Stock Market Information Production and Executive Incentives*

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Abstract

We find that an informationally efficient stock market induces firms to rely more heavily on pay-for-performance schemes. We construct five stock market informativeness measures using stock trading data and analysts' earnings forecast data. These variables, individually and collectively, account for the cross-sectional variation in chief executive officer (CEO) pay-performance sensitivity well. Our results are robust to the choice of estimators, samples, time periods, incentive measures, model specifications, and estimation methods. We also analyze the properties of the pay-performance sensitivities of nonCEO executives and executive teams; These have similar properties as CEO pay-performance sensitivity.

JEL Classification: D80, G14, G34, J33
Keywords: Market microstructure, pay-performance sensitivity, probability of informed trading, analysts' earnings forecast

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Abstract

We predict and find empirically that an informationally efficient stock market induces firms to rely more heavily on pay-for-performance schemes. We construct a set of five stock market informativeness measures, on the basis of the stock trading data and the analysts' earnings forecast data. We find that these variables, individually and collectively, account for the cross-sectional variations in chief executive officers' (CEOs') pay-performance sensitivities well. Our results are robust to the choice of estimators, samples, time periods, measures of incentives, model specifications, and estimation methods. We also analyze the properties of the pay-performance sensitivities for non-CEO executives and the executive teams. We show that they have similar properties as CEO pay-performance sensitivity.

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1 Introduction

Pay-for-performance schemes have gained huge popularity in the past two decades. While the use of stock grants, options, and other forms of equity-related incentive pay has become a common practice, it has also been the subject of an extensive and still expanding literature. One of the key questions of this literature is: Under what conditions will performance pay be more effective? Put differently, under what conditions will firms rely more heavily on pay-for-performance schemes?

Research on executive compensation and incentives has generated many useful insights. It has been found that firm size, return volatility (risk), growth opportunity, CEO tenure (or CEO reputation), ownership structure, industry, and time are all important determinants of equity-based incentives.[1] Our study adds to this literature by examining empirically an important determinant of managerial incentives, the stock market informativeness, which is suggested in Holmstrom and Tirole (1993).

Holmstrom and Tirole (1993) (HT hereinafter) analytically show that stock prices incorporate performance information that cannot be readily extracted from the firm's accounting data, and that the principal can use the inferred information to design a more effective compensation contract. That is, the more liquid the stock market is, the more informative is the stock price, and the more effective is the performance-related pay scheme in inducing managerial incentives. HT posits that concentrated ownership structure directly determines market liquidity and hence managerial incentives, but this particular role of the ownership confounds with other roles that may also affect executive incentives such as the corporate governance channel (e.g., Hartzell and Starks, 2003).

To motivate our econometric model of the relationship between managerial incentives

[1] See, for example, Demsetz and Lehn (1985) and Smith and Watts (1992) for research on firm size, Garen (1994), Aggarwal and Samwick (1999), and Jin (2002) for research on return volatility (risk), Smith and Watts (1992) and Gaver and Gaver (1993) for research on growth opportunity, Bertrand and Mullainathan (2001) and Milbourn (2002) for research on CEO tenure, and Ely (1991) and Murphy (1999) for research on industry and year effects. Hartzell and Starks (2003) explore how ownership, especially, institutional investors, affects managerial incentives.

and stock market informativeness, we build a simple model combining the optimal incentive contracting with stock trading. Our model abstracts from the ownership structure assumption and yields the same empirical implications as the HT model. We show analytically that there is a positive relation between pay-performance sensitivity and stock price informativeness.

We test the predictions using executive compensation data drawn from Compustat's ExecuComp database during the period 1992–2001. We focus our empirical analysis on CEO incentives. Following the compensation literature (e.g., Jensen and Murphy, 1990; Hall and Liebman, 1998; and Aggarwal and Samwick 1999), we estimate pay-performance sensitivity by examining the empirical relation between changes in executive firm-related wealth and changes in shareholder wealth. We use two metrics of pay-performance sensitivity. One is stock-based pay-performance sensitivity (PPS), which measures the change in dollar value of a CEO's holdings of stocks and stock options per $1,000 increase in the firm's shareholder wealth. The other is total pay-performance sensitivity (PPS_TOT), which measures the change in dollar value of a CEO's total firm-related wealth per $1,000 increase in the firm's shareholder wealth. Hall and Liebman (1998) and Murphy (1999) find that the former accounts for the majority of CEO incentives and can also be measured more precisely compared to other compensation components. We thus mainly rely on the stock-based PPS to interpret the empirical results.

We construct five proxies for stock market informativeness. We use the the stock trading data to compute probability of informed trading (PIN) for each firm-year observation (Easley, Kiefer, O'Hara, and Paperman, 1996, 1997). PIN directly estimates the amount of information held by traders on a specific stock. We also exploit the information contained in the analysts' earnings forecast data to construct four other proxies for stock market informativeness: $DISPER$ (the standard deviation of earnings forecast scaled by the absolute value of the mean earnings forecast), $DISPERP$ (the standard deviation of earnings forecast scaled by the stock price), FE (analyst earnings forecast error normalized by actual earnings), and FEP (analyst earnings forecast error normalized by the stock price). The five variables capture different aspects of stock market informativeness.

We conduct various empirical tests of the hypothesis that pay-performance sensitivity increases with stock market informativeness. We find strong empirical support for this hypothesis. Specifically, we find that pay-performance sensitivity is strongly and positively related to PIN, but significantly negatively related to FE, FEP, $DISPER$, and $DISPERP$, respectively.

All of these results are economically significant. Per $1,000 increase in the shareholder value, the CEO pay-performance sensitivities at the 25 percentile level of the stock market informativeness are $1.942, $1.784, $3.534, $2.481, and $5.4 smaller than the CEO pay-performance sensitivities at the 75 percentile level of the market informativeness, if the stock market informativeness proxies are PIN, FE, FEP, $DISPER$, and $DISPERP$, respectively. They represent respective reductions of 15.12%, 13.89%, 27.51%, 19.31%, and 42.04% from the median pay-performance sensitivity in our sample. Stock market informativeness also accounts for the cross-section differences in CEO pay-performance sensitivities. The overall results thus strongly suggest that an informationally efficient stock market induce firms to rely more heavily on equity-based incentives.

We include two ownership variables in all regressions. One variable captures the total institutional holdings and the other measures the concentration of institutional holdings. With the ownership effects controlled for, we use the five stock market informativeness measures to find a positive relation between CEO pay-performance sensitivity and stock market informativeness. This evidence suggests that the stock market informativeness measures capture the effect not accounted for by ownership structure.[2]

We find that our results are robust to the choice of estimators, samples, time periods, measures of incentives, model specifications, and estimation methods. We further extend

[2]Our results shows that ownership structure is not the only, even not the main, channel through which a firm's stock liquidity and stock price informativeness are affected. Our findings thus do not support the modelling assumption made in HT.

our analysis to non-CEO executives and the 'executive teams' as well.[3] We find that, like CEO pay-performance sensitivities, executive pay-performance sensitivities, individually or in teams, are positively related to the stock market informativeness. We also find that the impact of stock market informativeness on pay-performance sensitivity is much larger for CEOs than for non-CEO executives.

The paper proceeds as follows. Section 2 develops the main hypothesis of the paper. Section 3 discusses the data and the empirical method. Section 4 presents the empirical results. Section 5 discusses additional economic and measurement issues. Section 6 extends our empirical analysis to non-CEO executives and executive teams. Section 7 concludes.

2 Development of Hypothesis

The Holmstrom and Tirole (1993) study is one of the first papers to combine market microstructure with compensation contract theory. HT show that the stock price incorporates performance information that cannot be extracted from the firm's current or future profit data. The amount of information contained in the stock price is useful for structuring managerial incentives. An illiquid market makes the stock price less informative and thus reduces the benefits of stock market monitoring.

In HT, stock market acts as an external monitoring mechanism that aligns the managers' interest with that of shareholders. In the stock market an informed party (a speculator) take advantage of liquidity traders to disguise his private information and make money on it. Hence, the speculator has incentives to spend resources on collecting signals about the firm's fundamental value. The increased information flow into the market improves the information content of the stock price, which enable firms to design a more efficient managerial contracts. HT show analytically that the pay-performance sensitivity of managerial compensations is higher when the signal observed by the speculator is more precise or the amount of liquidity

[3] We thank the referee for making this suggestion to us.

trade is larger. (See Proposition 3 in HT). That is, the information content of stock price is positively related to the pay-performance sensitivity.

HT pinpoint the importance of the market microstructure aspect in inducing executive incentives. However, this aspect has not been rigorously tested in the literature partly because it is difficult to build an empirical analysis based on HT. To better motivate the empirical analysis of the relation between stock market informativeness and executive compensation, we propose in the Appendix an alternative one-period model which combines the optimal contracting with stock trading. In contrast with HT which assumes that ownership structure determines market liquidity endogenously, we assume that the market liquidity is exogenously given. This modeling choice, although yields the same empirical implications as those in HT, allows us to clearly control for the monitoring effect of ownership structure, and focus on examining how stock price informativeness affects the pay-performance sensitivity.

The key insights of our model, immediately from Propositions 2-3 in the Appendix, can be summarized as follows:

Main results: (1) The pay-performance sensitivity decreases with the manager's effort parameter, the degree of risk aversion, and increases with the degree of stock price informativeness. (2) The stock market informativeness increases with the number of informed traders which is determined by various market microstructure parameters, e.g., the cost of collecting information, market liquidity, uncertainty of the stock value, etc.

The key prediction from our model is consistent with the key prediction from HT. That is, the more informative the stock price is, the more effective is the compensation scheme in inducing managers' incentives. The core hypothesis for our empirical study is:

H1: The pay-performance sensitivity increases with stock market informativeness.

3 Data and Empirical Method

Our primary data set for executive compensation is the ExecuComp database from 1992 through 2001. The database reports annual compensation flows as well as information related to changes in the value of stock and stock option holdings for five most-paid executives, including the CEO, for each firm appearing in the S&P500 Index, S&P mid-cap 400 Index, and the S&P small-cap 600 Index. We obtain stock return data from the CRSP Monthly Stock File and accounting information from the Compustat Annual File. We use five proxies to measure the stock market informativeness and construct them from two databases. We compute a firm's probability of informed trading (PIN) in a given year by using intraday trading data extracted from the TAQ database. We calculate four other variables by using analysts' earnings forecast information retrieved from the I/B/E/S History Summary File. We obtain institutional equity holdings from the CDA Spectrum database, which derives these holdings from institutional investors' 13-f filings.

For our empirical study, we construct a sample containing 2,507 publicly traded firms and 17,584 CEO-firm-year observations. All monetary terms are in 1992 constant dollars. To remove the inflation effect from the empirical study, we adjust nominal stock returns with CPI to obtain returns in real terms.

3.1 Measuring CEO Incentives

Because the CEO makes most major corporate decisions and exerts the greatest influence on the firm among senior executives, we focus on incentive provisions for CEOs.[4] We measure incentive by the pay-performance sensitivity, which is defined as the dollar value change in the CEO's firm-specific wealth per $1,000 change in the shareholder value (Jensen and Murphy, 1990).

[4]We extend our empirical analysis to non-CEO executives and executive teams in Section 6. We identify CEOs by the fields "BECAMECE" and "CEOANN". Using only "CEOANN" is problematic, since there are many missing observations for the earlier periods of the sample (Milbourn, 2002).

CEO compensation comprises several different layers. Total current compensation (TCC) is the sum of salary and bonus. Total direct compensation (TDC) is the sum of total current compensation, other annual short-term compensation, payouts from long-term incentive plans, the Black-Scholes (1973) value of stock options granted, the value of restricted stocks granted, and all other long-term compensation. Both TCC and TDC measure the direct payment a CEO receives from his firm within one fiscal year. However, neither TCC nor TDC considers the indirect compensation that a CEO derives from a revaluation of stocks and stock options already granted to him in previous years.

We compute the change in value of a CEO's stock holdings over a given year as the beginning-of-year value of his stock holdings multiplied by this year's stock return. It is important to revalue the stock option portfolios. ExecuComp contains the values of unexercised exercisable and unexercisable in-the-money options, but the database measures only the intrinsic value of the option portfolios. We apply the Black-Scholes (1973) model to revalue the stock option portfolios. We adopt the Core and Guay's (1999) method to compute the hedge ratio delta (δ) of each option.[5] Delta refers to how the value of a stock option varies given a one-dollar change in the value of the underlying stock.[6] We then multiply the option deltas by the change in the firm's market value (or change in shareholders' wealth), adjusting for the percentage of stock shares represented by the options, and then add the value from stock option exercise to obtain the change in value of the CEO's option holdings. The change in CEO's total firm-specific wealth ($DTOTW$) is the sum of the direct compensation and the indirect compensation due to the revaluation of stocks and stock option holdings.

We define the change in shareholder value ($VCHANGE$) over a given year as the firm's beginning-of-year market value times the year's stock return. Using $VCHANGE$

[5]Core and Guay's (1999) method quite accurately accounts for the economically meaningful value of the in-the-money options, but their method ignores the value of out-of-the-money options. This may likely create systematic bias for firms with more underwater options and for firms with options that are at-the-money or near-the-money. This concern is partially alleviated since our results are robust to the subperiod analysis in Section 5.2 where the sample is divided into the bubble period and the post-bubble period.

[6]For simplicity, some researchers use 0.7 as the δ value.

and $DTOTW$, we calculate PPS_TOT as the dollar value change in the CEO's total firm-related wealth per $1,000 change in the shareholder value.

We define the stock-based pay-performance sensitivity (PPS) as the change in dollar value of the CEO's existing stock-based compensation (stocks and stock options) for a $1,000 change in the shareholders' wealth. We can interpret the stock-based pay-performance sensitivity as the CEO's stock ownership plus incentives from stock option holdings. Using the option delta (δ) we obtain:

$$PPS_{it} = (SHROWNPC_{it-1} + \frac{(Number\ of\ Options\ Held)_{it-1}}{(Number\ of\ Shares\ Outstanding)_{it-1}}\delta) * 1000, \qquad (1)$$

where $SHROWNPC$ is the CEO's ownership percentage.

PPS is more appealing than PPS_TOT for our empirical analysis. We can estimate the revaluations of existing stock and stock options with relative precision compared to measuring the impact of firm performance on the changes in total direct compensation. Including grants of stock options and restricted stocks can be problematic, because they might serve as an ex-post bonus mechanism rather than an ex-ante incentive mechanism. We therefore, focus primarily on the stock-based incentives. The analysis using PPS_TOT, which we include as a robustness check, yields essentially the same results.

Panel A of Table 1 presents the summary statistics of the CEO's compensation and incentive measures. For the average (median) CEO in our sample, total current compensation (TCC) is $960,776 ($680,813) in 1992 constant dollars. Total direct compensation (TDC) ranges from zero to $564.17 million, with an average value of $3.3 million and a median value of $1.42 million. An average (median) CEO holds 3.33% (0.43%) of his firm's stocks. A CEO gains an average of $1.92 million from stock option revaluation with a standard deviation of $34.86 million. The median option revaluation is worth $0.21 million. Overall, the change of the CEO's total firm-related wealth ($DTOTW$) has a mean value of $18.83 million and a median value of $2.3 million. We note that every compensation measure, particularly $DTOTW$, is highly right-skewed. The annual change in shareholders' value (VCHANGE) has a mean of \$457.17 million, and a median of \$61.79 million.

The mean and median values of the stock-based incentive measure (PPS), as defined in equation (2), are respectively, \$40.79 and \$12.85, respectively, per \$1,000 change in the shareholders' value. The PPS measure has a standard deviation of \$74.59 with a maximum value of \$994.45. The total pay-performance sensitivity (PPS_TOT) has a mean of \$46.51, which is higher than PPS, but it also has a slightly larger standard deviation (\$81.92). The median of PPS_TOT is \$13.09 and is almost the same as the median of PPS. The stock-based incentive does not deviate much from the total incentive, corroborating the findings in prior studies that changes in the value of stock and stock option holdings account for the majority of pay-performance sensitivities (Hall and Liebman, 1998; and Murphy, 1999).

Panel A of Table 1 also reports the summary statistics of pay-performance sensitivity for all executives, and the executive teams. We compute PPS_EXE based on equation (2) for all five most-paid executives within a firm (including the CEO). PPS_EXE measures the stock-based incentive of an individual executive. We obtain PPS_TEAM by summing up PPS_EXE across all five most-paid executives within a firm. PPS_TEAM captures the executive team's incentives. The mean and median values of PPS_EXE are \$15.76 and \$2.75, respectively, both of which are significantly smaller than those of CEO incentives. The mean (median) of PPS_TEAM is \$64.41 (\$24.25), and the majority of team incentives is attributable to the CEO incentives.

3.2 Measuring Stock Market Informativeness

3.2.1 Probability of Informed Trading (PIN)

Easley, Kiefer, O'Hara, and Paperman (1996, 1997) develop and use the PIN variable to measure the probability of informed trading in the stock market. The measure is based on the market microstructure model introduced in Easley and O'Hara (1992), where trades can come from liquidity traders or from informed traders. The literature has firmly established the PIN variable as a good measure of stock price informativeness in various settings.[7] PIN directly estimates the amount of information held by traders on a specific stock, and it is a good empirical variable to test our hypothesis that stock prices have an active role in enhancing pay-performance sensitivity.

Our description of the model and how we construct the PIN measure are as follows. There are three types of players in the game, liquidity traders, informed traders, and market makers. The arrival rate of liquidity traders who submit buy orders (or sell order) is ϵ. Every day, the probability that an information event occurs is α, in which case the probability of bad news is δ and the probability of good news is $(1-\delta)$. If an information event occurs, the arrival rate of informed traders is μ. Informed traders submit a sell order if they get bad news and a buy order if they get good news. Thus, on a day without information events, which occurs with probability $(1-\alpha)$, the arrival rate of a buy order will be ϵ and the arrival rate of a sell order will be ϵ as well. On a day with a bad information event (with probability $\alpha\delta$), the arrival rate of a buy order will be ϵ and the arrival rate of a sell order will be $\epsilon+\mu$. On a day with a good information event (with probability $\alpha(1-\delta)$), the arrival rate of a buy order will be $\epsilon+\mu$ and the arrival rate of a sell order will be ϵ. The likelihood function for a single trading day is:

$$\begin{aligned} L(\theta|B,S) &= (1-\alpha)e^{-\epsilon}\frac{(\epsilon)^B}{B!}e^{-\epsilon}\frac{(\epsilon)^S}{S!}+\alpha\delta e^{-\epsilon}\frac{(\epsilon)^B}{B!}e^{-\epsilon+\mu}\frac{(\epsilon+\mu)^S}{S!} \\ &\quad +\alpha(1-\delta)e^{-\epsilon+\mu}\frac{(\epsilon+\mu)^B}{B!}e^{-\epsilon}\frac{(\epsilon)^S}{S!}, \end{aligned} \tag{2}$$

where $\theta=(\epsilon,\alpha,\delta,\mu)$, B is the number of buy orders, and S is the number of sell orders in a single trading day. We infer trade direction from intraday data based on the algorithm proposed in Lee and Ready (1991).

[7] See, e.g., Easley, O'Hara, and Srinivas (1998); Easley, Hvidkjaer, and O'Hara (2002); Chen, Goldstein, and Jiang (2003); and Vega (2004).

Using the number of buy and sell orders in every trading day within a given year, $M = (B_t, S_t)_{t=1}^{T}$, and assuming cross-trading day independence,[8] we estimate the parameters of the model $(\epsilon, \alpha, \delta, \mu)$ by maximizing the following likelihood function:

$$L(\theta|M) = \prod_{t=1}^{t=T} L(\theta|B_t, S_t). \tag{3}$$

Then, we calculate PIN by dividing the estimated arrival rate of informed trades by the estimated arrival rate of all trades:

$$PIN = \frac{\alpha\mu}{\alpha\mu + 2\epsilon}. \tag{4}$$

We maximize the likelihood function in equation (4) for the parameter space θ and then calculate PIN for the period 1993-2001. There are 8,456 firm-year observations after we merge the TAQ database with the ExecuComp database.

Panel A of Table 2 presents summary statistics of PIN. In our sample, the average PIN is 0.163 with a standard deviation of 0.051. The median value of PIN is 0.157. The maximum PIN is 0.797 with a minimum of zero. The average sample property of our PIN estimates is consistent with the sample proprety identified in previous studies (see, e.g, Easley, Hvidkjaer, and O'Hara, 2002).

3.2.2 Measures Based on the Analysts' Forecast Data

Information-based trading can only be inferred by econometricians. We supplement the PIN measure with four other variables using the analysts' earnings forecast data from the I/B/E/S History Summary File. For each firm in the ExecuComp database, we use the summary information on analysts' fiscal year 1 earnings estimates in the ninth month of a

[8]This assumption is critical for estimating the model. However, Barclay and Warner (1993) find that informed traders engages in stealth trading. That is, they tend to camouflage their private information and spread trades over time. Therefore, the cross-trading day independence is unlikely to be satisfied. We thank the referee for pointing this out. As shown in Section 5.3, the impact of stealth trading on our results are likely negligible.

fiscal year as the raw measure.[9]

We compute FE as the absolute value of the difference between mean earnings forecast and actual earnings, divided by the absolute value of actual earnings. We calculate FEP as the absolute value of the difference between mean earnings forecast and actual earnings, scaled by the year-end stock price. When a firm's information production process is intense and effective, analysts following the firm's stock are more likely to agree with one another on the firm's earnings prospect. Both FE and FEP measure the intensity of a firm's information production. They serve as good proxies for the stock price informativeness.

We merge I/B/E/S/ with ExecuComp and delete the observations with zero actual earnings (FE would be undefined otherwise). This results in a sample of 9,420 firm-year observations over the period 1992-2001. Panel A of Table 2 presents summary statistics for FE. It has a mean (median) of 0.444 (0.066) and a standard deviation of 5.014. When we merger I/B/E/S with ExecuComp and delete the observations with zero year end stock price (FEP would be undefined otherwise), we obtain a sample with 9,421 firm-year observations. The mean and median values of FEP are 0.013 and 0.002 respectively. Its standard deviation is 0.093. We note that both FE and FEP are fat-tailed and extremely right-skewed.

Akinkya and Gift (1985), Diether, Malloy, and Scherbina (2002), and Johnson (2004) show that the dispersions of analysts' earnings forecasts is a proxy for the information environment in which various investors trade. A larger analyst forecast dispersion implies less intensive information production or a less transparent information environment and vice versa. We define $DISPER$ as the standard deviation of earnings forecasts scaled by the absolute value of the mean earnings forecast and times 100. If the mean earnings forecast is zero, we exclude the stock from the sample. Combining I/B/E/S/ with ExecuComp and deleting the observations with zero mean earnings forecast, we obtain a sample of 9,161 firm-year observations for the period 1992-2001. Panel A of Table 2 presents summary statistics

[9] We also conduct the analysis by using summary information on each of the other months' fiscal year 1 earnings estimates within that fiscal year. The summary information is stable across months and is very close to the annual average value. Results are qualitatively similar and are not reported for brevity.

of $DISPER$. Its mean (median) is 12.116 (3.175) and its standard deviation is 66.754.

We define $DISPERP$ as the standard deviation of earnings forecasts scaled by the year-end stock price and times 100. Its mean and median are 0.412 and 0.135 respectively. It has a standard deviation of 2.098. Both $DISPER$ and $DISPERP$ are fat-tailed and highly right-skewed.

Panel B of Table 2 presents the bivariate Pearson correlation coefficients and their significance levels of the five market informativeness variables. After merging the five variables, the number of observations drops to 4,503. In this sample, the correlation between PIN and FE is 0.019 and is not significant. The correlation between PIN and FEP however is significant at 0.068. The correlation between PIN and $DISPER$ is 0.04 and is significant at the 1% level. Its correlation with $DISPERP$ is also positively significant at the 1% level. FE are not significantly correlated with either $DISPER$ or $DISPERP$, although it is correlated with FEP at the 1% level. FEP is significantly correlated with both $DISPER$ and $DISPERP$ at the 1% level. The piecewise correlations among the five market informativeness proxies show similar properties, and are not reported for brevity.

Overall, our results suggest that the five variables capture different aspects of a firm's stock market informativeness. PIN, as argued in Easley et al. (2002), is more likely to capture the amount of private information contained in the stock price, while the four measures based on the analysts' forecast data might reflect both private and public information. However, such a distinction is only suggestive. We defer a detailed discussion of how these variables interact with each other in our context in Section 4.3.

3.3 Control Variables

Panel B of Table 1 summarizes the control variables we use in our empirical analysis. We obtain stock return data from CRSP. We calculate the market value ($MKTVAL$) at each year-end. Our sample comprises a range of firms with an average market capitalization of

\$4.29 billion and a median of \$0.86 billion. The smallest firm has only \$6,100 in market capitalization and the largest one has \$427.22 billion. We use the log value of market capitalization ($SIZE$) as one measure of firm size. The mean (median) value of $SIZE$ is 6.91 (6.76) with a standard deviation of 1.6. The firm's annualized percentage stock return ($ANNRET$) averages 22.45% with a median of 11.54%. The annualized percentage volatility of stock returns ($ANNVOL$), which we compute by using the past five years of monthly stock returns, has a mean value of 39.44% and a median value of 35.23%. We extract firm-specific accounting data from Compustat. To measure a firm's growth opportunities, we calculate Tobin's q as the ratio of the market value of assets to the book value of assets.[10] Table 1 shows that the average Tobin's q of the firms in our sample is 2.16. Its standard deviation and median are 2.75, and 1.48, respectively.

We construct two institutional ownership variables to control for the monitoring effect suggested in Harzell and Starks (2003), and to test the assumption made in the HT model — the market informativeness relates to pay-performance sensitivity through ownership structure. We define $INSTHOLD$ as the total institutional share holdings as a percent of the total number of shares outstanding. In HT, $INSTHOLD$ should be negatively related to market liquidity and pay-performance sensitivity. We expect institutional investors to have greater influence if the shares are concentrated on the hands of the larger investors. As in Hartzell and Starks (2003), we use the concentration of institutional ownership as a proxy for institutional influence. We define $INSTCON$ as the proportion of institutional investor ownership accounted for by the top ten institutional investors in the firm. As shown in Panel B of Table 1, on average, 56.47% of a firm's shares are owned by the institutional investors, and 60.07% of shares held by the institutional investors are controlled by the top ten institutional investors.

Other control variables are CEO tenure, industry dummies, and year dummies. We

[10] We obtain the market value of assets as the book value of assets (data 6) plus the market value of common equity (data 25 times data 199) less the book value of common equity (data 60) and balance sheet deferred taxes (data 74).

calculate CEO tenure as the number of years the executive has been the CEO of the firm as of the compensation year in ExecuComp. The mean and median of the CEO tenure are 7.68 and 5.5 years, respectively. The maximum tenure in our sample is 54.92 years. Finally, we construct 20 industry dummies based on the 2-digit SIC code from CRSP.

3.4 Econometric Specifications

There are two basic econometric methods in empirical studies of incentives. One is to directly regress the incentive measure against a set of explanatory variables. This approach makes the regression results immediately interpretable. It also provides the flexibility to control for factors that may affect the pay-performance sensitivity. Following this approach, we specify the basic model as:

$$\begin{aligned} PPS_{i,t} &= \gamma_0 + \gamma_1 INFOV_{i,t-1} + \gamma_2 size_{i,t-1} + \gamma_3 annvol_{i,t-1} + \gamma_4 Tobinq_{i,t-1} + \gamma_5 tenure_{i,t} \\ &\quad + \gamma_6 INSTHOLD_{i,t-1} + \gamma_7 INSTCON_{i,t-1} + \sum_{k \geq 8} \gamma_k dummies_{i,t} + \varepsilon_{i,t}, \end{aligned} \tag{5}$$

where PPS refers to the computed pay-performance sensitivity as specified in equation (2); $INFOV$ stands for the set of market informativeness variables, i.e., PIN, FE, FEP, $DISPER$, and $DISPERP$; and *dummies* are industry dummies and year dummies.

In equation (6), we control for several empirically relevant variables: firm size, return volatility, growth opportunities, CEO tenure, industry effects, year effects, and most importantly, institutional ownership. The coefficient γ_1 captures the influence of market informativeness on incentives and is our main parameter. We test our hypothesis by examining the sign and significance of the estimated γ_1.

Another specification, adopted in Jensen and Murphy (1990), and Aggarwal and Samwick (1999), among others, uses the CEO's compensation level as the dependent variable.

Based on the approach, we specify our model as:

$$\begin{aligned}
DTOTW_{i,t} \;\; = \;\; & \alpha + vchange_{i,t} * (\beta_0 + \beta_1 INFOV_{i,t-1} + \beta_2 size_{i,t-1} + \beta_3 annvol_{i,t} + \beta_4 Tobinq_{i,t-1} \\
& + \beta_5 tenure_{i,t} + \beta_6 INSTHOLD_{i,t-1} + \beta_7 INSTCON_{i,t-1} + \beta'_d dummies_{i,t}) \\
& + \beta_8 INFOV_{i,t-1} + \beta_9 size_{i,t-1} + \beta_{10} annvol_{i,t} + \beta_{11} Tobinq_{i,t-1} + \beta_{12} tenure_{i,t} \\
& + \beta_{13} INSTHOLD_{i,t-1} + \beta_{14} INSTCON_{i,t-1} \beta'_k dummies_{i,t} + \varepsilon_{i,t}, \qquad (6)
\end{aligned}$$

where $DOTOW_{i,t}$ denotes the changes in the CEO's firm-related wealth while employed by firm i in year t.[11]

To address cross-sectional variations in the pay-performance sensitivity, in equation (7) we interact the shareholder dollar return ($VCHANGE$) with firm size, return volatility, growth opportunities, CEO tenure, total institutional share holdings, the concentration of institutional share holdings, and industry and year dummies. To test the relation between the pay-performance sensitivity and the market informativeness, we interact the variable $INFOV$ with $VCHANGE$ to control for any heterogeneity in the pay-performance sensitivity beyond those attributable to firm size, return variability, growth opportunity, CEO tenure, industry effect, and year effect. The coefficient β_1 associated with this interaction term is the parameter of interest. If the heterogeneity of PPS does not depend on the market informativeness, the estimated β_1 will not be significantly different from zero. By including the control variables in equation (7), we ensure that our estimates of the interaction term coefficients are not affected by any relation between the control variables and the level of compensation that may happen to exist in the cross section.

[11] We can also replace $DTOTW$ in equation (7) with the total direct compensation or its different components or their annual changes. The breakdown of TDC helps us study how its different components, e.g., salary, bonus, and stock options grants, respectively, respond to the firm performance (see Albuquerque (2004)). This approach is less appealing in our context for two reasons. First, our goal is to examine the relation between stock market informativeness and CEO incentives. Having the empirically appropriate incentive measures is the key, but it is still unclear whether salary, bonus, stock or stock option grants should be counted as ex-post bonus or ex-ante incentive mechanisms. Second, it has been shown that CEO incentives are mainly provided through revaluations of existing stocks and stock options holdings (Hall and Liebman, 1998; and Murphy 1999). Even if salary, bonus, stock or stock option grants can be treated as the ex-ante incentive mechanisms, their individual effects on the overall CEO incentives are small.

3.5 Testable Hypotheses and Estimation Methods

As noted earlier, the five $INFOV$ variables, PIN, FE, FEP and $DISPER$, and $DISPERP$, capture the market informativeness from different perspectives. A larger value of PIN corresponds to a more informative market, and a larger value of FE, FEP, $DISPER$, or $DISPERP$ corresponds to a less informative market. The testing of our core hypothesis comprises several hypothesis tests, depending on which $INFOV$ variable and which econometric specification is used. Specifically, with the first econometric specification in equation (6), we have

H0': $\gamma_1 = 0$, versus

H1': $\gamma_1 > 0$ if the $INFOV$ variable is PIN; or versus

H1": $\gamma_1 < 0$ if the $INFOV$ variable is FE, FEP, $DISPER$, or $DISPERP$.

We replace γ_1 in the above hypotheses with β_1 if we use the second econometric specification (7).

Given the apparent right skewness in the CEO compensation and incentive data (as shown in Table 1), we follow the literature and estimate median regressions to control for the possible influence of outliers.[12] We obtain standard errors of the estimates by using bootstrapping methods.

As a robustness check, we replace each raw measure of the five market informativeness proxies with its cumulative distribution function (CDF) in both model specifications. As Aggarwal and Samwick (1999) argue, the use of CDF helps to make the highly non-homogeneous data homogeneous and the regression results economically sensible. It is easier to transform the estimated coefficient values into pay-performance sensitivities at any percentile of the distribution of the proxies. Thus, the CDFs give the regression results more immediate economic intuition than the raw measures.

[12]Most recent studies of executive compensation, e.g., Aggarwal and Samwick (1999) and Jin (2002), use the median regression approach to deal with the apparent right skewness in the CEO compensation and incentive data.

4 Empirical Results

4.1 Using PPS as the Dependent Variable

Our main empirical results are based on the econometric specification in equation (6), where we use CEO incentive measure as the dependent variable. Table 3 presents the median regression results of the stock-based pay-performance sensitivity PPS, defined in equation (2), by using the raw measures of the five stock market informativeness proxies. In all regressions we control for firm size, return volatility, growth opportunity, CEO tenure, total institutional holdings, the concentration of institutional holdings, industry dummy, and year dummy. For brevity we do not report coefficient estimates for the industry and year dummies.

Columns 1 shows how the CEO's incentives respond to the probability of informed trading (PIN). The estimated coefficients of the PIN measure (γ_1) is positive and statistically significant at the 1% significance level. γ_1 is 25.284 in Column 1. The difference in PPS between any two PIN levels is calculated as the difference in the two PIN values multiplied by γ_1. For example, because the maximum, median, and minimum PIN are 0.797, 0.157, and 0, respectively, the pay-performance sensitivity at the maximum PIN is \$16.18 higher than that at the median PIN as a result of \$1,000 increase in shareholder value, all else equal. The incentive with the median PIN is \$3.97 larger than the incentive with the minimum PIN. The economic magnitude of PIN on pay-performance sensitivity is significant, considering that the mean (median) stock-based pay-performance sensitivity in our sample is \$40.787 (\$12.845).

Columns 2-5 show the median regression results of using FE, FEP, $DISPER$, and $DISERP$, respectively. γ_1 in all the four regressions are negative and statistically significant (except for FE), indicating that a less informationally efficient market leads to a lower level of CEO incentives. Since all of the four variables are fat-tailed and right skewed, we do not discuss their economic significance now. We defer the discussion to later regressions, when the CDF transformations of these variables are used as proxies for market informativeness.

Table 3 also shows that the estimated coefficients of all of the control variables are statistically significant and consistent in both sign and magnitude across all five regressions. The coefficient of the lagged $SIZE$, γ_2, is around -2.81 to -2.45, reaffirming that the pay-performance sensitivity is negatively and strongly correlated with firm size. The coefficient of $ANNVOL$, γ_3, ranges from 6.61 to 18.09, implying a positive risk-incentive relation. Our results are consistent with the model prediction of Prendergast (2002) as well as the empirical evidence in Core and Guay (2002). However, we note that the empirical evidence on the risk-incentive relation is mixed, and the economic rationale is still subject to a heated debate (see the survey in Prendergast (2002)).

The coefficient of the lagged $Tobinq$, γ_4, is about 1.49 to 1.87. There is a clearly positive relation between growth opportunities and CEO incentives, corroborating the evidence reported in Smith and Watts (1992) and consistent with the hypothesis that a higher incentive level is needed when CEO effort becomes more valuable. There is also a positive relation between CEO tenure and PPS as the estimated coefficient of $tenure$ is approximately 0.99 to 1.37.

Notably, the coefficient of the total share holdings by institutional investors $INSTHOLD$ is significantly negative at -0.189 to -0.088, which seems to support the argument in HT that a higher level of insider ownership reduces market liquidity and as a consequence, the pay-performance sensitivity. The coefficient of the concentration of institutional share holdings $INSTCON$ is however significantly positive, and ranges from 0.035 to 0.154. This result is consistent with the finding in Hartzell and Starks (2003), and suggest that institutional influence enhance the pay-performance sensitivity.[13]

[13] We note that the two institutional variables only serve as control variables in our analysis. The addition of institutional variables does not change the signs and levels of significance of the five stock market informativeness measures suggests (1) The PPS – market informativeness relation is unlikely to be driven by the 'ownership – market liquidity' channel proposed in HT. (2) Institutional investors' monitoring effort does enhance PPS, but it seems to be an independent channel. That is, institutional investor variables play roles different from the market informativeness measures.

Our proxies for stock market informativeness are all fat-tailed and right skewed. A CDF transformation of the raw measures yields more homogenous data and economically meaningful results. Table 4 reports the results when we use the CDFs of the raw measurs as procies for the market informativeness. The estimate coefficients of the information variables (γ_1) are 3.883, -3.568, -7.067, -4.961, and -10.799, respectively, when their respective information variables are the CDFs of PIN, FE, FEP, $DISPER$, and $DISPERP$. All of them are statistically significant, and have the signs consistent with our hypothesis.

The economic significance of the result is large. The pay-performance sensitivities estimated at the 25% level of stock market informativeness are 1.942, 1.784, 3.534, 2.481, and 5.4 smaller than those estimated at the 75% level of market informativeness, representing respective reductions of 15.12%, 13.89%, 27.51%, 19.31%, and 42.04% of median pay-performance sensitivity in our sample.

The estimated coefficients of control variables are all statistically significant and have magnitudes similar to those in Table 3.

The above results provide support for our conjecture that the stock market informativeness positively affects the pay-performance sensitivity. Because we clearly control for institutional investor variables in all of the regressions, we conclude that the stock market informativeness and ownership structure influence pay-performance sensitivity differently. Ownership structure is more likely to influence pay-performance sensitivity through monitoring channel. The liquidity channel suggested in HT is likely less important.

4.2 Using DTOTW as the Dependent Variable

As we suggest in equation (7), an alternative empirical specification is to use the CEO compensation level as the dependent variable. We do the analysis and report the median regression results in Table 5. In all of the five regressions reported in Table 5, we use the lagged value of $CDF(PIN)$, $CDF(DISPER)$, $CDF(DISPERP)$, FE and FEP

separately as proxies for stock market informativeness. The STATA program does not produce converged results when using $CDF(FE)$, and $CDF(FEP)$ as proxies for stock markt informativeness. We thus report the results of using FE, and FEP, for both of which we achieve convergence.

In Columns 1-5, the coefficients of the interaction terms are related to incentives. All the coefficients of the interaction terms are statistically significant at the 1% level. The coefficients are consistent in both sign and magnitude with the corresponding estimates from Tables 3 and 4, where we use PPS as the dependent variable. The coefficient of $VCHANGE$, β_0, ranges from 11.210 to 16.727. The incentive is strongly and negatively related to $SIZE$ and β_2 is around minus 2. The incentive is strongly and positively related to $ANNVOL$ (β_3 around 13 to 30), $Tobinq$ (β_4 around 0.04 except for $CDF(DISPER)$ and $CDF(DISPERP)$), and $Tenure$ (β_5 around 0.612 to 0.855). Notably, the incentive is negatively related to $INSTHOLD$ (β_6 around -0.114 to -0.032), and positively related to $INSTCON$ (β_7 around 0.018 to 0.079).

The parameter of interest, β_1, is significant and positive in Column 1. It is significant and negative in other Columns. The t-statistics of the estimates are large enough to readily reject the null hypothesis. The results in Table 5 clearly pinpoint a strong and positive relation between CEO incentives and the various measures of the market informativeness.

Table 5 also reports the estimates of the coefficients that link the control variables to the *level* of CEO pay. Firm size is strongly and positively related to the total compensation, suggesting that CEOs of larger companies are able to extract rents from shareholders in the form of higher compensation levels independent of firm performance.[14] The positive size effect on the compensation level is also consistent with the evidence that larger firms require more talented managers who are more highly compensated (Smith and Watts, 1992) and who are consequently expected to be wealthier (Baker and Hall, 2002). The negative size effect on the PPS can be partially explained by the fact that a CEO in a larger firm has

[14]We thank the referee for suggesting this explanation to us.

difficulty in acquiring a large percentage of shares either directly or indirectly through stock and option grants (Demsetz and Lehn, 1985; and Baker and Hall, 2002).

Like Aggarwal and Samwick (1999), we also find a strong positive relation between return volatility and the level of CEO compensation, although the principal-agent theory does not give a clear prediction on whether the expected level of compensation is increasing with the firm stock return volatility. We conjecture that as the volatility of the underlying asset increases, the value of option portfolios held by a CEO increases, leading to a higher level of total compensation, all else equal.

We find that the estimated coefficients of $Tobinq$ are positive and significant in all regressions, which indicates a positive relation between the growth opportunity and the compensation level. Together with a positive relation between the growth opportunity and incentives, this finding is again consistent with Smith and Watts (1992). That is, a higher growth opportunity increases the marginal value of CEO effort. Therefore higher incentive and compensation levels are needed, holding all else fixed.

CEO tenure is positively related to both the incentive and compensation levels, which can be subject to different interpretations. On the one hand, Bertrand and Mullainathan (2001) and Bebchuk and Fried (2003) argue that the CEO has a lot of influence in setting his compensation contract. CEO tenure might measure the extent to which a CEO is entrenched and is therefore better able to appropriate money, including stock-related pay, for himself. On the other hand, CEO tenure is argued to be a proxy for CEO reputation and experience, which helps to improve incentives as uncertainty about a CEO's ability is resolved over time (Milbourn, 2002). A longer tenure also captures the accumulation of stock holdings and hence a higher level of compensation, other things equal. A third interpretation is that CEO tenure is a proxy for the agency cost. As CEOs approach retirement, increased equity incentives can be used to counteract potential horizon problems (Jensen and Murphy, 1990).

The relation between the five market informativeness proxies and the compensation level is mixed and in most cases, in insignificant. We only find that FEP significantly and positively affects the level of CEO compensation, for which we do not have a good explanation.

Both institutional variables are positively related to the level of CEO compensation. This finding seems to suggest that firms with larger institutional presence and influence are more likely to offer their CEOs a higher level of compensation. We do not explore these implications further as they are beyond the the scope of this study.

4.3 Using Various Information Variables Collectively

The five information variables capture different aspects of the stock market informativeness. However, one of the possibilities our analyses so far shy away is that the five information variables may capture the market informativeness collectively. We test this possibility in Table 6.

In Table 6, we use six different combinations of the information variables to capture the market informativeness. In all of the six combinations, we include $CDF(PIN)$, since PIN likely captures the amount of private information while the other five are more likely to reflect both private and public information. We summarize the key findings in Table 6 as follows. (1) Using the information variables collectively does not improve the models' goodness-of-fit significantly. The Pseudo R-squares in Table 6 are in line with those in Table 4. (2) When the various information variable enter the regressions collectively, their individual signs do not change. However, the levels of statistical significance and the magnitudes of estimates in general decrease, especially for $CDF(FE)$ and $CDF(FEP)$. (3) When all the five information variables are included in a regression (Column 6), $CDF(FE)$ and $CDF(FEP)$ become insignificant. However, the other three variables remain statistically significant at the 1% level. More important, their collective impact on the pay-performance sensitivity is much larger than that of any single information variable. Take results in Column 6 for example, improving a firm's level of price informativeness from the 25% level to the 75%

level can improve its CEO's pay-performance sensitivity by \$7.44, if the firm can improve its performance on PIN, $DISPER$, and $DISPERP$ at the same time.

5 Additional Economic and Measurement Issues

5.1 Using Alternative Pay-Performance Sensitivity Measures

PPS only considers the changes in the value of CEO stock and stock option holdings. The CEO's direct compensation from salary and bonus, new stock and stock option grants, long-term incentive pay and other annual compensation might also matter. PPS_TOT, defined as the dollar value change in the CEO's total firm-related wealth per \$1,000 change in the shareholder value, measures total CEO incentives because it is derived from both the direct and indirect stock-based CEO compensation. We repeat our analysis using PPS_TOT as the dependent variable. We use the CDFs of the five market informativeness proxies and report the median regression results in Table 7.

The results in Table 7 are consistent with those in Tables 3-4, when PPS is used as the dependent variable. The estimates for the parameter of interest, γ_1, are 4.180, -3.632, -7.715, -4.74, and -11.143 for $CDF(PIN)$, $CDF(FE)$, $CDF(FEP)$, $CDF(DISPER)$, and $CDF(DISPERP)$ respectively. All estimates are statistically significant at the 1% level. Similar to when PPS is used as the incentive measure, we find that the coefficient estimates using PPS_TOT are economically significant too.

The finding that using PPS_TOT yields results similar to those of using PPS as dependent variable substantiates the finding of Hall and Liebman (1998), among others, that changes in the value of CEO stock-based compensations contribute to nearly all of the pay-performance sensitivity, and that the CEO direct compensation has little impact on the pay-performance sensitivity. This finding also alleviates our concerns on how to compute TDC. E.g., should we also include future direct compensations into TDC, since firm performance might have an impact on the future pay levels? Should new stock and option grants be treated as ex-ante incentives or ex-post bonuses? Results in Table 7 suggests that the results are not sensitive to such choices.

5.2 Subperiod Analysis

We perform a subperiod analysis for three reasons: (1) The U.S. stock market bubble burst in 2000, rendering many executives' options virtually worthless. The way in which we compute the changes in value of stock option portfolios might create bias for firms with more out-of-money options, and for firms with options that are at-the-money or near-the-money. Comparing the results before and after the bubble burst is thus useful and interesting. (2) We might rationally suspect that a firm's incentive provision policies changed after the bubble burst, which might directly affect our results. (3) Most of the prior research uses data up to 1999. By conducting a subperiod analysis, we are able to compare our analysis with the prior research. We can also check the stability of the relation between the incentive and the variables of interest.

To conduct the subperiod analysis, we split our sample into two subsamples, the bubble period 1992-1999 and the post-bubble period 2000-2001. Using the stock-based PPS as the dependent variable and the CDF transformations of the five price informativeness measures as the main explanatory variables, we apply median regressions to the two subperiods. Table 8 presents the results of this subperiod analysis.

Columns (1)-(5) and Columns (1)'-(5)' in Table 8 report the results for the 1992-1999 period and the 2000-2001 period, respectively. There is very little difference in the results across the two periods. For each coefficient of the control variables, the corresponding estimates from the two subperiods have the same signs. Most of the estimates have similar magnitudes and significance levels across the two subperiods. For either subperiod, the incentive is negatively related to firm size and the total institutional share holdings, and positively related to return volatility, growth opportunities, CEO tenure, and the concentration of institutional share holdings. Interestingly, $INSTCON$ becomes insignificant in most of the regressions in 2000-2001. The corresponding estimates of the parameter γ_1 are consistent with each other across the two subperiods. All of them are statistically significant at the 5% level in both periods. Interestingly, the magnitudes of the estimates tend to be larger in 2000-2001.

To sum up, consistent with the full-sample analysis, the subperiod analysis brings about the same results, that is, CEO incentives increase with market informativeness. This relation is generally stable across the two subperiods despite the stock market bubble burst in 2000. The incentive enhancement effect due to the market informativeness seems to strengthen slightly after the bubble burst.

5.3 Conducting Analysis on Filtered Samples

To address the concerns that our results may be drive by some confounding effects, we further conduct our empirical analysis on filtered samples in Table 9.

We note that the cross-day trading independence is critical for estimating PIN. However, the existence of stealth trading (Barclay and Warner 1993) suggests that this assumption is unlikely to be satisfied. If informed traders indeed camouflage their private information and spread trades over time, we expect a stock's trading volumes to be autocorrelated. It is not clear how large an impact violating the cross-day trading independence will exert on the estimation of PIN.

To control for this potential bias, we compute the autocorrelations of daily trading volumes for each stock $AR_{i,t}$, on an annual basis. Every year, we sort the firms by $AR_{i,t}$. We delete the observations, whose ARs are above the 70th or 90th percentile levels. We then run the median regressions, as specified in equation (6), on the filtered samples. This method provide a partial remedy to the cross-day trading dependence. Panel A of Table 9 reports the median regression results.[15] The estimated coefficient of $CDF(PIN)$ is 4.633

[15]For brevity, we only report the estimated coefficients of the information variables in Table 9. All other

(3.853), if we cut the sample at the 70th (90th) percentile AR level. It is largely in line with the estimate based on the full sample, 3.883. Clearly dropping the observations with high autocorrelation in trading volumes does not change our results.

We repeat the same experiment in Panel B, using the KZ index defined in Kaplan and Zingales (1997) to filter the sample. The KZ index measures the severity of a firm's external financing constraints. Thus, dropping firm-year observations with higher KZ index may help to control for the potential bias caused by firms in financial distress. We delete the observations based on two KZ index threshold levels, the 70th and 90th percentile, both of which yield qualitatively similar results. As Shown in Models 3-6, the estimated coefficients of $CDF(PIN)$ are 4.162 (the 70th percentile) and 3.704 (the 90th percentile), respectively, and the estimated coefficients of $CDF(FEP)$ are -5.147 (the 70th percentile) and -6.961 (the 90th percentile).[16] They are qualitatively similar to their counterparts in Table 5, when coefficients are estimated on the full sample. Clearly, our results are unlikely to be driven by firms in financial distress.

We test in Panel C whether mergers and acquisitions affect our results. We define a dummy variable MAD, which takes the value of 1 if a firm engages in M&A deals (either as acquirer or as target) in a given year, and zero otherwise. There are in total 1,786 M&A transactions conducted by our sample firms during 1992-2001. We drop 1,671 firm-year observations with MAD equal to 1. We run median regressions on the filtered samples by using $CDF(PIN)$ and $CDF(FEP)$ as the informativeness measures. As shown in Models 7 and 9, the estimated coefficients of $CDF(PIN)$ and $CDF(FEP)$ are 4.357 and -6.596, respectively, both of which are in line with their counterparts estimated on the full samples and reported in Table 4. Dropping firms engaging in M&As does not change our results.

Lastly, in Panel D, we drop both financial distressed firms and M&A firms. As shown in Models 9 and 10, the two informativeness measures are still statistically significant and

variables have signs and significance levels similar to those estimated based on the full samples.

[16] All results in Panels B-D are robust to the choice of market informativeness measures. For brevity, we only report the results of using $CDF(PIN)$ and $CDF(FEP)$.

have signs and magnitudes similar to those estimated on the full samples.

5.4 Other Robustness Checks

We examine two other types of robustness: robustness of control variables, and robustness of estimation methods.

In addition to market capitalization, net sales and total assets are other commonly used variables to measure firm size. We replace market capitalization with either net sales or total assets in our econometric models. We also include the squared firm size proxies to control for possible nonlinearities in the data. All these alternative specifications yield similar results on the relation between CEO incentives and market informativeness.

In unreported median regressions we also control for other factors that may be related to CEO incentives, such as the ratio of capital over sales, R&D expense over capital, and the investment-capital ratio (Jin, 2002). These variables are likely to capture the value of CEO effort. Including those control variables does not change our main results qualitatively.

Following Core and Guay (1999), we try the log value of CEO tenure in the regression model to capture the possible concave relation between CEO incentives and CEO tenure. Again, our main results do not change qualitatively.

Apart from the median regressions on which we build our empirical analysis, we adopt other types of model estimation methods. We perform OLS with robust standard errors, CEO fixed-effects OLS (Aggarwal and Samwick, 1999), and robust regression (Hall and Liebman, 1998).[17] The CEO fixed-effects OLS controls for all differences in the average level of incentives across executives in the sample. Having CEO fixed effects helps alleviate the potential "unobserved endogeneity" problem if those unobservables tend to stay constant over time. All these regression methods generate qualitatively similar results. For brevity

[17] A robust regression begins by screening out and eliminating gross outliers based on OLS results, and then iteratively performs weighted regressions on the remaining observations until the maximum change in weights falls below a pre-set tolerance level, say, 1%.

we do not report these results.

6 Analysis of All Executives and Executive Teams

The literature of executive compensation has traditionally focused on CEO incentives, because CEOs make most major corporate decisions and exert the greatest influence on the firms among executives. However, if our analysis is correct, we expect our results to be applied to non-CEO executives, and the executive teams as well. We thus expand our analysis to all executives, and the executive teams, and report the results in Table 10.

In Columns 1-5 of Table 10, we use PPS_EXE, the stock-based pay-performance sensitivity of a top five most-paid executive of a firm, as the dependent variable, and the CDF transformations of the five market informativeness measures as our information variables. The results are qualitatively similar to those of using the CEO pay-performance sensitivity as the dependent variable (Table 4). Especially, the estimated coefficients of $CDF(PIN)$, $CDF(FE)$, $CDF(FEP)$, $CDF(DISPER)$, and $CDF(DISPERP)$ are respectively 0.820, -0.698, -1.332, -1.056, and -2.006. All of them are significant at the 1% level and have signs consistent with our conjecture.

Their economic significance is large too. The pay-performance sensitivities of an executive, regardless of whether he/she is a CEO or not, estimated at the 25% level of stock market informativeness are 0.41, 0.349, 0.666, 0.528, and 1.003, smaller than those estimated at the 75% level, representing respective reductions of 14.91%, 12.7%, 24.23%, 19.21%, and 36.49% of the median pay-performance sensitivity (the median of PPS_EXE in our sample is 2.749).

It is noteworthy that the estimated coefficient of CEO indicator, $CEOFLAG$, is significantly positive in all of the five regressions, and ranges from 6.04 to 8.83. Its magnitude is much larger than the median of PPS_EXE, reaffirming that the pay-performance sensitivity is much higher for CEOs.

We sum up PPS_EXE across all five most-paid executives within a firm and obtain PPS_TEAM. PPS_TEAM measures an executive team's incentive level. We repeat the regressions in Models (1)-(5), but use PPS_TEAM as the dependent variable. We find similar result. That is, stock market informativeness helps to enhance an executive team's pay-performance sensitivity (incentive). Specifically, the coefficients of $CDF(PIN)$, $CDF(FE)$, $CDF(FEP)$, $CDF(DISPER)$, and $CDF(DISPERP)$ are 9.832, -5.157, -14.471, -9.727, and -22.431, respectively. The estimated coefficients of all of the five informativeness measures are significant, and have consistent signs.

The median of PPS_TEAM is 24.252 in our sample, which suggests that a median executive team's stock-based wealth would increase \$24.252 per \$1,000 increase in the shareholder value. Keeping this in mind, we find that the economic magnitude of the market informativeness on the executive team's pay-performance sensitivity is quite large. The team pay-performance sensitivities, estimated at the 25% level of stock market informativeness, are 4.916, 2.579, 7.236, 4.864, and 11.216, smaller than those estimated at the 75% level of market informativeness, representing respective reductions of 20.27%, 10.63%, 29.84%, 20.06%, and 46.25% of the median of PPS_TEAM.

7 Summary and Conclusion

In this paper we examine the relation between executive incentives and stock market informativeness. Following Holmstrom and Tirole (1993), we develop a model that links market microstructure to CEO incentives. We empirically investigate whether stock market informativeness has a significant impact on the pay-performance sensitivity.

Using probability of informed trading, and various definitions of analysts' earnings forecast error, and dispersion of analysts' earnings forecasts as the proxies for the market informativeness, we conduct various empirical tests and justify the key prediction that CEO pay-performance sensitivity increases with market informativeness. Our results are robust to alternative estimators, measures of incentives, sample periods, model specifications, and estimation methods. They can also be extended to non-CEO executives and the executive teams. Our results suggest that more informative stock price may induce firms to rely more heavily on incentive pay.

Appendix: A Model Linking Market Microstructure to Executive Compensations

We introduce a single-period model that illustrates the link between stock trading and the effectiveness of market-based executive compensation.

At the initial point of time 0, a publicly held firm is established with a random terminal payoff at time 1: $\widetilde{r} = e + \delta$, where e is the effort level that the potential manager would privately choose and e cannot be contracted on. δ is a zero-mean, normally distributed random variable with variances, V_δ. The shares are issued on the firm's future cash flow.

At stage 1, the firm owner (the principal) hires one manager (the agent). The owner writes a compensation contract on two performance measures, – the firm's terminal payoff $\widetilde{r}$, and stock price P:

$$W = a + b_1\widetilde{r} + b_2 P, \tag{A. 1}$$

where a represents the fixed salary. b_1 and b_2 capture the sensitivities of the manager's compensation relative to the firm's terminal payoff, $\widetilde{r}$ and its stock price, P, respectively. Given the compensation contract, the manager chooses an effort level $e \in [0, \infty)$, which is not observable.

At stage 2, the stock market opens. Stock market participants can observe an informative yet non-contractible signal on the firm's future value δ, at a cost. We assume that there is an endogenous number of N investors who choose to do so. A potential investor will search for the private signal on δ only if the expected value of doing so exceeds her reservation value μ. The costly signal acquired by investor i (if she so chooses) is $\delta + \epsilon_i$, where ϵ_i is i.i.d. with a mean of zero and a variance of V_ϵ. Both the informed and uninformed traders submit their order flows to the market maker. Informed trader i submits a market order that is linear in her signal, $\beta(\delta + \epsilon_i)$. We assume that the total liquidity demand in the market is z and z is a zero-mean, normally distributed variable with variance V_z. Since there are N informed traders and z liquidity demand, the total order flow observed by the market maker is given by $\omega = N\beta\delta + \sum_{i=1}^{N}(\beta\epsilon_i) + z$. The competitive market maker, given the aggregate order flow ω, sets a price such that $P = E\left[\widetilde{r}|\omega\right]$. In order to obtain analytically tractable solutions, we ignore the manager's compensation W in the price function. Given that W in our model is linear in both $\tilde{r}$ and P, including it in the price function does not change the information content of the stock price. The stock price derived from this price function is informationally equivalent to that from the more general price function specification, $P = E\left[(\widetilde{r} - W)|\omega\right]$.

At time 1, the payoff is realized, the incentive contract is honored, and the firm is liquidated. The resulting liquidation proceeds are distributed between the manager and the principal.

All agents are risk-neutral except the manager. The manager's preference is represented by a negative exponential utility function over her compensation W with the (absolute) risk aversion coefficient γ. Her cost of choosing the effort e is denoted as $C(e) = \frac{1}{2}ke^2$. The cost is measured in money and is independent of the manager's wealth. The manager's evaluation of the normally distributed income W, given her choice of effort e, can then be represented in the certainty equivalent measure as follows:

$$U(W,e) = E(W) - \frac{\gamma}{2}Var(W) - C(e). \tag{A. 2}$$

Based on the model set-up, we can solve a rational-expectation equilibrium in which the players in the real sector (the principal and the manager) use the information contained in the stock price to make decisions, and both the real sector and the stock market reach equilibrium at the same time.

We begin with the stock market equilibrium. With z liquidity demand, the total order flow observed by the market maker is $\omega = N\beta\delta + \sum_{i=1}^{N}(\beta\epsilon_i) + z$. The market maker sets a linear price schedule of the form $P = e + \lambda\omega$ (Kyle, 1985). Using standard techniques, we obtain the equilibrium value of λ as $\lambda = V_z^{-\frac{1}{2}}\Gamma^{\frac{1}{2}}$, where $\Gamma = \frac{NV_\delta^2(V_\delta+V_\epsilon)}{[(N+1)V_\delta+2V_\epsilon]^2}$.

The expected profit of an informed trader is then given by $ER = \frac{V_\delta^2(V_\delta+V_\epsilon)V_z^{\frac{1}{2}}}{\Gamma^{\frac{1}{2}}[(N+1)V_\delta+2V_\epsilon]^2}$. A potential trader will make an effort to search for the private signal if and only if the expected profit from doing so exceeds her reservation value μ. Thus, the equilibrium number of informed traders N, is determined by

$$\frac{V_\delta^2(V_\delta+V_\epsilon)V_z^{\frac{1}{2}}}{\Gamma^{\frac{1}{2}}[(N+1)V_\delta+2V_\epsilon]^2} = \mu. \tag{A. 3}$$

Using the implicit function theorem, we obtain

Lemma 1 *The number of informed traders N, (1) decreases as the investors' reservation value μ on becoming informed increases, (2) increases as the volatility of the firm's cash flow V_δ increases, and (3) increases as the volatility of the liquidity trading V_z increases.*

Proof. Omitted and available from the authors. **Q.E.D.** ■

We also have

Lemma 2 *The (inverse) informativeness of the stock price P is given by*

$$Var(\delta|P) = \frac{V_\delta(V_\delta+2V_\epsilon)}{(N+1)V_\delta+2V_\epsilon}. \tag{A. 4}$$

Proof. Given the linear price schedule $P = e + \lambda\omega$, we have $Var(\delta|P) = Var(\delta|\lambda\omega)$. Thus,

$$Var(\delta|P) = V_\delta - \frac{Cov(\delta,\lambda\omega)^2}{Var(\lambda\omega)} = \frac{V_\delta(V_\delta+2V_\epsilon)}{(N+1)V_\delta+2V_\epsilon}. \tag{A. 5}$$

Q.E.D. ■

Equation (A. 4) shows that as N increases, the conditional variance $Var(\delta|P)$ decreases monotonically. From equation (A. 4), we have:

Proposition 1 *As the number of informed traders increases, the stock market becomes more informative.*

We can now solve the optimal compensation contract. We set up the principal's problem as follows:

$$\begin{aligned} \max_{a,b_1,b_2} \quad & E(\widetilde{r} - W) \\ \text{s.t.} \quad & \max_{e} E(W) - \frac{\gamma}{2} Var(W) - c(e) \geq \overline{W} \end{aligned} \tag{A. 6}$$

where $\overline{W}$ is the reservation utility to the manager.

The manager's compensation, as specified in (A. 1), is a linear function of both the realized payoff, $\tilde{r}$, and the stock price P. Rather than dealing with $W = a + b_1\tilde{r} + b_2 P$ directly, the analysis of contracting becomes analytically much easier if we transform the wage function into the following equivalent normalized function:

$$W = \hat{a} + b_1\tilde{r} + b_2\hat{P}, \tag{A. 7}$$

where $\hat{a} = a + b_2 E(P) = a + b_2 e^*$ and $\hat{P} = P - E(P) = P - e^*$. Note that equation (A. 7) is a linear transformation based on hypothesized equilibrium values. One benefit of dealing with $\hat{P}$ rather than P is that $\hat{P}$ is a zero-mean and normally distributed variable. Since the mean of $\hat{P}$ is zero, it is much easier to analytically illuminate its information role in the manager's contracting process. At equilibrium, $\hat{P}$ is informationally equivalent to P. That is, we have $Var(\hat{P}) = Var(P)$ and $Corr(\delta, \hat{P}) = Corr(\delta, P)$.

With $W = \hat{a} + b_1\widetilde{r} + b_2\hat{P}$, we can rewrite the principal's problem as

$$\begin{aligned} \max_{\hat{a},b_1,b_2} \quad & (1-b_1)e - \hat{a} \\ \text{s.t.} \quad & b_1 = ke \\ & \hat{a} = \overline{W} - b_1 e + \frac{b_1^2\gamma}{2} Var(\delta) + \frac{b_2^2\gamma}{2} Var(\hat{P}) + \gamma b_1 b_2 Cov(\delta, \hat{P}) + \frac{ke^2}{2} \end{aligned} \tag{A. 8}$$

The first-order conditions yield

$$\frac{1}{k} - b_1\gamma Var(\delta) - b_2\gamma Cov(\delta, \hat{P}) - \frac{b_1}{k} = 0, \tag{A. 9}$$

and

$$-\gamma b_2 Var(\hat{P}) - \gamma b_1 Cov(\delta, \hat{P}) = 0. \tag{A. 10}$$

Plugging $Cov(\delta, \hat{P}) = \rho V_\delta^{\frac{1}{2}} Var(\hat{P})^{\frac{1}{2}}$ into equation (A. 10), we have

$$b_2 = -b_1 \frac{\rho V_\delta^{\frac{1}{2}}}{Var(\hat{P})^{\frac{1}{2}}}. \tag{A. 11}$$

Plugging $b_2 = -b_1 \frac{\rho V_\delta^{\frac{1}{2}}}{Var(\hat{P})^{\frac{1}{2}}}$ back into equation (A. 9), we obtain

$$b_1 = (1 + \gamma k V_\delta (1 - \rho^2))^{-1}, \tag{A. 12}$$

where $\rho = [\frac{NV_\delta}{(N+1)V_\delta + 2V_\epsilon}]^{\frac{1}{2}}$.

Given equation (A. 11), we can rewrite the transformed compensation function in (A. 7) as:

$$W = \hat{a} + b_1(\tilde{r} - \frac{\rho V_\delta^{\frac{1}{2}}}{Var(\hat{P})^{\frac{1}{2}}} \hat{P}), \tag{A. 13}$$

where $\tilde{r} - \frac{\rho V_\delta^{\frac{1}{2}}}{Var(\hat{P})^{\frac{1}{2}}} \hat{P}$ is an aggregate measure built on two performance instruments. b_1 then captures the sensitivity of incentive pay to the aggregate performance measure. Immediately, we obtain:

Proposition 2 *In the rational expectations equilibrium, the optimal pay-performance sensitivity, b_1^*, is*

$$b_1^* = \frac{1}{1 + \gamma k V_\delta (1 - \rho^2)}. \tag{A. 14}$$

From equation (A. 14), we have $\frac{\partial b_1}{\partial k} < 0$, $\frac{\partial b_1}{\partial \gamma} < 0$, and $\frac{\partial b_1}{\partial V_\delta (1-\rho^2)} < 0$.

Since $V_\delta(1 - \rho^2) = Var(\delta|P)$, we have $\frac{\partial b_1}{\partial Var(\delta|P)} < 0$. $Var(\delta|P)$ captures the informativeness of stock price (Kyle 1985).

Further, we show

Proposition 3 *(1) The more costly it is to collect information about firm performance, the less sensitive is pay to performance ($\frac{\partial b_1}{\partial \mu} < 0$).*
(2) Given the number of informed traders N, the more volatile the cash flow, the less sensitive is pay to performance ($\frac{\partial b_1}{\partial V_\delta} < 0$).
(3) Given the number of informed traders N, the more dispersed are the informed investors' opinions (or the less informative of the performance signal), the less sensitive is pay to performance ($\frac{\partial b_1}{\partial V_\epsilon} < 0$).

Proof. Omitted and available from the authors. **Q.E.D.** ■

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Table 1 Summary Statistics: Executive Compensation/Incentive Measures and Firm /CEO Characteristics[a]

Variables	Mean	Std. Dev.	Median	Min	Max	Nobs
Panel A: Compensation and incentive measures						
TCC ($K)	960.776	1,348.354	680.813	0	91,634.85	17,584
TDC ($K)	3,299.286	9,899.765	1,424.882	0	564,171.19	17,051
SHROWNPC (%)	3.331	7.326	0.428	0	99.445	16,708
DOPTV($K)	1,920.610	34,856.17	211.803	-1,509,144	1,641,605	14,123
DTOTW ($K)	18,834.77	497,626.39	2,296.758	-22,056,001	35,166,453	17,348
VCHANGE ($M)	457.171	5,541.287	61.788	-257,239.5	182,126.2	16,944
PPS	40.787	74.590	12.845	0	994.446	16,769
PPS_TOT	46.506	81.916	13.093	0	997.479	16,904
PPS_EXE	15.762	47.584	2.749	0	2518.229	60,080
PPS_TEAM	64.414	102.989	24.252	0.001	2,571.736	14,701
Panel B: Control Variables						
MKTVAL ($M)	4,292.293	15,270.39	864.983	6.10e-3	427,220.76	17,369
SIZE	6.909	1.601	6.763	-5.100	12.965	17,369
ANNRET (%)	22.451	95.466	11.542	-96.654	7,010.12	17,349
ANNVOL (%)	39.438	18.845	35.227	10.279	347.80	16,890
TOBIN's Q	2.159	2.747	1.480	0.279	105.090	17,307
TENURE	7.682	7.409	5.500	0.083	54.917	16,028
INSTHOLD (%)	56.472	20.187	58.048	0.027	99.937	14,602
INSTCON (%)	60.066	15.071	58.294	21.142	100	14,676

[a] Total current compensation (TCC) is the sum of a CEO's annual salary and bonus. Total direct compensation (TDC) is the sum of TCC, other annual short-term compensation, payouts from log-term incentive plans, the Black-Scholes (1973) value of stock options granted, the value of restricted stocks granted, and all other long-term compensation. SHROWNPC is the CEO's year-end ownership percentage. We compute the annual change in a CEO's total firm-related wealth (DTOTW) as the sum of TDC and the changes in value of the CEO's existing stocks and stock options. The change in value of stock holdings is computed as the beginning-of-year value of CEO's stock holdings multiplied by the current year's stock return. The change in the value of stock options (DOPTV) equals the product of option deltas and the change in the firm's market value, adjusting for the percentage of stock shares represented by the options, and plus the value from stock option exercises. TCC, TDC, and DTOTW are expressed in thousands of dollars. We calculate the change in the firm's market value (VCHANGE) as the percentage stock returns times the market capitalization of equity at last year-end (in millions of dollars). The stock-based pay-performance sensitivity (PPS) is the change in value of the CEO's stock-based holdings (stocks and stock options) divided by the change in the firm's stock market value. We define the total pay-performance sensitivity (PPS_TOT) as the dollar value change in the CEO's total firm-related wealth per $1,000 change in the shareholder value. We calculate the stock-based pay-performance sensitivity of a top five high-paid executive of a firm (PPS_EXE) in the same way as we do PPS. The stock-based pay-performance sensitivity of an executive team (PPS_TEAM) is equal to the sum of PPS_EXE across all executives of a firm. Size is the log of MKTVAL, which is the fiscal-year-end equity market value (in millions of dollars). Stock return (ANNRET) is the annualized percentage return in real terms. We compute the annualized percentage volatility of stock returns (ANNVOL) using the past five years of monthly stock return data. We calculate Tobin's Q as the ratio of the market value of assets to the book value of assets. We compute TENURE as the CEO's tenure as of year t. INSTHOLD is the total institutional share holdings as a percent of the total number of shares outstanding. INSTCON is the top ten institutional share holdings as a percent of the total institutional share holdings. Nobs is the number of non-missing observations. All monetary variables are in 1992 constant dollars.

Table 2 Summary Statistics of Stock Price Informativeness Measures[a]

Panel A: Summary statistics of the five different price informativeness measures

Variables	Mean	Std Dev	Median	Min	Max	Nobs
PIN[b]	0.163	0.051	0.157	0	0.797	8,456
FE	0.444	5.014	0.066	0	422.5	9,420
FEP	0.013	0.093	0.002	0	5.006	9,421
DISPER	12.116	66.754	3.175	0	2,550	9,161
DISPERP	0.412	2.098	0.135	0	122.77	9,154

Panel B: Bivariate correlations among the price informativeness measures (Nobs = 4,503)

	PIN	FE	FEP	DISPER	DISPERP
PIN[b]	1.0000				
	(0.000)				
FE	0.019	1.000			
	(0.196)	(0.000)			
FEP	0.068	0.090	1.0000		
	(<0.0001)	(<0.0001)	(0.0000)		
DISPER	0.040	0.016	0.110	1.0000	
	(0.007)	(0.289)	(<0.0001)	(0.000)	
DISPERP	0.041	0.017	0.562	0.129	1.0000
	(0.006)	(0.244)	(<0.0001)	(<0.0001)	(0.000)

[a] Panel A reports summary statistics of the five stock price informativeness variables used in our empirical analysis. We compute PIN as the probability of informed trading per Easley, Kiefer, O'Hara, and Paperman (1996, 1997). We calculate the analyst earnings forecast error (FE) as the absolute value of the difference between the mean earnings estimate in the ninth month of a fiscal year and the actual earnings divided by the absolute value of the actual earnings. We compute FEP as the absolute value of the difference between the mean earnings estimate and the actual earnings divided by the year-end stock price. We calculate the analyst earnings forecast dispersion (DISPER) as the standard deviation of earnings forecasts scaled by the absolute value of the mean earnings forecast and times 100. We compute DISPERP as the standard deviation of earnings forecasts scaled by the year-end stock price and times 100. Nobs is the number of non-missing observations. The sample periods are 1993-2001 for PIN and 1992-2001 for FE, FEP, DISPER, and DISPERP, respectively. Panel B presents the bivariate Pearson correlations among the five price informativeness variables in a balanced sample containing 4,503 firm-year observations. We report in parentheses the significance level of each correlation coefficient.
[b] The sample period for PIN is 1993-2001 because we compute PIN using the TAQ database which starts its data coverage from 1993.

Table 3 Median Regression of CEO Stock-Based Pay-Performance Sensitivity (PPS): Using Raw Price Informativeness Measures, 1992-2001[a]

Independent Variables	(1)	(2)	(3)	(4)	(5)
Intercept	12.134***	17.771***	17.835***	17.618***	17.438***
	(1.897)	(2.511)	(2.695)	(2.431)	(2.641)
$PIN_{i, t-1}$	**25.284*** **				
	(3.093)				
$FE_{i,t-1}$		**-0.080**			
		(0.061)			
$FEP_{i,t-1}$			**-39.546*** **		
			(2.669)		
$DISPER_{i,t-1}$				**-0.004***	
				(0.002)	
$DISPERP_{i,t-1}$					**-2.486*** **
					(0.209)
$SIZE_{i, t-1}$	-2.453***	-2.775***	-2.803***	-2.720***	-2.705***
	(0.137)	(0.188)	(0.202)	(0.182)	(0.198)
$ANNVOL_{i, t}$	18.088***	6.612***	7.448***	7.944***	10.294***
	(1.170)	(1.378)	(1.482)	(1.351)	(1.470)
Tobin's $Q_{i, t-1}$	1.496***	1.864***	1.802***	1.842***	1.609***
	(0.114)	(0.067)	(0.072)	(0.065)	(0.071)
$Tenure_{i, t}$	0.990***	1.367***	1.369***	1.307***	1.299***
	(0.016)	(0.021)	(0.022)	(0.020)	(0.022)
$INSTHOLD_{i,t-1}$	-0.088***	-0.180***	-0.180***	-0.177***	-0.189***
	(0.008)	(0.011)	(0.012)	(0.011)	(0.012)
$INSTCON_{i,t-1}$	0.035***	0.146***	0.149***	0.134***	0.154***
	(0.013)	(0.018)	(0.020)	(0.018)	(0.019)
Sample Size	6,724	7,053	7,061	6,851	6,856
Pseudo R-square	0.101	0.120	0.120	0.119	0.122

[a]The dependent variable is the CEO's stock-based pay-performance sensitivity (PPS), which is defined as the change in value of the CEO's stock and stock options holdings per $1,000 change in shareholder value. We specify the model as: $PPS_{i,t} = \gamma_0 + \gamma_1 * INFOV_{i,\,t-1} + \gamma_2 * Size_{i,\,t-1} + \gamma_3 * annvol_{i,\,t} + \gamma_4 * Tobinq_{i,\,t-1} + \gamma_5 * Tenure_{i,\,t} + \gamma_6 * INSTHOLD_{i,\,t-1} + \gamma_7 * INSTCON_{i,\,t-1} +$ *industry dummies* + *year dummies* $+ \varepsilon_{i,\,t}$. We use raw measures of five price informativeness variables in the regressions. Coefficient estimates on industry dummies and year dummies are not reported for brevity. All monetary variables are in 1992 constant dollars. We report standard errors based on 20 bootstrap replications in parentheses. The sample period for the regression involving PIN is 1994-2001, since the PIN measure which we calculate from the TAQ database covers the period 1993-2001 and we need one-year lag for such a regression. *, **, and *** - significant at the 10%, 5%, and 1% levels, respectively.

Table 4 Median Regression of CEO Stock-Based Pay-Performance Sensitivity (PPS): Using the Cumulative Distribution Functions of the Price Informativeness Measures, 1992-2001[a]

Independent Variables	(1)	(2)	(3)	(4)	(5)
Intercept	14.169***	18.735***	20.400***	19.115***	22.197***
	(1.886)	(2.786)	(2.718)	(3.04)	(3.002)
CDF($PIN_{i, t-1}$)	**3.883*** **				
	(0.588)				
CDF($FE_{i,t-1}$)		**-3.568*** **			
		(0.728)			
CDF($FEP_{i,t-1}$)			**-7.067*** **		
			(0.727)		
CDF($DISPER_{i,t-1}$)				**-4.961*** **	
				(0.808)	
CDF($DISPERP_{i,t-1}$)					**-10.799*** **
					(0.827)
$SIZE_{i, t-1}$	-2.421***	-2.845***	-2.838***	-2.702***	-2.797***
	(0.143)	(0.209)	(0.204)	(0.228)	(0.224)
$ANNVOL_{i, t}$	17.990***	8.653***	10.161***	10.963***	13.386***
	(1.180)	(1.563)	(1.485)	(1.724)	(1.651)
Tobin's $Q_{i, t-1}$	1.437***	1.823***	1.313***	1.629***	0.910***
	(0.115)	(0.075)	(0.074)	(0.081)	(0.082)
$Tenure_{i, t}$	0.991***	1.365***	1.378***	1.314***	1.323***
	(0.016)	(0.023)	(0.022)	(0.025)	(0.025)
$INSTHOLD_{i,t-1}$	-0.086***	-0.178***	-0.187***	-0.174***	-0.184***
	(0.008)	(0.013)	(0.012)	(0.014)	(0.014)
$INSTCON_{i,t-1}$	0.035**	0.159***	0.168***	0.140***	0.159***
	(0.013)	(0.020)	(0.020)	(0.022)	(0.022)
Sample Size	6,724	7,053	7,061	6,851	6,856
Pseudo R-square	0.101	0.120	0.122	0.121	0.124

[a]The dependent variable is the CEO's stock-based pay-performance sensitivity (PPS), which is defined as the change in value of the CEO's stock and stock options holdings per $1,000 change in shareholder value. We specify the model as: $PPS_{i,t} = \gamma_0 + \gamma_1*INFOV_{i, t-1} + \gamma_2* Size_{i, t-1} + \gamma_3* annvol_{i, t} + \gamma_4*Tobinq_{i, t-1} + \gamma_5*Tenure_{i, t} + \gamma_6*INSTHOLD_{i, t-1} + \gamma_7*INSTCON_{i, t-1}$+ *industry dummies* + *year dummies*+ $\varepsilon_{i, t}$. We use the cumulative distribution functions (CDFs) of five price informativeness variables in the regressions. Coefficient estimates on industry dummies and year dummies are not reported for brevity. All monetary variables are in 1992 constant dollars. We report standard errors based on 20 bootstrap replications in parentheses. The sample period for the regression involving CDF(PIN) is 1994-2001, since the PIN measure which we calculate from the TAQ database covers the period 1993-2001 and we need one-year lag for such a regression. *, **, and *** - significant at the 10%, 5%, and 1% levels, respectively.

Table 5 Median Regression Using Total Compensation as Dependent Variable, 1992-2001[a]

Independent Variables	(1) CDF(PIN)	(2) CDF(DISPER)	(3) CDF(DISPERP)	(4) FE	(5) FEP
$VCHANGE_{i,t}$	16.727***	11.210***	12.612***	11.395***	11.538***
	(0.238)	(0.175)	(0.182)	(0.182)	(0.140)
$VCHANGE_{i,t}$*$INFOV_{i,t-1}$	0.680***	-0.995***	-5.493***	-0.525***	-51.717***
	(0.046)	(0.030)	(0.060)	(0.010)	(1.498)
$VCHANGE_{i,t}$*$SIZE_{i,t-1}$	-2.025***	-1.924***	-1.838***	-1.959***	-1.968***
	(0.015)	(0.011)	(0.011)	(0.012)	(0.009)
$VCHANGE_{i,t}$*$ANNVOL_{i,t}$	13.419***	28.900***	30.558***	27.883***	27.648***
	(0.126)	(0.087)	(0.087)	(0.092)	(0.070)
$VCHANGE_{i,t}$*Tobin's $Q_{i,t-1}$	0.070***	0.009***	-0.045***	0.043***	0.038***
	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
$VCHANGE_{i,t}$*$Tenure_{i,t}$	0.612***	0.855***	0.824***	0.846***	0.844***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$VCHANGE_{i,t}$*$INSTHOLD_{i,t-1}$	-0.032***	-0.114***	-0.138***	-0.105***	-0.106***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$VCHANGE_{i,t}$*$INSTCON_{i,t-1}$	0.018***	0.068***	0.079***	0.057***	0.061***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$INFOV_{i,t-1}$	179.767	109.334	-16.393	-7.999	2638.119***
	(197.49)	(160.879)	(170.263)	(15.070)	(504.813)
$SIZE_{i, t-1}$	1156.658***	1100.082***	1179.784***	1065.369***	1057.177***
	(49.139)	(47.737)	(48.370)	(49.421)	(37.812)
$ANNVOL_{i, t}$	3274.684***	2160.737***	2203.185***	2142.766***	1893.506***
	(388.332)	(348.362)	(344.764)	(348.337)	(266.638)
Tobin's $Q_{i, t-1}$	453.346***	738.872***	638.730***	701.801***	699.072***
	(38.767)	(16.990)	(17.850)	(17.101)	(13.092)
$Tenure_{i, t}$	57.437***	14.519***	15.627***	19.419***	20.471***
	(5.307)	(5.123)	(5.180)	(5.271)	(4.032)
$INSTHOLD_{i,t-1}$	3.978	18.862***	18.583***	18.195***	17.464***
	(2.774)	(2.823)	(2.850)	(2.912)	(2.228)
$INSTCON_{i,t-1}$	18.226***	20.602***	23.479***	21.088***	21.425***
	(4.367)	(4.502)	(4.537)	(4.636)	(3.542)
Sample Size	7,028	7,839	7,844	8,083	8,094
Pseudo R-square	0.159	0.150	0.152	0.150	0.150

[a] We use the annual change in a CEO's total firm-related wealth (DTOTW) as the dependent variable. We specify the model as: $DTOTW_{i,t} = \alpha + vchange_{i,t} *(\beta_0 + \beta_1*INFOV_{i, t-1} + \beta_2*Size_{i, t-1} + \beta_3*annvol_{i, t} + \beta_4*Tobinq_{i, t-1} + \beta_5*Tenure_{i, t} + \beta_6*Insthold_{i, t-1} + \beta_7*Instcon_{i, t-1} + \beta_d*Dummies) + \beta_8* INFOV_{i, t-1} + \beta_9 *Size_{i, t-1} + \beta_{10} *annvol_{i, t} + \beta_{11}*Tobinq_{i, t-1} + \beta_{12}*Tenure_{i, t} + \beta_{13}*Insthold_{i, t-1} + \beta_{14}*Instcon_{i, t-1} + Dummies + \varepsilon_{i, t}$. Dummies refer to industry dummies and year dummies. We use cumulative distribution functions (CDF) of PIN, DISPER, and DISPERP as proxies for stock price informativeness (INFOV). Since we do not achieve convergence in estimating the model with the CDF's of FE and FEP, we instead report in Columns (4) and (5) the estimation results with raw measures of FE and FEP. All variables are defined in Tables 1 and 2. Coefficient estimates on intercepts and dummies are not reported for brevity. All monetary variables are in 1992 constant dollars. We report standard errors based on 20 bootstrap replications in parentheses. The sample period for the regressions involving CDF(PIN) is 1994-2001, since the PIN measure which we calculate from the TAQ database covers the period 1993-2001 and we need one-year lag for such a regression. *, **, *** - significant at the 10%, 5%, and 1% levels, respectively.

Table 6 Median Regression of CEO Stock-Based Pay-Performance Sensitivity (PPS): Using Different Combinations of the CDFs of the Price Informativeness Measures, 1992-2001[a]

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	11.331***	11.096***	10.859***	12.057***	11.791***	12.832***
	(2.132)	(2.363)	(2.214)	(2.046)	(2.132)	(1.890)
CDF($PIN_{i, t-1}$)	3.240***	3.007***	3.041***	2.593***	2.444***	2.654***
	(0.673)	(0.749)	(0.694)	(0.643)	(0.669)	(0.589)
CDF($FE_{i,t-1}$)	-1.257**					-0.322
	(0.537)					(1.790)
CDF($FEP_{i,t-1}$)			-2.962***		-0.972	-0.335
			(0.584)		(0.655)	(1.999)
CDF($DISPER_{i,t-1}$)		-1.091*				-4.565***
		(0.651)				(1.378)
CDF($DISPERP_{i,t-1}$)				-4.355***	-3.788***	-7.653***
				(0.597)	(0.726)	(1.594)
$SIZE_{i, t-1}$	-1.910***	-1.853***	-1.884***	-1.815***	-1.820***	-1.874***
	(0.165)	(0.182)	(0.171)	(0.156)	(0.163)	(0.145)
$ANNVOL_{i, t}$	13.074***	13.575***	13.638***	15.490***	15.302***	14.765***
	(1.487)	(1.671)	(1.517)	(1.407)	(1.466)	(1.312)
Tobin's $Q_{i, t-1}$	1.126***	1.194***	0.980***	0.725***	0.740***	0.649***
	(0.132)	(0.147)	(0.138)	(0.130)	(0.136)	(0.120)
$Tenure_{i, t}$	0.846**	0.815***	0.846***	0.803***	0.804***	0.808***
	(0.016)	(0.018)	(0.017)	(0.016)	(0.016)	(0.014)
$INSTHOLD_{i,t-1}$	-0.102***	-0.095***	-0.097***	-0.096***	-0.093***	-0.104***
	(0.010)	(0.011)	(0.100)	(0.009)	(0.100)	(0.008)
$INSTCON_{i,t-1}$	0.065***	0.057***	0.079***	0.073***	0.078***	0.071***
	(0.015)	(0.016)	(0.015)	(0.014)	(0.015)	(0.013)
Sample Size	3,905	3,805	3,908	3,805	3,791	3,788
Pseudo R-square	0.104	0.105	0.105	0.107	0.107	0.108

[a]The dependent variable is the CEO's stock-based pay-performance sensitivity (PPS), which is defined as the change in value of the CEO's stock and stock options holdings per $1,000 change in shareholder value. We specify the basic model as: $PPS_{i,t} = \gamma_0 + \gamma_c*CINFOV_{i,\ t-1} + \gamma_2*\ Size_{i,\ t-1} + \gamma_3*\ annvol_{i,\ t} + \gamma_4*Tobinq_{i,\ t-1} + \gamma_5*Tenure_{i,\ t} + \gamma_6*INSTHOLD_{i,\ t-1} + \gamma_7*INSTCON_{i,\ t-1} +$ *industry dummies + year dummies*$+ \varepsilon_{i,\ t}$, where CINFOV's are various combinations of five price informativeness measures. We use the cumulative distribution functions (CDFs) of the five price informativeness measures in the regressions. We include CDF(PIN) in each combination. Coefficient estimates on industry dummies and year dummies are not reported for brevity. All monetary variables are in 1992 constant dollars. We report standard errors based on 20 bootstrap replications in parentheses. The sample period for regressions involving CDF(PIN) is 1994-2001, since the PIN measure which we calculate from the TAQ database covers the period 1993-2001 and we need one-year lag for such regressions. *, **, and *** - significant at the 10%, 5%, and 1% levels, respectively.

Table 7 Median Regression of CEO Total Pay-Performance Sensitivity (PPS_TOT): Using CDFs of the Stock Price Informativeness Measures, 1992-2001

Independent Variables	(1)	(2)	(3)	(4)	(5)
Intercept	14.517***	18.676***	20.215***	18.576***	22.646***
	(2.050)	(2.772)	(2.529)	(2.886)	(3.084)
CDF($PIN_{i, t-1}$)	**4.180*** **				
	(0.640)				
CDF($FE_{i,t-1}$)		**-3.632*** **			
		(0.725)			
CDF($FEP_{i,t-1}$)			**-7.715*** **		
			(0.676)		
CDF($DISPER_{i,t-1}$)				**-4.740*** **	
				(0.767)	
CDF($DISPERP_{i,t-1}$)					**-11.143*** **
					(0.850)
$SIZE_{i, t-1}$	-2.480***	-2.907***	-2.931***	-2.765***	-2.863***
	(0.156)	(0.208)	(0.189)	(0.216)	(0.230)
$ANNVOL_{i, t}$	18.212***	9.744***	11.108***	12.366***	11.919***
	(1.287)	(1.555)	(1.381)	(1.635)	(1.695)
Tobin's $Q_{i, t-1}$	1.485***	1.833***	1.368***	1.670***	0.978***
	(0.126)	(0.074)	(0.069)	(0.077)	(0.085)
$Tenure_{i, t}$	0.984***	1.428***	1.435***	1.377***	1.393***
	(0.017)	(0.023)	(0.021)	(0.024)	(0.026)
$INSTHOLD_{i,t-1}$	-0.092***	-0.188***	-0.184***	-0.181***	-0.189***
	(0.009)	(0.013)	(0.011)	(0.013)	(0.014)
$INSTCON_{i,t-1}$	0.054***	0.168***	0.186***	0.157***	0.186***
	(0.014)	(0.020)	(0.018)	(0.021)	(0.022)
Sample Size	6,724	7,053	7,061	6,851	6,856
Pseudo R-square	0.103	0.121	0.123	0.121	0.124

[a] The dependent variable is the CEO's total pay-performance sensitivity (PPS_TOT), which measures the dollar value change in CEO's total direct compensation and stock-based compensation per $1,000 increase in shareholder value. We specify the model as: $PPS\_TOT_{i,t} = \gamma_0 + \gamma_1 * INFOV_{i, t-1} + \gamma_2 * Size_{i, t-1} + \gamma_3 * annvol_{i, t} + \gamma_4 * Tobinq_{i, t-1} + \gamma_5 * Tenure_{i, t} + \gamma_6 * INSTHOLD_{i, t-1} + \gamma_7 * INSTCON_{i, t-1} +$ *industry dummies* + *year dummies*$+ \varepsilon_{i, t}$. We use the cumulative distribution functions (CDFs) of five price informativeness variables in the regressions. Coefficient estimates on industry dummies and year dummies are not reported for brevity. All monetary variables are in 1992 constant dollars. We report standard errors based on 20 bootstrap replications in parentheses. The sample period for the regression involving CDF(PIN) is 1994-2001, since the PIN measure which we calculate from the TAQ database covers the period 1993-2001 and we need one-year lag for such a regression. *, **, and *** - significant at the 10%, 5%, and 1% levels, respectively.

Table 8 Median Regression of the CEO Pay-Performance Sensitivity: Subperiod Analysis[a]

	Panel A: 1992-1999					Panel B: 2000-2001				
	(1) CDF ($PIN_{i,t-1}$)	(2) CDF ($FE_{i, t-1}$)	(3) CDF ($FEP_{i, t-1}$)	(4) CDF(DISP $ER_{i, t-1}$)	(5) CDF(DISP $ERP_{i, t-1}$)	(1)' CDF ($PIN_{i,t-1}$)	(2)' CDF ($FE_{i, t-1}$)	(3)' CDF ($FEP_{i, t-1}$)	(4)' CDF(DISP $ER_{i, t-1}$)	(5)' CDF(DISP $ERP_{i, t-1}$)
Intercept	12.523***	14.116***	15.670***	13.679***	18.061***	14.849***	25.019***	26.413***	23.305***	24.705***
	(2.403)	(3.247)	(2.995)	(3.897)	(3.431)	(3.791)	(4.622)	(5.324)	(4.266)	(4.628)
CDF($INFOV_{i, t-1}$)	2.442***	-2.603***	-5.757***	-2.732***	-7.549***	9.443***	-2.619**	-4.711***	-4.544***	-9.754***
	(0.714)	(0.810)	(0.770)	(1.002)	(0.915)	(1.336)	(1.331)	(1.572)	(1.221)	(1.429)
$SIZE_{i, t-1}$	-2.292***	-2.861***	-2.916***	-2.692***	-2.918***	-2.201***	-2.628***	-2.770***	-2.435***	-2.532***
	(0.185)	(0.250)	(0.230)	(0.300)	(0.263)	(0.284)	(0.321)	(0.368)	(0.295)	(0.317)
$ANNVOL_{i, t}$	21.314***	10.293***	11.051***	11.585***	12.952***	15.009***	10.932***	9.881***	12.129***	12.566***
	(1.631)	(1.982)	(1.788)	(2.416)	(2.076)	(2.088)	(2.208)	(2.453)	(2.039)	(2.135)
Tobin's $Q_{i, t-1}$	1.501***	3.682***	3.293***	3.647***	3.048***	1.141***	0.544***	0.474***	0.476***	0.178**
	(0.155)	(0.125)	(0.118)	(0.152)	(0.139)	(0.209)	(0.083)	(0.100)	(0.076)	(0.083)
$Tenure_{i,t}$	0.928***	1.324***	1.328***	1.265***	1.264***	1.248***	1.426***	1.430***	1.444***	1.444***
	(0.019)	(0.025)	(0.023)	(0.031)	(0.027)	(0.037)	(0.044)	(0.050)	(0.040)	(0.044)
$INSTHOLD_{i,t-1}$	-0.089***	-0.199***	-0.201***	-0.191***	-0.197***	-0.059***	-0.129***	-0.127***	-0.147***	-0.137***
	(0.010)	(0.014)	(0.013)	(0.017)	(0.015)	(0.018)	(0.022)	(0.025)	(0.02)	(0.021)
$INSTCON_{i,t-1}$	0.053***	0.181***	0.195***	0.164***	0.167***	-0.005	0.036	0.055	0.054	0.088**
	(0.016)	(0.023)	(0.021)	(0.028)	(0.024)	(0.030)	(0.037)	(0.043)	(0.035)	(0.037)
Sample Size	4,963	5,303	5,310	5,132	5,137	1,761	1,750	1,751	1,719	1,719
Pseudo R-square	0.097	0.127	0.128	0.127	0.129	0.117	0.122	0.123	0.124	0.127

[a] We divide the sample into two subperiods: 1992-1999 and 2000-2001. For each subperiod, we specify the model as: $PPS_{i,t} = \gamma_0 + \gamma_1 * INFOV_{i, t-1} + \gamma_2 * Size_{i, t-1} + \gamma_3 * annvol_{i, t} + \gamma_4 * Tobinq_{i, t-1} + \gamma_5 * Tenure_{i, t} + \gamma_6 * INSTHOLD_{i, t-1} + \gamma_7 * INSTCON_{i, t-1} + industry\ dummies + year\ dummies + \varepsilon_{i, t}$. We use the CDFs of the five price informativeness measures in the regressions and report their respective parameter estimates in the second row. Coefficient estimates on industry dummies and year dummies are not reported for brevity. All monetary variables are in 1992 constant dollars. We report standard errors based on 20 bootstrap replications in parentheses. The sample period for the regressions involving CDF(PIN) is 1994-2001, since the PIN measure which we calculate from the TAQ database covers the period 1993-2001 and we need one-year lag for such regressions. *, **, *** - significant at the 10%, 5%, and 1% levels, respectively.

Table 9 Robustness Analysis on Filtered Samples [a]

	$INFOV_{i,t-1}$	Sample Size	Pseudo R-square
Panel A Filtering by the autocorrelations of the daily trading volumes (AR)			
(1) deleting firms with AR above the 70% level (CDF(PIN))	4.633*** (0.698)	4,939	0.101
(2) deleting firms with AR above the 90% level (CDF(PIN))	3.852*** (0.669)	6,205	0.100
Panel B Filtering by the KZ Index			
(3) deleting firms with the KZ index above the 70% (CDF(PIN))	4.162*** (0.820)	4,795	0.107
(4) deleting firms with the KZ index above the 70% level (CDF(FEP))	-5.147*** (1.119)	4,892	0.131
(5) deleting firms with the KZ index above the 90% (CDF(PIN))	3.704*** (0.638)	6,142	0.104
(6) deleting firms with the KZ index above the 90% level (CDF(FEP))	-6.961*** (0.898)	6,460	0.126
Panel C Filtering by the MAD			
(7) deleting firms engaging in M&As (CDF(PIN))	4.357*** (0.716)	6,015	0.100
(8) deleting firms engaging in M&As (CDF(FEP))	-6.596*** (0.747)	6,305	0.123
Panel D Filtering by multiple variables			
(9) deleting firms with the KZ index above the 70% level or MAD =1 (CDF(PIN))	4.638*** (0.865)	4,341	0.104
(10) deleting firms with the KZ index above the 70% level or MAD =1 (CDF(FEP))	-4.843*** (1.127)	4,461	0.132

[a]The dependent variable is the CEO's stock-based pay-performance sensitivity (PPS). We specify the model as: $PPS_{i,t} = \gamma_0 + \gamma_1 * INFOV_{i,\,t-1} + \gamma_2 * Size_{i,\,t-1} + \gamma_3 * annvol_{i,\,t} + \gamma_4 * Tobinq_{i,\,t-1} + \gamma_5 * Tenure_{i,\,t} + \gamma_6 * INSTHOLD_{i,\,t-1} + \gamma_7 * INSTCON_{i,\,t-1} + industry\ dummies + year\ dummies + \varepsilon_{i,\,t}$. For brevity, we only report the estimated coefficients of the various information variables. We first calculate the autocorrelation of daily trading volumes (AR) for each firm on an annual basis. Models 1 and 2 reports the results of deleting firms, whose ARs are above 70% and 90% levels respectively. We then compute the KZ index based on the specification given in Kaplan and Zingales (1997). Models 3-6 report the results of deleting firms whose KZ index levels are above the 70% or 90% levels. We define a dummy variable MAD, whose value is 1 if a firm engages in an M&A activity in a given year, and zero otherwise. We filter our sample in Models 7 and 8 based on MAD. In Models 9-10, we filter our samples based on multiple variables, as indicated in the table. The information variables used in each regression is also indicated in the table. *, **, and *** - significant at the 10%, 5%, and 1% levels, respectively.

Table 10 Median Regression of the Pay-Performance Sensitivity: All Executives [a]

	Panel A: Dependent variable = PPS_EXE					Panel B: Dependent Variable = PPS_TEAM				
	(1) CDF ($PIN_{I,t-1}$)	(2) CDF ($FE_{i,t-1}$)	(3) CDF ($FEP_{i,t-1}$)	(4) CDF(DISP $ER_{i,t-1}$)	(5) CDF(DISP $ERP_{i,t-1}$)	(1)' CDF ($PIN_{I,t-1}$)	(2)' CDF ($FE_{i,t-1}$)	(3)' CDF ($FEP_{i,t-1}$)	(4)' CDF(DISP $ER_{i,t-1}$)	(5)' CDF(DISP $ERP_{i,t-1}$)
Intercept	5.437***	5.507***	6.093***	5.594***	6.415***	34.633***	49.505***	57.527***	51.907***	57.072***
	(0.219)	(0.260)	(0.243)	(0.258)	(0.278)	(4.207)	(5.502)	(6.219)	(6.172)	(5.068)
CDF($INFOV_{i,t-1}$)	0.820***	-0.698***	-1.332***	-1.056***	-2.006***	9.832***	-5.157***	-14.471***	-9.727***	-22.431***
	(0.068)	(0.068)	(0.065)	(0.069)	(0.077)	(1.280)	(1.426)	(1.646)	(1.617)	(1.365)
$SIZE_{i,t-1}$	-0.603***	-0.660***	-0.709***	-0.650***	-0.707***	-5.153***	-6.162***	-6.535***	-6.121***	-6.134***
	(0.017)	(0.020)	(0.018)	(0.019)	(0.021)	(0.318)	(0.411)	(0.465)	(0.461)	(0.377)
$ANNVOL_{i,t}$	3.062***	4.143***	4.152***	4.539***	4.297***	31.472***	15.237***	16.049***	19.155***	21.843***
	(0.138)	(0.148)	(0.135)	(0.149)	(0.155)	(2.614)	(3.005)	(3.306)	(3.400)	(2.709)
Tobin's $Q_{i,t-1}$	0.184***	0.255***	0.216***	0.227***	0.164***	3.815***	2.879***	2.380***	2.763***	1.647***
	(0.013)	(0.007)	(0.007)	(0.007)	(0.008)	(0.258)	(0.138)	(0.159)	(0.154)	(0.128)
$Tenure_{i,t}$	—	—	—	—	—	1.315***	1.837***	1.819***	1.745***	1.738***
						(0.034)	(0.044)	(0.049)	(0.050)	(0.040)
CEOFALG	6.042***	8.814***	8.828***	8.451***	8.396***	—	—	—	—	—
	(0.033)	(0.041)	(0.038)	(0.041)	(0.043)					
$INSTHOLD_{i,t-1}$	-0.001	-0.009***	-0.007***	-0.007***	-0.007***	-0.191***	-0.345***	-0.369***	-0.337***	-0.365***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.018)	(0.025)	(0.028)	(0.028)	(0.023)
$INSTCON_{i,t-1}$	-0.011***	0.005**	0.005***	0.004*	0.007***	0.062**	0.264***	0.283***	0.247***	0.307***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.029)	(0.040)	(0.045)	(0.045)	(0.036)
Sample Size	28,736	29,787	29,817	28,962	28,982	5,378	5,839	5,847	5,664	5,667
Pseudo R-square	0.061	0.071	0.071	0.071	0.072	0.126	0.145	0.147	0.145	0.151

[a] In Panel A, the dependent variable is PPS_EXE, i.e., the pay-performance sensitivity of a top five high-paid executive, CEO included, of a firm. Since the tenure information is not available for non-CEO executives, we drop the variable Tenure from all regressions. CEOFLAG is a dummy variable equal to 1 for CEOs and 0 otherwise. In Panel B, the dependent variable is PPS_TEAM. We sum up PPS_EXE's across all top five high-paid executives of a firm in a fiscal year to obtain PPS_TEAM. Tenure refers to CEO tenure and CEOFLAG is excluded from all regressions. In both Panels A and B we use the CDFs of the five price informativeness measures. Coefficient estimates on industry dummies and year dummies are not reported for brevity. All monetary variables are in 1992 constant dollars. We report standard errors based on 20 bootstrap replications in parentheses. The sample period for the regressions involving CDF(PIN) is 1994-2001. *, **, *** - significant at the 10%, 5%, and 1% levels, respectively.