y_1^k(\hat{a}))$.

3.1 The Second-Period Contracting

In this section, contracting occurs twice: initial contracting at time 0, and re-contracting at time 1. That is, this dynamic contracting problem consists of the first and second-period contracting problems. We consider the second-period problem first so as to solve the overall problem recursively.

Suppose that at time 0, agent $\hat{a}$ worked for firm k $(k \in \{S, L\})$ and at time 1, he is hired by firm i. The outcome of agent $\hat{a}$'s time-0 performance with firm k is realized at time 1 to be $Y_1^i(\hat{a})$, and firm i updates its belief on agent $\hat{a}$'s ability $\theta^{\hat{a}}$ based on the realized outcome $Y_1^i(\hat{a})$. Since both $Y_1^i(\hat{a})$ and $\theta^{\hat{a}}$ are normally distributed, and they are linearly related to each other through equation (1), $\theta^{\hat{a}}$ conditional on $Y_1^i(\hat{a})$ is normally distributed with its mean and variance given as follows:

$$E[\theta^{\hat{a}} \mid Y_1^k(\hat{a})] = m_{\theta^{\hat{a}}} + p^{\hat{a}k}\left(Y_1^k(\hat{a}) - e_0^{\hat{a}} f(K^k) - m_{\theta^{\hat{a}}} g(K^k)\right), \tag{2}$$

and

$$Var[\theta^{\hat{a}} \mid Y_1^k(j)] = \frac{\sigma_{\theta^{\hat{a}}}^2 \sigma^2 h^2(K^k)}{\sigma_{\theta^{\hat{a}}}^2 g^2(K^k) + \sigma^2 h^2(K^k)}, \tag{3}$$

where

$$p^{\hat{a}k} \equiv \frac{\sigma^2_{\theta^{\hat{a}}} g(K^k)}{\sigma^2_{\theta^{\hat{a}}} g^2(K^k) + \sigma^2 h^2(K^k)}. \tag{4}$$

That is, common beliefs on agent abilities are updated over time according to equation (2) with their conditional means and variances given by equations (2) and (3). This updating reduces the estimated variance of ability level from $\sigma^2_{\theta^{\hat{a}}}$ to that in equation (3). Equation (2) implies that each conditional mean is determined by a regression line regressing the ability level $\theta^{\hat{a}}$ on the realized outcome Y_1^k with an intercept of $m_{\theta^{\hat{a}}}$ and a slope of p^k.

As a result, the second-period contracting problem for firm i hiring agent $\hat{a}$ who worked for firm k for the first period can be stated as follows:

Problem 1 (The second-period contracting.) Choose pay contract $S_2^i(\hat{a})$ to maximize the expected profit to the shareholders in period 2 conditional on the agent's performance outcome in period 1:

$E[Y_2^i(\hat{a}) - S_2^i(\hat{a}) \mid Y_1^k(\hat{a})]$, subject to

(1) $Y_2^i(\hat{a}) = e_1^{\hat{a}}(i) f(K^i) + \theta^{\hat{a}} g(K^i) + h(K^i)\varepsilon_2^i$,

$Y_1^k(\hat{a}) = e_0^{\hat{a}}(k) f(K^k) + \theta^{\hat{a}} g(K^k) + h(K^k)\varepsilon_1^k$,

(2) $e_1^{\hat{a}}(i) \in \arg\max_{\hat{e}} E\left[-\exp\left\{-r\left(S_2^i(\hat{a}) - c(\hat{e})\right)\right\} \mid Y_1^k(\hat{a})\right]$

s.t. $Y_2^i(\hat{a}) = \hat{e} f(K^i) + \theta^{\hat{a}} g(K^i) + h(K^i)\varepsilon_2^i$,

$Y_1^k(\hat{a}) = e_0^{\hat{a}}(k) f(K^k) + \theta^{\hat{a}} g(K^k) + h(K^k)\varepsilon_1^k$,

(3) $E\left[-\exp\left\{-r\left(S_2^i(\hat{a})-c(e_1^{\hat{a}}(i))\right)\right\}\mid Y_1^k(\hat{a})\right]\geq -\exp\left(-rW_1^{\hat{a}}\right)$.

The first constraint is simply the production functions for periods 1 and 2. The second constraint is the agent's effort incentive constraint conditional on the outcome in period 1, and the third constraint is the participation constraint given the agent's reservation utility in period 1. The first order condition (FOC) from the incentive constraint combined with the participation constraint implies that the second period pay schedule:

$$S_2^i(\hat{a}) = \underbrace{W_1^{\hat{a}} + c(e_1^{\hat{a}}) + \frac{r}{2}\left(\frac{c_e(e_1^{\hat{a}})}{f(K^i)}\right)^2\left(\frac{g^2(K^i)\sigma_{\theta^{\hat{a}}}^2\sigma^2h^2(K^k)}{\sigma_{\theta^{\hat{a}}}^2 g^2(K^k)+\sigma^2h^2(K^k)}+\sigma^2h^2(K^i)\right)}_{\text{fixed compensation}}$$
$$+\underbrace{\left(\frac{c_e(e_1^{\hat{a}})}{f(K^i)}\right)\left\{Y_2^i(\hat{a})-\left(e_1^{\hat{a}}f(K^i)+E[\theta^{\hat{a}}\mid Y_1^k]g(K^i)\right)\right\}}_{\text{performance-based compensation}}. \quad (5)$$

Note that the sensitivity of the contract, or the sensitivity of the compensation to the realized outcome $Y_2^i(\hat{a})$, is $\frac{c_e(e_1^{\hat{a}})}{f(K^i)}$. The structure of equation (5) is well-known, consisting of two parts: fixed and performance-based compensations.

The first term of the fixed compensation is the agent's certainty equivalent reservation wealth, the second the cost of effort, and the third the compensation-risk premium. The performance-based compensation is in proportion $\frac{c_e(e_1^{\hat{a}})}{f(K^i)}$ to the unexpected outcome, $Y_2^i - E[Y_2^i \mid Y_1^k]$, which is realized minus expected outcomes. The performance-based compensation constitutes a compensation risk to the agent, on which the agent demands a risk premium.

By equation (5), the expected profit of firm i for the second period is

$$\pi^i(\hat{a}(k), W_1^{\hat{a}(k)}) := E[Y_2^i(\hat{a}) - S_2^i(\hat{a}) \mid Y_1^k(\hat{a})] = g(K^i)E[\theta^{\hat{a}} \mid Y_1^k(\hat{a})] + \Phi(K^k, K^i, \sigma_{\theta^{\hat{a}}}) - W_1^{\hat{a}},$$

where:

$$\Phi(K^k, K^i, \sigma_{\theta^{\hat{a}}}) = \max_e e(K^i)^{\gamma_f} - \frac{\kappa}{2}e^2 - \frac{r}{2}\left(\frac{\kappa e}{(K^i)^{\gamma_f}}\right)^2 \left(\frac{(K^i)^{2\gamma_g}\sigma_{\theta^{\hat{a}}}^2\sigma^2(K^k)^{2\gamma_h}}{\sigma_{\theta^{\hat{a}}}^2(K^k)^{2\gamma_g} + \sigma^2(K^k)^{2\gamma_h}} + \sigma^2(K^i)^{2\gamma_h}\right) \tag{6}$$

Substituting the FOC with respect to effort e back into the RHS of equation (6) we have

$$\Phi(K^k, K^i, \sigma_{\theta^{\hat{a}}}) = \frac{1}{2}e(K^i)^{\gamma_f} = \frac{1}{2}\frac{1}{\kappa(K^i)^{-2\gamma_f} + r\kappa^2\sigma^2\left(\frac{(K^i)^{2(\gamma_g - 2\gamma_f)}\sigma_{\theta^{\hat{a}}}^2}{\sigma_{\theta^{\hat{a}}}^2(K^k)^{2(\gamma_g - \gamma_h)} + \sigma^2} + (K^i)^{2(\gamma_h - 2\gamma_f)}\right)}. \tag{7}$$

3.1.1 Pay Sensitivity and Firm Size

Pay sensitivity has become an important issue in the agency literature since Jensen and Murphy (1990) argued that there is empirically a negative relationship between the sensitivity and firm size. The firm i's problem in equation (6) enables us to relate the sensitivity to firm size.

The FOC for equation (6) also implies that for firm *i* hiring agent $\hat{a}$ who worked for firm *k,* the sensitivity of the contract for the second period to motivate the agent to exert effort is

$$\frac{\kappa\hat{e}}{(K^i)^{\gamma_f}} \equiv \beta^i(\hat{a}(k)) \equiv \beta^{ki} = \frac{1}{1 + r\kappa\sigma^2\left(\frac{(K^i)^{2(\gamma_g - \gamma_f)}\sigma_{\theta^{\hat{a}}}^2}{\sigma_{\theta^{\hat{a}}}^2(K^k)^{2(\gamma_g - \gamma_h)} + \sigma^2} + (K^i)^{2(\gamma_h - \gamma_f)}\right)}. \tag{8}$$

Note that the sensitivity expression, equation (8), does not directly depend on agent type $\hat{a}$, because of our assumption that the risk aversion and effort cost functions for both agents are identical, but it does depend on the distribution of agent talents, $\sigma^2_{\theta^{\hat{a}}}$, as this is updated by information derived from the initial work experience. Thus the sensitivity depends on the agent's work experience *k,* because the experience affects the volatility of the second-period outcome as the distribution of the agent ability level is updated.

Equation (8) immediately relates the sensitivity to the size of the firm as follows:

Proposition 1: *Suppose that* K^k *, the size of the firm for which the manager previously worked for is given. Then, holding other things constant:*

(i) *The sensitivity is inversely related to the firm size, i.e.,* $\partial\beta^{ki}/\partial K^i < 0$*, if either the relative scale elasticities,* $\gamma_h - \gamma_f \geq \gamma_f - \gamma_g > 0$ *or* $\gamma_g > \gamma_f > 0$ *and* $\gamma_h > \gamma_f > 0$.

(ii) *The sensitivity is positively related to the firm size, i.e.,* $\partial\beta^{ki}/\partial K^i > 0$*, if either* $0 < \gamma_g - \gamma_f \leq \gamma_f - \gamma_h$ *or* $\gamma_f > \gamma_g > 0$ *and* $\gamma_f > \gamma_h > 0$.

Proofs are given in the *Appendix*.

Proposition 1 suggests that, for example, the large firm offers a lower- (higher-) powered incentive contract than the small firm, when expected marginal effort-productivity $(K^i)^{\gamma_f}$ is sufficiently lower (higher) than expected ability-productivity $(K^i)^{\gamma_g}$ and volatility growth $(K^i)^{\gamma_h}$ over firm size. Substituting our empirically derived elasticities estimated in Table 4 below, we find, based on stock market productivity measures for the entire sample, that $\gamma_g = 0.98 > \gamma_h = 0.81 > \gamma_f = 0.43$. The same inequalities are satisfied for accounting measures of productivity and for both large and small firms. Hence condition (i) rather condition (ii) is satisfied and pay-performance sensitivity is optimally negatively related to firm size, as is shown in Table 3 below with a partial correlation coefficient of 5.4%.

This implication is in contrast with Baker and Hall (2004) who argued that the sensitivity is negatively related to the firm size because dollar volatilities of profits of large firms are higher than those of small firms. However, our Proposition 1 indicates that the relationship depends more on relative sizes of γ_f, γ_g and γ_h than it does on differences in dollar volatilities. For example, if $\gamma_f = \gamma_g = \gamma_h$, then sensitivities of both the large and small firms are identical, even though the total dollar volatility of the large firm can be considerably higher than that of the small firm.[4]

3.1.2 Career Path and Sensitivity

Equation (8) also tells us how sensitivities are affected by executives' career paths.

Proposition 2: *Suppose that agents a and b are hired for the first period by firms S and L, respectively, and agent b (a) comes from a tighter distribution than a (b). If* $\gamma_g - \gamma_h \geq 0$ *and* $\sigma_{\theta^b} < \sigma_{\theta^a}$ *(if* $\gamma_g - \gamma_h \leq 0$ *and* $\sigma_{\theta^a} > \sigma_{\theta^b}$ *), then the second-period contract sensitivity for the agent who previously worked for the large firm is higher (lower) than the sensitivity for the agent who previously worked for the small firm.*

The statement comes directly from equation (8). To see this intuitively, note that equation (3) implies that if $\gamma_g - \gamma_h > 0$ and $\sigma_{\theta^b} > \sigma_{\theta^a}$, the conditional variance of the agent ability given his performance with the first-period firm is inversely (positively)

[4] Note the Baker and Hall (2004) do not take account of managerial ability at all insofar as ability is implicitly assumed to be identical for all managers. Moreover, the volatility growth $h(K) = \sigma K^{\gamma_h}$ is only implicit in Baker and Hall (2004) and is not formally modeled in their paper.

related to the firm size. That is, if $\gamma_g - \gamma_h > (<)\, 0$, the informativeness of the agent's past performance about his ability increases (decreases) with the firm size. Thus, if $\gamma_g - \gamma_h > (<)\, 0$, then the firm hiring a manager coming from the large firm would have lower (higher) outcome volatility and consequently it provides its manager with a higher-powered (lower-powered) contract than the other firm hiring a manager coming from the small firm would.

Since our empirical estimation set out in Table 4 below shows that $\gamma_g - \gamma_h > 0$ for all market and accounting productivity measures, irrespective of whether all CEOs are included or the two sized-based samples, the model predicts that the contract sensitivity for the manager who moves from one large firm to another, or for that that matter stays in a large firm, will have higher contract sensitivity than the manager who moves from a small firm to a large firm. There is only a relatively small sample of 125 CEO movers out of nearly 20,000 productivity year observations. We regress the change in $\hat{\beta}_{t-1}^{ki}$ sensitivity for the new hire relative to the incumbent on the difference between the firm size of the new hire relative to the incumbent for our sample of movers. As predicted, the sign is negative with a significant *t*-value of 1.86 at about the 6% level and an R2 of 2.73%.

3.2 Pay and Firm Size: Labor Market Equilibrium

In this section, we examine relationships between expected executive pay and firm size over the two contracting periods. As can be inferred from the form of the salary function in equation (5), the main issue in computing the expected executive pay is to understand how the executive reservation certainty-equivalent wealth level $W_1^{\hat{a}}$ is determined. It will be seen that the wealth level can depend on labor market competition for agents which is based on each agent's ability estimated from his past performance. In the labor market, each firm assesses each agent's ability given his past performance, and makes a job offer. Then, he chooses from job offers by the two firms. As a consequence, the agent's certainty reservation wealth is competitively determined.

For this, we model labor market competition between the two firms as follows. At time 0, agent a works for firm S, and agent b works for firm L. Then at time 1, there can be two possible cases: case (SS; LL) where agent a is rehired by firm S, and agent b is also rehired by firm L; and case (SL; LS) where agent a now works for firm L, and agent b now works for firm S.

We define the executive labor market equilibrium as follows. Each firm makes job offers to all agents on a first-come first-served basis. All job offers are structured in the form of equation (5). For example, a job offer made out to agent $\hat{a}$ by firm i is represented by a level of certainty equivalent wealth $W_0^{\hat{a}i}$ with the contract structure given in the form of equation (5). Thus, the two agents $(\hat{a},\hat{b})$ receive job offers $(W_1^{\hat{a}S},W_1^{\hat{b}S})$ from firm S and $(W_1^{\hat{a}L},W_1^{\hat{b}L})$ from firm L. If agent $\hat{a}$ takes the offer by firm S before agent $\hat{b}$ does, then agent $\hat{a}$ enjoys a certainty equivalent wealth level of $W_1^{\hat{a}S}$, and agent $\hat{b}$ is hired by firm L.

It should be clear that each firm would like to hire an agent who would produce an expected profit to the firm at least as great as the other agent would. However, each firm's decision can also affect/be affected by the other firm's decision. We examine the following type of executive labor market equilibrium.

Definition 1: *The executive job market is in equilibrium with agents* $\hat{a}$ *and* $\hat{b}$ *choosing to work for firms S and L, respectively, if job offers* $(W_1^{\hat{a}i}, W_1^{\hat{b}i})$ *to agents* $(\hat{a}, \hat{b})$ *by firm* i *, for* $i = S$ *and* L *, satisfy the following properties.*

(i) (Profit maximization.)

$$W_1^{\hat{a}S} \in \arg\max_W \pi^S(\hat{a}, W) \ \textit{s.t.} \ W \geq W_1^{\hat{a}L} \textit{, and } \pi^S(\hat{a}, W_1^{\hat{a}S}) \geq \max_W \pi^S(\hat{b}, W) \text{ s.t. } W \geq W_1^{\hat{b}L}.$$

$$W_1^{\hat{b}L} \in \arg\max_W \pi^L(\hat{b}, W) \ \textit{s.t.} \ W \geq W_1^{\hat{b}S} \textit{, and } \pi^L(\hat{b}, W_1^{\hat{b}L}) \geq \max_W \pi^L(\hat{a}, W) \text{ s.t. } W \geq W_1^{\hat{a}S}.$$

(ii) (Expected zero profit condition for the small firm.)

$$\pi^S(\hat{a}, W_1^{\hat{a}S}) = \pi^S(\hat{b}, W_1^{\hat{b}L}) = 0.$$

Condition (i) implies that each firm chooses an agent to maximize its expected profit. When the small and large firms hire agents $\hat{a}$ and $\hat{b}$, respectively, condition (i) implies that the small firm makes an offer to agent $\hat{a}$ by matching the offer by the large firm to the same agent such that $W_1^{\hat{a}S} = W_1^{\hat{a}L}$ and $\pi^S(\hat{a}, W_1^{\hat{a}S}) \geq \pi^S(\hat{b}, W_1^{\hat{b}L})$, and similarly that we have $W_1^{\hat{b}L} = W_1^{\hat{b}S}$ and $\pi^L(\hat{b}, W_1^{\hat{b}L}) \geq \pi^L(\hat{a}, W_1^{\hat{a}S})$. Condition (ii) suggests that agents' reservation certainty-equivalent wealth levels are determined by their job opportunities with the small firm, and that the small firm's expected profit is always driven to zero (perhaps by job/product market competition).

The next proposition sheds some light on equilibrium hiring decisions in the second period. First, let us define:

$$\begin{aligned} &A(K^S, K^L; \sigma_{\theta^a}, \sigma_{\theta^b})\left(g(K^L) - g(K^S)\right) \\ &= \left\{\Phi(K^S, K^S, \sigma_{\theta^a}) - \Phi(K^L, K^S, \sigma_{\theta^b}) - \Phi(K^S, K^L, \sigma_{\theta^a}) + \Phi(K^L, K^L, \sigma_{\theta^b})\right\}. \end{aligned}$$

Then $A(K^S, K^L; \sigma_{\theta^a}, \sigma_{\theta^b})\left(g(K^L) - g(K^S)\right)$ measures the comparative advantage of agent *b* over agent *a* in terms of the marginal effort contribution to the large firm's expected profit over that of the small firm. If $A(K^S, K^L; \sigma_{\theta^a}, \sigma_{\theta^b})\left(g(K^L) - g(K^S)\right)$ is positive, agent *b's* marginal effort-contribution to the expected profit of the large firm is relatively larger than that of agent *a*.

Proposition 3: *Suppose that agents a and b are hired for the first period by firms S and L, respectively. If* $E[\theta^a - \theta^b \mid Y_1] \leq (>) A(K^S, K^L; \sigma_{\theta^a}, \sigma_{\theta^b})$*, then in equilibrium, agents a (b) and b(a) are rehired (hired) for the second period by firms,* S *and* L*, respectively, with their second-period reservation certainty equivalent wealth levels given by* $W_1^a = g(K^S)E[\theta^a \mid Y_1^S(a)] + \Phi(K^S, K^S, \sigma_{\theta^a}),$ *and* $W_1^b = g(K^S)E[\theta^b \mid Y_1^L(b)] + \Phi(K^L, K^S, \sigma_{\theta^b}).$

The small-firm manager moves to the large firm in the second period if and only if his expected ability conditional on his first period performance, $E[\theta^a \mid Y_1]$, turns out to be sufficiently large, such that $E[\theta^a \mid Y_1] > E[\theta^b \mid Y_1] + A(K^S, K^L, \sigma_{\theta^a}, \sigma_{\theta^b})$. In this sense, one may view the function *A* as a measure of executive job mobility: a high *A* means a low probability for small-firm managers to move to large firms. In other words, $E[\theta^b - \theta^a \mid Y_1] + A(K^S, K^L, \sigma_{\theta^a}, \sigma_{\theta^b})$ measures the comparative advantage of agent *b* over agent *a* in terms of contributions by both ability and effort to the expected profit of the large firm. Thus, the agent worked for the small firm can be hired by the large firm only when his expected ability level is large enough to get over the large firm manager's comparative advantage.

Unlike the matching literature in which more talented managers are automatically allocated to larger firms, agents hiring/moving decisions in this paper are based not only on perceived/expected ability levels but also on the volatilities of their ability levels due to uncertainty as to what their ability really is, as outcomes of agents' effort depend on both ability levels and their distributions.

3.3 The First-Period Contracting Problem

Agent $\hat{a}$'s, $\hat{a} \in \{a,b\}$, effort choice decision for the first period can be affected by his job market prospects for the second period. Thus, the first-period principal's problem can be stated as follows.

Problem 2: Choose an initial-period pay schedule $S_1^i(\hat{a})$ to maximize expected first-period shareholder profit:[5]

$$E[Y_1^i(\hat{a}) - S_1^i(\hat{a})] \text{, subject to}$$

(1) $Y_1^i(\hat{a}) = e_0^{\hat{a}} f(K^i) + \theta^{\hat{a}} g(K^i) + h(K^i)\varepsilon_1^i$,

(2) $e_1^{\hat{a}} \in \arg\max_{\hat{e}} E\left[-\exp\left\{-r\left(S_1^i(\hat{a}) - c(\hat{e}) + W_1^{\hat{a}}\right)\right\}\right]$,

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[5] Note that at time 0, shareholders' expected profit of the large firm for both periods 1, and 2 is $E[Y_1^L(b) - S_1^L(b) + \pi_1^L(b, W_1^{bL})\chi_A + \pi_1^L(a, W_1^{aL})(1-\chi_A)]$, where $\chi_A(\omega) = 1$ for $\omega \in \left\{\hat{\omega} \in \Omega \mid E[\theta^a - \theta^b \mid Y_1](\hat{\omega}) \le A(K^S, K^L)\right\}$, and $\chi_A(\omega) = 0$, otherwise. Here, Ω is a complete description of all uncertainties in this paper. However, since it can be shown that the second-period profit $E[\pi_1^L(b, W_1^{bL})\chi_A + \pi_1^L(a, W_1^{aL})(1-\chi_A)]$ in equilibrium is independent of the agent's time-0 effort e_0^b , shareholders' optimal decision for the agent's time-0 effort can be computed ignoring the expected second-period profit. Thus, as far as optimal effort decisions are concerned, shareholders are only concerned with maximizing the expected profit from the first period. That is, optimal effort levels maximize $E[Y_1^L(b) - S_1^L(b)]$ subject to appropriate constraints, as stated in Problem 2.

s.t. $Y_1^i(\hat{a}) = \hat{e}f(K^i) + \theta^{\hat{a}}g(K^i) + h(K^i)\varepsilon_1^i$,

(3) $E\left[-\exp\left\{-r\left(S_1^i(j) - c(e_0^{\hat{a}}) + W_1^{\hat{a}}\right)\right\}\right] \geq -\exp\left(-rW_0^{\hat{a}}\right)$.

The main difference between Problems 1 and 2 is that in Problem 1, the agent's first-period wealth consists of not only $S_1^i(\hat{a}) - c(e_0^{\hat{a}})$, direct compensation from the firm net of effort cost, but also $W_1^{\hat{a}}$, the certainty equivalent wealth the agent can expect from the second period contracting. Young agents have career concerns that impact on their choice of their first managerial position.

Without loss of generality, we again assume optimal contracts are linear such that $S_1^i(\hat{a}) = \alpha^i + \beta^i Y_1^i(\hat{a})$ for agent $\hat{a}$ working for firm i.

Proposition 4: *Let firm* $k \in \{\text{S,L}\}$ *hires agent* $\hat{a} \in \{a,b\}$ *at time zero. Then fixed and incentive parameters* $(\alpha^{\hat{a}k}, \beta^{\hat{a}k})$ *for the optimal contract are given as follows:*

$$\begin{aligned}\alpha^{\hat{a}k} &= W_0^{\hat{a}} - \Phi(K^k, K^S, \sigma_{\theta^{\hat{a}}}) + c(\hat{e}^{\hat{a}}) - g(K^S)m_{\theta^{\hat{a}}} - \beta^{\hat{a}k}(\hat{e}^{\hat{a}} f(K^k) + m_{\theta^{\hat{a}}} g(K^k)) \\ &\quad + \frac{r}{2}(\beta^{\hat{a}k} + g(K^S)p^{\hat{a}k})^2\left(\sigma_{\theta^{\hat{a}}}^2 g^2(K^k) + \sigma^2 h^2(K^k)\right).\end{aligned} \tag{9}$$

$$\begin{aligned}\beta^{\hat{a}k} &= \frac{c'(e)}{f^k} - g(K^S)p^{\hat{a}k} \\ &= \frac{1}{1 + r\kappa\left(K^k\right)^{-2\gamma_f}\left(\sigma_{\theta^{\hat{a}}}^2 (K^k)^{2\gamma_g} + \sigma^2 (K^k)^{2\gamma_h}\right)} - \frac{\sigma_{\theta^{\hat{a}}}^2 (K^k K^S)^{\gamma_g}}{\sigma_{\theta^{\hat{a}}}^2 (K^k)^{2\gamma_g} + \sigma^2 (K^k)^{2\gamma_h}}\end{aligned} \tag{10}$$

Thus, the expected compensation to the agent is

$$E[S^k(Y_1^k)] = W_0^{\hat{a}} - \Phi(K^k, K^S, \sigma_{\theta^{\hat{a}}}) - g(K^S)m_{\theta^{\hat{a}}} + \Psi(K^k, \sigma_{\theta^{\hat{a}}}) \tag{11}$$

and the expected profit of firm *k* hiring agent $\hat{a}$ is

$$E[Y_1^k - S^k] = m_{\theta^{\hat{a}}}\left(g(K^k) + g(K^S)\right) - W_0^{\hat{a}} + \Phi(K^k, K^S, \sigma_{\theta^{\hat{a}}}) + \Psi\left(K^k, \sigma_{\theta^{\hat{a}}}\right), \tag{12}$$

where initial certainty equivalent wealth:

$$W_0^{\hat{a}} = 2m_{\theta^{\hat{a}}} g(K^S) + \Psi(K^S, \sigma_{\theta^{\hat{a}}}) + \Phi(K^S, K^S, \sigma_{\theta^{\hat{a}}}),$$

and $$\Psi\left(K^k, \sigma_{\theta^{\hat{a}}}\right) = \frac{1}{2} \frac{1}{\kappa (K^k)^{-2\gamma_f} + r\kappa^2 \left(K^k\right)^{-4\gamma_f} \left(\sigma_{\theta^{\hat{a}}}^2 (K^k)^{2\gamma_g} + \sigma^2 (K^k)^{2\gamma_h}\right)}.$$

Recall that in the second period, there is no future career concern problems and the contract sensitivity is the marginal cost of effort per marginal expected output, $\frac{c'(e)}{f^k}$. However, Proposition 4 also implies that, in the first-period contracting, the sensitivity is adjusted for the agent's career concern by product of the scale term for ability in the small firm and the updating talent regression slope coefficient, i.e., $g(K^S)p^k$. That is, in the first period, the contract sensitivity does not have to be equal to the marginal cost of effort per marginal expected output, because the agent has already built-in (implicit) incentives to work even without an explicit incentive contract. This kind of adjustment is well-known. See Gibbons and Murphy (1992).

Proposition 4 also implies that the expected pay differential between large and small firms is made up of the following two components:

$$E[S_1^L] - E[S_1^S] = \underbrace{W_0^b - W_0^a - E\left[W_1^b - W_1^a\right]}_{\text{current period reservation wealth differential}} + \underbrace{\Psi(K^L, \sigma_{\theta^b}) - \Psi(K^S, \sigma_{\theta^a})}_{\text{effort production differential}}. \quad (13)$$

Note that the current period certainty equivalent reservation wealth is $W_0^{\hat{a}} - E\left[W_1^{\hat{a}}\right]$, that is, the certainty equivalent wealth for the agent's lifetime career (over the two periods) minus the expected future certainty equivalent wealth. Representing the difference in negotiating power between two agents in the labor market, the current period reservation certainty equivalent differential has the following structure:

$$W_0^b - W_0^a - E\left[W_1^b - W_1^a\right] = \underbrace{(m_{\theta^b} - m_{\theta^a})g(K^S)}_{\text{ability differential}} + \underbrace{\Psi(K^S,\sigma_{\theta^b}) - \Psi(K^S,\sigma_{\theta^a})}_{\substack{\text{effort production differential}\\ \text{to the small firm}}}$$
$$+\underbrace{\Phi(K^S,K^S,\sigma_{\theta^b}) - \Phi(K^L,K^S,\sigma_{\theta^b})}_{\substack{\text{compensation for disadvantages}\\ \text{in furure job market}}} \qquad (14)$$

This structure tells us that sources of negotiating power lie in expected ability, the volatility of ability, and disadvantages/advantages of working for the large firm in the future job market.

To sum up, the sources of the difference in pay size between executives of large and small firms are (1) the ability production differential had each agent worked for the small firm (reference firm), (2) the effort production differential had each agent worker for the small firm, (3) compensation for disadvantages the large-firm executive may experience in future executive labor markets, and (4) the actual effort production differential between the large and small firm. By contrast, in Edmans, Gabaix and Landier (2007) pay differentials are entirely determined by talent/ability differentials. In this paper, the talent differential is just one of many sources of the difference in pay size. In particular, if $\gamma_g < \gamma_h$, disadvantages suggested in the third source can occur, as the volatility of updated expectation of executive ability level after the first period will be higher for the large-firm executive, because dollar-return from production is more volatile for the large firm than it is for the small firm. That is, the large-firm profit outcome in the initial period provides a weaker signal as to agent ability than for the small-firm agent due to the volatility difference. However, if $\gamma_g > \gamma_h$, which is what we observe empirically, then working for the large firm can help send a less noisy signal about his ability to the future job market.

The second differential can increase the pay for the agent working for the large firm if the volatility of the agent's ability is lower than that of the other agent working for the small firm (reference firm), simply because the low volatility can improve effort incentives. However, note that this differential in fact has nothing to do actual improvement of effort incentives, but it is simply added as a consequence of labor market competition in which the small firm bids for the agent with low volatility in ability. On the other hand, the fourth differential is compensation for actual improvement of effort incentives.

Now, we examine effects of firm size on managerial salaries:

Proposition 5: *At time 0, agents a and b are hired by firms S and L, respectively, if and only if*

$$\Delta\pi_0 := (m_{\theta^b} - m_{\theta^a})\left(g(K^L) - g(K^S)\right) + \int_{K^S}^{K^L}\int_{\sigma_{\theta^a}}^{\sigma_{\theta^b}} \Phi_{K^k\sigma_\theta}(K^k, K^S, \sigma_\theta)d\sigma_\theta dK^k$$
$$+\int_{K^S}^{K^L}\int_{\sigma_{\theta^a}}^{\sigma_{\theta^b}} \Psi_{K\sigma_\theta}\left(K, \sigma_\theta\right)d\sigma_\theta dK \geq 0.$$

Remark: The necessary and sufficient condition for Proposition can be alternatively stated as

$$\begin{aligned}\Delta\pi_0 = & \underbrace{(m_{\theta^b} - m_{\theta^a})\left(g(K^L) - g(K^S)\right)}_{\text{talent contribution differential}} \\ & \underbrace{+\Phi(K^S, K^S, \sigma_{\theta^a}) - \Phi(K^S, K^S, \sigma_{\theta^b}) + \Psi\left(K^S, \sigma_{\theta^a}\right) - \Psi\left(K^S, \sigma_{\theta^b}\right)}_{\text{reservation CEO wealth differential}} \\ & + \underbrace{\Phi(K^L, K^S, \sigma_{\theta^b}) - \Phi(K^L, K^S, \sigma_{\theta^a})}_{\text{advantage of working for the large firm in future job market}} \\ & \underbrace{+\Psi\left(K^L, \sigma_{\theta^b}\right) - \Psi\left(K^L, \sigma_{\theta^a}\right)}_{\text{current period effort production differential}} \\ & \geq 0.\end{aligned}$$

Note that this condition can be satisfied if $m_{\theta^b} \geq m_{\theta^a}$, $(\sigma_{\theta^b} - \sigma_{\theta^a})\Psi_{K\sigma_\theta} \geq 0$ and $(\sigma_{\theta^b} - \sigma_{\theta^a})\Phi_{K^k\sigma_\theta} \geq 0$, and also that $sign(\Phi_{K^k\sigma_\theta}) = sign(\gamma_g - \gamma_h)$; and if $\gamma_g \leq 2\gamma_f$ and $2\gamma_h - 2\gamma_f - \gamma_g \leq 0$, then $\Psi_{K^k\sigma_\theta} \leq 0$.

Corollary 1: *If* $m_{\theta^b} \geq m_{\theta^a}$ *, and* $\sigma_{\theta^b} = \sigma_{\theta^a}$ *, then, at time 0, agents a and b are hired by firms S and L, respectively.*

Proposition 5 provides the necessary and sufficient condition under which agent *b* is hired by the large firm. When $\Delta\pi_0 > 0$, the large firm prefers agent *b* to *a*. In the following example, we use empirical data reported in Tables 1 and 4 to see if current CEOs hired by large firms may be justified based on the average ability of such managers.

Example 1: Suppose $K^S = 1{,}026$, $K^L = 25{,}151$, $r = 0.05$, $\kappa = 0.4703$, $m_{\theta^a} = 1.09262$, $m_{\theta^b} = 1.1287$, $\gamma_f = 0.4290$, $\gamma_g = 0.9851$, $\gamma_h = 0.8122$, $\sigma = 0.7567$, $\sigma_{\theta^a} = 0.96633$, and $\sigma_{\theta^b} = 0.4817$. Then $\Delta\pi_0 = 736.22 > 0$, $E[S_1^S] = 1{,}026.44$, and $E[S_1^L] = 1{,}041.27$.

In this example, $\Delta\pi_0 > 0$ which implies that current CEOs of large firms might have been hired because the CEOs of large firms were expected to earn higher net profits to the large firms than CEOs of small firms were. This example is consistent with the popular intuition that CEOs of large firms have on average greater expected talent levels with lower talent volatilities.

However, Proposition 5 and Corollary 1 also allude to the possibility that large firms may not necessarily choose more talented agents, unless the volatilities are the same. Here, we provide a numerical example in which the large firm hires the manager with lower expected talent.

Example 2: Suppose $K^S = 1{,}026$, $K^L = 25{,}151$, $r = 0.05$, $\kappa = 0.01$, $m_{\theta^a} = 1.5$, $m_{\theta^b} = 1.0$, $\gamma_f = 0.4290$, $\gamma_g = 0.9851$, $\gamma_h = 0.8122$, $\sigma = 0.7567$, $\sigma_{\theta^a} = 0.96633$, and $\sigma_{\theta^b} = 0.4817$. Then $\Delta\pi_0 = 4{,}022.83 > 0$, $E[S_1^S] = 19{,}632.76$, and $E[S_1^L] = 37{,}148.43$.

In Example 2, agent *b* is hired by the large firm at time 0, although his expected talent level is lower than that of the other agent. Note however that agent *b*'s talent volatility is lower than that of the other agent, which helps improve work incentives. In this case, agent effort contribution can affect the outcome more than the expected talent differential can, and thus the large firm is more concerned with improving incentives than the talent differential, and consequently hires agent *b*.

The next proposition provides some sufficient conditions under which the agent working for the large firm is expected to be more highly paid than the other agent working for the small firm.

Proposition 6: *Suppose that agents a and b are hired by the small and large firms, respectively. If* $m_{\theta^b} \geq m_{\theta^a}$, $\sigma_{\theta^b} \leq \sigma_{\theta^a}$, $\gamma_g \leq \gamma_h$, *and* $\max[\gamma_g, \gamma_h] < 2\gamma_f$, *and then the first-period expected pay of the large firm manager is higher than that of the small firm.*

Evaluating the inequalities included in Proposition 5 utilizing the estimated elasticity values reported in Table 4 below for all firm sizes and measures, neither inequality is satisfied as $\max[\gamma_g, \gamma_h] > 2\gamma_f$ and $\gamma_g > \gamma_h$. Hence in the first period of the manager's career, we cannot guarantee that the larger firm manager will be paid more in equilibrium than the smaller firm manager.

4. Empirical Implementation

4.1 Model Specification

For empirical estimation purposes, we use equation (10) in Proposition 4 to express the stochastic production function (1) in terms of (at least theoretically) observables as follows:

$$Y_t^i(\hat{a}) \equiv \hat{Y}_t^{i\hat{a}} = \frac{1}{\kappa}\left(\beta_{t-1}^{i\hat{a}} + \left(K_{t-1}^S\right)^{\gamma_g} p_{t-1}^{\hat{a}i}\right) \times \left(K_{t-1}^{i\hat{a}}\right)^{2\gamma_f} + \hat{\theta}^{\hat{a}}(K_{t-1}^{i\hat{a}})^{\gamma_g} + \sigma \times (K_{t-1}^{i\hat{a}})^{\gamma_h} \times \varepsilon_t^i, \quad (15)$$

where $p_{t-1}^{\hat{a}i} = \frac{\sigma_{\theta^{\hat{a}}}^2 (\hat{K}_{t-1}^i)^{\gamma_g}}{\sigma_{\theta^{\hat{a}}}^2 (\hat{K}_{t-1}^i)^{2\gamma_g} + \sigma^2 (\hat{K}_{t-1}^i)^{2\gamma_h}}$, and $\hat{\theta}_t^{\hat{a}} \equiv E[\theta_t^{\hat{a}} \mid Y_{t-1}^k]$ is the expected conditional talent. Note at unobservable effort has been substituted out of the equation and replaced by the incentive contract following the lead of Baker and Hall (2004).

The comprehensive end-of-period wealth measure, $\hat{Y}_t^{i\hat{a}}$, is generated by the stochastic CEO production process with the CEO combining his effort imputable from his opening incentive contract and his talent with the available capital he has to work with given by the opening total value of firm assets, K_{t-1}. Such a comprehensive wealth approach to measuring CEO performance is both recommended and utilized by Baker and Hall (2004) and Gabaix and Landier (2008) on the grounds that the actions of the CEO this period have implications for shareholder and debtholder wealth well into the future, not in just the increment to claimant wealth in the current period.[6]

Observed output $\hat{Y}_t^{i\hat{a}}$ is calculated as firm claimant (shareholder plus debt holder) wealth at the end of period *t* which is additional to the opening value of assets that the manager has at his disposal at the beginning of the period. We separately analyze two sets of wealth measures: the first based on market values and the second on

[6] Note that these authors use essentially the total value of assets at the period end, K_t, as their wealth measure without taking into account net cash distributions to claimants.

accounting values. We begin with the market value method. This is made up of three components. The first component is the total value of the firm's assets at the end of period t funded by both equity and debt, K_t. This is computed as the book value of total assets (item 6 from Compustat) plus the market value of total equity (item 199*(items 25+40)) minus book value of equity (item 60) minus deferred taxes (item 74). To this is added the second component made up of cash distributed as dividends (items 21+19) plus cash distributed to debt-holders (items 15–62). From this must be deducted the third component which is the net value of new shares issued (items108+115) and new debt issued (items 111+114–301). The accounting value method is very similar to the market value method except that now the total book value of assets is simply Compustat Item6. The second and third components are the same. In the absence of new net equity or debt issues, earnings generated by the manager are either retained and thus added to assets or are paid out to claimants.

With respect to our market measure and in keeping with the regression analysis of Gabaix and Landier (2008, Table I), we use the opening market value of total assets as described above for the end of period wealth measure except lagged one period, as the best size proxy for the capital stock measure that is most associated with CEO pay, rather than income or sales that Gabaix and Landier (2008) show are inferior in their ability to explain CEO pay. Our alternate accounting measure is simply the opening *book* value of total assets.

To provide the estimated sensitivity for each year of the executive's career, $\hat{\beta}_{t-1}^{i\hat{a}}$, we use the opening sum of the executive's shareholding, restricted stock and the share-equivalent of the executive's option holdings relative to total shareholdings estimated from the Black-Scholes Delta formula (modified to include dividends).[7] The Black-Scholes values of option holdings are not provided in ExecuComp. They were computed using two different methods. Using the first method an inventory of option holdings was constructed for each CEO based on the ExecuComp data for newly issued options with a given strike price and expiry date. All share prices, shares on issue and stock split data was obtained from ExecuComp for consistency purposes.[8] A four-year escrow period was assumed with one-quarter of the options coming out of escrow each year and is described more fully in Garvey and Swan (2002). Only options most in the money were exercised according to data supplied by ExecuComp.

In addition to this inventory method, a simpler method described by Core and Guay (2002) was also computed and the two sets of results compared. It was found that the two sets of results were quite comparable and the more comprehensive inventory method was chosen in preference. In converting option holdings into share equivalents, attention was paid to the dilutionary effects of option issuance on shares outstanding. ExecuComp has data explicitly on this up until 1994 and was estimated for subsequent years. Perhaps the most significant component of estimated incentive values is shares held privately by the CEO. These are sourced from ExecuComp, either as a percentage of shares outstanding or as shares held. Great care was taken to ensure consistency in these computations using just ExecuComp and Compustat data as share numbers outstanding from CRSP were not always consistent and to remove cases where there were obvious transcription errors in either the share or option data or missing observations.

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[7] For the first year that the CEO appears in the database the sensitivity for that year is employed in lieu of the opening value since the opening value is not available.

[8] For many stocks inconsistencies arose between ExecuComp and CRSP which made it necessary to use the one data source for this purpose.

The manager's effort level implied from the opening incentive contract value, $\beta_{t-1}^{\hat{a}}$, together with his individual (unobservable as such) conditional talent factor, $\hat{\theta}_t^{\hat{a}}$, and stochastic volatility factor, is applied to the opening value of total assets under management given by K_{t-1} to generate the specified end of fiscal year wealth belonging to all claimants.

The CEO tenure with a particular firm is assumed to have a minimum length of one completed financial year and continue until the CEO resigns, retires or dies. Hence an observation on a CEO year's productivity performance is only included for completed years. We adopt as our unit of account each CEO-year but also compute the number of individual years that the CEO heads up an individual firm to form a particular CEO stint for the *i*th firm. The length of an individual tenure, $n^{i\hat{a}}$, varies and is captured as an explanatory variable in the individual pay and CEO income regressions. The superscript $i\,\hat{a}$ refer to the value for each annual observation of the performance of the ith firm and the subscript *t*-1 to the beginning of fiscal year opening value.

We provide direct estimates of the parameters of the non-linear expression (15) in Table 4 below. A problem with the equation is that neither the individual talent factors, $\theta_t^{\hat{a}}$, themselves, nor the conditional expectations, $\hat{\theta}_t^{\hat{a}}$, are directly observable. To overcome this problem we first estimate equation (15) by focusing on the second-period problem (ignoring the first-period problem with a career concern). It is estimated as two separate components. The first component of equation (15) is estimated using non-linear least squares as:

$$\hat{Y}_t^{i\hat{a}} = \frac{\hat{\beta}_{t-1}^{i\hat{a}}}{\kappa}\left(\hat{K}_{t-1}^{i\hat{a}}\right)^{2\gamma_f} + \bar{\hat{\theta}}_t^{\hat{a}}(\hat{K}_{t-1}^{i\hat{a}})^{\gamma_g} + Controls + \xi_t, \qquad (16)$$

where regression coefficient, $\bar{\hat{\theta}}_t^{\hat{a}}$, is the estimated mean conditional talent factor taken over all CEO-years in the sample. Note that all the other terms in equation (15) drop out as the random term ε_t^i is zero in expectation and the career concern (slope) term p^k from equation (4) is set to zero. Controls consist of both two digit Industry Dummies and the length of experience with the firm prior to the CEO appointment if an internal appointment, and ξ_t is the *iid* error term. Year dummies were deliberately excluded to investigate the model's capacity to explain real CEO pay rises over the sample period. However, only one of the industry control dummies was statistically significant in the non-linear least squares estimates but nonetheless generated large coefficients that added to noise and prevented conversion of the non-linear estimation. Hence the values of all industry dummies were set to zero. Note that the parameters of the dollar volatility term in equation (15), σ and γ_h, need to be estimated separately as the term ε_t^i in dollar volatility $\sigma\left(K_{t-1}^{ij}\right)^{\gamma_h}\varepsilon_t^i$, is a standard normal random variable with mean zero. These are estimated via equation (18) below.

Our sample consists of 19,067 career years of CEOs *not* from a regulated industry or an industry with an unusual capital structure. The two-digit codes excluded are 22 (utilities), 52 (finance and insurance), 55 (management of companies and enterprises) or exceeding 90 (public administration). Included CEO years have appeared in S&Ps ExecuComp over the period 1992-2006 with no missing observations and a minimum tenure of a full financial year. ExecuComp includes firms over these periods that have appeared within the top 1500 S&P firms.

All dollar amounts including the value of assets, the firm's total market and accounting income and the CEOs total pay are converted to constant dollars of 2006 using the CPI.

The second (accounting) measure is identical to the first except that the book value of total assets replaces the market value of total assets. Distributions in the form of dividend and interest payments and new cash injections remain as before. Both performance measures are deflated by the estimated average pay-performance sensitivity and then the natural logarithm taken to obtain the dependent variable in regression equation (A4) in the Appendix.

The sample of CEO yearly observations is ranked by size of opening total assets expressed in 2006 dollar values based on the CPI, $K_{t-1}^{i\hat{a}}$, and is split into two equal halves by number of observations, representing large and small firms separately. The sample utilizing market values is also split into CEO years with a positive contribution ($K_t^{i\hat{a}} + \text{Net Cash Dist}_t - K_{t-1}^{i\hat{a}} > 0$) and with a negative contribution.

All productivity and associated data for CEO years based on market performance values are summarized in Table 1 and for accounting values, in Table 2. For space reasons the accounting estimates for the large and small samples separately are not presented. The mean terminal (end of period) wealth level is \$12,962m for the observations on CEO performance for the entire sample in Table 1 and is less than the mean opening value of assets, \$13,088. This nearly doubles for the sample of large firms to \$24,913m and for small firms, only \$1,012m. Hence size is highly skewed. Unsurprisingly, the mean $\hat{\beta}_{t-1}^{i\hat{a}}$ sensitivity coefficient at 0.0381 for small firms is about double that for large firms, 0.0173. Total mean annual pay from ExecuComp for large companies at \$7.8m in 2006 prices is many times higher than for small companies at

$2.3m. Inclusive of income from shares owned by CEOs, mean total CEO income is $33.5m for large companies and $7.9m for small. Note that only 46% of CEO years display positive market performance, generating terminal wealth well in excess of the opening asset value and it is the reverse for the negative performers.

The partial correlation coefficients (in levels) for the entire market-based sample are provided in Table 3. Perhaps the most striking feature of these correlations is the unsurprising 97% correlation between opening and end of year wealth (inclusive of distributions and net of new debt and equity issues). This illustrates the ubiquity of size and largely explains the exceptionally good model fit in Table 4 below for the complete market-based samples. The negative correlation between the incentive sensitivity, $\hat{\beta}_{t-1}^{i\hat{a}}$, and flow pay measure from ExecuComp indicates the tendency for managers with high share ownership to receive less direct (explicit) pay from the board, inclusive of new option grants.

<< INSERT TABLES 1 to 3 ABOUT HERE>>

The non-linear Least Squares CEO productivity regression results in real terms are summarized in Table 4 for the productivity measures based on market and book values and those displaying either positive or negative income, all based on the entire sample, and the large and small sub-samples that have been estimated separately using market productivity only. Starting values for the coefficients were obtained via the estimation of equations (A4) and (A6) in the Appendix. For the positive and negative performer breakdowns the same set of coefficients based on the entire sample have been employed. For the full sample the results show in column 1 for the market-based measure based on explicit incentives only (equation (16)) that the estimated shadow price of effort represented by Kappa at 0.47 is far lower than for large firms, when estimated separately for the large-firm sample, with a value of 3.54 and for small firms, 0.0072, also estimated separately. While this in itself is not surprising as one would expect large firms to be harder and more costly to manage, the magnitude of the difference quite large and should indicate a considerably lower shadow price of effort in smaller companies if we allow shadow prices and technology to differ between the two classes or organization. As far as we are aware, this is the first time that this coefficient has been estimated as Baker and Hall (2004) do not estimate it. They assume a value of one. The low and insignificant Gamma_f estimate for small companies seems anomalous. Hence more attention is paid to the complete and large company samples. In fact, since the estimates for the entire sample control for shadow price and technology effects, we rely largely on these.

<< INSERT TABLE 4 ABOUT HERE>>

For the entire sample using market performance measures, CEO effort productivity increases by 43% for each doubling of firm size (total assets under management) while ability productivity, which can be either positive or negative, increases by a much higher 99%. Thus there are approximately constant returns to scale in talent and this is true for all samples. Large firms have a higher effort-scale sensitivity of 52% when this sample is estimated separately. Perhaps smaller firms are much more "hands on" while larger firms invest more in systems that reap scale economies.

The estimated mean CEO conditional ability level, $\bar{\hat{\theta}}_t^{\hat{a}}$, for the market measure and full sample is 1.18 which is slightly greater than the mean of the predicted values of 1.11 found by treating the estimating equation (16) as an identity (not shown). The non-linear nature of the estimating equation ensures that the estimated and simulated means found by setting the regression residuals to zero will differ at least slightly. The mean estimated conditional ability level for large firms is surprisingly low at 1, rising to 1.65 for small firms but the higher mean talent level for small firms arises because of differences in production function coefficients. While are findings are surprising given the theoretical predictions of Rosen (1982) that the largest firms would necessarily hire the most able managers, we believe ours to be the first estimates for CEOs that do not rely on extreme value theory that automatically assigns the most talented managers to the largest firms. All the estimated coefficients in Table 4 for all firms and large firms are significant at the 1% level irrespective of the use of market or accounting measures.

The slopes of the actual and predicted terminal wealth levels were estimated. They indicate that predicted values are relatively unbiased with close to a 45 degree slope. The R2 for the entire sample is high at 95%, falling to only 34% for small firms.

Computed from the residuals of the estimating equation, conditional talent prediction estimates are constructed for every CEO year and summarized in Table 4. Due to space limitations only the means and standard deviations are reported for the large and small sub-samples separately but not for the entire sample. The pairs of "All Firms", "Positive Wealth Gain" and Negative Wealth Gain" columns all utilize coefficients estimated for the entire sample whereas the remainder is confined to either the large or small firm sample. The predicted conditional mean of talent using the all firm market measure in the first column is 1.13 with a standard deviation of ability of 0.48 when calculated for the large-firm sample, falling to 1.09 for the small firm sample with a much higher standard deviation of talent of 0.97, or almost double. Using the production function estimates obtained with just the large firms results in a mean talent level of 1 with a standard deviation of 0.43. This is very similar to the estimates for the large sample obtained using all CEO-years in the regression. With just the small firms in the regression, and thus different technology, the mean conditional talent level at 1.6 is much higher due to the low contribution of CEO effort but so is the standard deviation at 1.37. Once again, the same pattern of not too dissimilar predicted mean ability levels for the large and small firm samples but a much tighter distribution of talent for the large firm samples can be seen in both the positive and negative performer samples. Within every large sample estimate the distribution of talent remains volatile even though less so than in the small firm sample.

Hence, contrary to the Gabaix and Landier (2008) estimates that found negligible differences in ability levels from the CEO in their median company, number 250, in size and number one, we find a remarkable diversity in CEO talent as measured by *ex post* performance. These findings are consistent with our model in which the CEOs own *ex ante* ability may be unknown even to himself and where in the marketplace for CEOs it is possible that more capable managers are priced out of the market within the group of large companies. Within the context of our model the tighter distribution from which CEOs of large companies are drawn is consistent with the far greater predictability of performance for large-company CEOs and their far higher pay.

In column 2 of Table 4 we provide estimates inclusive of period 2 career concerns relevant for agents that are not yet at the end of their careers. The slope term $p^{\hat{a}i}$ cannot be computed for each CEO as we do not know the distribution of talent prior to estimation. However, the average value can be estimated as follows: CEOs who were rehired in smaller firms from their current firm (empirically large) moved to an average firm size of $\hat{K}_{t-1}^{S}$ = \$12,437.7m in equation (15), yielding a slightly modified version of equation (16) above given by:

$$\hat{Y}_t^{i\hat{a}} = \frac{1}{\kappa}\left(\beta_{t-1}^{i\hat{a}} + \left(K_{t-1}^{S}\right)^{\gamma_g} \overline{p}\right) \times \left(K_{t-1}^{i\hat{a}}\right)^{2\gamma_f} + \overline{\hat{\theta}}^{\hat{a}} (K_{t-1}^{i\hat{a}})^{\gamma_g} + Controls + \xi_t, \quad (17)$$

which crudely takes into account career concerns by having a uniform talent updating slope term $p_{t-1}^{\hat{a}i} \equiv \overline{p}$ which according to the theory should be CEO-specific but cannot be observed. It converges to $\overline{p} =$ 0.000058. Consequently, the estimated impact of career concerns, once the size of the firm relevant for movers is taken into account, is very large relative to the average size of the incentive term, $\beta_{t-1}^{i\hat{a}}$ and is thus not realistic. With the inclusion of career concerns in the estimated equation it has the effect of raising the estimated Kappa coefficient by over ten fold which indicates a higher shadow price of effort and thus a smaller role for explicit incentives as was anticipated and also greater scale economies in effort (higher Gamma_f). Apart from these changes, the other alterations are quite small.

The partial correlation matrix provided by Table 3 above shows that predicted conditional talent is positively and quite strongly correlated with end-of-period market wealth, total pay, and particularly total CEO income, but is negatively correlated with CEO equity-based incentives (Beta), and particularly CEO age. Younger CEOs appear to be more talented and will naturally also be more concerned about their future career. Within the entire market-based sample there is a slight positive correlation with size (total assets) consistent with the higher mean talent level for large firm managers.

To obtain the third element in the production function, observations on average dollar volatility of the firm during each CEO year are used to estimate the elasticity of the stochastic production function with respect to volatility:

$$ln\left(CEO \text{ year dollar volatility}_t\right) = ln\left(\sigma\right) + \gamma_h ln\left(K_{t-1}^{i\hat{a}}\right) + \varepsilon_t^i, \quad (18)$$

utilizing the original 19,067 observations and the split samples of large and small firms that form the basis of the equation (18) estimates. These regression results are summarized in Table 4 above, along with the other coefficients of the stochastic production function. The results indicate that productivity is extremely sensitive to share price volatility with the scale elasticity ranging between 84 percent for the sample of large firms based on market values and as low as 50 percent for small firms based on accounting values. The summary sigma constant measure ranges from a low of 0.6 for large firms to 9.7 for small firms based on accounting values.

The next question to be addressed is how total CEO pay responds to both increases in total assets under management and to conditional talent differences. While it is well-established that CEO pay is higher in larger companies, we are not aware of studies showing the responsiveness of pay to differences in talent levels. To address these questions the log of ability, size, volatility and other variables are regressed on the log of a comprehensive measure of fiscal year CEO total (flow) pay sourced from ExecuComp in constant 2006 dollars:

$$\begin{aligned} &ln\left(\text{Ttl py}_t\right) = ln\left(\text{Fix py}\right) + \rho_\theta ln\left(\hat{\theta}_t^{\hat{a}}\right) + \rho_\beta ln\left(\beta^{i\hat{a}}\right) + \rho_K ln\left(K_{t-1}^{i\hat{a}}\right) + \rho_\sigma ln\left(\text{Dol Vol}_t\right) \\ &+\rho_{yrs\ off} ln\left(Car\ lth_{it}\right) + \rho_{\text{pre}\ CEO}\, ln\left(\text{Exp}\right) + \rho_{CEO\ Dual} Dum_{Dual\ t} + Res\ Dum_t + Cont_t + \varepsilon_t \end{aligned} \quad ,(19)$$

where ln is the natural logarithm, ρ_θ is the elasticity with respect to ability, ρ_K is the elasticity of pay with respect to the opening value of total assets under management, ρ_σ the elasticity with respect to the risk born by the manager (dollar volatility), $\rho_{years\ in\ office}$ is the elasticity of the length of the CEO tenure stint with the *i*th firm, $\rho_{\text{pre CEO experience}}$ is the elasticity with respect to years with the firm prior to appointment as CEO, and $\rho_{\text{CEO duality}}$ the impact of CEO-Chair duality. Experience with the firm prior to appointment was included when ExecuComp records such information so as to examine the role of firm-specific experience and the existence of internal CEO selection tournaments in setting CEO pay. Otherwise, it is assumed that the CEO was hired either externally or with little firm-specific knowledge prior to assuming the role.

Since the predicted conditional talent levels include negative values and thus prevent the estimation of elasticity measures, the estimates were normalized with a mean of zero and standard deviation of unity. The distribution was then shifted to the right to ensure that all conditional talent estimates are positive prior to taking logs. A comprehensive measure of total pay from ExecuComp is used. Pay consists of salary plus bonus plus long-term incentive plan plus the value of new options and restricted stock allocated. Additional controls consist of two-digit industry dummies (not shown). Year dummies were deliberately excluded so as to be able to examine the capacity of the modeling to predict rising real pay levels over the sample period. The results are summarized in Table 5.

<< INSERT TABLE 5 ABOUT HERE>>

The impact of the estimated talent for each CEO year in elasticity form on pay is shown in the second row of the Table. These impact estimates range from 30% for all firms to 110% for firms with positive income utilizing the accounting productivity measure and 18% for large firms based on market productivity. This indicates that CEOs employed by firms with positive performance capture over 67% their exceptional talent in the form of higher pay. By contrast, for negative performers the relationship is insignificant indicating the absence of penalty for poor performance. This would indicate that incentive contracts treat negative performance as having a component of bad luck with less severe penalties in place which is more conducive to risk-taking. The elasticity of pay with respect to the incentive share, $\hat{\beta}_{t-1}^{i\hat{a}}$, is negative across the board. This indicates that CEOs are penalized by the board in terms of flow incentives when they possess stock incentives, either shares or the share equivalents of option holdings. Hence they are seen as substitutes by the board.

For all firms based on the market measure the elasticity with respect to total assets is 29% and lower at 25% for large firms and thus fairly consistent with the literature but is on the low side. This is to be expected because in our regressions managerial talent is held constant. Accounting measures produce slightly lower estimates of around 20% and for firms with positive market performance the rate is 31%. The risk borne by the CEO is captured by the inclusion of the stock dollar volatility term, as indicated by the inclusion of risk in the pay schedule, equation (5) above. In the market-based regressions it has typically an elasticity of approximately 16% but is higher at around 28% based on accounting measures. Years in office is significantly rewarded with a relatively small positive elasticity of around 9% for additional years in office. When the influence of career concerns on pay levels is taken into account in column 2, the differences are quite small.

The elasticity estimates for years of experience with the firm prior to CEO appointment indicate that external appointees are paid more and that this experience is not rewarded. In fact, it is penalized with an elasticity of around 5%. The fact that pay falls with internal seniority casts doubt on the efficacy of internal tournaments for promotion to CEO (see, for example, Rosen (1981)). CEOs who accept the dual role of board chair typically receive about 11.5% higher pay. However, for positive performers it is 8.5% and for negative, 13.6%, indicating some evidence that poor performers with influence pay themselves relatively more. Hence, this finding provides at least some support for rent-seeking arguments along the lines of Bebchuk and Fried (2004). Finally, CEOs who die in office are paid at a much lower rate but Table 6 below reveals that talented managers who die in office have exceptionally high income. This is probably because older managers are more likely to own shares and, consequently, to receive less direct pay given evidence of substitutability.

In Table 6 the same model as in Table 5 is used to explain total CEO income inclusive of share, and share equivalent of option holdings, ownership. The estimated pay sensitivity $\beta_{t-1}^{\hat{a}}$, CEO income share times the change in the firm's market value, is added to the ExecuComp flow pay estimate used in Table 5 to obtain estimates of the CEOs total income inclusive of incentives. Since firms experiencing negative shareholder income can result in overall negative CEO income, this turns out to be the case for several thousand CEO-years. The same log specification as in equation (19) was utilized to explain CEO income, requiring that negative observations be dropped.

Comparing Table 6 with Table 5, it is apparent that CEO conditional talent plays a much more important role in rewarding CEOs using a comprehensive income measure relative to the simple pay measure. For the entire sample using the market measure the sensitivity of income to talent is now much higher at 87%, rising to 185% for positive performers. Thus while the $\beta_{t-1}^{\hat{a}}$ sensitivity measure tends to be small for CEOs of large firms, it especially rewards talented managers. Once again, the sensitivity of non-performers income to talent is quite low and is in fact reversed in sign for both measures. The sensitivity of income to $\beta_{t-1}^{\hat{a}}$ is, naturally, positive with a typical elasticity of around 22%, rising to 29% for positive performers. However, the lower level of penalties for negative performers may be due to the truncation of negative

CEO income at zero. The asset under management elasticity is low at 14% based on market productivity. Perhaps the most surprising finding is the high exposure of income to risk. For the overall sample it is 37%, rising as high as 56% for small firms and the accounting measure. This indicates once again that CEOs require much higher expected pay for bearing firm-specific risk due to high diversification costs.

<< INSERT TABLE 6 ABOUT HERE>>

Table 7 reports results indicating the ability of the CEO panel pay model summarized in Table 5 to explain the growth in real pay levels over the sample period. The actual mean pay, number of annual observations for market-based and accounting-based predictions and the corresponding estimates for the five categories of estimates are set out for each of eight sample years. For the overall category, the actual pay increased by 117% from 1993 to 2005 in real terms. The base year is 1993 instead of 1992 due to the small number of observations in the commencement year. Moreover, 2005 is chosen instead of 2006 because the very high average pay in 2006 seems anomalous. Predicted pay increased by 50% whereas actual pay increased by 115%. Since there are no year or time dummies involved, the predicted rise is entirely due to explicable economic factors. Table 8 shows that these factors are firm size and risk (dollar volatility). For the 500 largest companies, firm size has increased by 108% and dollar volatility by 187%.

<< INSERT TABLES 7 AND 8 ABOUT HERE>>

5. Conclusions

Our modeling shows that when it is sufficiently productive, the large firm expectedly pays higher salary than the small firm. (See Proposition 5). In a managerial assignment world with CEO talent common knowledge, it can be socially optimal that large firms (or firms with better production technologies) hire managers with high abilities. Thus, it is conventionally argued that there should be a positive relationship between pay and firm size because large firms hire high ability managers who deserve high pay. However, in an agency world, a large firm (with better production technology) may not always be willing to hire a high (expected) ability manager, partly because most ability rent belongs to the agent in labor market competition and partly because salaries are affected by both the agent expected ability and its volatility. We argue that even when a large firm hires a low-ability manager, the expected pay for the low ability manager can be higher than that for a high-ability manager who is hired by a small firm, if the large firm's productivity and the firm size are sufficiently higher and larger than those of the small firm. We find that, indeed, CEOs in large firms are paid a lot more than in small firms but on average have only slightly higher conditional talent. More importantly, CEOs in large firms have much higher talent risk-adjusted ability as ability dispersion is lower than for small firms.

We also find that unlike Jensen and Murphy (1990) or Baker and Hall (2004), one may not claim a negative relationship between the sensitivity and the firm size as problematic without looking at relative productivities across firms. When we check these estimated productivities we find, indeed, that the sensitivity relationship with firm size is optimally negative in equilibrium. Schaefer (1998) found that the pay-performance sensitivity is inversely proportional to the square root of firm size.

We analyze managerial career paths which can also affect the contract sensitivity. Since we find that managerial ability contribution increases faster than the total market productivity volatility as the firm size increases, we expect that a manager who previously worked for a large firm will be given a contract with a higher sensitivity than a manager who previously worked for a small firm. We find significant statistical support for this hypothesis.

Finally, we present a number of new and surprising empirical results that indicate there is some degree of alignment between CEO productivity with respect to scale and CEO pay. A noteworthy aspect of our findings is that while talented high-performing CEOs are financially rewarded, poorly performing CEOs do not seem to be penalized.

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APPENDIX

Proofs

Proof of Proposition 1:Note that the sign of the performance sensitivity with respect to firm size:

$$sign\left(\frac{\partial}{\partial K^i}\left(\frac{\kappa\hat{e}}{(K^i)^{\gamma_f}}\right)\right) = -sign\left(\frac{(\gamma_g-\gamma_f)(K^i)^{2(\gamma_g-\gamma_f)-1}\sigma_\theta^2}{\sigma_\theta^2(K^k)^{2(\gamma_g-\gamma_h)}+\sigma^2} + (\gamma_h-\gamma_f)(K^i)^{2(\gamma_h-\gamma_f)-1}\right)$$

$$= -sign\left(\frac{(\gamma_g-\gamma_f)(K^i)^{2(\gamma_g-\gamma_h)}\sigma_\theta^2}{\sigma_\theta^2(K^k)^{2(\gamma_g-\gamma_h)}+\sigma^2} + (\gamma_h-\gamma_f)\right)$$

$$= -sign\left((\gamma_g+\gamma_h-2\gamma_f)-(\gamma_g-\gamma_f)\frac{\sigma^2}{\sigma_\theta^2(K^k)^{2(\gamma_g-\gamma_h)}+\sigma^2}\right).$$

This quantity is $<\ 0$ if $\gamma_h-\gamma_f\ \geq\ \gamma_f-\gamma_g>0$, and $>\ 0$ if $0<\gamma_g-\gamma_f\ \leq\ \gamma_f-\gamma_h$.

The rest of the statement of the proposition is obvious. □

Proof of Proposition 2: Let

$$\beta(K^k, K^i, \sigma_{\theta^{\hat{a}}}) = \frac{1}{1+r\kappa\sigma^2\left(\frac{(K^i)^{2(\gamma_g-\gamma_f)}\sigma_{\theta^{\hat{a}}}^2}{\sigma_{\theta^{\hat{a}}}^2(K^k)^{2(\gamma_g-\gamma_h)}+\sigma^2} + (K^i)^{2(\gamma_h-\gamma_f)}\right)}$$

Then, we have

$$\beta(K^L, K^i, \sigma_{\theta^b}) - \beta(K^S, K^i, \sigma_{\theta^a})$$
$$= \int_{K^S}^{K^L}\frac{\partial}{\partial K^k}\beta(K^k, K^i, \sigma_{\theta^b})dK^k + \int_{\sigma_{\theta^a}}^{\sigma_{\theta^b}}\frac{\partial}{\partial\sigma_\theta}\beta(K^S, K^i, \sigma_\theta)d\sigma_\theta.$$

Since $sign\left(\partial\beta/\partial K^k\right) = sign(\gamma_g-\gamma_h)$, and $\frac{\partial\beta}{\partial\sigma_\theta}<0$, if $\gamma_g-\gamma_h\geq 0$ and $\sigma_{\theta^b}<\sigma_{\theta^a}$, then $\beta(K^L, K^i, \sigma_{\theta^b}) - \beta(K^S, K^i, \sigma_{\theta^a})>0$; and if $\gamma_g-\gamma_h\leq 0$ and $\sigma_{\theta^b}>\sigma_{\theta^a}$, then $\beta(K^L, K^i, \sigma_{\theta^b}) - \beta(K^S, K^i, \sigma_{\theta^a})<0$. □

Proof of Proposition 3: Suppose that $\hat{a}$ and $\hat{b}$ are hired for the second period by the small and large firms, respectively. Then, by condition (i), we have $\pi^S(\hat{a},W_1^{\hat{a}S}) \geq \pi^S(\hat{b},W_1^{\hat{b}L})$. Thus,

$$g(K^S)E[\theta^{\hat{a}} \mid Y_1] + \Phi(K^{k_{\hat{a}}},K^S,\sigma_{\theta^{\hat{a}}}) - W_1^{\hat{a}S} \geq g(K^S)E[\theta^{\hat{b}} \mid Y_1] + \Phi(K^{k_{\hat{b}}},K^S,\sigma_{\theta^{\hat{b}}}) - W_1^{\hat{b}L},$$
$$g(K^S)E[\theta^{\hat{a}} - \theta^{\hat{b}} \mid Y_1] + \Phi(K^{k_{\hat{a}}},K^S,\sigma_{\theta^{\hat{a}}}) - \Phi(K^{k_{\hat{b}}},K^S,\sigma_{\theta^{\hat{b}}}) \geq W_1^{\hat{a}S} - W_1^{\hat{b}L}.$$

We also have:

$$\pi^L(\hat{b},W_1^{\hat{b}L}) \geq \pi^L(\hat{a},W_1^{\hat{a}S}),$$
$$g(K^L)E[\theta^{\hat{b}} \mid Y_1] + \Phi(K^{k_{\hat{b}}},K^L,\sigma_{\theta^{\hat{b}}}) - W_1^{\hat{b}L} \geq g(K^L)E[\theta^{\hat{a}} \mid Y_1] + \Phi(K^{k_{\hat{a}}},K^L,\sigma_{\theta^{\hat{a}}}) - W_1^{\hat{a}S},$$
$$W_1^{\hat{a}S} - W_1^{\hat{b}L} \geq g(K^L)E[\theta^{\hat{a}} - \theta^{\hat{b}} \mid Y_1] + \Phi(K^{k_{\hat{a}}},K^L,\sigma_{\theta^{\hat{a}}}) - \Phi(K^{k_{\hat{b}}},K^L,\sigma_{\theta^{\hat{b}}}),$$

Combining the above inequalities, we have:

$$g(K^S)E[\theta^{\hat{a}} - \theta^{\hat{b}} \mid Y_1] + \Phi(K^{k_{\hat{a}}},K^S,\sigma_{\theta^{\hat{a}}}) - \Phi(K^{k_{\hat{b}}},K^S,\sigma_{\theta^{\hat{b}}}) \geq W_1^{\hat{a}S} - W_1^{\hat{b}L}$$
$$\geq g(K^L)E[\theta^{\hat{a}} - \theta^{\hat{b}} \mid Y_1] + \Phi(K^{k_{\hat{a}}},K^L,\sigma_{\theta^{\hat{a}}}) - \Phi(K^{k_{\hat{b}}},K^L,\sigma_{\theta^{\hat{b}}}),$$

that is,

$$\left(g(K^L) - g(K^S)\right)E[\theta^{\hat{a}} - \theta^{\hat{b}} \mid Y_1]$$
$$\leq \Phi(K^{k_{\hat{a}}},K^S,\sigma_{\theta^{\hat{a}}}) - \Phi(K^{k_{\hat{b}}},K^S,\sigma_{\theta^{\hat{b}}}) - \Phi(K^{k_{\hat{a}}},K^L,\sigma_{\theta^{\hat{a}}}) + \Phi(K^{k_{\hat{b}}},K^L,\sigma_{\theta^{\hat{b}}}).$$

If $(\hat{a},\hat{b}) = (a,b)$, then the above inequality implies

$E[\theta^a - \theta^b \mid Y_1] \leq A(K^S,K^L;\sigma_{\theta^a},\sigma_{\theta^b})$.

If $(\hat{a},\hat{b}) = (b,a)$, then the same inequality implies

$E[\theta^a - \theta^b \mid Y_1] \geq A(K^S,K^L;\sigma_{\theta^a},\sigma_{\theta^b})$.

On the other hand, by the zero profit condition for the small firm in the definition of equilibrium in the executive labor market, reservation certainty equivalent wealth levels $(W_1^{\hat{a}S},W_1^{\hat{a}L})$ are determined as follows:

$\pi^S(\hat{a},W_1^{\hat{a}S}) = 0,$ and $\pi^S(\hat{b},W_1^{\hat{b}L}) = 0.$ That is,

$$\pi^S(\hat{a},W_1^{\hat{a}S}) = g(K^S)E[\theta^{\hat{a}} \mid Y_1^{k_{\hat{a}}}(\hat{a})] + \Phi(K^{k_{\hat{a}}},K^S,\sigma_{\theta^{\hat{a}}}) - W_1^{\hat{a}S} = 0,$$
$$\pi^S(\hat{b},W_1^{\hat{b}L}) = g(K^S)E[\theta^{\hat{b}} \mid Y_1^{k_{\hat{b}}}(\hat{b})] + \Phi(K^{k_{\hat{b}}},K^S,\sigma_{\theta^{\hat{b}}}) - W_1^{\hat{b}L} = 0.$$

Therefore, the assertion of the proposition follows. □

Proof of Proposition 4: Suppose that at time 0, agent $\hat{a}$ is hired by firm *k*. Then by Proposition 3, we know that agent $\hat{a}$ will move to firm *i* (=*S*,*L*) for the second period with a certainty equivalent wealth of $W_1^{\hat{a}}(=g(K^S)E[\theta^{\hat{a}} \mid Y_1^k(\hat{a})]+\Phi(K^k,K^S,\sigma_{\theta^{\hat{a}}}))$. Note that $W_1^{\hat{a}}$ is unaffected by the agent's choice of a firm to join for the second period. Then, given contract $S_1^k(\hat{a})=\alpha^{\hat{a}k}+\beta^{\hat{a}k}Y_1^k(\hat{a})$, the agent's expected utility at time 0 is:

$$
\begin{aligned}
&E\left[-\exp\left\{-r\left(S_1^k(\hat{a})-c(\hat{e})+W_1^{\hat{a}k}\right)\right\}\right]\\
&=E\left[-\exp\left\{-r\left(\alpha^{\hat{a}k}+\beta^{\hat{a}k}Y_1^k(\hat{a})-c(\hat{e})+g(K^S)E[\theta^{\hat{a}} \mid Y_1^k(\hat{a})]+\Phi(K^k,K^S,\sigma_{\theta^{\hat{a}}})\right)\right\}\right]\\
&=E\left[-\exp\left\{-r\begin{pmatrix}\alpha^{\hat{a}k}+\Phi(K^k,K^S,\sigma_{\theta^{\hat{a}}})-c(\hat{e})\\ +g(K^S)\left(m_{\theta^{\hat{a}}}-p^k\overline{e}f(K^k)-p^k m_{\theta^{\hat{a}}}g(K^k)\right)\\ +(\beta^{\hat{a}k}+g(K^S)p^k)Y_1^k(\hat{a})\end{pmatrix}\right\}\right]\\
&=-\exp\left\{-r\begin{pmatrix}\alpha^{\hat{a}k}+\Phi(K^k,K^S,\sigma_{\theta^{\hat{a}}})-c(\hat{e})\\ +g(K^S)\left(m_{\theta^{\hat{a}}}-p^k\overline{e}f(K^k)-p^k m_{\theta^{\hat{a}}}g(K^k)\right)\\ +(\beta^{\hat{a}k}+g(K^S)p^k)(\hat{e}f(K^k)+m_{\theta^{\hat{a}}}g(K^k))\\ -\frac{r}{2}(\beta^{\hat{a}k}+g(K^S)p^k)^2\left(\sigma_{\theta^{\hat{a}}}^2 g^2(K^k)+\sigma^2h^2(K^k)\right)\end{pmatrix}\right\} \qquad \text{(A2)}\\
&=-\exp(-rW_0^{\hat{a}})
\end{aligned}
$$

By the FOC with respect to effort level *e*, we have first-period pay sensitivity of:

$$\beta^{\hat{a}k}=\frac{c'(e)}{f^k}-g(K^S)p^k.$$

Note that in equilibrium, $\hat{e}=\overline{e}$, and thus the definition of $W_0^{\hat{a}}$ in equation (A2) implies equation (9).

Thus, first-period expected pay is:

$$E[S^k(Y_1^k)]=W_0^{\hat{a}}-\Phi(K^k,K^S,\sigma_{\theta^{\hat{a}}})+c(\hat{e})-g(K^S)m_{\theta^{\hat{a}}}+\frac{r}{2}\left(\sigma_{\theta^{\hat{a}}}^2 g^2(K^k)+\sigma^2h^2(K^k)\right)\left(\frac{c'(e)}{f^k}\right)^2,$$

and the expected profit to firm *i* for the first period is:

$$
\begin{aligned}
E[Y_1^k-S_1^k]=&\,ef(K^k)+m_{\theta^{\hat{a}}}\left(g(K^k)+g(K^S)\right)-W_0^{\hat{a}}+\Phi(K^k,K^S,\sigma_{\theta^{\hat{a}}})\\
&-c(\hat{e})-\frac{r}{2}\left(\sigma_{\theta^{\hat{a}}}^2 g^2(K^k)+\sigma^2h^2(K^k)\right)\left(\frac{c'(e)}{f^k}\right)^2. \qquad \text{(A3)}
\end{aligned}
$$

Then the FOC with respect to effort *e* for firm *i* to maximize expected profit implies:

$$\frac{\kappa e}{\left(K^k\right)^{\gamma_f}}=\frac{1}{1+r\kappa\left(K^k\right)^{-2\gamma_f}\left(\sigma_{\theta^{\hat{a}}}^2\left(K^k\right)^{2\gamma_g}+\sigma^2\left(K^k\right)^{2\gamma_h}\right)}.$$

Thus, the sensitivity of the contract at time 0 becomes as stated in (10), and the expected compensation as in (11).

On the other hand, by Definition 1-(ii), the equilibrium certainty equivalent wealth of agent $\hat{a}$ is $W_0^{\hat{a}}=2m_{\theta^{\hat{a}}}g(K^S)+\Phi(K^S,K^S,\sigma_{\theta^{\hat{a}}})+\Psi(K^S,\sigma_{\theta^{\hat{a}}})$. Thus by substituting this certainty equivalent wealth and the FOC back into equation (A3), we have equation (12). □

Proof of Proposition 5: If agent $\hat{a}$ ($\in\{a,b\}$) were hired by the small firm, Proposition 4 implies the net profit to the firm would be as follows:

$$E[Y_1^S-S^S(\hat{a})]=m_{\theta^{\hat{a}}}\left(g(K^S)+g(K^S)\right)-W_0^{\hat{a}}+\Phi(K^S,K^S,\sigma_{\theta^{\hat{a}}})+\Psi\left(K^S,\sigma_{\theta^{\hat{a}}}\right).$$

If agent $\hat{a}$ ($\in\{a,b\}$) were hired by the large firm, the profit to the firm would be as follows:

$$E[Y_1^L-S^L(\hat{a})]=m_{\theta^{\hat{a}}}\left(g(K^L)+g(K^S)\right)-W_0^{\hat{a}}+\Phi(K^L,K^S,\sigma_{\theta^{\hat{a}}})+\Psi\left(K^L,\sigma_{\theta^{\hat{a}}}\right).$$

Since by Definition 1-(ii), the small firm is indifferent between the two agents in equilibrium, we have $E[Y_1^S-S^S(a)]=E[Y_1^S-S^S(b)]=0$. Thus,

$$\begin{aligned}W_0^a-W_0^b&=2(m_{\theta^a}-m_{\theta^b})g(K^S)+\Phi(K^S,K^S,\sigma_{\theta^a})-\Phi(K^S,K^S,\sigma_{\theta^b})\\&\quad+\Psi\left(K^S,\sigma_{\theta^a}\right)-\Psi\left(K^S,\sigma_{\theta^b}\right).\end{aligned}$$

On the other hand, Definition 1-(i) implies the following condition should hold in equilibrium for agent *b* to be hired by the large firm.

$$\begin{aligned}&(m_{\theta^b}-m_{\theta^a})\left(g(K^L)+g(K^S)\right)+W_0^a-W_0^b\\&+\Phi(K^L,K^S,\sigma_{\theta^b})-\Phi(K^L,K^S,\sigma_{\theta^a})+\Psi\left(K^L,\sigma_{\theta^b}\right)-\Psi\left(K^L,\sigma_{\theta^a}\right)\geq 0.\end{aligned}$$

By substitution,

$$\begin{aligned}
&(m_{\theta^b}-m_{\theta^a})\left(g(K^L)-g(K^S)\right)+\Phi(K^S,K^S,\sigma_{\theta^a})-\Phi(K^S,K^S,\sigma_{\theta^b})\\
&+\Psi\left(K^S,\sigma_{\theta^a}\right)-\Psi\left(K^S,\sigma_{\theta^b}\right)+\Phi(K^L,K^S,\sigma_{\theta^b})\\
&-\Phi(K^L,K^S,\sigma_{\theta^a})+\Psi\left(K^L,\sigma_{\theta^b}\right)-\Psi\left(K^L,\sigma_{\theta^a}\right)\\
&=(m_{\theta^b}-m_{\theta^a})\left(g(K^L)-g(K^S)\right)+\int_{K^S}^{K^L}\int_{\sigma_{\theta^a}}^{\sigma_{\theta^b}}\Phi_{K^k\sigma_\theta}(K^k,K^S,\sigma_\theta)d\sigma_\theta dK^k\\
&+\int_{K^S}^{K^L}\int_{\sigma_{\theta^a}}^{\sigma_{\theta^b}}\Psi_{K\sigma_\theta}\left(K,\sigma_\theta\right)d\sigma_\theta dK\geq 0.
\end{aligned}$$

The above inequality holds under the stated hypotheses of the proposition □

Proof of Proposition 6: From equations (13) and (14), we have

$$\begin{aligned}
E[S_1^L]-E[S_1^S]&=(m_{\theta^b}-m_{\theta^a})g(K^S)+\Psi(K^S,\sigma_{\theta^b})-\Psi(K^S,\sigma_{\theta^a})\\
&\quad+\Phi(K^S,K^S,\sigma_{\theta^b})-\Phi(K^L,K^S,\sigma_{\theta^b})+\Psi(K^L,\sigma_{\theta^b})-\Psi(K^S,\sigma_{\theta^a})\\
&=(m_{\theta^b}-m_{\theta^a})g(K^S)+2\int_{\sigma_{\theta^a}}^{\sigma_{\theta^b}}\Psi_{\sigma_\theta}(K^S,\sigma_\theta)d\sigma_\theta\\
&\quad-\int_{K^S}^{K^L}\Phi_{K^k}(K^k,K^S,\sigma_{\theta^b})dK^k+\int_{K^S}^{K^L}\Psi_K(K,\sigma_{\theta^b})dK.
\end{aligned}$$

For the second statement, note that since $\gamma_g < 2\gamma_f$, $\gamma_h < 2\gamma_f$, and $\gamma_g \leq \gamma_h$, we have $\frac{\partial}{\partial K^k}\Phi(K^k,K^S,\sigma_\theta)<0$, and $\frac{\partial}{\partial K}\Psi(K,\sigma_\theta)>0$. Therefore, $E[S_1^L]-E[S_1^S]\geq 0$. □

Starting Values for Non-Linear Estimation

In order to be able to estimate the production function in levels starting values of the parameters are required for non-linear estimation of the period 2 model excluding career concerns. Equation (15) is modified to remove the term p^k and then rearranged as:

$$\left\{\hat{Y}_t^{i\hat{a}}-\left[\overline{\hat{\theta}}_t^{\hat{a}}(\hat{K}_{t-1}^{i\hat{a}})^{\gamma_g}+\hat{\sigma}(\hat{K}_{t-1}^{i\hat{a}})^{\gamma_h}\varepsilon_t^i\right]\right\}=\frac{1}{\kappa}\left(\hat{\beta}_{t-1}^{i\hat{a}}+\left(\hat{K}_{t-1}^S\right)^{\gamma_g}\overline{p}\right)\left(\hat{K}_{t-1}^{i\hat{a}}\right)^{2\gamma_f}. \qquad \text{(A4)}$$

Since the econometrician cannot observe the CEO-specific talent updating terms in equation (15), we have $p_{t-1}^{\hat{a}i}\equiv\overline{p}$ in equation (A4) above as a coefficient to be estimated for period 1 in the model with this coefficient set to zero in period 2.

We obtain initial starting estimates of the effort and ability production elasticities in turn, beginning with the effort elasticity. These starting values are then used in the direct estimation of the non-linear production function. We take advantage of the fact that the ability of the $\hat{a}$ th agent, $\theta_t^{\hat{a}}$, is a drawing from a random distribution and thus may not be systematically related to capital stock size $\hat{K}_{t-1}^{i\hat{a}}$ and that ε_t^i is a standard-normal random variable with a zero mean. Thus as an approximation we can take the expression in square brackets on the LHS of equation (A4) to be zero in expectation. On taking logarithms we now obtain a simple estimable equation using ordinary least squares (OLS):

$$ln\left\{\frac{\hat{Y}_t^{ia}}{\left(\hat{\beta}_{t-1}^{i\hat{a}}+\left(\hat{K}_{t-1}^{S}\right)^{\gamma_g}\overline{p}\right)}\right\}=ln\left(\frac{1}{\kappa}\right)+2\gamma_f ln\left(\hat{K}_{t-1}^{i\hat{a}}\right), \qquad \text{(A5)}$$

with the intercept estimate $\hat{\alpha}_0 = ln\left(\frac{1}{\kappa}\right)$, the (common) marginal cost of effort coefficient, $\hat{\kappa}=e^{-\hat{\alpha}_0}$, the estimated effort elasticity with respect to the production function, $\hat{\gamma}_f=\frac{1}{2}\hat{\alpha}_1$, where $\hat{\alpha}_1$ is the slope coefficient. These values are then used as starting values in the non-linear estimation of the regression equation based on the production function, equations (16) and (17) in the text. The use of the non-linear approach is true to the assumed additive nature of the specified error structure.

The starting values for the ability elasticity and mean ability level are now estimated as follows: Once again setting the error term ε_t^i to its expected value of zero and p^k to zero, we have by rearranging equation (15) in the text:

$$ln\left[\hat{Y}_t^i(\hat{a})-\frac{1}{\hat{\kappa}}\left(\hat{\beta}_{t-1}^{i\hat{a}}+\left(\hat{K}_{t-1}^{S}\right)^{\gamma_g}\overline{p}\right)\left(\hat{K}_{t-1}^{i\hat{a}}\right)^{2\hat{\gamma}_f}\right]=ln\left(\overline{\hat{\theta}}_t^{\hat{a}}\right)+\gamma_g ln(\hat{K}_{t-1}^{i\hat{a}}), \qquad \text{(A6)}$$

where $\bar{\hat{\theta}}_t^{\hat{a}}$ denotes the mean level of ability for the sample.

Table 1: Summary Statistics of CEO Careers, 1992-2006, Based on Market Productivity/Wealth

Fiscal year values in constant 2006 dollars based on the CPI. Sources are S&P ExecuComp, S&P Compustat and CRSP. All CEOs excluding those in financial services and with tenure of at least one year as a stint in one firm are included. Market wealth/productivity consists of the total market value of assets (equity plus total debt) at fiscal year end plus the net value of all distributions to equity and debt holders during the year. Pay-performance sensitivity ($\hat{\beta}_{t-1}^{i\hat{a}}$) consists of the proportion of shares on issue held by the CEO at fiscal year open from ExecuComp inclusive of restricted stock plus the share equivalent (hedge ratio value) of his option holdings based on the Black Scholes formula. Total Pay consists of the value of salary plus bonus plus restricted stock grants plus the value of option grants as reported by ExecuComp and converted to 2006 prices. Total CEO income consists of Total Pay as before plus $\hat{\beta}_{t-1}^{i\hat{a}}$ times the change in the firm's equity market value. The dollar volatility of the firm's stock is computed from CRSP data as the product of the standard deviation of returns and the opening value of market capitalization for each financial year. The CEOs firm experience prior to being appointed CEO is computed from the date the CEO joined the firm until appointed CEO where this is recorded by ExecuComp. Where this information is not reported the CEO is assumed to have been externally recruited. The average age of the CEO over his tenure is computed for the smaller sample of CEOs for which ExecuComp supplies this information. The larger and smaller firm samples are obtained by equally dividing the entire sample of size-ranked CEO fiscal years. The sample of positive and negative performances are found by dividing the sample between CEO fiscal years in which the income to claimants on the firm (dividends plus capital gains plus distributions to debt holders) is positive and the remainder for which the income is negative.

Variable	No.	Mean	Median	Std Dev	Min	Max
Overall Sample						
Mkt Val Terminal Wlth ($M)	19,067	12,962	2,349	46,238	-63,546	1,119,028
Mkt Val Ttl Asts ($M)	19,067	13,088	2,480	45,890	0	1,078,253
Beta (PPS)	19,067	0.0277	0.0030	0.0674	0.0000	0.7370
Total Pay ($000)	18,892	5,073	2,479	19,301	0	2,268,428
Total Income ($000) incl. Shares	18,850	20,735	3,091	608,649	-32,528,084	47,694,393
Dol Volat ($M)	19,067	1,946	427	7,332	1	220,876
Career Length (Yrs)	19,067	6.7	6	3.5221	1	15
Yrs Exp (Pre-CEO)	19,067	6.6	2	8.7021	0	48
CEO Age (Yrs)	13,316	55.5	56	7.8	29	91
Sample of Large Firms						
Mkt Val Terminal Wlth ($M)	9,533	24,913	8,002	63,163	-63,546	1,119,028
Mkt Val Ttl Asts ($M)	9,533	25,151	8,255	62,616	2,480	1,078,253
Beta (PPS)	9,533	0.0173	0.0016	0.0532	0.0000	0.5829
Total Pay ($000)	9,461	7,844	4,473	26,815	0	2,268,428
Total Income ($000) incl. Shares	9,452	33,505	5,203	854,298	-32,528,084	47,694,393
Dol Volat ($M)	9,533	3,642	1,200	10,083	11	220,876
Career Length (Yrs)	9,533	6.9	7	3.4727	1	15
Yrs Exp (Pre-CEO)	9,533	8.6	4	10.0373	0	43
CEO Age (Yrs)	6,407	56.0	56	7.3	29	85

Table 1: Continued.

Variable	No. Obs.	Mean	Median	Std Dev	Min	Max
Sample of Small Firms						
Mkt Val Terminal Wlth ($M)	9,534	1,012	831	1,026	-25,559	21,241
Mkt Val Ttl Asts ($M)	9,534	1,026	898	635	0	2,480
Beta (PPS)	9,534	0.0381	0.0061	0.0777	0.0000	0.7370
Total Pay ($000)	9,431	2,293	1,479	3,083	0	67,725
Total Income ($000) incl. Shares	9,398	7,891	1,797	93,421	-450,656	7,912,450
Dol Volat ($M)	9,534	249	180	288	1	16,507
Career Length (Yrs)	9,534	6.6	6	3.5666	1	15
Yrs Exp (Pre-CEO)	9,534	4.6	2	6.5385	0	48
CEO Age (Yrs)	6,909	55.1	55	8.3	29	91
Sample of Firms with Positive Market Performace						
Mkt Val Terminal Wlth ($M)	8,713	16,401	3,084	55,389	13	1,119,028
Mkt Val Ttl Asts ($M)	8,713	13,673	2,423	48,688	0	966,654
Beta (PPS)	8,713	0.0307	0.0031	0.0728	0.0000	0.7370
Total Pay ($000)	8,643	5,548	2,733	25,766	0	2,268,428
Total Income ($000) incl. Shares	8,631	63,613	6,360	783,573	-581,074	47,694,393
Dol Volat ($M)	8,713	1,715	405	5,273	1	112,151
Career Length (Yrs)	8,713	6.9	7	3.5038	1	15
Yrs Exp (Pre-CEO)	8,713	6.9	2	8.9142	0	48
CEO Age (Yrs)	6,263	55.5	55	7.8	30	90
Sample of Firms with Negative Market Performace						
Mkt Val Terminal Wlth ($M)	10,354	10,068	1,810	36,567	-63,546	913,421
Mkt Val Ttl Asts ($M)	10,354	12,596	2,530	43,392	0	1,078,253
Beta (PPS)	10,354	0.0252	0.0029	0.0623	0.0000	0.5780
Total Pay ($000)	10,249	4,672	2,270	11,249	0	805,983
Total Income ($000) incl. Shares	10,219	-15,481	1,528	402,418	32,528,08	5,295,721
Dol Volat ($M)	10,354	2,140	449	8,690	2	220,876
Career Length (Yrs)	10,354	6.6	6	3.5284	1	15
Yrs Exp (Pre-CEO)	10,354	6.3	2	8.5100	0	48
CEO Age (Yrs)	7,053	55.6	56	7.9	29	91

Table 2: Summary Statistics of CEO Careers, 1992-2006, Based on Accounting Productivity

Fiscal year values in constant 2006 dollars based on the CPI. Sources are S&P ExecuComp, S&P Compustat and CRSP. All CEOs excluding those in financial services and with tenure of at least one year as a stint in one firm are included. Accounting wealth/productivity consists of the total book value of assets (equity plus total debt) at fiscal year end plus the net value of all distributions to equity and debt holders during the year. The sample of positive and negative performances are found by dividing the sample between CEO fiscal years in which the income to claimants on the firm (accounting income plus distributions to debt holders) is positive and the remainder for which the income is negative. The remaining variables are defined as in Table 1.

Variable	No. Obs.	Mean	Median	Std Dev	Min	Max
Overall Sample						
Book Val Terminal Wlth ($M)	19,067	8,205	1,239	35,568	-88,737	1,073,094
Book Val Ttl Asts ($M)	19,067	8,585	1,423	35,447	0	922,600
Beta (PPS)	19,067	0.0277	0.0030	0.0674	0.0000	0.7370
Total Pay ($000)	18,892	5,073	2,479	19,301	0	2,268,428
Total Income ($000) incl. Shares	18,850	20,735	3,091	608,649	-32,528,084	47,694,393
Dol Volat ($M)	19,067	1,946	427	7,332	1	220,876
Career Length (Yrs)	19,067	6.7	6	3.5221	1	15
Yrs Exp (Pre-CEO)	19,067	6.6	2	8.7021	0	48
CEO Age (Yrs)	13,316	55.5	56	7.8	29	91
Sample of Firms with Positive Accounting Performace						
Book Val Terminal Wlth ($M)	7,830	10,127	1,413	44,608	8	1,073,094
Book Val Ttl Asts ($M)	7,830	8,894	1,198	40,090	0	922,600
Beta (PPS)	7,830	0.0340	0.0037	0.0758	0.0000	0.7370
Total Pay ($000)	7,757	5,116	2,504	8,747	0	195,897
Total Income ($000) incl. Shares	7,744	45,380	3,970	787,434	-10,238,235	47,694,393
Dol Volat ($M)	7,830	2,060	441	7,336	7	220,876
Career Length (Yrs)	7,830	6.9	7	3.4921	1	15
Yrs Exp (Pre-CEO)	7,830	6.7	2	8.7200	0	48
CEO Age (Yrs)	5,580	55.5	55	8.0	30	86
Sample of Firms with Negative Accounting Performace						
Book Val Terminal Wlth ($M)	11,237	6,867	1,123	27,491	-88,737	763,917
Book Val Ttl Asts ($M)	11,237	8,371	1,600	31,813	0	854,169
Beta (PPS)	11,237	0.0234	0.0027	0.0604	0.0000	0.6298
Total Pay ($000)	11,135	5,043	2,467	24,058	0	2,268,428
Total Income ($000) incl. Shares	11,106	3,550	2,661	442,419	-32,528,084	23,636,837
Dol Volat ($M)	11,237	1,866	420	7,328	1	219,824
Career Length (Yrs)	11,237	6.6	6	3.5350	1	15
Yrs Exp (Pre-CEO)	11,237	6.5	2	8.6881	0	48
CEO Age (Yrs)	7,736	55.6	56	7.8	29	91

Table 3: Partial Correlation Coefficient Matrix for Entire Sample Utilizing Company Market Productivity, 1992-2006

	Talent	Wealth	Asset	Beta	Pay	Income	Volat	Career	Exper	Age
Pred Talent (Theta)	1									
Mkt Terminal Wealth	0.0669	1								
Mkt Val Total Assets	0.0180	0.9739	1							
Beta (income share)	-0.0451	-0.0486	-0.0535	1						
Total Pay (ExecuComp)	0.0313	0.1540	0.1554	-0.0354	1					
Total Income incl. Shares	0.0761	0.0976	0.0339	0.0846	0.0317	1				
Dollar Volatility	0.0049	0.6065	0.6618	-0.0339	0.1625	-0.0130	1			
CEO Career Length (Yrs)	-0.0039	0.0290	0.0211	0.1625	0.0069	0.0181	0.0244	1		
Yrs Experience (Pre-CEO)	-0.0084	0.1602	0.1588	-0.0486	0.0071	-0.0045	0.1016	0.0565	1	
CEO Age	-0.0462	0.0214	0.0175	0.1264	-0.0029	-0.0111	-0.0112	0.0401	0.0836	1

Table 4: CEO Production Function - Non-Linear Regression

Equation Estimates

Non-linear regression estimates of the CEO production function as given by equation (16) in the text. The dependent variable is the residual based on the financial year total dollar market wealth (total market value of assets at end of year plus total net distributions made up of dividends and interest payments less the net value of new equity and debt capital raisings) for each of the three market samples, All Firms, Large Firms, and Small Firms and total dollar accounting wealth (total book value of assets at end of year plus total distributions made up of dividends and interest payments) for each of the three accounting samples. The three coefficients, Kappa (κ), Gamma_f (γ_f), and Gamma_g (γ_g), are estimated separately for the entire market sample and entire accounting sample and the two subsamples of large and small stocks. The coefficient representing the impact of career concerns is estimated only for the entire sample using the market method. The coefficients for the entire market sample are applied to firm CEO years with positive incomes (dividends plus capital gains plus total payments to debt holders) and also to firm-years with negative incomes. The average Theta ($\overline{\theta}$) (CEO ability) factor is estimated for the entire sample and the large and small sub-samples. The mean and standard deviation, values of Theta (θ^{ij}) are also implied by treating the estimated production function as an identity with differing Theta values for each CEO year are reported for the large and small subsamples respectively.

Coefficient	All Firms			Pos Wlth Gain		Neg Wlth Gain		Large	Small
	Mkt.		Accg.	Mkt.	Accg.	Mkt.	Accg.	Mkt.	Mkt.
	NA	Career	NA	NA	NA	NA	NA	NA	NA
Kappa (κ)	0.4703*	5.8908*	0.5603*	0.4703*	0.5603*	0.4703*	0.5603*	3.5356*	0.0072***
(t-value)	(10.07)	(11.38)	(12.03)	(10.07)	(12.03)	(10.07)	(12.03)	(8.15)	(1.94)
Shadow Price Career (p)	NA	0.000058*	NA	NA	NA	NA	NA	NA	NA
(t-value)	NA	(11.13)	NA	NA	NA	NA	NA	NA	NA
Gamma_f (γ_f)	0.4290*	0.5369*	0.4415*	0.4290*	0.4415*	0.4290*	0.4415*	0.5172*	0.0334
(t-value)	(108)	(218)	(133)	(108)	(133)	(108)	(133)	(104)	(0.92)
Gamma_g (γ_g)	0.9851*	0.9674*	0.9956*	0.9851*	0.9956*	0.9851*	0.9956*	0.9980*	0.9274*
(t-value)	(7,565)	(589)	(8,425)	(7,565)	(8,425)	(7,565)	(8,425)	(5,414)	(880)
Est. Av. Ability (θ))	1.1827*	1.1296*	1.0327*	1.3640*	1.1665*	0.9920*	0.8877*	1.0024*	1.6520*
(t-value)	(616)	(470)	(679)	(686)	(816)	(526)	(510)	(436)	(137)
Slope: Pred Prod	1.0018*	1.0008*	1.0022*	0.9975*	0.9990*	1.0050*	1.0028*	0.9993*	1.0206*
(t-value)	(595)	(595)	(665)	(661)	(799)	(511)	(497)	(406)	(70.34)
RSq	0.9489	0.9490	0.9586	0.9805	0.9879	0.9618	0.9564	0.9454	0.3417
Sample of Large Firms									
Pred Ability (θ)) Mean	1.1287	1.093307	0.94073	1.4289	1.1901	0.8809	0.7873	1.0050	NA
Pred Ability (θ)) Std Dev	0.4817	0.563253	0.42619	0.4799	0.2943	0.3126	0.4223	0.4286	NA
Sample of Small Firms									
Pred Ability (θ)) Mean	1.09262	1.071099	0.8916	1.5753	1.2325	0.6789	0.6235	NA	1.6329
Pred Ability (θ)) Std Dev	0.96633	1.074954	0.89531	1.0272	0.9350	0.6775	0.7624	NA	1.3685
Dollar Volatility Regression									
Gamma_h (γ_h)	0.8122*	0.8122*	0.6556*	0.8122*	0.6556*	0.8122*	0.6556*	0.8389*	0.7735*
(t-value)	(256)	(256)	(151)	(256)	(151)	(256)	(151)	(118)	(94.12)
Sigma σ	0.7567*	0.7567*	3.8143*	0.7567*	3.8143*	0.7567*	3.8143*	0.5888*	0.9838
(t-value)	(10.78)	(10.78)	(40.62)	(10.78)	(40.62)	(10.78)	(40.62)	(7.97)	(0.30)
RSq	0.7741	0.7741	0.5455	0.7741	0.5455	0.7741	0.5455	0.5931	0.4820

Table 5: Determinants of CEO (Flow) Pay Levels (in Logarithms) Based on ExecuComp Pay Data, 1992-2006, in 2006 Prices

Equation (19) in the text is estimated for each of the five groups identified in Table 4 and using the predicted ability/talent estimates from Table 4 for each of the five groups.

Variable	All Firms			Pos Income		Neg Income		Large	Small
	Mkt		Acc	Mkt	Acc	Mkt	Acc	Mkt	Mkt
	NA	Career	NA	NA	NA	NA	NA	NA	NA
Intercept Log(Fix Pay)	2.7153*	2.7394*	3.6034*	3.5634*	3.5587*	3.1179*	3.7198*	3.1633*	3.4150*
(t-value)	(12.76)	(12.56)	(15.77)	(16.83)	(14.02)	(13.12)	(15.52)	(12.36)	(14.13)
Log Pred. Ability (θ)	0.3043*	0.2817*	0.0576	0.6685*	1.1039*	-0.0157	-0.0389	0.1785*	0.1763*
(t-value)	(5.20)	(4.85)	(0.96)	(13.26)	(14.58)	(0.27)	(0.66)	(2.63)	(3.54)
Log Beta (PPS)	-0.0149*	-0.0151*	-0.0144*	-0.0058	-0.0055	-0.0197*	-0.0150*	-0.0116**	-0.0146*
(t-value)	(5.82)	(5.87)	(5.61)	(1.53)	(1.40)	(5.78)	(4.39)	(2.51)	(5.13)
Log Total Assets	0.2961*	0.2960*	0.2012*	0.3048*	0.2290*	0.3470*	0.2196*	0.2543*	0.3067*
(t-value)	(25.21)	(25.20)	(25.11)	(15.88)	(17.75)	(23.08)	(20.46)	(12.79)	(17.59)
Log Dollar Volatility	0.1624*	0.1626*	0.2760*	0.1558*	0.2383*	0.1195*	0.2614*	0.1684*	0.1467*
(t-value)	(13.67)	(13.68)	(33.99)	(7.90)	(18.34)	(7.97)	(24.13)	(9.39)	(9.29)
Log Years in Office	0.0913*	0.0913*	0.0871*	0.0672*	0.0793*	0.1020*	0.1018*	0.1078*	0.0824*
(t-value)	(7.72)	(7.72)	(7.36)	(3.65)	(4.15)	(6.75)	(6.81)	(5.52)	(5.86)
Log Yrs Pre-CEO Exp	-0.0527*	-0.0527*	-0.0527*	-0.0461*	-0.0390*	-0.0604*	-0.0565*	-0.0623*	-0.0409*
(t-value)	(8.00)	(8.01)	(8.00)	(4.60)	(3.73)	(7.06)	(6.72)	(6.23)	(4.70)
Chair-CEO Duality	0.1151*	0.1150*	0.1172*	0.0855*	0.1033*	0.1362*	0.1175*	0.1516*	0.0804*
(t-value)	(7.47)	(7.47)	(7.61)	(3.66)	(4.28)	(6.81)	(5.93)	(5.82)	(4.50)
Departure-Resigned	-0.0240	-0.0240	-0.0259	-0.0343	-0.0717***	-0.0019	-0.0083	0.0247	-0.0665**
(t-value)	(0.97)	(0.98)	(1.05)	(0.87)	(1.77)	(0.06)	(0.27)	(0.58)	(2.37)
Departure-Retired	-0.0790*	-0.0789*	-0.0720*	-0.0584**	-0.0864*	-0.0876*	-0.0564**	-0.0737*	-0.1015*
(t-value)	(4.10)	(4.09)	(3.74)	(1.96)	(2.81)	(3.54)	(2.31)	(2.67)	(3.71)
Departure-Deceased	-0.3125*	-0.3130*	-0.2993*	-0.3677*	-0.3180*	-0.2446*	-0.2698*	-0.2178***	-0.3709*
(t-value)	(4.59)	(4.59)	(4.39)	(3.69)	(3.13)	(2.67)	(2.96)	(1.75)	(4.95)
No Observations	16,675	16,675	16,675	7,716	6,998	8,959	9,677	8,379	8,296
RMSQ	0.8955	0.8956	0.8961	0.9255	0.9122	0.8487	0.8714	1.0010	0.7664
RSq	0.3932	0.3931	0.3923	0.3870	0.4025	0.4262	0.4063	0.2468	0.2250

*Significant at 1%; **Significant at 5%; ***Significant at 10%

Table 6: Determinants of CEO Income Levels (in logs), Based on Execucomp Pay plus Imputed Share Income, 1992-2006, in 2006 Prices

The same equation (19) is estimated as in Table 5 except that the dependent variable is now CEO income made up of total pay as given by ExecuComp plus the income from shares and option holdings equivalents based on the $\hat{\beta}_{t-1}^{i\hat{a}}$ income share of the annual change in equity market capitalization.

Variable	**All Firms**			**Pos Income**		**Neg Income**		**Large**	**Small**
	Mkt		**Acc**	**Mkt**	**Acc**	**Mkt**	**Acc**	**Mkt**	**Mkt**
	NA	**Career**	NA	NA	NA	NA	NA	NA	NA
Intercept Log(Fix Pay)	2.7153*	2.7394*	3.6034*	3.5634*	3.5587*	3.1179*	3.7198*	3.1633*	3.4150*
(t-value)	(12.76)	(12.56)	(15.77)	(16.83)	(14.02)	(13.12)	(15.52)	(12.36)	(14.13)
Log Pred. Ability (θ)	0.3043*	0.2817*	0.0576	0.6685*	1.1039*	-0.0157	-0.0389	0.1785*	0.1763*
(t-value)	(5.20)	(4.85)	(0.96)	(13.26)	(14.58)	(0.27)	(0.66)	(2.63)	(3.54)
Log Beta (PPS)	-0.0149*	-0.0151*	-0.0144*	-0.0058	-0.0055	-0.0197*	-0.0150*	-0.0116**	-0.0146*
(t-value)	(5.82)	(5.87)	(5.61)	(1.53)	(1.40)	(5.78)	(4.39)	(2.51)	(5.13)
Log Total Assets	0.2961*	0.2960*	0.2012*	0.3048*	0.2290*	0.3470*	0.2196*	0.2543*	0.3067*
(t-value)	(25.21)	(25.20)	(25.11)	(15.88)	(17.75)	(23.08)	(20.46)	(12.79)	(17.59)
Log Dollar Volatility	0.1624*	0.1626*	0.2760*	0.1558*	0.2383*	0.1195*	0.2614*	0.1684*	0.1467*
(t-value)	(13.67)	(13.68)	(33.99)	(7.90)	(18.34)	(7.97)	(24.13)	(9.39)	(9.29)
Log Years in Office	0.0913*	0.0913*	0.0871*	0.0672*	0.0793*	0.1020*	0.1018*	0.1078*	0.0824*
(t-value)	(7.72)	(7.72)	(7.36)	(3.65)	(4.15)	(6.75)	(6.81)	(5.52)	(5.86)
Log Yrs Pre-CEO Exp	-0.0527*	-0.0527*	-0.0527*	-0.0461*	-0.0390*	-0.0604*	-0.0565*	-0.0623*	-0.0409*
(t-value)	(8.00)	(8.01)	(8.00)	(4.60)	(3.73)	(7.06)	(6.72)	(6.23)	(4.70)
Chair-CEO Duality	0.1151*	0.1150*	0.1172*	0.0855*	0.1033*	0.1362*	0.1175*	0.1516*	0.0804*
(t-value)	(7.47)	(7.47)	(7.61)	(3.66)	(4.28)	(6.81)	(5.93)	(5.82)	(4.50)
Departure-Resigned	-0.0240	-0.0240	-0.0259	-0.0343	-0.0717***	-0.0019	-0.0083	0.0247	-0.0665**
(t-value)	(0.97)	(0.98)	(1.05)	(0.87)	(1.77)	(0.06)	(0.27)	(0.58)	(2.37)
Departure-Retired	-0.0790*	-0.0789*	-0.0720*	-0.0584**	-0.0864*	-0.0876*	-0.0564**	-0.0737*	-0.1015*
(t-value)	(4.10)	(4.09)	(3.74)	(1.96)	(2.81)	(3.54)	(2.31)	(2.67)	(3.71)
Departure-Deceased	-0.3125*	-0.3130*	-0.2993*	-0.3677*	-0.3180*	-0.2446*	-0.2698*	-0.2178***	-0.3709*
(t-value)	(4.59)	(4.59)	(4.39)	(3.69)	(3.13)	(2.67)	(2.96)	(1.75)	(4.95)
No Observations	16,675	16,675	16,675	7,716	6,998	8,959	9,677	8,379	8,296
RMSQ	0.8955	0.8956	0.8961	0.9255	0.9122	0.8487	0.8714	1.0010	0.7664
RSq	0.3932	0.3931	0.3923	0.3870	0.4025	0.4262	0.4063	0.2468	0.2250

*Significant at 1%; **Significant at 5%; ***Significant at 10%

Table 7: Actual and Predicted Mean CEO Total Pay Based on ExecuComp by Years in 2006 Prices, $000

The pay prediction model as set out in equation (19) and Table 5 is used to predict pay levels in the prices of 2006 by the eight years specified in the table below and for the five sample categories broken down by market and accounting productivity measures. Actual average pay based on ExecuComp and the sample sizes for the years involved are also presented.

Year	Act Mean Pay	No Obs	Mkt.	No Obs	Accg.
All Firms					
1992	3,207	317	4,603	317	4,572
1993	2,779	1029	3,549	1029	3,499
1995	2,913	1436	3,306	1436	3,234
2000	7,029	1435	5,732	1435	6,199
2002	5,703	1306	5,652	1306	6,165
2004	5,814	1220	5,198	1220	5,295
2005	5,986	1159	5,313	1159	5,422
2006	8,683	934	5,613	934	5,775
Large Firms					
1992	3,577	256	4,908	251	5,009
1993	3,490	535	4,387	544	4,384
1995	4,429	607	4,488	612	4,386
2000	10,139	729	7,419	707	7,920
2002	8,384	687	7,227	689	7,789
2004	8,292	678	6,441	689	6,553
2005	8,212	675	6,450	683	6,581
2006	12,286	585	6,601	590	6,802
Small Firms					
1992	1,797	61	1,388	66	1,648
1993	1,981	494	1,546	485	1,582
1995	1,787	829	1,436	824	1,463
2000	4,009	706	1,804	728	2,593
2002	2,708	619	1,763	617	2,121
2004	2,599	542	1,703	531	1,832
2005	2,792	484	1,737	476	1,876
2006	2,503	349	1,748	344	1,907
Positive Income					
1992	3,390	163	4,968	117	5,187
1993	2,878	528	4,109	458	4,063
1995	2,954	888	4,051	724	3,718
2000	8,502	628	6,784	564	7,910
2002	6,432	285	4,798	380	6,653
2004	6,029	610	5,920	476	6,274
2005	6,588	450	5,507	375	5,733
2006	6,365	413	6,542	305	6,687
Negative Income					
1992	3,099	154	4,421	200	4,402
1993	2,700	501	3,261	571	3,283
1995	2,872	548	2,783	712	3,054
2000	6,075	807	5,297	871	5,922
2002	5,403	1021	5,427	926	5,977
2004	5,676	610	4,671	744	4,787
2005	5,697	709	5,194	784	5,397
2006	9,807	521	4,901	629	5,407

Table 8: Increase in Firm Size and Dollar Volatility, 1992-2006, in $2006 Prices

Observations on the total market value of assets and risk (dollar volatility) are presented for two years, 1992 and 2006, for the top 100 firms and top 500.

Sample	Year	Mean	Median	Std	Min	Max
Total Market Value of Assets						
Top 100	1993	59,416	38,532	58,102	20,844	344,716
	2005	134,717	71,522	187,000	34,614	1,078,253
	% Change	126.7%	85.6%	221.8%	66.1%	212.8%
Top 500	1993	17,746	7,539	33,515	2,273	344,716
	2005	36,902	12,459	96,892	3,933	1,078,253
	% Change	107.9%	65.3%	189.1%	73.1%	212.8%
Dollar Volatility						
Top 100	1993	3,579	2,805	3,344	232	23,561
	2005	10,786	7,002	11,793	330	76,798
	% Change	201.4%	149.7%	252.6%	42.1%	226.0%
Top 500	1993	1,239	665	1,941	81	23,561
	2005	3,558	1,676	6,502	19	76,798
	% Change	187.1%	152.1%	234.9%	-76.1%	226.0%