The Endogeneity of Managerial Compensation in Firm Valuation: A Solution

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Much of the empirical literature that has examined the functional relationship between firm value and managerial ownership levels assumes that managerial ownership levels are exogenous and are the only component of managerial compensation related to firm performance. This assumption is contrary to the theoretical and empirical literature wherein managerial compensation is endogenously determined and includes both shares and options. Using instruments for managerial compensation and panel data to control for unobservable heterogeneity in the firm's contracting environment, we estimate a system of simultaneous equations. We find that firms are in equilibrium when they endogenously set their chief executive officer's compensation.

The separation of ownership and control, first described by Berle and Means (1932), suggests that managers (who have private information and control over a corporation) can indulge in non-shareholder wealth-maximizing activities because shareholders are too diffuse to monitor them. More recently, Jensen and Meckling (1976) suggest that managers be given more of an ownership stake in the firm in order to ameliorate this principal-agent problem between shareholders and managers. Higher ownership in the firm helps align managerial interests with shareholder interests and reduces unobservable perquisite consumption by managers. Using an adverse selection model, Leland and Pyle (1977) argue that managers keep a high ownership stake in the firm to signal to the public markets that they have projects of high quality. Their model also proposes a positive relationship between managerial ownership and firm value. Recently a number of studies suggest managerial entrenchment at higher levels of managerial ownership[1] [Stulz (1988), Mørck,

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[1] Stulz (1988) is a theoretical model whereas the rest of the studies are empirical. Throughout this article I use the phrase "previous literature" in referring to these empirical studies. Although the empirical studies find a

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Shleifer, and Vishny (1988), McConnell and Servaes (1990), Hermalin and Weisbach (1991), Hubbard and Palia (1995a), Kole (1995), Holderness, Kroszner, and Sheehan (1999)], and accordingly find firm value to first increase and then decrease with increases in managerial ownership levels.

Whereas this literature has found a functional relationship between firm value and managerial ownership levels, it explicitly assumes that managerial ownership is *exogenous* and is the only component of managerial compensation whose value is related to firm performance. This assumption is contrary to the idea that managerial compensation is *endogenously* determined. In their review article, Jensen and Warner state that "[a] caveat to the alignment/entrenchment interpretation of the cross-sectional evidence, however, is that it treats ownership as exogenous, and does not address the issue of what determines [managerial] ownership concentration" (1988, p. 13). Grinblatt and Titman suggest that "Unfortunately, it is difficult to interpret the evidence on the relation between value creation and ownership concentration because the ratio of a firm's market value to its book value, . . . measures more than how well the firm is managed. . . . Perhaps, management ownership is related to market-to-book ratios because there are more benefits associated with controlling companies with more intangible assets" (1997, p. 612).

If firms are a nexus of contracts that are simultaneously chosen to maximize shareholder value, focusing on one such contract (namely managerial compensation), without controlling for the differences in the firm's contracting environment or *firm type* is misleading. In this article I suggest that managerial compensation is related to observable and unobservable *firm characteristics* that arise due to differences in the contracting environment.[2] More importantly, I estimate a system of simultaneous equations in order to accurately identify the impact of managerial compensation on firm value by using four *instrumental variables* [namely chief executive officer (CEO) experience, CEO quality of education, firm volatility, and CEO age] that are expected to be related to compensation. I use these four instruments as they have been motivated by different studies to be related to the structure of managerial compensation. I also estimate the relationship of these instrumental variables to CEO compensation and find them to be related in this sample.

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nonmonotonic relationship, substantial differences exist in the shape of the relationship found, the definition of managerial ownership used, and when the relationship becomes positive or negative. For example, Mørck, Shleifer, and Vishny (1988) define managerial ownership as the percentage of shares owned by the entire board, and find a piecewise linear relationship between Tobin's Q and managerial ownership—wherein Q increases from 0% to 5%, then decreases between 5% and 25%, and once again turns positive at ownership levels greater than 25%. On the other hand, McConnell and Servaes (1990) define managerial ownership as the fraction of shares owned by corporate insiders and find a quadratic relationship between managerial ownership and Q. They find the relationship to turn slightly negative when managerial ownership reaches between 40% and 70%. Hermalin and Weisbach (1991) define managerial ownership as the fraction owned by the current chief executive officer and all former chief executive officers on the board, and find Q to increase until ownership reaches 1%, turns negative in the ownership range of 1% to 5%, turns positive again in the ownership range of 5% to 20%, and then turns negative for ownership levels greater than 20%.

[2] This is in the spirit of the initial article in this research area by Demsetz and Lehn (1985), who examine the determinants of ownership using cross-sectional data, where ownership is defined as the ownership of *shareholders* with 5% or more in the firm.

In this study I use data that have both cross-sectional and time variation (our panel dataset consists of 3,260 observations for 361 firms in the 13-year period 1981–1993), whereas the previous literature on managerial compensation is based on cross-sectional regressions. I observe that compensation and firm value are simultaneously determined by many firm characteristics that are unobservable and difficult to measure (such as differences in managerial monitoring technology, differences of market power in the product market, and differences in intangible assets). These unobservable firm characteristics, which I term "unobservable firm heterogeneity," are not included in the usual cross-sectional regressions but can be controlled for in panel data.[3] In fact, when I empirically test for any omitted factors, I find that they exist and that they are unchanging over time—suggesting that a fixed effects model is the optimal estimation methodology.[4]

Given that theories and empirical studies of optimal compensation contracts suggest that current performance, managerial ability, experience, and firm age are some of the relevant variables that are related to managerial contracts, panel regressions allow us to control for unobservable variables (to the econometrician) in the cross-sectional studies. A related article by Himmelberg, Hubbard, and Palia (1999; hereafter HHP) has examined the determinants of managerial ownership using panel data and finds that managerial ownership levels can be explained by unobserved firm effects and observed firm characteristics. This article differs from HHP by including options and, more importantly, uses four valid instruments in order to accurately estimate the system of equations simultaneously, whereas HHP does not find any powerful instruments. HHP also does not have a predetermined variable in the Q equation (a variable that is related to Q and not related to managerial compensation). I examine the total pay for performance sensitivity at the chief executive level, whereas HHP examines managerial ownership at the board of directors level. Like HHP we also examine the determinants of the structure of managerial compensation.

I find that the structure of managerial compensation is positively related to firm-specific characteristics such as capital structure, capital intensity, firm size, and CEO experience, among others. Accordingly I estimate a separate equation for incentive-compatible compensation, and then use four instrumental variables, namely, CEO experience, CEO quality of education, firm volatility, and CEO age that are expected to be related to compensation.

[3] In criticizing the literature that examines the pay-performance relationship of chief executive officers, Murphy motivates the optimal use of panel data in the following manner: "Second, most previous results are based on cross-sectional analysis. . . . Economic theories of efficient compensation suggest that, in addition to current performance, contracts will depend on other factors. . . . Absent a theory indicating the relevant variables, and data on these variables, these cross-sectional models are inherently subject to a serious omitted variables problem" (1995, p. 12).

[4] See Section 1 for more details on the estimation methodology.

The idea that managerial compensation is an endogenous response to the contracting environment faced by the firm has been posited both in the theoretical and empirical literature. Holmstrom (1979) derives the sharing rule between managers and shareholders as the second-best optimal solution in an optimization program, wherein managers are risk averse, shareholders are risk neutral, and managerial effort is unobservable to the shareholders. The Pareto-optimal compensation rule is linear and positive in observed output, for it trades off the beneficial impact of providing a fixed level of compensation to the risk-averse manager and an incentive for managers to expend effort. Other models have also endogenously determined the optimal wage contract in different constructs [e.g., Grossman and Hart (1983) and Holmstrom and Milgrom (1991)]. In addition, many empirical articles such as Murphy (1985) and Jensen and Murphy (1990b), among others, estimate regressions, wherein managerial compensation is the dependent variable and not an exogenous regressor. Smith and Watts (1992) and Gaver and Gaver (1993) also find that firms with lower investment opportunities have lower CEO compensation and less frequent use of both option and bonus plans. They attribute these findings to a contracting hypothesis, wherein firms with fewer investment opportunities have managerial actions that are more readily observable and therefore do not need a strong pay-performance relationship to align managerial and shareholder interests. In summary, this literature argues that firms vary by contracting environments (i.e., by firm type) and the CEO's pay-performance sensitivity has been optimized in response to the firm's contracting environment.

Accordingly the equilibrium hypothesis suggests that we would expect to see no relationship between the CEO's pay-performance sensitivity and firm value after one controls for firm type (captured by observable and unobservable firm characteristics). The nonequilibrium hypothesis suggests that shareholders and/or the board of directors have not optimized the CEO's pay-performance contract whose sensitivity should be changed. According to this view, increasing the CEO's pay-performance sensitivity results in increases in firm value [e.g., Jensen and Murphy (1990b)], or results in increases and then decreases in firm value [e.g., Mørck, Shleifer, and Vishny (1988), McConnell and Servaes (1990)]. I examine which of these two hypotheses are confirmed by the data. When I estimate the firm value equation using the two-stage least squares, fixed effects model, I find that incentive-compatible compensation has a positive but statistically insignificant effect on firm value, suggesting that firms are in equilibrium when setting their CEO's pay-performance sensitivity.

This article also extends the previous literature in two *other ways*. First, theoretical models suggest that shareholder incentive-compatible compensation is any managerial remuneration whose value fluctuates with shareholder wealth. Options granted to managers fulfills this requirement[5] and are increasingly used by compensation practitioners. The previous literature omits options granted to managers, which this article includes. The firm's proxy statement filed with the SEC discloses the percentage of equity owned by its senior managers and board of directors, but does not reveal the number of options granted to all board members. Options data is disclosed only for the top five managers, including the chief executive officer (CEO). Given that CEO ownership in the firm is a large component of the total managerial ownership in the firm, I focus attention at the CEO level. In doing so, I follow the methodology of studies that have examined the CEO's pay-performance relationship. Specifically I create a variable that is the CEO's pay-performance sensitivity, defined as the percentage of shares outstanding owned by the CEO, plus the percentage of shares outstanding in options awarded to the CEO times the Black–Scholes hedge ratio (i.e., the sensitivity of CEO's options to changes in firm value).[6] When a pooled ordinary least squares (OLS) regression is run, a quadratic relationship is found between this variable and firm value at the three-digit SIC level [consistent with McConnell and Servaes (1990)]. However, when my methodology is used a statistically insignificant relationship is found. Second, this approach brings together two related strands of literature. One strand has examined the relationship between firm value and total managerial ownership, whereas the other has examined the relationship between firm value and the structure of the CEO's compensation contract [see, e.g., Murphy (1985) and Jensen and Murphy (1990b)]. Accordingly I use the CEO's pay-performance sensitivity which embeds the value of the CEO's share ownership in the context of the structure of the CEO's entire compensation contract.

The article is organized as follows. In Section 1 I explain the estimation methodology and Section 2 describes the data. Section 3 describes the different variables used in the empirical tests. In Section 4 I present empirical results. Section 5 concludes.

1. Estimation Methodology

I begin by explaining the estimation methodology. I use panel data to control for unobservable characteristics of the contracting environment and, like the previous literature, use Tobin's Q as the proxy for firm value. I specify below the system of equations. I use a firm-level fixed effects model with

[5] Most of the empirical articles that examine the CEO pay-performance relationship [e.g., Murphy (1985), Jensen and Murphy (1990b), and Hubbard and Palia (1995b)] have examined the sensitivity of ownership and options to increases in shareholder wealth.

[6] Strictly speaking, the value of salary and bonus also fluctuates with shareholder wealth because bonuses are tied to firm performance. However, many studies such as Jensen and Murphy (1990b) have found the sensitivity of salary and bonus to firm performance to be extremely small when compared to the sensitivity of options and share ownership to firm performance. More recently, after our sample period of 1981–1993, the SEC has required firm proxy statements to disclose the CEO's salary and bonus separately.

year dummies in order to relate firm performance and incentive-compatible compensation.

$$Q_{it} = \alpha_i + \beta_1' \, LCOMP_{it} + \boldsymbol{\beta}' \, C_{it} + \beta_2' \, X_{it} + \gamma_t + \epsilon_{1it} \qquad (1)$$

$$LCOMP_{it} = \delta_i + \theta_1 \, Q_{it} + \boldsymbol{\tau} \, \boldsymbol{Z_{it}} + \boldsymbol{\theta} \, C_{it} + \gamma_t + \epsilon_{2it} \qquad (2)$$

In Equation (1), firm value is given by Q_{it}, where t is a time subscript, α_i is the individual fixed effects estimated for each firm i, γ_t is a dummy variable for each year, $LCOMP_{it}$ is the logistic transformation of the CEO's pay-performance sensitivity *COMP*,[7] which is defined as the proportion of shares owned by the CEO plus the proportion of shares awarded to the CEO in options times the Black–Scholes hedge ratio. $\boldsymbol{C_{it}}$ is the various control variables that are included by the previous literature in different specifications (research and development expenses, advertising expenses, capital structure, and firm size), X_{it} is a predetermined variable[8] (treasury stock), and β_1', $\boldsymbol{\beta}'$, and β_2' are the panel regression coefficients [see Hsiao (1986) and Greene (1993) for how these coefficients are estimated], and ϵ_{1it} is the error term. Equation (1) suggests that firm value Q_{it} increases as the CEO's pay-performance sensitivity $LCOMP_{it}$ increases.

Equation (2) shows that $LCOMP_{it}$ is an endogenous variable and is specified when δ_i is the individual fixed effects estimated for each firm i, $\boldsymbol{Z_{it}}$ is four exogenous instrumental variables[9] (specifically, CEO experience, CEO quality, firm volatility, and CEO age), γ_t is the year effects, C_{it} is the control variables θ_1, $\boldsymbol{\tau}$, and $\boldsymbol{\theta}$ is the estimated regression coefficients, and ϵ_{2it} is the error term. I also show that $LCOMP_{it}$ is related to these instrumental variables. I observe that the above system of equations satisfies the rank and order conditions for model identification [see Greene (1993)]. That is, each equation has its own predetermined variable, X_{it} for Equation (1) and $\boldsymbol{Z_{it}}$ for Equation (2).

I note that the epsilons in Equations (1) and (2) can be correlated in estimating a simultaneous system of equations using cross-sectional data, when certain firms have unobservable characteristics (such as intangible assets). However, I use panel data which can control for unobservable heterogeneity among firms. In this model, each firm has a separate intercept. As long as intangible assets are fixed per firm over time, a fixed effects model can control for these unobservables. I also specifically check whether the fixed effects model is the appropriate technique for the panel sample or whether I need

[7] Because the dependent variable in Equation (2) is bounded from zero to unity, I use the logistic transformation of COMP, namely, $LCOMP = \ln\,(COMP/(1 - COMP))$.

[8] I also estimate this system of equations using the firm's 10-year lagged Tobin's Q as an alternative predetermined variable in Equation (1).

[9] For robustness, I reestimate the system of equations using the lagged values of the instrumental variables $\boldsymbol{Z_{it-1}}$.

to use the random effects model. I find in that the fixed effects model dominates both simple pooled OLS regressions and the random effects model.[10] Further, any macroeconomic trend of firms investing in more intangible assets is captured by the year dummies γ_t.

Hence I analyze a two-stage least squares solution for Equation (1) by estimating Equation (2), with firm-level fixed effects and different transformations of the instrumental variables $\boldsymbol{Z_{it}}$, and getting the fitted values of $LCOMP_{it}$. These fitted values are then used as instruments for $LCOMP_{it}$. Because $LCOMP_{it}$ is the logistic transformation of $COMP_{it}$, the estimated regression coefficient β_1' cannot be interpreted as the marginal effect of an increase in COMP_{it} on Q_{it}. I calculate the marginal effect using the delta method [see Greene (1993, p. 297)] to be $[1/(COMP_{it} * (1 - COMP_{it}))] * \beta_1'$, which is evaluated at the median level of $COMP_{it}$. I also examine if the error term in the two-stage least squares is uncorrelated with the instrumental variables $\boldsymbol{Z_{it}}$, that is, $E[\epsilon_{1it}\boldsymbol{Z_{it}}] = 0$. Under standard OLS assumptions we can conduct an F-test to examine this null hypothesis. I find no evidence of correlation in our system of equations.

I note that the previous literature uses as their estimation methodology a cross-sectional regression variant of Equation (1) which is specified as follows:

$$Q_i = \alpha_j + \beta_1 COMP_i + \boldsymbol{\beta} C_i + \epsilon_i, \tag{3}$$

where i denotes different firms, j different three-digit SIC codes, $\boldsymbol{C_i}$ the control variables mentioned above, α, β_1, and $\boldsymbol{\beta}$ the estimated regression coefficients, and ϵ_i the error term. The functional relationship of Tobin's Q to $COMP_i$ has been found to be either inverted-U [McConnell and Servaes (1990)] or a piecewise linear specification that is first increasing in Q, then decreasing in Q, and then increasing in Q, with each increase in managerial ownership [Mørck, Shleifer, and Vishny (1988)]. In my estimation methodology I also check for these nonlinear functional forms.

I estimate three different specifications for the simultaneous system of equations. The first specification does not include any control variables, the second specification includes the control variables $\boldsymbol{C_{it}}$ specified above, and the third specification expands the control variables $\boldsymbol{C_{it}}$ to also include other variables that have recently been found to be statistically significant such as

[10] Specifically, I permit an F-test on the restriction of equal intercepts at the group level. This restriction is rejected at the 5% level for all my specifications, suggesting that the fixed effects model does better than running OLS on the pooled data. I also conduct Breusch and Pagan's (1980) Lagrange multiplier test and find that the random effects model also does better than OLS on the pooled data. I test which of these two panel estimation techniques (fixed effects or random effects) should be used by conducting Hausman and Taylor's (1981) specification test. Using the Wald criterion, they suggest that the covariance of an efficient estimator, with its difference from an inefficient estimator, is zero. I find evidence in support of the fixed effects procedure over the random effects procedure. Accordingly, I always use the fixed effects procedure.

free cash flow and capital intensity [HHP (1999)], board and ownership structure [Core, Holthausen, and Larcker (1999)], and whether the CEO founded the company [Hall and Liebman (1998)].

2. Data Description

I obtain data for CEO compensation from Brian Hall, details of which are described in Hall and Liebman (1998). These compensation data are largely built from the annual proxy statements filed by firms with the Securities and Exchange Commission (SEC), and span the 13 years 1981–1993. Each firm's yearly stock return is calculated from the Center for Research in Security Prices (CRSP) daily stock return file, and all other firm-specific data (e.g., research and development expenses, annual dividend paid, total assets, etc.) is from Standard and Poor's Compustat. I obtain the 1981–1993 interest rates on 10 year constant-maturity Treasury bonds from the 1997 *Economic Report of the President.* The CEO-specific education data are obtained from different yearly issues of Marquis' *Who's Who in Finance and Industry* and from different yearly issues of Dun and Bradstreet's *Reference Book of Corporate Managements.* The final sample consists of 361 firms, many of which have 13 years of complete data (1981–1993). In most specifications, there are 3,260 observations, as data for some firms are missing for some years. However, in one specification, which includes the founder dummy as a regressor, only 2,367 observations are used because the founder variable has a lot of missing data.

3. Variables

In this section I describe the proxies used for the dependent variable firm value, the independent variables, and the instrumental variables. I motivate the use of each variable and how I calculate each proxy, and if relevant, the item number in Compustat is given in parentheses.

3.1 Firm value

The empirical corporate finance literature has proxied for firm value[11] by using Tobin's Q, where Q is defined as the ratio of the market value of the firm to the replacement value of the firm's assets. As in Smith and Watts (1992) and Shin and Stulz (1998), I calculate Q_{it} as the ratio of the market value of equity (item24 $\times$ item25) minus the book value of equity (item60) plus the book value of assets (item6) to the book value of assets.

[11] Whereas the financial economics literature has generally used Tobin's Q as the proxy for firm value, some studies have estimated production functions whose residual (called productivity) is used as a proxy for firm value [e.g., Kim and Maximovic (1990), Lichtenberg and Siegel (1990), and Palia and Lichtenberg (1999)].

3.2 Compensation

I define the proxy for shareholder incentive-compatible compensation as the CEO's pay-performance sensitivity. Specifically, it is defined as the proportion of shares outstanding owned by the CEO plus the proportion of shares outstanding in options awarded to the CEO times the Black–Scholes hedge ratio (i.e., the sensitivity of CEO's options to changes in firm value). The sensitivity of options to firm value follows Yermack (1995), and uses the Black and Scholes (1973) option valuation model that allows for continuously paid dividends [Noreen and Wolfson (1981), Murphy (1985)]. Then the CEO's pay-performance sensitivity due to options is given by N_t divided by the total shares outstanding times $e^{-dT}\Phi(D^*)$, where N_t is the number of options granted in year t at exercise price X, S^* is the year-end stock price S times the discounted value of the dividend yield d, $\Phi(\cdot)$ is the cumulative standard normal distribution function, and $D^* = [\ln(S/X) + (r - d + \sigma^2/2)T]/\sigma\sqrt{T}$. I assume that each option has a 10-year maturity [as in Houston and James (1995)]. I estimate σ, the standard deviation of stock returns in the previous 12-month period, and use the interest rates on the constant-maturity 10-year Treasury bonds in year t as the relevant risk-free rate r_t.

3.3 Treasury stock

For the system of equations to be properly identified, a predetermined variable X_{it} is needed in Equation (1). I choose the firm's treasury stock variable *TRE,* defined as the ratio of the dollar treasury stock (item88) to total assets.[12] I use this variable because it might have a positive relationship to firm value because of accounting considerations. A simple example might help illustrate this point. Consider two firms A and B, both of which have \$10 in book value of equity, no debt, 10 shares outstanding, and a price of \$3 per share. Therefore each company has a price-to-book ratio of 3. Company B buys back two shares while company A does not. Because treasury stock has to be valued in the balance sheet at a cost equal to market value at the time of purchase, company B's new book value of equity is \$4 (the original \$10 less the market value purchase of two shares for \$6).[13] Even if there is no positive information conveyed by the buyback (e.g., the company has been purchasing its shares in the capital markets because their managers regularly exercise their newly vested stock options), the new price-to-book ratio for company B rises to 24/4 or 6. Company A did not buy back their own shares and still has a price-to-book ratio of 3. Accordingly one finds treasury

[12] It is possible that the ratio of treasury stock to assets is related to the CEO's pay-performance sensitivity through firm size or through firm's buying back stock to reward their CEO through compensation. In order to ensure that my results are not driven by the choice of the predetermined variable X_{it}, in Equation (1) I reestimate the system of equations by choosing a variable that has no a priori relationship with the CEO's pay-performance sensitivity, namely the firm's 10-year lagged Tobin's Q.

[13] For a more detailed explanation of the accounting treatment of treasury stock see any accounting textbook [e.g., Maher, Stickney, and Weil (1998)].

stock to be positively related to firm value. Of course, if the price of company B's shares increases because of positive information dissemination, the price-to-book ratio would be even higher for company B after the buyback.

3.4 Instrumental variables

3.4.1 Experience. It is not unusual for managers with different years of experience to be given different pay-performance sensitivities. Murphy (1986) suggests that a manager's ability is unknown at the beginning of his or her term. Hence, in the early years, performance is used as information to update managerial ability and will consequently have a large impact on their pay-performance sensitivity. In the later years, when estimates of ability are more precise, deviations from expected performance are only due to the random variation of output and have lesser effects on managerial pay-performance sensitivity. Murphy (1986) finds evidence that the growth in a CEO's compensation is more sensitive to stock returns earlier in a CEO's career than later, and this result is confirmed by Barro and Barro (1990) in a sample of banks. We proxy for CEO experience (*EXP*) by the number of years the CEO has been CEO in the firm.

3.4.2 Quality. Rosen (1992) suggests that in addition to providing performance incentives, one of the functions of the executive labor market is to identify competent and talented managers. Jensen and Murphy (1990a, p. 44) explain that "a highly sensitive pay-for-performance system will cause high-quality people to self-select into a company." They suggest that recent research in the analysis of executive pay has stressed incentives, while paying less attention to "slotting" people into jobs. A few studies have recently started to examine this function of the executive labor market.[14] Whereas these models link managerial quality with increasing pay-performance sensitivity, one might suggest that managerial quality is highly subjective and extremely hard to measure. Any reliable metric of CEO quality is likely to have an easily measurable component and an unobservable component. We hence can split up CEO quality into observed quality (as in the prestige of the school the CEO attended) and unobserved managerial quality (as in leadership characteristics, social networks that prestigious schools provide, personality traits emphasized in a school's admission policy, etc). As long as there is a correlation between the rankings of the schools and unobserved managerial quality, one might find a positive relationship between the observed education quality variable and the CEO's pay-performance sensitivity.[15] Palia (2000)

[14] For example, Murphy, Shleifer, and Vishny (1991) suggest that the allocation of talent has significant effects on the growth rate of a country. In their model, people with significant increasing returns to ability [or superstars in the Rosen (1981) sense] choose occupations where much of the rents on their talent can be retained. Hence, they find evidence that countries with a higher proportion of engineering college majors grow faster, and countries with a higher proportion of law concentration majors grow slower.

[15] Accordingly, Chevalier and Ellison (1999) find that mutual fund managers with higher education quality, that is, those that were educated by universities with higher average SAT scores, tend to outperform other funds.

finds that electric utilities have a lower CEO pay-performance sensitivity and a lower quality of CEO education than a control sample of manufacturing firms. This result is consistent with the idea that restricting the investment opportunity sets of firms and the associated pay structure of CEOs allows the functioning managerial labor market to slot scarce managerial talent to higher-value firms.

In order to obtain a measure for the subjective CEO quality variable, I examine the CEO's education at both the undergraduate and graduate level. I begin by examining whether firms have CEOs whose undergraduate degrees are from a top school. Given that the college rankings change over time, we obtain a list of the 13 top-ranked undergraduate programs in the 1960s [Coleman (1973)], approximately the time that the CEOs in our sample were pursuing an undergraduate degree. These undergraduate colleges (other than engineering colleges) in alphabetical order are Brown, Columbia, Cornell, Dartmouth, Duke, Georgetown, Harvard, Johns Hopkins, Northwestern, Pennsylvania, Princeton, Stanford, and Yale. I also differentiate an engineering degree from other undergraduate degrees so as not to rank them in the same order as other undergraduate programs. In engineering, I pick six schools that were ranked as the top 10 schools in 1964 in three of the four fields of chemical engineering, civil engineering, electrical engineering, and mechanical engineering (Cartter 1966). Given that the CEO's resume does not give the engineering speciality, I find that this procedure allows me to choose the top engineering programs. Alphabetically they are Berkeley, CalTech, Illinois, Michigan, MIT, and Stanford. I also proxy for the quality of education by finding the earliest rankings of postgraduate college programs. Note that the ranking of programs in law is not necessarily the same as in business. For the MBA degree, I choose the earliest ranking of programs I could find (MBA 1974) to obtain the 10 top-ranked schools. Alphabetically they are Carnegie, Chicago, Columbia, Harvard, Michigan, Northwestern, Sloan, Stanford, Tuck, and Wharton. For law I once again pick the earliest ranking I could find [Useem and Karabel (1986)] who give the nine top-ranked law schools in 1974. Alphabetically they are Berkeley, Chicago, Columbia, Harvard, Michigan, NYU, Pennsylvania, Stanford, and Yale. If a CEO has graduated from an undergraduate or graduate program from a top school, the dummy variable *QUAL* is set to unity, and zero otherwise.

3.4.3 Firm volatility. Principal-agent models suggest that the optimal contract to managers involves a trade-off between incentives for the manager and managerial risk aversion. Accordingly the higher the firm's volatility the

Examining the privatization of Russian shops, Barberis et al. (1995) find that the presence of new owners and managers increases the likelihood of restructuring, whereas giving equity incentives to old managers does not promote restructuring.

lower the use of high-powered incentives to managers.[16] Demsetz and Lehn (1985) also suggest that the higher the volatility of the firm, the higher the managerial discretion, and therefore managers have to be given more variable compensation. Using this line of thinking, Holderness, Kroszner, and Sheehan (1999) find that managerial ownership stakes had increased from 13% in 1935 to 25% in 1995. They find that managerial ownership is positively related to firm volatility in 1995 and negatively related to managerial ownership in 1935. They suggest that shareholders might have preferred smaller stakes for managers in 1935 because in that year firms had higher volatility than in 1995. I estimate the volatility variable *SIG* defined as the standard deviation of the firm's daily returns for each year.[17]

3.4.4 Age. Gibbons and Murphy (1992) suggest that younger executives are willing to take more costly unobservable actions because of career concerns. In maximizing the total incentives from explicit pay-performance incentives and implicit career concerns, Gibbons and Murphy suggest that holding CEO's tenure constant, the CEO's pay-performance sensitivity should increase as the CEO ages. This is because career concerns provide fewer incentives as the CEO is near retirement, and therefore a higher CEO's pay-performance sensitivity has to be offered at such a time.

3.5 Control variables

3.5.1 Research and development expenses, and advertising expenses. Given that intangible assets or "soft capital" should affect firm value in the future, and might not be captured by current *Q* values, prior research [e.g., Mørck, Shleifer, and Vishny (1988), McConnell and Servaes (1990)] has included research and development expenses and advertising expenses in their set of regressors as proxies of future growth opportunities. These studies found intangible assets to be positively related to firm value. Similarly I include variables *R&D* and *ADV*, the ratio of research and development expenses (item46) to total assets, and the ratio of advertising expenses (item45) to total assets, respectively. Given that Compustat does not report research and development expenses and advertising expenses for all firms in all years, I create two dummy variables that are set to unity (*R&DDUM* and *ADVDUM*) whenever the relevant expense is missing. Some researchers

[16] The use of volatility and firm size as valid instruments is undertaken by HHP. One might argue against using these variables as instruments because high-*Q* might be a proxy for high-growth opportunities and such firms might be smaller and have higher volatility. In the neoclassical setting, studies of fixed investment suggest that when managers maximize the expected present value of future profits from capital with a capital accumulation constraint and with adjustment costs that are linearly homogeneous in investment and capital [see Hayashi (1982)], deviations of *Q* from its equilibrium values are explained by the costs of adjusting the capital stock which are proportional to the investment rates. Therefore the inclusion of research and development, advertising expenses, and investment rates should control for growth opportunities, and makes the a priori case for omitting these variables from the *Q* equation.

[17] The formula used for SIG is $(254/119)\sum_{t=1}^{120}(\ln(1+r_{it})-\overline{\ln(1+r_i)})^2)^{0.5}$.

eliminate observations with these missing values, but this procedure seems undesirable because it reduces the sample size and biases the results in favor of research and development and advertising intensive firms.

3.5.2 Capital structure. Much of the theoretical and empirical literature has shown debt to be beneficial for firm value. Accordingly we control for the debt equity ratio *DEBT*, defined as the book value of total debt (item9 + item34) to book value of assets.

3.5.3 Firm size. The literature has found firm size to be positively related to the CEO's pay-performance sensitivity [see Rosen (1992) for a review]. On the other hand, Mørck, Shleifer, and Vishny (1988), McConnell and Servaes (1990), Smith and Watts (1992), among others, find firm size to be negatively related to firm value. Accordingly I create a variable, *SIZE,* that is the logarithm of the market value of equity (item24 × item25) as the proxy for firm size.

3.5.4 Free cash flow and capital intensity. HHP found managerial ownership to be related to the free cash flow variable of Jensen (1986) and to the capital intensity of the firm. Although free cash flow is empirically unobservable, as in HHP, I create the variable FCF, defined as the ratio of operating profits (item13) to total assets as the empirical proxy. I also create the variable *CAP*, defined as the ratio of capital stock (item8) to assets.

3.5.5 Other corporate governance variables. On the one hand, studies have found that CEO compensation can be effected by board and ownership structure [Core, Holthausen, and Larcker (1999)], and whether the CEO founded the company [Hall and Liebman (1998)].[18] On the other hand, studies have also found these corporate governance variables to have an impact on firm value. Jensen (1993) and Yermack (1996) show that smaller board size is better for firm performance. Yermack (1996) also finds that larger ownership by officers and directors results in higher firm values. Johnson et al. (1985) find that founders that suddenly died resulted in higher abnormal returns on press announcement. Given that these corporate governance variables affect both CEO compensation and firm value they cannot be used as instruments. I proxy for board structure by the size of the board *BRD,* and for ownership structure by the proportion of the firm owned by officers and directors *BOWN*. A dummy variable *FDER* is set to unity when the CEO is a member of the founding family or of a family that acquired control, and set to zero otherwise.

[18] Strictly speaking, there are many attributes of board and ownership structure [Core, Holthausen, and Larcker (1999)] that are related to each other and are also endogenously chosen in response to the firm's contracting environment [Hermalin and Weisbach (1998)]. As they are each endogenous, each variable requires a separate equation. Not doing so makes the coefficients on these other corporate governance variables inconsistent. I include these variables as controls only in order to ensure that my results on the CEO's pay-performance sensitivity variable are robust to their inclusion.

4. Empirical Tests and Results

I begin by examining the data in Table 1, which presents the descriptive statistics of the different variables used in the empirical analysis. My sample of firms has an average Tobin's Q of 1.22 and a median value of 1.13,

Table 1
Descriptive statistics

Variable	Definition	Mean	Median	Standard deviation	Observations
Tobin's Q (Q)	(Market value of equity − book value of equity + book value of assets) ÷ book value of assets	1.22	1.13	0.78	3,260
CEO's compensation sensitivity *(COMP)*	Proportion of shares owned by CEO + (proportion of shares awarded to CEO in options ∗ Black-Scholes hedge ratio)	0.02	0.001	0.06	3,260
Logistic transformation of CEO's compensation sensitivity *(LCOMP)*	$\log(COMP/(1 - COMP))$	−6.31	−6.45	2.52	3,260
Treasury stock *(TRE)*	Ratio of treasury stock to book value of assets	0.02	0.00	0.06	3,260
CEO's experience *(EXP)*	Number of years as CEO	8.60	6.00	7.19	3,260
CEO's quality *(QUAL)*	Dummy equal to unity if CEO graduated from prestigious university	0.26	0.00	0.44	3,260
Stock return volatility *(SIG)*	Standard deviation of the firm's daily stock returns in the last 120 trading days of each year	0.30	0.26	0.15	3,260
CEO's age *(AGE)*	CEO's age in years	57.35	58.00	6.34	3,260
Research & development expenses *(R&D)*	Ratio of R&D expenses to book value of assets	0.01	0.00	0.03	3,260
Advertising expenses *(ADV)*	Ratio of advertising expenses to book value of assets	0.01	0.00	0.04	3,260
Capital structure *(DEBT)*	Ratio of book value of total debt to book value of assets	0.25	0.23	0.15	3,260
Firm size *(SIZE)*	Logarithm of market value of equity	7.28	7.24	1.22	3,260
Free cash flow *(FCF)*	Ratio of operating profits to book value of assets	0.12	0.12	0.08	3,260
Capital intensity *(CAP)*	Ratio of capital stock to book value of assets	0.37	0.35	0.28	3,260
Board size *(BRD)*	Number of directors on the board	13.43	13.00	4.31	3,257
Board share ownership *(BOWN)*	Proportion of shares owned by officers and directors	0.07	0.002	0.12	3,255
Dummy for CEO being founder *(FDER)*	Dummy equal to unity if CEO is member of founding family or of family that acquired control	0.11	0.00	0.36	2,375

The sample consists of 361 firms for the 13 years 1981–1993.

suggesting that these firms are reasonably profitable with valuable investment opportunity sets. The CEO's pay-performance sensitivity variable (*COMP*) has an average value of 2.04% and a median value of 0.157%. This suggests that most of these firms have a component of the CEO's wealth related to firm performance, even with the stringent assumption that all bonuses paid to the CEO are fixed and are not related to firm performance.[19] The logistic transformation of compensation *LCOMP* has an average value of −6.31 and a median value of −6.45. In addition, I find *LCOMP* has 35.62% of its total variance as within firm variation, and the remaining 64.38% varies between firms cross-sectionally. The average ratio of treasury stock to assets is 2%. The average number of years the CEO has been CEO is 8.6, and about 26% of them have attended a top-ranked school. The average age of the CEO is 57.35 years and the average volatility is 30%.

The sample firms have an average logarithm of firm size (*SIZE*) of $7.28 million, a mean ratio of research and development to assets of 0.01, and an average ratio of advertising to assets of 0.01. I find the average debt-to-equity ratio in our sample is 0.25, with a similar median value of 0.23. The firms have an average 12% of assets in free cash flow, and a mean capital intensity of 37% of total assets. The mean number of directors on the board is 13.43 with a similar median value of 13 directors. Officers and directors own on average 7% of the firm, with the median ownership being only 0.2%. On average 11% of the sample involved founders of firms.

Using treasury stock as the predetermined variable in Equation (1), I begin the estimation of the simultaneous set of equations specified by Equations (1) and (2). Specifically I instrument for the endogenous compensation variable using transformations of four instrumental variables, namely, CEO experience, CEO quality, firm volatility, and CEO age. I then use the fitted values of Equation (2) (that is, with firm-level fixed effects and different transformations of the instrumental variables $\mathbf{Z}_{it}$) in estimating Equation (1). I also use a fixed effects model in all regressions in order to control for any firm-level heterogeneity, and I do not present the individual coefficients on the year dummy variables. The results of such an analysis are given in Table 2. In the first specification, I do not control for any other variables in the *Q* regression. I find that *LCOMP* is positive but not statistically significantly related to firm performance, with a coefficient of 0.006 and an associated t-statistic of 0.59. The marginal effects evaluated at the median level of *COMP* is 3.720. I also note that the unobservable contracting environment that each firm faces is controlled by the fixed effects regression. In fact, an F-test for testing the null hypothesis of equal intercepts across firms suggests strong rejection. The treasury stock variable *TRE* is weakly positively related to firm value.

In the second specification, I control for the intangible firm-specific variables (research and development expenses, and advertising expenses), capital

[19] During the sample years, salary and bonus were generally not presented separately in the proxy statements.

Table 2
Two-stage least squares, firm-level fixed effects regression of Tobin's Q (linear specification)

Variable			
LCOMP	0.006 *3.720* (0.59)	0.008 *5.067* (1.31)	0.005 *2.907* (0.53)
TRE	0.094* (1.95)	0.044 (1.46)	0.051 (1.28)
R&D	—	10.037*** (7.54)	9.366*** (6.05)
R&DDUM	—	0.075 (1.03)	0.073 (0.84)
ADV	—	3.278*** (3.11)	3.712*** (3.06)
ADVDUM	—	0.032 (0.59)	0.081 (1.18)
DEBT	—	0.000 (0.53)	0.000 (0.05)
SIZE	—	0.265*** (12.70)	0.440*** (14.28)
FCF	—	—	0.000 (1.13)
CAP	—	—	0.000 (1.12)
BRD	—	—	−0.026*** (−3.50)
BOWN	—	—	0.696*** (3.17)
FDER	—	—	−0.099 (−1.21)
Adjusted R^2	0.039	0.636	0.622
No. of observations	3,260	3,260	2,367
F-statistic for test of E $[\epsilon_{1it}\ \boldsymbol{Z_{it}}] = 0$; where $\boldsymbol{Z_{it}}$ are instrumental variables	0.160	0.390	0.530

The table shows the results from estimating a set of simultaneous equations specified below, using different transformations of the instrumental variables $\boldsymbol{Z_{it}}$, firm-level fixed effects α_i and δ_i, year dummies γ_t, in order to relate firm value (Q_{it}) and the CEO's pay-performance sensitivity.

$$Q_{it} = \alpha_i + \beta_1' \, LCOMP_{it} + \boldsymbol{\beta}' \, \boldsymbol{C_{it}} + \beta_2' \, X_{it} + \gamma_t + \epsilon_{1it}$$

$$LCOMP_{it} = \delta_i + \theta_1 \, Q_{it} + \tau \, Z_{it} + \boldsymbol{\theta} \, \boldsymbol{C_{it}} + \gamma_t + \epsilon_{2it}$$

$LCOMP_{it}$ is the logistic transformation of the CEO's pay-performance sensitivity *COMP*, which is defined as the proportion of shares owned by the CEO plus the proportion of shares awarded to the CEO in options times the Black-Scholes hedge ratio. $\boldsymbol{C_{it}}$ are the various control variables that are included by the previous literature in different specifications (research and development expenses, advertising expenses, capital structure, firm size, free cash flow, capital intensity, board size, board ownership, and a founder dummy), X_{it} a predetermined variable (treasury stock), and β_1', $\boldsymbol{\beta}'$, and β_2' the panel regression coefficients. Because *LCOMP* is the logistic transform of COMP, I present in italics the marginal effects evaluated at the median level of compensation using the delta method [see Greene (1993, p. 297)]. *, **, and *** denotes significance at 10%, 5%, and 1% level, respectively. Year effects and firm-level fixed effects are not reported. The sample consists of 361 firms for the 13 years 1981–1993.

structure, and firm size variables that have been used in the previous literature. Once again, we find that *LCOMP* is statistically insignificantly related to firm performance (with a t-statistic of 1.31), and research and development expenses, advertising expenses, and firm size are positively related to firm value.

In the third specification, I construct a comprehensive set of control variables that has been shown by the current literature to be related to firm value. I find that the coefficient on *LCOMP* is 0.005, which remains statistically insignificant (with a t-statistic of 0.53). The research and development variable *R&D* remains positively related to firm value, as does the advertising variable *ADV*. The firm size variable *SIZE* continues its strong positive association with firm value. Neither the free cash flow variable *FCF* nor the capital intensity variable *CAP* are statistically significant. We find that a smaller board results in higher firm value, as does higher ownership by officers and directors. The founder dummy is not statistically significantly related to firm value. Note that these other corporate governance variables are also endogenously chosen in response to the firm's contracting environment [Hermalin and Weisbach (1998), Stulz (1988)], and therefore strictly require a separate equation. Not doing so makes their coefficient estimates inconsistent. We include these variables as controls only to ensure that our results on the CEO's pay-performance sensitivity variable is robust to their inclusion. In summary, I note that all three specifications find the CEO's pay-performance sensitivity to be positive but statistically insignificantly related to firm value,[20] and this result is robust to the presence of many control variables.[21]

To check whether my system of equations is properly identified, I examine if the error term in the two-stage least squares is not correlated with the instrumental variables $\boldsymbol{Z_{it}}$, that is, $E[\epsilon_{1it}\boldsymbol{Z_{it}}] = 0$. In the last line of Table 2, we find very low F-statistics in all three specifications, not allowing us to reject the null hypothesis of zero correlation between the error terms and instruments. This suggests that the system of equations is properly identified.[22]

I now provide evidence on the validity of our instruments for the compensation variable in two tables. Note that I motivated the choice of instruments in Section 4.4. Specifically compensation is related to CEO experience [Murphy (1986)], CEO quality [Jensen and Murphy (1990a), Barberis et al. (1995)],

[20] In order to ensure that the results in Table 2 are not driven by choosing treasury stock as the predetermined variable in Equation (1), I reestimate our system of equations using the 10-year lagged Tobin's Q as the predetermined variable. Once again, in all three specifications, *LCOMP* has a positive but statistically insignificant relation with firm value. Research and development and firm size continue their strong positive relation with firm value. Advertising has a statistically significant positive relation with firm value, and loses its significance when we include the selling and administration variable. The F-test for $E\,[\epsilon_{1it}, Z_{it}] = 0$ shows low F-statistics in all three specifications, not allowing us to reject the null hypothesis of zero correlation between the error terms and instruments. In summary, all these results are strongly consistent with those in Table 2, suggesting that the choice of the predetermined variable in Equation (1) has no significant impact on my results.

[21] One of the benefits of using panel data to control for firm level heterogeneity is that influential outliers (like Microsoft) have less of an impact than in cross-sectional regressions. What I use in a fixed effects model are differences in means [see Greene (1993)]. To check the robustness of our results to outliers, we removed the top 5% of $LCOMP_{it}$ from our sample and reestimated Table 2. None of the results changed significantly.

[22] None of the results changed significantly when we reestimated the entire system of equations using lagged instrumental variables $\boldsymbol{Z_{it-1}}$, instead of the contemporaneous instrumental variables $\boldsymbol{Z_{it}}$.

firm volatility [Demsetz and Lehn (1985)], and CEO age [Gibbons and Murphy (1992)]. In Table 3 I run fixed effects regressions of compensation on these four instrumental variables, and different transformations thereof, and find that compensation is related to these instruments. I observe that a fixed effects regression has the highest goodness-of-fit and is selected as the right model for these panel regressions [based on an F-test on equal intercepts for each firm and a Hausman and Taylor (1981) specification test]. The R^2 also jumps in the first specification from 0.205 to 0.616 when I use a firm-level fixed effects model, and from 0.236 to 0.618 in the second specification.

I now analyze the impact of each instrument on the CEO's pay-performance sensitivity. In the first specification, I find that all four instruments are statistically significantly related to *LCOMP* when using pooled OLS regressions. But I know that these regression coefficients are biased upward if the true model is a fixed effects model (from the discussion above). I therefore interpret the results from the fixed effects model only. I find that the CEO's pay-performance sensitivity is affected positively by CEO experience and CEO age. A one standard deviation increase in experience evaluated at the average level of CEO age would result in a 7.59% increase in the median level of *COMP*. In the case of CEO age, a one standard deviation increase in CEO age evaluated at the average level of CEO experience and quality would result in a 22.41% increase in the median level of *COMP*. None of the variables involving firm volatility are statistically significantly related to compensation. CEO quality interacts with CEO age in a positive way, suggesting that a one standard deviation increase in CEO quality evaluated at the average level of CEO age would result in a 42.50% increase in the median level of *COMP*.

I observe that the strong relationship of our instruments to a CEO's pay-performance sensitivity in Table 3 is driven by time variation through CEO turnover in our three instruments (CEO experience, age, and quality and different transformations thereof).[23] This suggests that the previous literature's approach of including CEO compensation as an exogenous variable [e.g., Mørck, Shleifer, and Vishny (1988) and McConnell and Servaes (1990)] without controlling for CEO turnover suffers from an omitted variable problem. But it also presents an interesting but subtle issue for us. The instrumental variable approach might suggest that I am measuring only the effect of CEO turnover on firm value and none of the effect of CEO compensation on firm value (as in Mørck, Shleifer, and Vishny, and McConnell and Servaes). In Table 4 I show that this is not the case. For ease of explanation, let β_{yx} be the impact of CEO compensation x on firm value y, β_{yz} be the impact of the instruments z on firm value, β_{xz} be the effect of the instruments on CEO

[23] CEO turnover might arise through voluntary retirement or through threats to managerial security. Such threats might include unsuccessful tender offers, forced CEO departures, and the addition of a 5% blockholder to the board [e.g., Berger, Ofek, and Yermack (1997) find that leverage increases in the aftermath of such threats to managerial security].

Table 3
Validity of instruments 1: regression of compensation *(LCOMP)* on instruments

Instruments	Pooled	Firm-level fixed effects	Pooled	Firm-level fixed effects
Constant	−4.980***	—	−25.53***	—
	(−11.16)		(−2.65)	
EXP	0.166***	0.043***	0.496***	0.249**
	(25.70)	(4.58)	(6.14)	(2.54)
QUAL	0.194***	0.077	2.050***	−3.130**
	(1.99)	(0.50)	(2.02)	(−2.57)
SIG	2.945***	−0.259	20.90***	−0.030
	(9.79)	(−0.96)	(6.82)	(−0.01)
AGE	−0.060***	0.022**	1.027**	0.569***
	(−8.15)	(2.21)	(2.03)	(2.88)
$(EXP)^2$	—	—	0.009***	0.005*
			(3.42)	(1.90)
$(SIG)^2$	—	—	−13.75**	1.587
			(−6.15)	(0.87)
$(AGE)^2$	—	—	−0.022**	−0.027***
			(−2.50)	(−2.88)
$(EXP)^3$	—	—	−0.000**	−0.000*
			(−2.51)	(−1.68)
$(SIG)^3$	—	—	4.057***	−0.392
			(5.24)	(−0.63)
$(AGE)^3$	—	—	0.000***	0.000***
			(3.04)	(2.91)
EXP ∗ SIG	—	—	−0.066	0.012
			(−1.58)	(0.37)
EXP ∗ QUAL	—	—	−0.004	−0.025
			(−0.30)	(−1.30)
SIG ∗ QUAL	—	—	−0.192	−0.547
			(−0.28)	(−0.95)
AGE ∗ EXP	—	—	−0.008***	−0.004**
			(−6.08)	(−2.55)
AGE ∗ SIG	—	—	−0.145***	−0.026
			(−3.17)	(−0.71)
AGE ∗ QUAL	—	—	−0.031*	0.062***
			(−1.74)	(2.80)
Adjusted R^2	0.205	0.616	0.236	0.618

The table shows the results relating the CEO's pay-performance sensitivity to different transformations of the instrumental variables $\mathbf{Z}_{it}$, using both OLS and firm-level fixed effects δ_i, namely,

$$LCOMP_{it} = \delta_i + \boldsymbol{\tau}\mathbf{Z}_{it} + \gamma_t + \epsilon_{2it}$$

where $LCOMP_{it}$ is the logistic transformation of the CEO's pay-performance sensitivity *COMP*, which is defined as the proportion of shares owned by the CEO plus the proportion of shares awarded to the CEO in options times the Black–Scholes hedge ratio. *, **, and *** denotes significance at 10%, 5%, and 1% level, respectively. Year effects and firm-level fixed effects are not reported. The sample consists of 361 firms for the 13 years 1981–1993.

Table 4
Validity of instruments 2: firm-level fixed effects regression of *LCOMP* and *Q* on instruments

Instruments	*LCOMP*	*Q*
EXP	0.249***	0.058**
	(2.54)	(2.01)
QUAL	−3.130***	−0.367
	(−2.57)	(−1.34)
SIG	−0.030	−0.050
	(−0.01)	(−0.09)
AGE	0.569***	0.049
	(2.88)	(0.40)
$(EXP)^2$	0.005*	0.001
	(1.90)	(1.62)
$(SIG)^2$	1.587	0.344
	(0.87)	(0.84)
$(AGE)^2$	−0.027***	−0.001
	(−2.88)	(−0.75)
$(EXP)^3$	−0.000*	−0.000**
	(−1.68)	(−2.30)
$(SIG)^3$	−0.392	−0.057
	(−0.63)	(−0.41)
$(AGE)^3$	0.000***	0.000
	(2.91)	(1.09)
$EXP * SIG$	0.012	−0.010
	(0.37)	(−1.39)
$EXP * QUAL$	−0.025	0.008
	(−1.30)	(1.53)
$SIG * QUAL$	−0.547	−0.081
	(−0.95)	(−0.62)
$AGE * EXP$	−0.004**	−0.000
	(−2.55)	(−1.48)
$AGE * SIG$	−0.026	−0.003
	(−0.71)	(−0.39)
$AGE * QUAL$	0.062***	0.005
	(2.80)	(1.18)
Adjusted R^2	0.618	0.421
p-value for the restriction that the coefficients on the instruments are jointly equal to zero	0.000***	0.098*

The table shows the results relating the logistic trasnformation ($LCOMP_{it}$) of the CEO's pay-performance sensitivity and firm value (Q_{it}) to different transformations of the instrumental variables $\mathbf{Z_{it}}$ using a firm-level fixed effects model. *, **, and *** denotes significance at 10%, 5%, and 1% level, respectively. Year effects and firm-level fixed effects are not reported. The sample consists of 361 firms for the 13 years 1981–1993.

compensation (strictly speaking the β's are vectors, but for ease of explanation let them be scalars). The variable of analytical interest is therefore β_{yx}. Then Angrist, Imbens, and Rubin (1996) generally show that $\beta_{yx} = \frac{\beta_{yz}}{\beta_{xz}}$. If the effect is really from CEO turnover, what is being essentially captured in estimating β_{yx} is β_{yz}. The highly statistically significant values on many of the z-variables in the first column of Table 4 suggests that β_{xz} is strongly statistically significant. At the bottom of Table 4, an F-test for examining if these instrumental variables are jointly equal to zero strongly rejects at the 1% level. I then examine the effect of the instruments on firm value and find only some of them to be statistically significant, which is also captured by the lower R^2. An F-test for examining if these instrumental variables are jointly equal to zero rejects at the 10% level. The much higher incidence of statistically significant variables in the regression of x on z, than in the regression of y on z (and the higher F-statistics for their joint significance) suggests that the effect on β_{yx} is primarily due to β_{xz} (CEO compensation) and secondarily due to β_{yz} (CEO turnover).

In order to further ensure that the results in Table 2 are not driven by CEO turnover, I reestimate each specification using a CEO-level fixed effects model, in which each CEO gets a separate dummy. The results of such an estimation are given in Table 5. Once again, in all three specifications I find that *LCOMP* is positive but statistically insignificantly related to firm performance. *R&D* and *ADV* remain statistically significantly related to firm performance, whereas the endogenous variables *BRD* and *BOWN* lose their statistical significance. In all three specifications, the test of overidentifying restrictions suggest that the system of equations is well identified.

As in Demsetz and Lehn (1985) and HHP (1999), I check if compensation is endogenously related to firm-specific variables. In Table 6 I estimate both OLS regressions and fixed effects regressions that control for unobserved firm heterogeneity. In each specification the year effects and firm-level fixed effects are not reported. Once again, I find that in all specifications an F-test rejects the null hypothesis of equal intercepts across firms. The higher goodness-of-fit also lends support for the fixed effects methodology. These results suggest that even after controlling for observable firm characteristics, interpreting OLS regressions can be misleading because they do not capture differences in the firm's unobservable contracting environment. In the first specification, I include the firm's intangible assets, debt, size, and the instrumental variables. I find that compensation is significantly positively related to capital structure, capital intensity, the instrumental variables CEO experience and CEO age, and negatively related to firm size. In the second and third specifications, I include the comprehensive set of regressors that have been found by different studies to be related to managerial compensation. All the results from the first specification remain basically the same. In addition, I find that the CEO's pay-performance sensitivity is increased when he has a smaller board, and when the officers and directors on the board have a higher share ownership in the firm. No statistically significant impact is found on the founder dummy. However, one should remember that the coefficient estimates on *BRD*, *BOWN*, and *FDER* are inconsistent, as these variables are also endogenous, and consequently require a separate equation each. In summary, my results show strong support for the hypothesis that managerial compensation is indeed endogenous and is related to *both* observable and unobservable differences in the firm's contracting environment.

Table 5
Validity of instruments 3: two-stage least squares, CEO level fixed effects regression of Tobin's Q (linear specification)

Variable			
LCOMP	0.002 *1.352*	0.001 *0.329*	0.002 *1.636*
	(0.15)	(0.04)	(0.15)
TRE	0.125	0.114	0.115
	(1.40)	(1.38)	(1.06)
R&D	—	10.219***	9.790***
		(3.53)	(3.13)
R&DDUM	—	0.214	0.293
		(1.08)	(1.30)
ADV	—	3.564**	3.056**
		(2.11)	(1.99)
ADVDUM	—	0.002	−0.025
		(0.02)	(−0.18)
DEBT	—	−0.000	−0.000
		(−0.23)	(−0.62)
SIZE	—	0.164***	0.211**
		(2.80)	(2.53)
FCF	—	—	0.000
			(0.19)
CAP	—	—	0.000
			(0.41)
BRD	—	—	−0.007
			(−0.43)
BOWN	—	—	0.508
			(1.06)
FDER	—	—	−0.117
			(−0.62)
Adjusted R^2	0.010	0.438	0.411
No. of observations	3,260	3,260	2,367
F-statistic for test of $E[\epsilon_{1it}\mathbf{Z_{it}}] = 0$; where $\mathbf{Z_{it}}$ are instrumental variables	0.080	0.590	0.480

The table shows the results from estimating a set of simultaneous equations specified below, using different transformations of the instrumental variables $\mathbf{Z_{it}}$, CEO-level fixed effects α_i and δ_i, year dummies γ_t, in order to relate firm value (Q_{it}) and the CEO's pay-performance sensitivity.

$$Q_{it} = \alpha_i + \beta_1' LCOMP_{it} + \boldsymbol{\beta}' \mathbf{C_{it}} + \beta_2' X_{it} + \gamma_t + \epsilon_{1it}$$
$$LCOMP_{it} = \delta_i + \theta_1 Q_{it} + \tau Z_{it} + \boldsymbol{\theta} \mathbf{C_{it}} + \gamma_t + \epsilon_{2it}$$

$LCOMP_{it}$ is the logistic transformation of the CEO's pay-performance sensitivity COMP, which is defined as the proportion of shares owned by the CEO plus the proportion of shares awarded to the CEO in options times the Black-Scholes hedge ratio. $\mathbf{C_{it}}$ are the various control variables that are included by the previous literature in different specifications (research and development expenses, advertising expenses, capital structure, firm size, free cash flow, capital intensity, board size, board ownership, and a founder dummy), X_{it} a predetermined variable (treasury stock), and β_1', $\boldsymbol{\beta}'$, and β_2' the panel regression coefficients. Because *LCOMP* is the logistic transform of *COMP*, I present in italics the marginal effects evaluated at the median level of compensation using the delta method [see Greene (1993, p. 297)]. *, ** , and *** denotes significance at 10%, 5%, and 1% level, respectively. Year effects and CEO-level fixed effects are not reported. The sample consists of 361 firms for the 13 years 1981–1993.

Having established that compensation is endogenous, the validity of the instruments, and that the system of equations is properly specified, I hence examine if the appropriate relationship between compensation and firm value is an inverted U, as found by McConnell and Servaes (1990). Specifically I create a quadratic specification that includes the usual linear compensation variable *LCOMP* and the squared compensation variable $(LCOMP)^2$. If the true relationship is an inverted U, I should find a positive and statistically significant coefficient on *LCOMP* and a negative and statistically significant coefficient on $(LCOMP)^2$. The results of such an estimation are given in Table 7. In all three specifications I find *LCOMP* to have a positive but statistically insignificant coefficient, and the variable $(LCOMP)^2$ to have a negative coefficient that is also statistically insignificant. These results provide no evidence in support of the inverted U relationship. In addition, the consistent decrease in all three specifications of the goodness-of-fit for the quadratic specification (as opposed to the linear specification in Table 2) also suggests that the linear specification seems more appropriate for my sample.

I note that the empirical tests have differed from the analysis of the previous literature (that examines the relationship between *Q* and managerial ownership) in two ways other than examining the endogeneity of the compensation variable. One, I use panel regressions that control for firm-level heterogeneity and the previous literature generally estimates cross-sectional regression. Two, I use a variable that is the CEO's pay-performance sensitivity and the previous literature examines the fraction or percentage of the firm that is owned by the board and top managers. In Table 8 I estimate the specifications where compensation is assumed to be exogenous. I examine the quadratic specification using the compensation variables *COMP* and $(COMP)^2$. Once again, I do not report the coefficients on the year dummies. I begin by estimating cross-sectional regressions on the pooled data. I find a significant quadratic relationship, wherein *COMP* is positive and statistically significant, and $(COMP)^2$ is negative and statistically significant. The inflection point when the relationship between compensation and firm value turns negative is approximately 44.05%. These results mimic the results of McConnell and Servaes (1990). Further, research and development expenses, advertising expenses, and size are all positively related to firm value, whereas capital structure is negatively related to firm value. Given that many studies [e.g., Mørck, Shleifer, and Vishny (1988)] have controlled for different industry effects using three-digit SIC codes, I reestimate the quadratic specification while controlling for industry effects. I find that the quadratic relationship still holds, as does the statistical significance of the research and development expenses, advertising expenses, and size. The inflection point where the relationship turns negative changes to 47.33% when I control for three-digit SIC codes.

I next examine the piece-wise linear relationship of Mørck, Shleifer, and Vishny (1988). Specifically, I define variables $MSV1 = COMP$ if $COMP$

Table 6
Determinants of compensation *(LCOMP)*

Variable	Pooled			Firm-level fixed effects		
Constant	1.747***	1.733***	−2.565***	—	—	—
	(3.11)	(3.09)	(−4.61)			
R&D	2.638	2.534	2.368	−0.170	−0.184	0.787
	(1.51)	(1.45)	(1.58)	(−0.04)	(−0.04)	(0.17)
R&DDUM	−0.508***	−0.490***	−0.160	0.183	0.204	0.170
	(−4.44)	(−4.27)	(−1.53)	(0.70)	(0.78)	(0.65)
ADV	1.669	1.640	3.605***	5.694	5.652	3.240
	(1.20)	(1.18)	(3.07)	(1.51)	(1.50)	(0.90)
ADVDUM	−0.588***	−0.588***	0.013	0.072	0.096	0.064
	(−5.25)	(−5.24)	(0.12)	(0.37)	(0.48)	(0.32)
DEBT	0.000	0.000	−0.000	0.002***	0.002***	0.003***
	(1.19)	(0.12)	(−0.80)	(3.10)	(2.99)	(3.78)
SIZE	−0.786***	−0.784***	−0.465***	−1.130*	−1.139*	−0069
	(−19.63)	(−19.56)	(−11.24)	(−1.67)	(−1.78)	(−0.76)
FCF	—	0.001**	0.000	—	−0.000	−0.001***
		(2.21)	(1.44)		(−1.59)	(−2.84)
CAP	—	0.000	0.001***	—	0.001**	0.002***
		(0.38)	(3.09)		(2.56)	(3.10)
BRD	—	—	−0.035***	—	—	−0.067***
			(−2.94)			(−3.04)
BOWN	—	—	5.702***	—	—	6.253***
			(15.64)			(9.88)
FDER	—	—	1.594***	—	—	0.492**
			(11.35)			(2.01)
EXP	0.158***	0.159***	0.087***	0.043***	0.043***	0.039***
	(25.23)	(25.24)	(12.84)	(4.53)	(4.58)	(3.62)
QUAL	0.143	0.137	0.003	0.059	0.065	0.080
	(1.53)	(1.46)	(0.04)	(0.39)	(0.43)	(0.49)
SIG	1.042***	1.104***	0.916***	−0.428	−0.420	−0.013
	(3.42)	(3.61)	(2.70)	(−1.51)	(−1.48)	(−0.04)
AGE	−0.046***	−0.046***	−0.017**	0.024**	0.023**	0.018*
	(−6.43)	(−6.47)	(−2.34)	(2.40)	(2.36)	(1.73)
Adjusted R^2	0.292	0.292	0.463	0.617	0.618	0.625
No. of observations	3,260	3,260	2,367	3,260	3,260	2,367

The table shows the results relating the CEO's pay-performance sensitivity to different transformations of the instrumental variables $\boldsymbol{Z_{it}}$, using both OLS and firm-level fixed effects δ_i, namely,

$$LCOMP_{it} = \delta_i + \tau Z_{it} + \boldsymbol{\theta C_{it}} + \gamma_t + \epsilon_{2it},$$

where $LCOMP_{it}$ is the logistic transformation of the CEO's pay-performance sensitivity *COMP*, which is defined as the proportion of shares owned by the CEO plus the proportion of shares awarded to the CEO in options times the Black-Scholes hedge ratio. $\boldsymbol{C_{it}}$ are the various control variables that are included by the previous literature in different specifications (research and development expenses, advertising expenses, capital structure, firm size, free cash flow, capital intensity, board size, board ownership, and a founder dummy). *, **, and *** denotes significance at 10%, 5%, and 1% level, respectively. Year effects and firm-level fixed effects are not reported. The sample consists of 361 firms for the 13 years 1981–1993.

Table 7
Two-stage least squares, firm-level fixed effects regression of Tobin's Q (quadratic specification)

Variable						
LCOMP	0.014	*9.077*	0.014	*8.523*	0.012	*7.373*
	(0.72)		(0.91)		(0.98)	
$(LCOMP)^2$	−0.000	*−0.501*	−0.000	*−0.535*	−0.000	*−0.600*
	(−0.42)		(−0.60)		(−0.53)	
TRE	0.317		0.255		0.230	
	(0.98)		(1.06)		(1.15)	
R&D	—		9.966***		9.293***	
			(3.35)		(3.15)	
R&DDUM	—		0.078		0.080	
			(0.48)		(0.48)	
ADV	—		3.318		3.759	
			(1.41)		(1.63)	
ADVDUM	—		0.036		0.087	
			(0.29)		(0.67)	
DEBT	—		0.000		−0.000	
			(0.22)		(−0.02)	
SIZE	—		0.264***		0.442***	
			(5.68)		(7.53)	
FCF	—		—		0.000	
					(0.53)	
CAP	—		—		0.000	
					(0.58)	
BRD	—		—		−0.026*	
					(−1.87)	
BOWN	—		—		0.685*	
					(1.68)	
FDER	—		—		−0.129	
					(−0.81)	
Adjusted R^2	0.024		0.553		0.595	
No. of observations	3,260		3,260		2,367	
F-statistic for test of E $[\epsilon_{1it}\,\boldsymbol{Z_{it}}] = 0$; where $\boldsymbol{Z_{it}}$ are instrumental variables	0.170		0.520		0.540	

The table shows the results from estimating a set of simultaneous equations specified below, using different transformations of the instrumental variables $\boldsymbol{Z_{it}}$, firm-level fixed effects α_i and δ_i, year dummies γ_t, in order to relate firm value (Q_{it}) and the CEO's pay-performance sensitivity.

$$Q_{it} = \alpha_i + \beta_1' \, LCOMP_{it} + \beta_2' \, (LCOMP_{it})^2 + \boldsymbol{\beta}' \, \boldsymbol{C_{it}} + \beta_3' \, X_{it} + \gamma_t + \epsilon_{1it}$$

$$LCOMP_{it} = \delta_i + \theta_1 \, Q_{it} + \tau \, Z_{it} + \boldsymbol{\theta} \, \boldsymbol{C_{it}} + \gamma_t + \epsilon_{2it}$$

$LCOMP_{it}$ is the logistic transformation of the CEO's pay-performance sensitivity *COMP*, which is defined as the proportion of shares owned by the CEO plus the proportion of shares awarded to the CEO in options times the Black-Scholes hedge ratio. $\boldsymbol{C_{it}}$ are the various control variables that are included by the previous literature in different specifications (research and development expenses, advertising expenses, capital structure, firm size, free cash flow, capital intensity, board size, board ownership, and a founder dummy), X_{it} a predetermined variable (treasury stock), and β_1', β_2', $\boldsymbol{\beta}'$, and β_3' the panel regression coefficients. Because *LCOMP* is the logistic transform of *COMP*, I present in italics the marginal effects evaluated at the median level of compensation using the delta method [see Greene (1993, p. 297)]. *, ** , and *** denotes significance at 10%, 5%, and 1% level, respectively. Year effects and firm-level fixed effects are not reported. The sample consists of 361 firms for the 13 years 1981–1993.

Table 8
Specifications where compensation is exogenous (quadratic specification)

Variable	Pooled	Three-digit SIC, fixed effects without instruments		Three-digit SIC, fixed effects with instruments	
Constant	0.545*** (4.95)	—	—	—	—
COMP	4.080*** (12.54)	1.490*** (4.47)	—	0.704 (0.86)	—
$(COMP)^2$	−4.631*** (−7.53)	−1.574*** (−2.88)	—	−0.967 (−0.97)	—
MSV1	—	—	3.087*** (3.96)	—	1.086 (1.24)
MSV2	—	—	2.517*** (5.25)	—	0.981 (1.43)
MSV3	—	—	−0.861** (−1.98)	—	−0.095 (−0.73)
R&D	7.603*** (15.62)	9.780*** (15.27)	9.421*** (14.65)	9.382*** (14.31)	9.143*** (13.95)
R&DDUM	0.062** (1.96)	0.221*** (5.60)	0.211*** (5.38)	0.230*** (5.82)	0.221*** (5.63)
ADV	4.195*** (10.67)	5.554*** (10.46)	5.647*** (10.67)	5.421*** (10.25)	5.539*** (10.50)
ADVDUM	−0.179*** (−5.65)	−0.054 (−1.53)	−0.053 (−1.49)	−0.058 (−1.63)	−0.053 (−1.49)
DEBT	−0.000* (−1.67)	−0.000*** (−3.85)	−0.000*** (−3.80)	−0.000*** (−3.42)	−0.000*** (−3.36)
SIZE	0.110*** (10.07)	0.083*** (7.83)	0.087*** (8.14)	0.088*** (7.91)	0.093*** (8.37)
Adjusted R^2	0.301	0.597	0.601	0.604	0.608
Inflection point	44.05	47.33	—	36.40	—

Under the assumption that the CEO's pay-performance sensitivity is exogenous, this table shows the results relating firm value (Q_{it}) to the CEO's pay-performance sensitivity using OLS three-digit SIC code controls, and firm-level fixed *, **, and *** denotes significance at 10%, 5%, and 1% level, respectively. Year effects, SIC dummies, and coefficients on the instrumental variables are not reported. The sample consists of 361 firms for the 13 years 1981–1993.

$< .05$, and $MSV1 = .05$ if $COMP \geq .05$; $MSV2 = 0$ if $COMP < .05$, $MSV2 = COMP - .05$ if $.05 \leq COMP < .25$, and $MSV2 = .20$ if $COMP \geq .25$; and $MSV3 = 0$ if $COMP < .25$, and $MSV3 = COMP - .25$ if $COMP \geq .25$. I then regress firm value on the three independent variables *MSV*1, *MSV*2, and *MSV*3 while controlling for three-digit SIC codes and the usual control variables (R&D, advertising, capital structure, and firm size). I find *MSV*1 and *MSV*2 to be positive and statistically significantly related to firm value, and *MSV*3 to be negative and statistically significantly related to firm value. These results are similar to those found by McConnell and Servaes (1990) when they examine the piece-wise linear relationship, but are different from Mørck, Shleifer, and Vishny's results (1988) in the *MSV*2 and *MSV*3 variables.

In the next two specifications, I examine the quadratic and piece-wise linear relationships when we exogenously include our four instrumental variables and their different transformations. For exposition, I do not report the regression coefficients and the t-statistics on the instrumental variables. Now I find no statistically significant relation between *COMP*, $(COMP)^2$, and firm value, as well as between *MSV*1, *MSV*2, and *MSV*3 and firm value. These results again confirm that managerial compensation is highly correlated with the instrumental variables.

5. Conclusions

Much of the empirical literature that has examined the relationship between firm value and managerial ownership levels assumes that managerial ownership levels are exogenous and are the only component of managerial compensation that is related to firm performance. This assumption is contrary to both the theoretical and empirical literature wherein managerial compensation is endogenously determined. Using panel data to control for unobservable heterogeneity in the firm's contracting environment, I estimate a system of simultaneous equations to identify the impact of the structure of managerial compensation on firm value. In doing so, I control for firm type, capturing both observable and unobservable firm characteristics. I extend the definition of managerial pay-performance sensitivity to not just include the sensitivity of CEO share ownership to changes in firm value, but also the sensitivity of CEO's options granted to changes in firm value. I estimate a separate equation for incentive-compatible compensation, by using four instrumental variables (namely, CEO experience, CEO age, CEO quality of education, and firm volatility) that are expected to be related to compensation. I motivate the use of these four instruments and also confirm that they are related to compensation in the sample. When I estimate the firm value equation using the two-stage least squares, fixed effects model, I find that shareholder incentive-compatible compensation is not statistically significantly related to firm value. This suggests that firms are in equilibrium when they set their CEO's compensation contract in response to differences in their contracting environment (captured by both observable and unobservable firm characteristics).

I also show that when I estimate OLS regressions that control for differences in three-digit SIC codes, I find the familiar inverted-U relationship between managerial compensation and firm value that has been found in the previous literature [e.g., McConnell and Servaes (1990)]. This suggests that estimating cross-sectional regressions that do not control for differences in the firm's unobservable contracting environment can give quite a different relationship than when the model is more precisely specified using panel data.

Future research might use the methodology of this article (namely, simultaneous equations with fixed effects to control for unobservable heterogeneity in the firm's contracting environment) when testing whether certain decision variables such as the size of the board of directors, the proportion of outsiders on the board, and capital structure, are related to firm value. In addition, whereas this article has a separate equation for the managerial compensation variable only, one might extend this model to have a separate equation for each firm-specific variable and each component of managerial compensation (e.g., capital structure, research and development expenses, advertising expenses, share ownership, options, board and ownership structure, etc.). Of course, such a system of equations would involve the difficult task of finding an exogenous variable for each equation. I leave such issues for future research.

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