# Internet Appendix for
# "Does customer base structure influence managerial risk-taking incentives?"
# (Not to be published)

This Internet Appendix provides supplemental analyses and robustness tests to the main results presented in "Does customer base structure influence managerial risk-taking incentives?". Section A provides detailed discussion about estimating pay convexity in performance-vesting (p-v) stock and cash awards. Section B presents the results of additional tests discussed in the main text. The tables are organized as follows:

Table IA1: Customer concentration and average named executive officers (NEO) vega
Table IA2: Ending the sample period in 2005
Table IA3: Instrumental variables approach with additional controls

## Section A. Estimating pay convexity in performance-vesting stock and cash awards

We estimate the pay convexity in performance-vesting (p-v) provisions following the empirical methods developed by Bettis et al. (2018). In this section, we briefly describe the implementation of the methods and summarize the key assumptions and equations used for the computation.

We consider the p-v provisions in restricted stocks and cash awards. For simplicity, we focus on single-metric p-v provisions following Bettis et al. (2018). The single p-v metric is based on the firm's stock price or accounting performance, such as earnings, ROI, ROE, and sales. Therefore, there can be four categories depending on the type of award and that of performance metric, namely, accounting-based stock awards, stock price-based stock awards, accounting-based cash awards, and stock price-based cash awards. We exclude stock price-based cash awards from the analysis because our sample from ISS Incentive Lab contains very few observations in that category.

To estimate the pay convexity in p-v grants, we need to first compute their expected economic values. In general, when a grant is based on a single metric, accounting performance or stock price, we can assume that metric to follow a specific stochastic process (ABM or GBM) and estimate the grant's expected value accordingly by considering the performance-contingency. The valuation of accounting-based stock awards, however, is further complicated by the fact that their values are determined by both the accounting metric used and stock price, and that the two metrics could be interdependent. A tractable approach is to assume that they jointly follow a stationary multivariate cumulative distribution. Specifically, we make the following assumptions in the estimation.

***Assumption 1*:** The accounting metric ($A_t$) follows an Arithmetic Brownian Motion (ABM):

$$dA_t = \mu_A dt + \sigma_A dW_{At}$$

***Assumption 2*:** Stock price ($P_t$), if included, follows a Geometric Brownian Motion (GBM):

$$dP_t = \mu_P P_t dt + \sigma_P P_t dW_{Pt}$$

where $\mu_i$ ($i = A$ or $P$) and $\sigma_i$ are respectively the drift and volatility, and $W_{it}$ is a Wiener process (standard Brownian Motion).

***Assumption 3***: For accounting-based stock awards, the rates of change in $A_t$ and $P_t$ have a stationary multivariate distribution, as in Assumptions 1 and 2, where their correlation is $\xi$.

Based on these assumptions, we compute the predicted values of $A_t$ and $P_t$ as follows

(1) For valuing stock awards based on stock price performance, we need to predict the stock price in the grant-execution year, $\tau$. Assumption 2 is used here, and the predicted stock price in year $t$ is given by:

$$P_t = P_{t-1} * \exp\left(\mu_P - \frac{\sigma_P^2}{2} + \sigma_P \omega_{P,t}\right)$$

where $\omega_{P,t} \sim N(0,1)$ is a standard normal random variable, and $exp$ denotes the exponential function operator.

(2) For valuing cash awards based on a single accounting metric, we need to predict the accounting metric in year $\tau$. Assumption 1 is used here, and the predicted accounting metric in year $t$ is given by:

$$A_t = A_{t-1} + \mu_A + \sigma_A \omega_{A,t}$$

where $\omega_{A,t} \sim N(0,1)$ is a standard normal random variable.

(3) For valuing stock awards based on a single accounting metric, we need to predict both the accounting metric and stock price in year $\tau$. Assumption 3 is used, and the predicted accounting metric and stock price in year $t$ are given by:

$$P_t = P_{t-1} * \exp\left(\mu_P - \frac{\sigma_P^2}{2} + \sigma_P \omega_{P,t}\right)$$

$$A_t = A_{t-1} + \mu_A + \sigma_A \omega_{A,t}$$

$$\begin{bmatrix} \omega_{P,t} \\ \omega_{A,t} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \xi & \sqrt{1-\xi^2} \end{bmatrix} \begin{bmatrix} \delta_{1,t} \\ \delta_{2,t} \end{bmatrix}$$

where $\delta_{1,t} \sim N(0,1)$ and $\delta_{2,t} \sim N(0,1)$ are two independent standard normal random variables, and $\xi$ is the correlation between the rates of change in $A_t$ and $P_t$.

The parameters in the above equations are estimated following the implementation described in Bettis et al. (2018). First, we use the 10-year treasury yield at the time of the grant as a proxy for the drift rate in both accounting metrics and stock price. Second, we estimate the inputs to the covariance matrix by averaging firm-level estimates across SIC two-digit industries over the sample period. A firm's stock return volatility is the annualized standard deviation of its monthly stock returns over the past year. For each accounting metric, the volatility is calculated as the standard deviation of its quarterly observations over the past 5 years. The correlation between the accounting metric and stock returns is also derived. To be consistent, we measure stock returns over the same quarter as that of the accounting metric calculation.

Employing the above procedure, for each grant we simulate one million paths and take the average to arrive at the predicted $A_\tau$ and $P_\tau$. Using the predicted $A_\tau$, $P_\tau$, or both, we then compute the (realized) grant value through linear interpolation and discount this value to its present value.[27] Finally, to calculate pay convexity, we increase the volatility of the corresponding metric by 1% and estimate a new expected present value of the same grant. The difference between the two present values is the pay convexity of that p-v (stock or cash) grant.

[27] A typical performance-vesting grant specifies three levels of performance target: threshold, target, and max. They are named *goalthreshold*, *goaltarget*, *goalmax* respectively in the Incentive Lab database. Between the threshold and the max is an "incentive zone," a range which contains a "target" number of shares or amount of cash granted at a corresponding "target" performance level. Within the incentive zone, the grant value is a three-segment polyline.

**Table IA1. Customer concentration and average NEO vega**

This table examines the impact of customer concentration on risk-taking incentives in name executive officers (NEO)' compensation contracts. The dependent variable is the natural logarithm of one plus the average *Vega* of NEOs, where *Vega* is the change (in thousands of dollars) in the value of the executive's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. We define NEOs as non-CEO executives whose compensation is disclosed in ExecuComp. The main variables of interest are the two customer concentration measures. *Customer HHI* is the corporate customer sales-based Herfindahl-Hirschman Index. *Major customer sales* is the fraction of a firm's total sales to all corporate customers that account for at least 10% of total sales. All other variables are defined in Appendix. Industry-year fixed effects are constructed based on the two-digit Standard Industrial Classification (SIC) codes. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

| | Dependent variable: *Ln(1+Average NEO Vega)* | |
|---|---|---|
| | (1) | (2) |
| Major customer sales | 0.343*** | |
| | (3.91) | |
| Customer HHI | | 0.913*** |
| | | (5.50) |
| Ln(Sales) | 0.470*** | 0.471*** |
| | (33.34) | (33.53) |
| ROA | -0.260** | -0.241** |
| | (-2.22) | (-2.09) |
| Tobin's Q | 0.215*** | 0.214*** |
| | (14.44) | (14.35) |
| Leverage | -0.176* | -0.181* |
| | (-1.85) | (-1.89) |
| Volatility | -2.525*** | -2.536*** |
| | (-8.77) | (-8.80) |
| Stock return | -0.026 | -0.026 |
| | (-1.59) | (-1.61) |
| Age | -0.006** | -0.006** |
| | (-2.36) | (-2.42) |
| Tenure | 0.006** | 0.006** |
| | (2.16) | (2.17) |
| CEO ownership | -0.166*** | -0.165*** |
| | (-3.08) | (-3.06) |
| CEO duality | 0.102*** | 0.102*** |
| | (3.30) | (3.28) |
| Industry-Year FE | Yes | Yes |
| N | 38,317 | 38,317 |
| Adjusted $R^2$ | 0.375 | 0.375 |

**Table IA2. Ending the sample period in 2005**

In this table, we repeat the baseline analysis, but ending the sample period in 2005. The dependent variable is the natural logarithm of one plus *Vega*, where *Vega* is the change (in thousands of dollars) in the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. The main variables of interest are the two customer concentration measures. *Customer HHI* is the corporate customer sales-based Herfindahl-Hirschman Index. *Major customer sales* is the fraction of a firm's total sales to all corporate customers that account for at least 10% of total sales. All other variables are defined in Appendix. Industry-year fixed effects are constructed based on the two-digit Standard Industrial Classification (SIC) codes. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

| | Dependent variable: *Ln(1+Vega)* | |
|---|---|---|
| | (1) | (2) |
| Major customer sales | 0.369*** | |
| | (2.93) | |
| Customer HHI | | 0.749*** |
| | | (2.99) |
| | | |
| All controls | Yes | Yes |
| Industry-Year FE | Yes | Yes |
| N | 17,106 | 17,106 |
| Adjusted $R^2$ | 0.412 | 0.412 |

## Table IA3. Instrumental variables approach with additional controls

This table presents estimates using the instrumental variables method based on two-stage least square (2SLS) panel regressions with the additional controls discussed at the end of Section 4.4. Panel A presents the first-stage regression results where dependent variables are different measures of customer concentration. The instrumental variables are as follows. *Customer industry M&A* is a measure of the intensity of merger and acquisition (M&A) activities in customers' industries. *Customer regulation index* is a measure of aggregate regulatory restrictions of customers' industries. Panel B reports the second-stage regression results. The dependent variable is the natural logarithm of one plus *Vega*, where *Vega* is the change (in thousands of dollars) in the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. *Investment intensity* is defined as capital expenditures scaled by total assets. *Borrowing cost* is the ratio of interest expenses to total debt. *Debt maturity* is the fraction of long-term debt maturing in one year. *Institutional ownership* is constructed as the total number of shares held by institutional investors divided by the total number of shares outstanding, based on data from SEC 13f filings. The same set of control variables and industry-year fixed effects as in our baseline models are also included. The estimated parameters of the other controls are not reported for brevity. Industry-year fixed effects are constructed based on the two-digit Standard Industrial Classification (SIC) codes. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

| Panel A. First-stage regressions | | | | | | |
|---|---|---|---|---|---|---|
| | Dependent variables: | | | | | |
| | *Major cust. Sales* | *Customer HHI* | *Major cust. Sales* | *Customer HHI* | *Major cust. Sales* | *Customer HHI* |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Customer industry M&A | 16.323*** | 12.628*** | | | 11.658*** | 7.926*** |
| | (8.66) | (8.38) | | | (5.05) | (5.85) |
| Customer regulation index | | | 0.012*** | 0.012*** | 0.006** | 0.009*** |
| | | | (5.12) | (6.66) | (2.26) | (5.14) |
| Investment intensity | 0.512*** | 0.176** | 0.462*** | 0.196*** | 0.485*** | 0.190** |
| | (3.25) | (2.33) | (2.82) | (2.64) | (2.75) | (2.46) |
| Borrowing cost | -0.012 | -0.008 | -0.008 | -0.012 | -0.013 | -0.007 |
| | (-0.78) | (-1.23) | (-0.53) | (-1.62) | (-0.76) | (-0.91) |
| Debt maturity | 0.023 | 0.009 | 0.010 | -0.002 | 0.017 | 0.002 |
| | (0.87) | (0.67) | (0.40) | (-0.18) | (0.61) | (0.12) |
| Institutional ownership | 0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.04) | (-0.27) | (-0.57) | (-0.74) | (-0.15) | (-0.29) |
| All controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry-Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 3213 | 3213 | 2633 | 2633 | 2140 | 2140 |
| F-statistic | 75.07 | 70.28 | 26.25 | 44.30 | 25.95 | 30.70 |
| Hansen's *J* test *p*-value | | | | | 0.562 | 0.135 |

| Panel B. Second-stage regressions | | | | | | |
|---|---|---|---|---|---|---|
| | Dependent variable: *Ln(1+Vega)* | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Major customer sales | 1.919** | | 2.324** | | 2.429*** | |
| | (2.55) | | (2.20) | | (3.66) | |
| Customer HHI | | 2.481** | | 2.231** | | 2.396*** |
| | | (2.50) | | (2.10) | | (3.14) |
| Investment intensity | -0.893 | -0.348 | -1.288 | -0.651 | -1.212 | -0.488 |
| | (-1.08) | (-0.44) | (-1.45) | (-0.78) | (-1.47) | (-0.57) |
| Borrowing cost | -0.003 | -0.004 | -0.013 | -0.006 | 0.067 | 0.055 |
| | (-0.02) | (-0.03) | (-0.11) | (-0.05) | (0.51) | (0.42) |
| Debt maturity | -0.118 | -0.097 | -0.179 | -0.150 | -0.189 | -0.155 |
| | (-0.80) | (-0.65) | (-1.33) | (-1.08) | (-1.36) | (-1.08) |
| Institutional ownership | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.36) | (1.43) | (0.55) | (0.45) | (0.87) | (0.80) |
| | | | | | | |
| All controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry-Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 3213 | 3213 | 2633 | 2633 | 2140 | 2140 |
| Adjusted $R^2$ | 0.338 | 0.334 | 0.376 | 0.337 | 0.399 | 0.362 |