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Does customer base structure influence managerial risk-taking incentives?

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Abstract

We find strong evidence that when a firm's customer base is more concentrated, the firm's CEO receives more risk-taking incentives in her compensation package. This finding is robust to numerous alternative measures, alternative specifications, alternative subsamples, and different attempts that mitigate endogeneity concerns. Further, the positive effect of customer concentration on CEO risk-taking incentive provision is more prominent when the CEO is more reluctant to take risks, when the firm has more investment opportunities, and when the firm is more prone to the costs of losing large customers. These findings are consistent with the notion that boards provide additional risk-taking incentives to offset the CEO's aversion to the risk of non-diversified revenue streams, thereby preventing excessive managerial conservatism at the expense of value maximization.

JEL classification: G30; G34; L14

Keywords: Executive compensation; Risk-taking incentives; Corporate governance; Customer concentration; Product market relationships

1. Introduction

Much of the literature on the standard moral hazard problem (Mirrlees, 1976; Holmstrom, 1979) and the design of managerial compensation focuses on the importance of the sensitivity of CEO wealth to performance as an incentive alignment mechanism (Jensen and Murphy, 1990; Bizjak et al., 1993). Yet the optimal structure of incentives is also a function of the exposure of CEO wealth to firm risk through convex payoffs (Guay, 1999; Core and Guay, 2002; Coles et al., 2006). Despite the significant operational and policy implications of managerial risk-taking incentives (Chava and Purnanandam, 2010; Armstrong and Vashishtha, 2012; Bakke et al., 2016), empirical work on how firms design manager pay convexity in relation to their decision-making environment involving moral hazard remains limited (Coles and Li, 2020). This paper makes a step forward by examining the economic link between risk-taking incentives in managerial compensation and an important organizational feature in the firm's supply chain, the concentration of its customer base.

Firms' dependence on major customers is a critical determinant of their values and corporate policies. While forging enduring trade relationships could help a firm achieve a stronger competitive position (Patatoukas, 2012), relying on major customers for a large proportion of sales represents a significant source of risk for the supplying firm. For example, a supplier may incur significant losses when its major customers become financially distressed or declare bankruptcy, switch to a different supplier, or decide to change their products (Hertzel and Officer, 2012; Kolay et al., 2016; Dhaliwal et al., 2016). Further, developing and maintaining bilateral relationships with major customers require customized supplier investments that are highly risky with low redeployability value outside of the relationship (Rauch, 1999; Kale and Shahrur, 2007). A strand of literature has examined the role of customer concentration risk in determining corporate policies and outcomes.[1] In this paper, we extend this line of research by showing how customer risk affects CEOs' risk-taking incentives.

Why does customer risk have an influence on CEO compensation? While diversified shareholders do not care much about the customer risk that is idiosyncratic and could be diversified away, risk-averse managers with undiversified human capital do. Hence, they may have incentives to invest conservatively and forgo risky but positive-NPV projects, accentuating moral hazard problems. As formalized in the theoretical model of Edmans and

[1] For example, recent evidence suggests that suppliers with a more concentrated customer base are associated with stricter borrowing terms (Campello and Gao, 2017), more constrained access to external capital (Liu et al., 2018), higher cash holdings (Itzkowitz, 2013), and higher costs of equity (Dhaliwal et al., 2016).

Gabaix (2011), when firm (customer) risk is higher, it is optimal to offer the CEO more pay convexity to offset her risk aversion and induce her to undertake value-creating risky projects. The pay convexity here refers to the sensitivity of CEO wealth to stock return volatility, or *vega*. A higher vega makes risk more valuable to managers, encouraging risk-taking behavior (Coles et al., 2006; Gormley et al., 2013). We therefore hypothesize that there is a positive relation between customer concentration and supplier CEO vega.

To test this hypothesis, we follow prior studies (e.g., Patatoukas, 2012; Dhaliwal et al., 2016; Campello and Gao, 2017) and measure customer concentration or customer risk with *Major customer sales*, which is the fraction of a firm's total sales to all corporate major customers, and *Customer HHI*, a Herfindahl-Hirschman index based on major corporate customer sales. Using both measures, we show that customer concentration is positively associated with supplier CEO vega, lending support to our hypothesis. This finding is robust to alternative measures of risk-taking incentives and customer concentration, alternative model specifications, alternative sample periods, and alternative subsamples as well as controlling for cash and performance incentives in compensation contracts. In particular, our results do not change when we use a more comprehensive measure of vega incentives following the methodological approach of Bettis et al. (2018) that accounts for the recent trend of performance-vesting (p-v hereafter) stock grants displacing options.

An important concern of the above baseline results is that our estimates of the relation between customer concentration and CEO vega may tell us little about causality because of omitted variable and reverse causality concerns. Our customer concentration measures may not be exogenous, and hence the estimated positive relation could occur either because the same firm characteristics omitted from our analysis drive simultaneously both customer base structure and CEO vega, or because higher vega induces CEOs to choose a more concentrated customer base. To address these concerns and establish causality, we perform several tests.

First, we conduct a propensity score matching (PSM) algorithm, whereby firm-years with at least one major customer are matched with otherwise indistinguishable firm-years without major customers. This approach helps to control the effects of observable firm characteristics and pin down the effect of customer risk on CEO vega. We continue to observe a higher CEO vega for firms with higher customer risk.

Second, we focus on the concentration-vega relation for newly appointed CEOs to mitigate the concern that CEOs may have the ability to influence both customer base structure and their own pay. The results are robust in this analysis.

Third, we employ an instrumental variable approach to address the endogeneity concern. Following the existing literature (Campello and Gao, 2017; Gutiérrez and Philippon, 2017; Duan et al., 2019), we construct two instruments for customer concentration, namely, *Customer Industry M&A*, which is a measure of the M&A intensity in customer industries, and *Customer regulation index*, which is an index capturing the level of aggregate regulatory restrictions in customer industries. Both instrumental variables could lead to changes in customer concentration and hence satisfy the relevance condition of the instrumental variable approach. However, there is little evidence that these instruments could directly influence a supplier's CEO compensation package other than through their effects on the firm's customer base structure. Hence, the instruments reasonably satisfy the exclusion restriction of the instrumental variable approach. We once again find a positive and significant effect of (instrumented) customer concentration on CEO vega.

Fourth, we undertake tests to mitigate reverse causality concerns, i.e., the structure of managerial incentives is determined to induce certain investment outcomes that might alter the concentration of customer firms' product markets, resulting in a positive concentration-vega relation. Specifically, we re-examine the effect of customer concentration on CEO vega after excluding the largest suppliers in terms of sales. Large firms are more likely to have the market power and incentive to actively influence customer firms' product markets and are more subject to this reverse causality concern. The fact that our results still hold after the exclusion suggests that our findings do not appear to arise from reverse causation. In addition, following Cen et al. (2017), we exploit newly established major customer relationships and find a large and significant increase in CEO vega after the relationship establishment event, but the pattern is absent before the event. These observations reassure that the positive concentration-vega relation is unlikely driven by reverse causation.

In summary, all the above approaches and tests produce consistent evidence that increased customer concentration positively affects CEO vega. While any approach and any piece of evidence is open to alternative interpretations, all the evidence taken together is difficult to reconcile with specific alternative arguments, and hence suggests there appears a causal link between customer concentration and CEO vega.

Next, we examine the cross-sectional heterogeneity in the effect of customer concentration on CEO vega. The first set of tests explores how CEOs' and suppliers' characteristics alter our baseline results. As argued earlier, when exposing to undiversifiable customer risk, risk-averse CEOs could bypass risky but valuable investments. To encourage value-enhancing risk taking, CEO compensation should include more pay convexity. If customer concentration affects supplier CEO vega through such a channel, the effect should be stronger when the CEO is less open and/or more susceptible to risk-taking, and when supplier firms have higher investment opportunities so that the potential loss due to excessive CEO conservatism is larger. To test the above conjectures, we examine the cross-sectional heterogeneity of our main findings based on CEOs' risk attitudes and firms' investment opportunities. The existing literature proposes that, compared to old CEOs, young CEOs are more willing to take risks due to career incentives (e.g., Prendergast and Stole, 1996). Relatedly, compared to specialist CEOs, generalist CEOs are less likely to shy away from risk taking given their broad outside options (e.g., Custódio et al., 2013; Mishra, 2014). We construct two partition variables based on above rationales to capture CEOs' risk attitudes. In addition, we use *Tobin's Q* to measure a firm's investment opportunities, following the existing literature. Our analyses show that the effect of customer concentration is more pronounced for older CEOs and specialist CEOs, as well as for suppliers with higher investment opportunities. These results lend support to the notion that boards provide additional risk-taking incentives in CEOs' compensation packages to offset their aversion to the risk of non-diversified revenue streams, thereby preventing excessive managerial conservatism at the expense of value maximization.

Our second set of cross-sectional heterogeneity tests examines how characteristics of customer-supplier relationships alter our main results. Arguably, if major customers can switch suppliers at a relatively low cost or if the suppliers make more risky, relationship-specific investments (RSI), the customer risk is higher. Hence, customer concentration should have a more pronounced effect on CEO vega. Following Dhaliwal et al. (2016) and Kale and Shahrur (2007), we measure customers' costs of switching to other suppliers by the dependent supplier's industry market share, and measure supplier RSI by the supplier's intensity of research and development (R&D) activities. Consistent with our conjectures, we find that the positive effect of customer concentration on CEO vega is more pronounced when customers' cost of switching suppliers is lower and when suppliers' RSI is higher. Overall, our heterogeneity tests provide further support to our inferences of the positive effect of customer concentration on CEO vega, because it is hard to come up with an omitted variable that biases our results equally in all cross-sectional dimensions discussed above.

In the final part of the paper, we examine the relation between a concentrated base of government customers and the supplier CEO's risk-taking incentives in her compensation package. While the focus of our paper is on corporate customers, suppliers could rely on governments for a large fraction of sales as well. Government customers differ considerably from corporate customers. In particular, they are much less likely to default or declare bankruptcy, and their purchases are typically longer-term and not completely profit-driven (Banerjee et al., 2008; Goldman et al., 2013). As a result, government customers represent a more stable source of revenues that could help mitigate the risk associated with losing major customers. Hence, when there is a concentrated base of safer government customers, the risk of losing substantial future revenues from major customers is reduced, and thus the need for pay convexity to offset risk aversion is lower. Consistent with the above argument, interestingly, we find a negative relation between government customer concentration and supplier CEO vega. This finding is in contrast to the positive effect of corporate customer concentration on CEO vega. Together, the contrasting results between government and corporate customers provide further support to our hypothesis that the makeup of the customer base and, by implication, the stability of the revenue stream matter for the provision of risk-taking incentives to CEOs in their compensation packages.

Our study contributes to three strands of literature. First, it adds to the literature on the determinants of CEO risk-taking incentives. Guay (1999) and Coles et al. (2006) show that firms with substantial investment opportunities provide more risk-taking incentives in managerial compensation. Ellul et al. (2017) find that after unemployment benefits become more generous, boards increase CEO pay convexity to encourage risk taking. Chang et al. (2016) document that financial distress risk is positively associated with pay convexity of new CEOs. Bakke et al. (2019) show that an increase in product market competition brought about by heightened foreign entry leads to boards decreasing CEO risk-taking incentives. These studies, however, largely ignore the role played by a firm's customer base in CEOs' risk-taking incentive provisions. Our paper contributes to this line of inquiry by providing evidence that boards evaluate a firm's customer base structure when determining CEO pay convexity.

Second, it adds to the growing literature on the role of customers as important firm stakeholders. Prior work shows that a firm's customer base structure could influence various corporate policies.[2] Some studies provide evidence that customer concentration is an important source of firm risk. For example, Campello and Gao (2017) show that the concentration of a supplier's customer base adversely affects its relations with creditors.

[2] For example, existing studies find that a firm's customer base structure is related to its financial contracting (Cen et al., 2016), firm profitability (Patatoukas, 2012; Irvine et al., 2016), capital structure (Kale and Shahrur, 2007; Banerjee et al., 2008), accounting practices (Hui et al., 2012), earnings management (Raman and Shahrur, 2008), cash holdings (Itzkowitz, 2013), innovation (Chu et al., 2019), misconduct (Chen et al., 2020), and tax strategies (Cen et al., 2017).

Dhaliwal et al. (2016) find that higher customer concentration risk is associated with higher costs of equity, and Liu et al. (2018) provide evidence that customer concentration risk hinders suppliers' ability to raise external funding through receivable securitization. Our findings enrich this stream of research by showing that customer concentration risk could have a significant effect on the supplier CEO's risk-taking incentives in her compensation package.

Third, our paper is related to a small group of studies documenting that considerations from firms in the same industry or in the supply chain affect the optimal structure of the firm in question. For example, Karuna (2007) finds that firms provide stronger performance incentives when competition from industry rivals is greater. Hertzel et al. (2008) show that suppliers to bankruptcy filing firms experience negative and significant stock price reactions around filing and pre-filing distress dates. Coles et al. (2018) find that the external pay gap between the CEO in question and the highest-paid CEO in the same industry provides tournament incentives that affect firm performance and risk. Harford et al. (2019) demonstrate that significant trade relationships and economic links incrementally explain firms' acquisition activities. Complementary to these studies, we examine how economic links along the supply chain affect managerial risk-taking incentives in the context of moral hazard. In turn, the fact that product market relationships are sufficiently important to be manifested in the design of managerial incentive schemes suggests an extended concept of the firm as a managed economic system that permeates a firm's formal boundaries, entailing system-wide considerations about incentive provision problems.

In a contemporaneous paper, Liu et al. (2020) study a similar question to ours. Exploiting import tariff reductions as an experimental setting, they also provide evidence that a firm's relationship with major customers can have a substantial effect on its managerial compensation structure. Yet, the two papers differ in important aspects. First, their construction of important customer relationships includes both major customers that account for at least 10% of the firm's total revenue and other voluntarily-disclosed, nonmajor customers (i.e., contribute less than 10% of total sales). We, however, focus only on major customers and adhere to the objective cutoff rule to maintain uniformity.[3] Also, it is important to note that our customer concentration risk argument relies primarily on the proportion of sales to major customers being sufficiently large: if such a customer removes its business from a supplier, this would be a serious disruption to that supplier. Second, Liu et al.

[3] We discuss this issue in more details in Section 2.3.

(2020) restrict their sample to manufacturing firms and show that manufacturing firms with varying degrees of customer concentration adjust CEO vega differently in response to competition shocks. Our results, based on a full sample of firms with information available on ExecuComp, suggest that CEO vega depends on customer concentration directly, allowing for greater generalizability and providing a more complete picture on the relation between customer relationship and CEO compensation.

The rest of the paper is organized as follows. Section 2 describes the sample and variable constructions. Section 3 discusses the main results and robustness tests. Section 4 addresses potential endogeneity issues. Section 5 examines the cross-sectional heterogeneity in the relation between customer concentration and CEO vega. Section 6 concludes.

2. Data sources, sample selection, and methodology

2.1. Data sources and sample selection

We investigate the relation between customer concentration and CEOs' incentive contracts in this paper. Hence, our starting point to construct the sample is the universe of firms over the period 1992-2018 in the ExecuComp database that provides CEO compensation information. We then expend this information to include customer-supplier data from Compustat's Segment Customer files. Moreover, we obtain firm-level financial data from Compustat, stock price information from CRSP, and CEO characteristics from ExecuComp. All continuous variables are winsorized at the 1^{st} and 99^{th} percentiles to mitigate the potential impact of outliers. We drop observations with missing values for the variables employed in the regressions. The final sample includes firms in the intersection of these databases, consisting of 38,366 firm–year observations for 3,474 unique firms.

2.2. Empirical specification

To examine the relation between customer concentration and managerial risk-taking incentive provision at the supplier-year level, we estimate the following panel regression model:

$$Ln(1 + Vega)_{i,t} = \alpha + \beta \cdot Customer\ Concentration_{i,t} + \gamma \cdot Control_{i,t} + Industry * year_{i,t} + \varepsilon_{i,t} \quad (1)$$

The measures of CEO risk-taking incentives and customer concentration are discussed in detail in the following subsections. *Control* represents a vector of firm and CEO characteristics that affect the CEO's incentive contracts following the existing literature. We include *Industry*year*, the industry-year interaction fixed effects, to mitigate any concern about omitted variables that are correlated with a firm's customer base structure and vary within industries and years. Similar to prior studies (e.g., Dhaliwal et al., 2016; Campello and Gao, 2017; Cen et al., 2017), we do not include firm fixed effects in our regressions due to limited within-firm variation in the customer concentration variables. We return to this issue shortly.

2.3. Measuring customer concentration

We identify firms' major customers using Compustat's Segment Customer database. This information is publicly available as SFAS No. 14 (before 1997) and FAS No. 131 (after 1997) require firms to report all customers that account for 10% or more of total firm revenues. The Segment database provides the type and name of a major customer along with the dollar amount of annual revenues generated from each major customer. Although regulations only require suppliers to disclose customers representing at least 10% of revenues, suppliers could voluntarily report customers that account for less than 10% of revenues (i.e., nonmajor customers). We exclude these customers from our concentration calculations for two important reasons.[4] First, voluntary disclosure choices in the context of information about customers are a result of the tradeoff between the benefits of reducing information asymmetry and the costs of being in a disadvantaged position compared to competitors (Ellis et al., 2012). Thus, the presence of nonmajor customers in the data would be endogenously determined, resulting in a sample selection problem. That is, if product market competition incentivizes firms to withhold information about sales (Dedman and Lennox, 2009), then nonmajor customers are less likely to appear in competitive industries and in times of high competition, creating a bias that varies with the degree of competition faced by the firm. Second, a prerequisite for the customer concentration risk to be a major concern in a moral hazard context is that the proportion of sales to major customers must be sufficiently large in the sense that losing such customers would have a material adverse effect on the supplier. For both reasons, we adhere to the objective 10% cutoff rule and focus on major customers.

We use two measures to capture the extent to which a supplier's customer base is concentrated. For the first measure, we follow Banerjee et al. (2008) and Dhaliwal et al. (2016) and define *Major customer sales* as the fraction of a supplier's annual total sales

[4] Our results are robust to including these customers.

captured by all major customers, where major customers are those that account for at least 10% of the supplier's annual revenues.

The second measure, *Customer HHI,* follows Patatoukas (2012), who constructs the customer concentration variable based on the notion of a Herfindahl-Hirschman Index of sales to major customers. Specifically, we measure supplier *i*'s customer concentration in year *t* across the supplier's *J* major customers as:

$$Customer\ HHI_{it} = \sum_{j=1}^{J} \left(\frac{Sales_{ijt}}{Sales_{it}}\right)^2$$

where $Sales_{ijt}$ represents supplier *i*'s sales to major customer *j* in year *t*, and $Sales_{it}$ represents supplier *i*'s total sales in year *t*. *Customer HHI* ranges between zero and one with higher values indicating a more concentrated customer base. It takes a value of zero when a supplier does not disclose sales to any major customers and takes a value of one when a supplier depends on a single major customer for all of its annual revenues.

[Insert Table 1 about here]

It is worth noting that our main source of variation in the customer concentration variables comes from the cross section. To get a sense of the relative variation of the customer concentration measures in our sample, we calculate between- and within-firm variances in Panel A of Table 1. As one can see, there is more variation in each of the measures across firms than within firms. The within-firm standard deviation of *Customer HHI* (*Major customer sales*) is 4.6% (9.5%). For comparison, the between-firm standard deviation of *Customer HHI* (*Major customer sales*) is 7.5% (17.3%). This observation is consistent with Dhaliwal et al. (2016), Campello and Gao (2017), and Cen et al. (2017), who also note that the limited within-firm variation in customer concentration variables may work against including firm fixed effects in regressions and suggest using industry-year fixed effects instead, which we follow in our empirical specifications.[5]

2.4. Measuring risk-taking incentives

[5] Since the variation in customer concentration arises mainly in the cross-section, firm fixed effects may not be a good match for our empirical context (Zhou, 2001). Unsurprisingly, our results overall suggest that the relation between customer concentration and CEO vega is strong in the cross-section but not prominent in the time series.

We follow the existing literature and measure managerial risk-taking incentives by the sensitivity of CEO wealth to stock return volatility, or *Vega*, defined as the change 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 (Guay, 1999; Core and Guay, 2002; Coles et al., 2006).[6] To alleviate concerns that arise from the skewness of vega, we measure CEO risk-taking incentives as *Ln*(*1 + Vega*) in our analysis.[7] In addition to this traditional way of capturing managerial risk-taking incentives, as an extension, we construct a more comprehensive vega that considers the pay convexity in p-v grants that become increasingly important in recent years, following the empirical methods of Bettis et al. (2018). We discuss this analysis in more detail in Section 3.2.1.

2.5. Control variables

Following the prior literature, we include several firm and CEO characteristics that are related to the design of CEO incentive compensation (Coles et al., 2006; Low, 2009; Hayes et al., 2012; Cohen et al., 2013). First, we control for firm characteristics, including firm size, measured as the natural logarithm of sales (*Ln*(*Sales*)); profitability, measured as both the return on assets (*ROA*) and stock returns (*Stock return*); investment opportunities, measured as Tobin's q (*Tobin's q*); information quality, measured as stock return volatility (*Volatility*); and firm leverage (*Leverage*). Moreover, the CEO characteristics that we control for include age (*Age*), tenure (*Tenure*), an indicator of whether the CEO also serves as the chairman of the board (*CEO duality*), and an indicator of whether the CEO holds more than 5% of the firm's outstanding shares (*CEO ownership*). Appendix provides detailed variable definitions.

2.6. Summary statistics

Panel B of Table 1 reports summary statistics of the variables used in our baseline analysis. The dependent variable *Vega* has a mean value of \$115,398, which is comparable to the reported mean of \$149,453 in Table 1 of Hayes et al. (2012). On average, sales to all major customers account for 7.7% of total revenue. For the subset of suppliers that disclose at

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[6] A related measure is the fraction of option compensation. We do not use this measure because options have ambiguous implications for risk. On the one hand, options increase in value with firm risk. Their convex pay structure creates an incentive to take risk because managers share in the gains but not all of the losses. On the other hand, options increase the sensitivity of a risk-averse CEO's wealth to the underlying stock price, weakening the CEO's risk-taking incentives (Carpenter, 2000; Ross, 2004). Further, option compensation increases wealth, which may alter risk tolerance. Together, the net effect of option compensation on risk taking is not clear a priori and depends upon the level of CEO wealth, the degree of diversification in a CEO's personal portfolio, and the risk-aversion parameter, among others (Guay, 1999).

[7] Our results are not materially affected if we replace *Ln(1 + Vega)* with *Vega*.

least one major customer, the mean sales to all major customers account for 34.0% of these suppliers' total revenue.[8] The mean *Customer HHI* is 2.2% for the whole sample and 9.6% for the subset of suppliers with at least one major customer. These results are comparable to those of Dhaliwal et al. (2016) and Campello and Gao (2017).

An average firm in our sample has a sales revenue of $4.76 billion, a return on assets of 3.5%, a Tobin's q of 1.88, a stock return of 14.4%, stock return volatility of 0.11, and a leverage of 23.7%. In addition, the average CEO is 56 years old and has a tenure of 8 years. 51.9% of our sample CEOs also serve as the chairman of their board and 9.2% hold more than 5% of total shares outstanding.

3. Customer concentration and supplier CEO risk-taking incentive provision

3.1. Baseline results

We start our analysis by examining whether a concentrated customer base affects the supplier CEO's risk-taking incentives in her compensation package. Table 2 presents the results of this analysis, using both measures of customer concentration. The coefficient estimates of *Major customer sales* and *Customer HHI* are positive and significant at the 1% level, suggesting a positive relation between customer concentration and supplier CEO vega. To interpret the economic significance, we compare the differences in customer concentration and CEO vega between suppliers that do not depend on any major customers and the average supplier with at least one major customer. The average supplier with at least one major customer has a total percentage of sales to all major customers of 34.0% and a customer concentration HHI of 0.096. Since both customer concentration measures take the value of zero for suppliers that do not have any major customers, the coefficient estimates in regressions (1) and (2) suggest that firms with at least one major customer offer risk-taking incentives in managerial compensation that are 11.8% (= 0.346 × 0.340) and 8.9% (= 0.923 × 0.096) higher, respectively.

[Insert Table 2 about here]

The results for the control variables are relatively stable in terms of their magnitude and significance levels across the different specifications, and are generally consistent with those in the prior literature. Similar to Chang et al. (2016), we find that pay-risk sensitivity is higher for chairman-CEOs and decreases with CEO age. Consistent with Bakke et al. (2019),

[8] In 23% of our observations, a firm reports that at least one major customer accounts for 10% or more of revenues.

we also find that CEO vega is positively associated with firm size and investment opportunities.[9]

3.2. Robustness tests

This section reports an extensive set of robustness checks we undertake to strengthen our baseline findings.

3.2.1. Performance-vesting provisions

Despite the voluminous literature on stock options and risk taking (see, for example, Hayes et al., 2012; Armstrong and Vashishtha, 2012; Gormley et al., 2013; Bakke et al., 2016), options themselves are not the only source of risk-taking incentives in managerial compensation. Over the past decade, performance-vesting (p-v) provisions that set certain performance hurdles for equity and/or cash awards have played an increasingly important role in conveying compensation convexity. According to Bettis et al. (2018), the usage of p-v equity awards to top executives in large U.S. companies has grown from 20% in 1998 to almost 70% in 2012. In particular, there has been a shift away from option grants towards p-v stock grants, and this trend was pronounced around FAS123R, which removed the preferential treatment in reporting and expensing option pay from 2006 onward (Bettis et al., 2010; Bettis et al., 2018).

If the convexity in compensation contracts comes primarily from p-v stock grants, especially in the later years of our sample, the conventional vega becomes an incomplete measure of risk-taking incentives provided to CEOs. We conduct two tests to ensure that this issue does not contaminate our inferences. As a first step, we restrict our sample to the period before the change of compensation disclosure rules in 2006, which is likely to be less contaminated by the measurement error in CEO vega. We report the results in Table IA2 of the Internet Appendix and confirm that the results are not much affected by this restriction.

Second, to more formally address the measurement concern, we follow the empirical methods developed by Bettis et al. (2018) and construct more comprehensive measures of

[9] While not the main focus of the paper, as a complement, we broaden the inquiry and examine the effect of customer concentration on risk-taking incentives for other named executive officers (NEOs) beside the CEO. We define NEOs as non-CEO executives whose compensation is disclosed in ExecuComp and construct an analogous measure based on the average vega of NEOs' compensation contracts. We then estimate the relation between the customer concentration measures and *Average NEO vega*, using the same set of controls as in Table 2. The results shown in Table IA1 of the Internet Appendix provide parallel evidence that customer concentration is positively related to NEO vega as well, pointing to a broader scope for the effect of customer concentration.

pay convexity: *Augmented vega_S*, which enhances the conventional vega by adding the pay convexity arising from p-v stock awards, and *Augmented vega_SC*, which enhances the conventional vega by incorporating the pay convexity arising from both p-v stock and p-v cash awards. Our data on p-v provisions are from the ISS Incentive Lab, which limits the sample period for this analysis to 1998-2018 because this database has broad coverage only from 1998 onward. Following Bettis et al. (2018), we focus on p-v awards with a single (accounting or stock) performance metric to keep the task manageable. We discuss further details about the estimation procedure and variable construction in the Internet Appendix. Table 3 reports regression results in which the dependent variables are the two augmented CEO vega measures. The coefficient estimates on customer concentration variables are all positive and significant at the 1% level. It is reassuring to observe that our results remain unchanged using these two alternative managerial incentive measures that take p-v provisions into account.

[Insert Table 3 about here]

3.2.2. Additional robustness tests

We perform a series of other robustness tests. First, we explore different ways of defining the customer concentration variable. In the baseline results, we already use two measures of customer concentration. In Panel A of Table 4, we take a step further and consider three more measures: (i) *Major customer* is an indicator variable set to one if a firm discloses at least one corporate customer that accounts for 10% or more of its total revenue and zero otherwise; (ii) *Major customer max* is the highest percentage sales to major customers; and (iii) *Major customer count* is the total number of a firm's major customers. The results show that the positive relation between customer concentration and CEO risk-taking incentive provisions is robust to using the three alternative measures.

[Insert Table 4 about here]

Second, in June 1997, the FASB issued FAS No. 131, revising SFAS No. 14, which affected disclosure requirements of some of the segment customer information. To ensure that this rule change does not drive our findings, we restrict the beginning of our sample period to 1998 and re-estimate the baseline specifications. Panel B of Table 4 reports the results. The estimated effect is not much affected.

Third, one may argue that institutional investors and corporate governance could affect our baseline results as previous studies show that these are important determinants of CEO compensation (Core et al., 1999; Hartzell and Starks, 2003). To address this concern, we retrieve institutional equity holding data from the Thomson Reuters Institutional (13f) Holdings database and construct a variable *Institutional ownership*, and use a *Takeover index* developed by Cain et al. (2017).[10] We include these two variables in our baseline regressions and report the results in Panel C of Table 4. We continue to observe positive and significant coefficient estimates of customer concentration variables.

Fourth, in our baseline, we include industry-year fixed effects to account for potential heterogeneity in customer concentration across sectors in a given year. We now add state-year fixed effects to further account for potential heterogeneity within states and years. Panel D of Table 4 presents the results. Again, we find a positive relation between customer concentration and CEO vega.

Fifth, one may be concerned that our results could be driven by the financial crisis in 2008 because there were significant changes in both customer relationships and CEO risk-taking incentive provisions. In Panel E of Table 4, we repeat our baseline analysis in a sample that excludes the 2008-2009 crisis period. We show that our results are robust to excluding the financial crisis period.

Finally, it is possible that customer concentration affects the provision of performance incentives, or delta, to supplier firm managers. Such incentives expose the manager to more firm risk (Guay, 1999), which, in turn, could be an important consideration in the determination of vega. To address this concern and better isolate the effect of customer concentration on vega, we explicitly control for other aspects of compensation incentives in Panel F of Table 4, constructing and including the following variables. *Ln*(*1+Delta*) is the natural logarithm of one plus delta, where delta is defined as the change in the value of the CEO's wealth due to a 1% increase in the firm's stock price. We estimate delta following Guay (1999) and Core and Guay (2002).[11] *Ln*(*Cash*) is the natural logarithm of CEO cash compensation, where cash compensation consists of salary and bonus. The coefficient estimate on the customer concentration variables remains positive and significant across all

[10] The takeover index is constructed based on the passage of 12 different types of state anti-takeover laws, one federal statute, and three state standards of review, where higher values indicate greater susceptibility to hostile takeovers. The state laws are matched to the firms based on their state of incorporation. The data are available at: https://pages.uoregon.edu/smckeon/.

[11] Note that this estimated delta does not incorporate the sensitivity of p-v grants to stock performance.

specifications, suggesting that our results are robust to controlling for cash and performance incentives in compensation contracts.

Overall, the results in Table 4 reinforce our key finding of a positive relation between customer concentration and CEO risk-taking incentives. Our baseline findings remain relatively stable across all robustness checks. For instance, the coefficient estimate on *Major customer sales* ranges from 0.153 to 0.365. The stability of these coefficient estimates suggests that any potential bias arising from omitted variables or unobserved selection is likely to be low (Oster, 2019).

4. Addressing potential endogeneity

While the results so far are robust and consistent with the hypothesis, the observed relation between customer concentration and supplier CEO vega could tell us little about causality given the endogeneity of the relation between risk-incentive compensation and risk. For example, there could be some unobserved firm and CEO characteristics affecting both the concentration of the firm's customer base and managerial risk-taking incentives. Alternatively, managerial incentive compensation is arguably designed in anticipation of a particular risk environment. In this section, we adopt a multi-pronged approach to mitigate these concerns. Overall, the tests confirm our baseline results and show that the data are inconsistent with several particular concerns. While these observations are reassuring, we are mindful that it is never possible to completely rule out alternative explanations in general.

4.1. Propensity score matching estimates

As a first step to alleviate endogeneity problems, we employ a propensity score matching approach whereby firm-year observations with a major customer are matched with those without a major customer. A perfect experiment for examining the effect of a concentrated customer base on the supplier CEO's risk-taking incentive provision would be one that compares CEO vega of firms that rely on at least one major customer in a year with that of the same firm in the same year, had it not relied on any major customers. However, since this counterfactual cannot be observed, we have to adopt a second-best experiment based on matching, whereby we compare CEO vega of a customer-dependent supplier with that of another non-dependent supplier that is sufficiently similar to the dependent supplier.

We proceed in two steps to identify a matched sample of firm-years without a major customer that exhibit no significant differences in other observable characteristics with those with a major customer. We first estimate the probability that a firm has at least one major customer by running a logit regression, reported in regression (1) of Panel A of Table 5, that includes the same controls as in the regressions in Table 2.[12] Consistent with Banerjee et al. (2008) and Campello and Gao (2017), the results show that on average customer-dependent supplier firms are smaller and have higher investment opportunities. Moreover, these firms appear to be less profitable during our sample period. In the second step, we construct matched samples using the nearest-neighbor method based on the propensity scores calculated from the first-step logit model. Specifically, each firm-year observation with a major customer (the treatment group) is matched with the firm-year observation without a major customer (the control group) with the closest propensity score. To ensure that observations in the treatment and control groups are sufficiently indistinguishable, we require that the maximum difference (i.e., the caliper) in the propensity score between each firm-year with a major customer and that of its matched peer does not exceed 0.001 in absolute value.[13]

[Insert Table 5 about here]

To verify that firms in the treatment and control groups are truly comparable, we conduct two diagnostic tests. The first test consists of re-estimating the logit model for the post-match sample. The results are shown in regression (2) of Panel A of Table 5. None of the coefficient estimates is statistically significant, suggesting that there are no distinguishable trends in CEO vega between the two groups. Further, the coefficient estimates in regression (2) are much smaller in magnitude than those in regression (1), suggesting that the results in regression (2) are not simply an artifact of a decline in degrees of freedom in the restricted sample. The second test consists of examining the difference for each observable characteristic between the treatment firms and the matched control firms. The results are reported in Panel B of Table 5. Again, none of the differences in observable characteristics between the treatment and control firms is statistically significant. Overall, the diagnostic test results suggest that the propensity score matching removes all observable differences other than the difference in the concentration of the firm's customer base, increasing the likelihood that any difference in CEO vega between the two groups is due to customer concentration.

Finally, Panel C of Table 5 reports the propensity score matching estimates.[14] The results suggest that there is a significant difference (at the 5% confidence level) in CEO vega

[12] The results are robust to adding the following controls in the logit regressions: *R&D intensity*, *Investment intensity*, *SGA/Sales*, and *Adv/sales*, as well as using a probit model in the first step.

[13] Our results remain robust when we increase the maximum permissible difference in propensity scores to 0.01 and 0.005 in absolute value.

[14] The difference in means between the treatment group and matched control group is the propensity score matching estimate of the average treatment effect on the treated (ATT).

between firms with a major customer and those without. In detail, CEOs of firms with a major customer have a 6.9% higher vega than those in otherwise indistinguishable firms without a major customer.

4.2. Newly appointed CEOs

A major concern of our baseline results is that some unobservable CEO characteristics might affect both customer concentration and risk-incentive compensation in the same direction, resulting in the observed positive concentration-vega relation. For example, incumbent CEOs who have had more interactions with the board could have greater abilities to affect their own compensation packages and at the same time influence the concentration of the customer base. To help address this concern and isolate the effect of customer concentration on CEO vega, we examine a subset of newly appointed CEOs who should have little or no time to gain control over corporate decisions or their own pay (Chang et al., 2016).

[Insert Table 6 about here]

In Table 6, we examine how the vega of the supplier's newly appointed CEO is affected by its customer concentration. Newly appointed CEO's vega is measured over the first full fiscal year after the CEO assumes office, as the first year's compensation package could reflect less than a full year's pay for CEOs with tenure less than one year.[15] The same set of controls as in the baseline models are included, except *Tenure* which is omitted because new CEOs by definition have zero tenure. The variables of interest are the customer concentration measures. Using both measures, the coefficient estimates on the concentration variable are positive and significant at the 5% or 1% level. These observations suggest that firms with more concentrated customer bases provide their newly appointed CEOs with greater risk-taking incentives, which once again supports our hypothesis.

4.3. Instrumental variable estimates

Our baseline estimates of the concentration-vega relation are likely to be tainted with several endogeneity concerns. First, customers might assess suppliers' managerial compensation packages prior to entering contracts. To the extent that pay convexity is perceived to intensify the conflict of interests between shareholders and other key stakeholders (Kuang and Qin, 2013; Akins et al., 2019), major customers may avoid suppliers

[15] If the tenure is less than one year, we use the vega for the second year after the CEO assumes office. For a similar approach, please refer to Berry et al. (2006). As a robustness check, we find that the results continue to hold if we define newly appointed CEOs' vega based on their first-year compensation.

with high CEO vega, making it difficult for such suppliers to develop important trade relationships. This potential selection driven by customers would spuriously reduce the estimated relation between customer concentration and CEO vega.

In terms of omitted variables, there could be some unobserved firm characteristics affecting both the structure of customer base and managerial risk-taking incentives. For example, firms with inclusive stakeholder strategies are likely to be more attractive to large customers, while in the meantime they might be more cautious in providing convex payoffs (Leung et al., 2019). Alternatively, firms that operate in a more competitive business environment could provide stronger managerial incentives (Karuna, 2007), and such firms also face greater challenges in maintaining major customer relationships. In both cases, a spurious negative relation could exist between customer concentration and CEO vega, which are likely to attenuate the positive coefficient estimate on customer concentration towards zero, i.e., bias against finding a significantly positive customer concentration effect.

To further address these endogeneity concerns, we use an instrumental variable approach to extract plausibly exogenous component of customer concentration and use it to explain supplier CEO vega. Regarding the sources of plausibly exogenous variation, we use two instrumental variables that capture the concentration of the firm's customer base, but are uncorrelated with supplier CEO vega, except through variables we control for. For the purpose of this analysis, we focus on supplier firms that disclose at least one major corporate customer because the instruments used offer meaningful variation with which to capture customer concentration only when there are major corporate customers.[16]

Our first instrument *Customer Industry M&A*, initially proposed by Campello and Gao (2017), exploits the variation in the intensity of merger and acquisition activity in customers' industries (downstream M&A) that could drive changes in customer concentration. Existing research suggests that mergers of customers with other firms in the same industry lead to stronger combined buyer positions and in turn a more concentrated customer base (Fee and Thomas, 2004; Bhattacharyya and Nain, 2011). In support of this view, Campello and Gao (2017) document that the sales of a supplier to acquirer customers increase rapidly following downstream mergers, with 30% growth in the same year of the merger and 80% growth in two years after the merger. Therefore, we expect the M&A intensity in customer industries to increase the concentration of the supplier's customer base, satisfying the relevance condition of the instrumental variable approach.

[16] Nonetheless, our results are not much affected if we do not impose this sample restriction.

Meanwhile, as argued by Campello and Gao (2017), it is reasonable to expect that downstream M&A activities should only affect the supplier CEO's incentive pay through its effects on customer concentration, because downstream M&A activities among customers are likely independent of the supplier's CEO compensation policy choices. However, one might be concerned that downstream M&A activities are potentially influenced by the supplier's industry dynamics that could ultimately affect both the supplier's customer base and its CEO's risk-taking incentives. This concern is mitigated by the inclusion of the supplier's industry-year fixed effects in our tests, which, as we discuss previously, allows us to eliminate any unobserved industry dynamics that may contaminate the validity of the instrument.

To construct *Customer Industry M&A*, we take the following steps. We first obtain the firm-level annual costs of M&A activities from Compustat (Item AQC). The industry-level five-year mean M&A intensity is then measured as the average M&A intensity of an industry (two-digit SIC) over the past five years, where industry M&A intensity is computed as the aggregate M&A costs divided by the aggregate sales across all firms within that industry in a given year. Finally, for a supplier *i* in year *t*, *Customer Industry M&A* is the weighted sum of the five-year M&A intensity across the industries to which the firm's major customers belong, weighted by the supplier's percentage sales to each customer. The variable is then defined as follows:

$$Customer\ industry\ M\&A_{it} = \sum_{j=1}^{n} \%Sales_{ijt} \times Industry\ five\ year\ average\ \left(\frac{M\&A\ costs}{Sales}\right)_{jt}$$

Our second instrument, *Customer regulation index,* exploits plausibly exogenous variation in aggregate regulatory restrictions of customers' industries, which has also been used by Gutiérrez and Philippon (2017) and Duan et al. (2019). The rationale behind this instrument is that rising regulatory stringency introduces barriers that limit entry by actual and potential rivals. Such barriers are advantageous to incumbent firms and may ultimately shift market power towards a small number of sizable firms, increasing the concentration of the customer base (Gutiérrez and Philippon, 2017). We therefore expect a positive relation between regulatory restrictions and customer concentration. Meanwhile, it seems quite unlikely that the differences in the level of regulation across customers' industries can be directly linked to the supplier CEO's risk-taking incentives. Again, the inclusion of supplier industry-year fixed effects in our tests allows us to address the possibility that some government regulations affect both the supplier and customer industries concurrently.

To construct this instrument, we obtain the industry-specific regulation data from the RegData database compiled by McLaughlin and Oliver (2018).[17] The RegData covers all US federal regulations issued by various regulatory agencies. A primary attraction of this data is that it quantifies two dimensions of regulatory quality, namely *restrictiveness*, meaning the occurrence of words/phrases indicating binding constraints in the regulatory text, and *relevance*, the applicability of each regulation to a specific industry. Combining the two proxies, we compute *Industry regulation index* for each industry year as the weighted sum of the number of legally binding words (including "shall", "must", "may not", "prohibited", and "required") contained in regulatory text across all regulations, weighted by the relevance of each regulation to that industry.[18] Finally, for each supplier year, *Customer regulation index* is the weighted sum of *Industry regulation index* across the industries to which the firm's major customers belong, weighted by the supplier's percentage sales to each customer.

$$Customer\ regulation\ index_{it} = \sum_{j=1}^{n} \%Sales_{ijt} \times Industry\ regulation\ index_{jt}$$

Panel A of Table 7 presents the results of the first-stage regressions in which the dependent variables are the customer concentration variables. The explanatory variables include the above-mentioned instruments and the same set of controls as in the baseline models in Table 2. Regressions (1) and (2) use *Customer Industry M&A* as the instrument, regressions (3) and (4) use *Customer regulation index*, and regressions (5) to (6) use both instruments. Consistent with the rationale behind the instruments, the results show that a supplier's customer concentration is positively correlated to the customer industries' M&A intensity as well as to the customer industries' aggregate regulatory restrictions. In particular, the coefficient estimates on the instruments across all specifications are significant at the 1% level. The reported *F-statistics* are also large for all 6 regressions, suggesting that none of our instruments is weak. Finally, the *p*-values for Hansen's (1982) *J* over-identification test are large, suggesting that we cannot reject the null hypothesis that the instruments are valid.

[Insert Table 7 about here]

[17] The dataset spans 1970-2017 and is available at: https://quantgov.org/regdata-us/.

[18] The industry regulation index is based on the four-digit North American Industry Classification System (NAICS) classification, the only industry classification available in the RegData database. See Al-Ubaydli and McLaughlin (2017) for a more detailed description of the industry regulation index. The same index has been used by Hassan et al. (2019) to capture industry-level regulatory stringency.

Panel B of Table 7 reports the results for the second-stage regressions whose dependent variable is supplier CEO vega. The variable of interest is the variable with the predicted values of the customer concentration variables from the first-stage regressions. The coefficient estimates of the variable of interest in all 6 regressions are positive and significant, confirming the positive effect of customer concentration on supplier CEO vega. The results from the instrumental variable approach further support that our baseline findings are not due to endogeneity in customer base structure.

Comparing the results obtained from the OLS regressions (Table 2) with those obtained from the above two-stage least squares (2SLS) regressions, it is interesting to observe that the magnitudes of the 2SLS coefficient estimates are larger than those of the OLS estimates (although the coefficient estimates from both approaches are positive and statistically significant). This observation is consistent with our earlier discussion that spurious negative concentration-vega relation caused by customer selection and/or omitted variables being the main driving force that biases the coefficient estimates of interest downward in OLS regressions. Once we use the instruments to clean up the spurious negative correlation, the endogeneity of customer base structure is mitigated and the coefficient estimates increase, i.e., become more positive. Substantiating the attenuation bias in the OLS estimates, we perform the Hausman test and it rejects the null hypothesis that the 2SLS and OLS coefficient estimates on the customer concentration variables are the same.

An important concern of the instrumental variable approach is that the instruments may lose value with repeated use because they can be rivalrous: each successful use of an instrument potentially compromises the validity of all other uses of that instrument (Heath et al., 2020). In our case, the previous uses of the two instruments, *Customer Industry M&A* and *Customer regulation index*, by Campello and Gao (2017), Gutierrez and Phillipon (2017), and Duan et al. (2019) show that loan features, investment intensity, and ownership structure could be affected by customer concentration and hence are correlated with the instruments. Since valid instruments should vary only in response to exogenous factors, it seems important to account for potential endogenous factors shown to be correlated with our instruments. To ensure the validity of the analysis given previous studies and help reconcile the exclusion condition with existing evidence, we include more controls for loan features, investment intensity, and ownership structure in our 2SLS regressions: *Borrowing cost* is the ratio of interest expenses to total debt. *Debt maturity* is the fraction of long-term debt maturing in one year. *Investment intensity* is defined as capital expenditures scaled by total assets. *Institutional ownership* is constructed as the total number of shares held by institutional investors divided by the total number of shares outstanding, based on the data obtained from SEC 13f filings. We report the results in Table IA3 of the Internet Appendix. We find that the results are qualitatively similar with these additional controls. In addition, none of the coefficient estimates on the additional controls for loan features, investment intensity, and ownership structure is statistically significant, which provides additional assurance for the satisfaction of the exclusion condition of our instrumental variables.

4.4. Addressing reverse causality

While our identification attempts so far all point to a causal effect of customer concentration on CEO's risk-taking incentives, a plausible alternative interpretation of our main results is that supplier CEOs' risk-taking incentives affect the characteristics of customer firms in the product market, resulting in the positive relation between customer concentration and CEO vega. For example, it could be that the structure of managerial compensation is chosen to induce certain investment outcomes (Bizjak et al., 1993), and that some of these investments might create forces for consolidation or fragmentation in customer firms' product markets. This alternative interpretation suggests that the direction of causality could be the other way around. To gain insights about whether our findings are driven by reverse causality, we undertake two tests.

First, we restrict our sample to a subset of firm-year observations for which the reverse causation problem is less severe. Large firms are more likely to have the market power and motive to actively influence customer firms' product markets and hence are more subject to the reverse causality concern. We re-examine the effects of customer concentration after excluding, respectively, the largest 10% and the largest 25% suppliers in terms of sales and report the results in Table 8. We find that the customer concentration variables continue to be economically and statistically significant in all specifications. To the extent that the concentration of customer base can be viewed as predetermined for small firms, these findings provide further assurance that the positive concentration-vega relation does not appear to arise from reverse causation.

[Insert Table 8 about here]

Second, we follow Cen et al. (2017) and investigate the effect of relationship establishment events on supplier CEO vega. A trend of increasing CEO vega before the event would suggest the presence of reverse causality, and vice versa. Relationship establishment is defined as when a firm reports a major customer in year t for the first time in which the relationship lasts for at least three years (i.e., years t, $t + 1$, and $t + 2$). In untabulated analyses, there are two key takeaways. First, we find that, in a four-year period around the relationship establishment with major customers, the dependent supplier's CEO vega increases by 5.6% from year t to year $t + 2$, consistent with the prediction. Second, the increase in CEO vega becomes large and significant only after the relationship establishment but is absent before the relationship establishment, suggesting that the positive concentration-vega relation is unlikely driven by reverse causation.[19]

5. Cross-sectional heterogeneity

In this section, we conduct cross-sectional tests that make use of variation in several characteristics of supplier CEOs, supplier firms, and customer-supplier relationships to shed light on the mechanisms underlying our main findings. Specifically, we examine whether the effect of customer concentration on CEO vega varies with supplier CEOs' attitudes toward (customer concentration) risk, supplier firms' investment opportunities, customer firms' cost of switching to different suppliers, and relationship-specific investments (RSI). Overall, these heterogeneity tests provide further support to our causal inferences of the positive effect of customer concentration on CEO vega, because it is difficult to come up with an omitted variable that biases our results equally in all cross-sectional dimensions discussed in this section.

5.1. Supplier CEOs' risk attitudes

5.1.1. CEO age

We substantiate the argument that firms with higher customer concentration provide greater CEO pay convexity to reduce risk-related conflicts between shareholders and managers. If firms use convex pay structure to offset managerial risk aversion and encourage value-enhancing risk taking, then the positive relation between customer concentration and supplier CEO vega should be more prominent when the CEO is less open to risk taking (i.e., risk-taking incentives in compensation are more needed).

We proxy for a CEO's openness to risk taking with her age: a younger CEO is more willing to take risk. Prendergast and Stole (1996) develop a theoretical model that predicts that younger CEOs with long career horizons to reap benefits have stronger incentives to

[19] One caveat of this test, however, as mentioned in Cen et al. (2017), is that the "new" relationship establishment defined here is not necessarily new. It could be that the supplier starts to disclose a particular customer or a customer becomes a major customer as the customer just crosses the 10% disclosure requirement threshold.

signal superior ability by taking greater risk in firm decisions. Consistent with this view, Serfling (2014) and Li et al. (2017) provide empirical evidence that younger (older) CEOs are associated with higher (lower) stock return volatility and more (less) risky investment and financial policies.[20] Hence, we expect the positive customer concentration-vega relation to be weaker for firms led by young CEOs, where additional risk-taking incentives in the form of pay convexity are less needed.

[Insert Table 9 about here]

To test this prediction, in Panel A of Table 9 we split the sample into quartiles based upon the age of the CEO descendingly. The Old CEO columns indicate the top quartile sample, and the Young CEO columns indicate the bottom quartile sample. We then repeat the analyses in Table 2 in subsamples of old and young CEOs separately. For brevity, we report only the coefficient estimates on the customer concentration variables, although the same set of control variables and industry-year fixed effects as in our baseline models are included. For both measures of customer concentration, we find that the coefficient of interest is statistically significant only when the firm is run by an old CEO and that the estimated effect is more than four to six times larger for old CEO firms than for young CEO firms.

5.1.2. CEO general managerial ability

In a similar vein, in Panel B of Table 9 we test the idea that the positive relation between customer concentration and supplier CEO vega is more prominent when the CEO is more susceptible to firm risk associated with customer base structure, entailing stronger risk-taking incentives in compensation. Prior literature has argued that CEOs with general managerial abilities (generalist CEOs) can move across firms and industries more easily compared to specialist CEOs with focused business experience (Custódio et al., 2013; Mishra, 2014). As a result, the broader set of outside options available to generalist CEOs makes them less sensitive to customer concentration risk. Thus, we expect that the positive customer concentration-vega relation should be less (more) prominent for firms with generalist (specialist) CEOs.

[20] We acknowledge another strand of the literature that considers the impact of CEO age on firm risk preferences. Models incorporating career concerns, such as those of Hirshleifer and Thakor (1992) and Holmstrom (1999), predict that younger CEOs are more risk-averse because they do not yet have reputations as high quality managers and thus can be punished more severely for poor performance through reduced human capital in the managerial labor market. Further, given that younger CEOs are further away from retirement, they are expected to be more affected by the loss of labor market value than older CEOs. Together, these arguments lead to the prediction that the positive concentration-vega relation should be more pronounced for firms led by young CEOs, which we do not find in our data.

We use the variable General Ability Index, or *GAI*, developed by Custódio et al. (2013), to measure CEO general managerial ability. The index incorporates five aspects of a CEO's lifetime career experience, including the past number of (i) positions, (ii) firms, and (iii) industries in which the CEO worked; (iv) whether the CEO has held a CEO position at a different company; and (v) whether the CEO has worked for a conglomerate firm. Specifically, the value of the index for CEO i in year t is calculated based on the following model:

$$GAI_{i,t} = 0.268 \cdot X1_{i,t} + 0.312 \cdot X2_{i,t} + 0.309 \cdot X3_{i,t} + 0.218 \cdot X4_{i,t} + 0.312 \cdot X5_{i,t}$$

where *X1* is the number of positions the CEO held during his or her career; *X2* is the number of firms where a CEO worked; *X3* is the number of industries at the four-digit SIC level in which a CEO worked; *X4* is a dummy variable that equals one if the CEO held a CEO position at another firm and zero otherwise; and *X5* is a dummy variable that equals one if the CEO worked for a multi-division firm and zero otherwise. The index is the first factor of a principal component analysis of the five proxies. A higher value of the index indicates greater general managerial ability. As in Custódio et al. (2013), the index is standardized to have a zero mean and a unit standard deviation. A higher value of the index indicates greater general managerial ability. Due to the availability of the general ability index data, the sample period for this analysis spans from 1993 to 2007.[21]

We then split the sample into firms with generalist CEOs and those with specialist CEOs based on the sample median of *GAI* and separately estimate baseline specifications for these two subsamples. The generalist (specialist) CEO sample consists of firm-year observations with above (below) median *GAI*. The results in Table 9 Panel B suggest that, for both measures, the effect of customer concentration on CEO vega is positive and significant at the 1% level for the specialist CEO sample, whereas the effect becomes statistically insignificant for the generalist CEO sample. Overall, the results in Table 9 are consistent with the notion that the board factors in the likely impact of customer concentration risk on managerial risk taking when designing CEO compensation packages.

5.2. Supplier firms' investment opportunities

We also consider whether the effect of customer concentration varies with the supplier firm's investment opportunities, as measured by *Tobin's Q*. If convex compensation schemes are used to prevent CEOs from forgoing valuing-creating risky projects in response to

[21] We thank the authors of Custódio et al. (2013) for kindly sharing their general ability index data.

increased customer concentration risk, then the positive effect of customer concentration on CEO vega should be more pronounced for firms with greater investment opportunities, where the potential loss due to excessive CEO conservatism is high.

[Insert Table 10 about here]

In Table 10, we partition the sample into high and low investment opportunity firms based on the sample median of *Tobin's Q* and repeat our baseline tests for these two subsamples. Consistent with the prediction, we find that the coefficient estimates of customer concentration variables are positive and significant in the subsample of firms with high investment opportunities, and insignificant in the subsample of firms with low investment opportunities. In addition, the magnitudes of the coefficient estimates of the customer concentration index for firms with high investment opportunities is almost three times as large as those in the firms with low investment opportunities. The results suggest that the positive effect of customer concentration on CEO vega is more pronounced in firms with high investment opportunities.

5.3. Customers' costs of switching suppliers

One of the primary concerns with having a concentrated customer base is that a major customer may switch to other suppliers, resulting in significant losses to the dependent supplier. Relying on a major customer for a large fraction of sales is especially risky when the customer can switch suppliers at a relatively low cost. Therefore, if pay convexity helps offset the CEO's aversion to the risk of losing major customers, then we would expect the positive effect of customer concentration on supplier CEO vega to be more pronounced when major customers face lower switching costs.

[Insert Table 11 about here]

To test this conjecture, we follow Dhaliwal et al. (2016) and proxy for customers' switching costs using *Supplier market share*, defined as the fraction of the supplier's total three-digit SIC industry sales captured by the supplier.[22] The lower the supplier's market share, the more alternative suppliers that customers can purchase from, and the lower the switching costs. We repeat the baseline analysis using subsamples with high and low values of *Supplier market share* based on the sample median.

[22] The results are similar if we use the two-digit SIC industry classification.

Table 11 presents the results. We find that when the supplier firm's sales account for a small fraction of its total industry sales, the coefficient estimates on the concentration variables are positive and significant at the 1% level. In contrast, the coefficient estimates become much smaller in magnitude and statistically insignificant when the supplier firm's sales account for a large fraction of its total industry sales. These findings are consistent with our conjecture and suggest that the positive effect of customer concentration on CEO vega is more pronounced when customers face lower barriers to switching suppliers.

5.4. Relationship-specific investments

We next examine whether relationship-specific investments made by suppliers influence the effect of customer concentration on CEO vega. Major customer-supplier relationships are typically characterized by suppliers producing unique or customized products that offer little value outside the relationships (Titman and Wessels, 1988). Suppliers that have made relationship-specific investments face a greater risk of being unable to redeploy assets after the loss of a major customer. Moreover, as suppliers invest more in relationship-specific assets, they are more likely to be "held up" and subject to ex-post opportunistic behavior by customers.[23] Thus, to the extent that relationship-specific investments intensify customer concentration risk, we postulate that the positive effect of customer concentration on supplier CEO vega should be more prominent when suppliers engage in more relationship-specific investments.

Following Kale and Shahrur (2007) and Raman and Shahrur (2008), our measure of relationship-specific investments is the intensity of the supplier's R&D activities, computed as R&D expenditures scaled by total assets. This measure exploits the fact that research intensive suppliers tend to use more specialized inputs and produce unique products that require more relationship-specific investments for their customers (Levy, 1985; Allen and Phillips, 2000).

[Insert Table 12 about here]

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[23] Another possibility is that when suppliers make relationship-specific investments, major customers would also be more willing to invest in the relationships. In turn, these investments made by customers can increase the costs of switching suppliers and reduce the risk of losing major customers. This reasoning, however, leads to the prediction that the positive relation between customer concentration and CEO vega should be stronger when the relationships involve less specialized investments, which we do not observe in our data.

In Table 12, we partition our sample firms into subsamples with high and low R&D intensity based on its sample median, and repeat the baseline tests for these two subsamples.[24] The results show that the effect of customer concentration on CEO vega is positive and significant at the 1% level for high R&D intensity firms, whereas the effect becomes much smaller in magnitude and statistically insignificant for low R&D intensity firms. These results are consistent with the view that supplier CEOs receive less risk-taking incentives in their compensation packages as customer concentration increases when the relationships involve less relationship-specialized investments.[25]

5.5. Government customers and supplier CEO risk-taking incentives

Our analysis so far has focused on the effects of relying on major corporate customers. However, many supplier firms also report the government as their major customers. Unlike corporate customers, government customers are much less likely to default or declare bankruptcy. They are also more concerned about public interest and may therefore help financially distressed suppliers stay afloat to save the suppliers' employees from losing jobs. Further, government customers generally purchase for consumption and their purchases are longer-term and not profit-driven (Banerjee et al., 2008; Goldman et al., 2013), which reduces the likelihood that the government will switch to other suppliers. All of these suggest that suppliers with a concentrated base of government customers gain operational efficiencies from, but do not bear much of the risk of, relying on major corporate customers. As such, if convex incentive structures alleviate the CEO's aversion to the risk associated with major corporate customers, then we expect the positive concentration-vega relation to disappear, or even reverse for safer government customers.

To test this conjecture, we use the Compustat segment files to identify suppliers that report a government customer as accounting for at least 10% of total annual revenues.[26] We then create two measures to capture government customer concentration that mirror our corporate customer concentration measures. *Government customer sales* is the fraction of a

[24] The sample median is zero as firm-years with missing R&D information are assigned a zero value. This approach allows us to be consistent with the literature on R&D and innovation as well as to preserve as many observations as possible. As robustness, we confirm that the findings of the split-sample analysis (based on R&D intensity) persist when we exclude firm-years with missing R&D information.

[25] Note that our preferred interpretation of the split-sample analysis results could be muddied by the likelihood that CEO vega stimulates the firm's investments in R&D. Caution should be exercised in interpreting the results.

[26] Customers reported as "Domestic Government" or "U.S. Navy", etc., are classified as "government". In very few cases, companies report foreign governments as their major customers. Following Banerjee et al. (2008), we classify both domestic and foreign government customers as government customers.

supplier's total sales to all government customers that account for at least 10% of total sales, and *Government customer HHI* is the sales-based Herfindahl-Hirschman Index of government customers. In our sample, 5.2% of the suppliers report at least one major government customer. For these suppliers, sales to all government customers on average account for 43.2% of annual revenues.

[Insert Table 13 about here]

The results in Table 13 show a negative relation between both measures of government customer concentration and CEO vega. The coefficient estimate on *Government customer sales*, for example, implies that firms with at least one major government customer offer risk-taking incentives in managerial compensation that are 19.1% (= -0.442 × 0.432) lower. These findings are consistent with the view that the government with high creditworthiness and concerns for public interest represents a more stable source of revenues than other types of customers, and hence they could help lower the risk associated with the customer base structure.

6. Conclusion

In this paper, we have examined how a firm's customer base concentration affects its CEO's risk-taking incentives in her compensation package, as measured by vega. The results suggest that there is a positive relation between customer concentration and supplier CEO vega. When the customer base is more concentrated, the supplier firm's CEO receives more risk-taking incentives. This finding is robust to different approaches that account for potential endogeneity. Our findings shed light on how major customers, as an important source of revenues, shape the supplier firm's managerial incentive contracts.

Exploring cross-sectional heterogeneity of our baseline results, we show that the positive effect of customer concentration on CEO vega is stronger when the CEO is more reluctant to take firm risk, when suppliers have high investment opportunities, when it is less costly for customers to switch to other suppliers, and when suppliers make more relationship-specific investments. Finally, we provide evidence that suppliers with a concentrated base of safer government customers offer less risk-taking incentives. Overall, our findings suggest that boards evaluate a firm's customer base structure and provide additional pay convexity to offset the CEO's aversion to customer concentration risk, thereby preventing excessive managerial conservatism at the expense of value maximization.

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Table 1
Summary statistics

Panel A reports a summary of the relative variation in the measures of customer concentration between and within firms. The first row reports the standard deviation for the full sample. The second and third rows report the standard deviation across different firms controlling for the time-series mean and within each firm. Panel B reports summary statistics for the variables used in our baseline analysis. For each variable, we report the number of observations, mean, standard deviation, 25^{th} percentile, median, and 75^{th} percentile. All variables are defined in Appendix.

Panel A. Panel variance statistics

	Major customer sales	Customer HHI
Overall std. dev.	0.181	0.076
Between firm std. dev.	0.173	0.075
Within firm std. dev.	0.095	0.046

Panel B. Descriptive statistics

	Obs.	Mean	Std. dev.	25^{th}	Median	75^{th}
Main variables						
Vega (thousand $)	38,366	115.398	199.723	7.823	39.271	124.973
Ln(1+Vega)	38,366	3.387	1.964	2.177	3.696	4.836
Ln(1+Augmented vega_S)	32,538	4.001	2.247	2.788	4.495	5.657
Ln(1+Augmented vega_SC)	32,538	4.006	2.252	2.806	4.498	5.660
Major customer sales	38,366	0.077	0.181	0.000	0.000	0.000
Customer HHI	38,366	0.022	0.076	0.000	0.000	0.000
Customer concentration measures for firms with a major customer						
Major customer sales	8738	0.340	0.233	0.144	0.263	0.470
Customer HHI	8738	0.096	0.136	0.020	0.045	0.107
Control variables						
Sales (million $)	38,366	4755.908	9162.636	488.957	1352.919	4220.266
ROA	38,366	0.035	0.096	0.011	0.040	0.079
Tobin's Q	38,366	1.882	1.210	1.133	1.470	2.128
Leverage	38,366	0.237	0.190	0.072	0.219	0.355
Volatility	38,366	0.109	0.058	0.068	0.095	0.133
Stock return	38,366	0.144	0.452	-0.123	0.099	0.335
Age	38,366	55.910	7.009	51.000	56.000	60.000
Tenure	38,366	8.328	7.030	3.000	6.000	11.000
CEO ownership	38,366	0.092	0.289	0.000	0.000	0.000
CEO duality	38,366	0.519	0.500	0.000	1.000	1.000

Table 2
Customer concentration and CEO vega

This table examines the impact of customer concentration on risk-taking incentives in the CEO's compensation package. 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	0.346***	
	(3.00)	
Customer HHI		0.923***
		(4.15)
Ln(Sales)	0.512***	0.513***
	(27.78)	(27.98)
ROA	-0.385**	-0.367**
	(-2.46)	(-2.35)
Tobin's Q	0.177***	0.176***
	(8.86)	(8.79)
Leverage	-0.001	-0.006
	(-0.01)	(-0.04)
Volatility	-2.594***	-2.605***
	(-6.53)	(-6.54)
Stock return	0.012	0.012
	(0.55)	(0.54)
Age	-0.014***	-0.014***
	(-4.34)	(-4.39)
Tenure	0.010***	0.010***
	(2.72)	(2.73)
CEO ownership	-0.693***	-0.692***
	(-8.11)	(-8.10)
CEO duality	0.298***	0.298***
	(7.14)	(7.14)
Industry-Year FE	Yes	Yes
N	38,366	38,366
Adjusted R^2	0.317	0.318

Table 3
Incorporating pay convexity of performance-vesting provisions

This table re-estimates the effect of customer concentration on managerial risk-taking incentives using more comprehensive pay convexity measures that incorporate single-metric performance-vesting (p-v) stock and cash awards. *Ln(1+Augmented vega_S)* is the natural logarithm of one plus *Augmented vega_S*, where *Augmented vega_S* is the augmented vega after incorporating the pay convexity arising from p-v stock awards. *Ln(1+Augmented vega_SC)* is the natural logarithm of one plus *Augmented vega_SC*, where *Augmented vega_SC* is the augmented vega after incorporating the pay convexity arising from both p-v stock and p-v cash awards. 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. The same set of control variables and industry-year fixed effects as in our baseline models are 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.

	Dependent variable			
	Ln(1+Augmented vega_S)		*Ln(1+Augmented vega_SC)*	
	(1)	(2)	(3)	(4)
Major customer sales	0.385***		0.374***	
	(2.85)		(2.71)	
Customer HHI		1.018***		1.015***
		(3.74)		(3.71)
All controls	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	32,538	32,538	32,538	32,538
Adjusted R^2	0.296	0.297	0.300	0.300

Table 4
Robustness checks

This table contains a number of checks testing the robustness of the relationship between customer concentration and risk-taking incentives in the CEO's compensation package to alternative model specifications, subsamples, and variable definitions. For each robustness check, we estimate OLS regressions separately for alternative measures of customer concentration. The same set of control variables and industry-year fixed effects as in our baseline regressions are included, unless otherwise specified. For brevity, we only report the coefficients on the customer concentration variables. 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)*
Panel A. Alternative measures of customer concentration	
Major customer	0.085*
	(1.78)
Major customer max	0.523***
	(3.31)
Major customer count	0.046*
	(1.88)
N	38,366
Panel B. Starting the sample period in 1998	
Major customer sales	0.351***
	(2.84)
Customer HHI	0.953***
	(3.89)
N	32,538
Panel C. Controlling for institutional ownership and the Cain et al. (2017) takeover index	
Major customer sales	0.365***
	(3.58)
Customer HHI	1.051***
	(4.02)
N	23,690
Panel D. Including state-year fixed effects	
Major customer sales	0.300**
	(2.54)
Customer HHI	0.844***
	(3.70)
N	37,346
Panel E. Excluding the 2008-2009 crisis period	
Major customer sales	0.298**
	(2.56)
Customer HHI	0.822***
	(3.63)
N	34,914
Panel F. Controlling for *Ln(1+Delta)* and *Ln(Cash)*	
Major customer sales	0.153*
	(1.67)
Customer HHI	0.428**
	(2.47)
N	38,366

Table 5
Propensity score matching estimate

This table reports the propensity score matching estimation results. Panel A reports parameter estimates from the logit model used to estimate propensity scores. The dependent variable is an indicator variable equal to one for firms with at least one major customer, and zero otherwise. All independent variables are defined in Appendix. Industry and 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. Panel B reports the univariate comparisons of firm characteristics between firms with and without a major customer. Panel C reports the average treatment effect estimates. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Panel A. Pre-match propensity score regression and post-match diagnostic regression

	Dependent variable: Dummy equals one for firms with a major customer and zero otherwise	
	Pre-match	Post-match
	(1)	(2)
Ln(Sales)	-0.251***	0.006
	(-21.66)	(0.42)
ROA	-0.049	-0.238
	(-0.33)	(-1.40)
Tobin's Q	0.042***	0.014
	(3.32)	(0.97)
Leverage	-0.102	-0.017
	(-1.18)	(-0.17)
Volatility	3.938***	0.030
	(12.75)	(0.08)
Stock return	-0.100***	-0.040
	(-3.07)	(-1.07)
Age	-0.015***	0.002
	(-6.61)	(0.81)
Tenure	-0.002	-0.000
	(-0.89)	(-0.17)
CEO ownership	0.082	-0.014
	(1.58)	(-0.23)
CEO duality	-0.043	0.007
	(-1.36)	(0.19)
Industry and year FE	Yes	Yes
N	36,800	14,853
Pseudo R^2	0.228	0.002

Panel B. Difference in firm characteristics				
	Firm-years with a major customer	Firm-years with no major customers	Difference	t-stat
Ln(Sales)	6.929	6.933	-0.004	-0.15
ROA	0.030	0.033	-0.003	-1.52
Tobin's Q	2.048	2.048	0.000	-0.00
Leverage	0.221	0.220	0.001	0.43
Volatility	0.124	0.123	0.001	0.60
Stock return	0.133	0.138	-0.005	-0.63
Age	55.329	55.243	0.086	0.74
Tenure	8.245	8.252	-0.007	-0.06
CEO ownership	0.097	0.099	-0.002	-0.58
CEO duality	0.479	0.480	-0.001	-0.11

Panel C. Propensity score matching estimate				
	Firm-years with a major customer	Firm-years with no major customers	Difference	t-stat
Vega	3.401	3.332	0.069	2.27**

Table 6
Customer concentration and CEO vega: Newly appointed CEOs

This table examines the relation between customer concentration and CEO vega on the sample of newly appointed CEOs. 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. The same set of control variables and industry-year fixed effects as in our baseline models are 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.

	Dependent variable: *Ln(1+Vega)*	
	(1)	(2)
Major customer sales	1.429***	
	(4.71)	
Customer HHI		2.292**
		(2.50)
All controls	Yes	Yes
Industry-Year FE	Yes	Yes
N	2342	2342
Adjusted R^2	0.271	0.262

Table 7
Instrumental variables approach

This table presents estimates using the instrumental variables method based on two-stage least square (2SLS) panel regressions. 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. The same set of control variables and industry-year fixed effects as in our baseline models are included. The estimated parameters of the other controls are not reported for brevity. The Hausman test examines whether the OLS and 2SLS coefficients on the customer concentration variables are statistically different. 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 variable					
	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	12.902***	10.245***			9.780***	6.877***
	(7.28)	(8.31)			(4.57)	(5.72)
Customer regulation index			0.009***	0.011***	0.006**	0.007***
			(4.87)	(7.20)	(2.31)	(5.37)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	4157	4157	3653	3653	2917	2917
F-statistic	53.06	68.98	23.70	51.89	23.41	37.28
Hansen's *J* test *p*-value					0.753	0.160

Panel B. Second-stage regressions						
	Dependent variable: *Ln(1+Vega)*					
	(1)	(2)	(3)	(4)	(5)	(6)
Major customer sales	2.277***		2.898**		2.753***	
	(2.87)		(2.51)		(3.50)	
Customer HHI		2.868***		2.582**		2.784***
		(2.84)		(2.50)		(3.21)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	4157	4157	3653	3653	2917	2917
Adjusted R^2	0.342	0.343	0.351	0.336	0.372	0.352
Hausman test *p*-value	0.013	0.007	0.018	0.082	0.081	0.066

Table 8
Customer concentration and CEO vega: Excluding largest suppliers

This table estimates the baseline regressions after excluding, respectively, the largest 10% and 25% suppliers in terms of sales. 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. The same set of control variables and industry-year fixed effects as in our baseline models are 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.

	Dependent variable: *Ln(1+Vega)*			
	Excluding largest 10%		Excluding largest 25%	
	(1)	(2)	(3)	(4)
Major customer sales	0.397***		0.377***	
	(3.38)		(3.26)	
Customer HHI		0.887***		0.917***
		(3.86)		(4.12)
All controls	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	28,707	28,707	34,526	34,526
Adjusted R^2	0.256	0.256	0.285	0.286

Table 9
Effect of supplier CEOs' risk attitudes

This table examines whether the positive relation between customer concentration and supplier CEO vega varies with supplier CEOs' attitudes to firm (customer concentration) risk. We use two proxies: *Age* is the age of the CEO; and *General Ability Index* (*GAI*) is an index developed by Custódio et al. (2013) to measure a CEO's general managerial skills. In Panel A, we split the sample into quartiles based upon the age of the CEO. The Old CEO columns indicate the top quartile sample, and the Young CEO columns indicate the bottom quartile sample. In Panel B, we then split the sample into firms with generalist CEOs and those with specialist CEOs based on the sample median of *GAI* and separately estimate baseline specifications for these two subsamples. The generalist (specialist) CEO sample consists of firm-year observations with above (below) median *GAI*. 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. The same set of control variables and industry-year fixed effects as in our baseline models are 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. CEO age

	Dependent variable: *Ln(1+Vega)*			
	Old CEO		Young CEO	
	(1)	(2)	(3)	(4)
Major customer sales	0.475**		0.107	
	(1.97)		(0.65)	
Customer HHI		1.535***		0.227
		(3.50)		(0.74)
All controls	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	9502	9502	10,128	10,128
Adjusted R^2	0.300	0.301	0.309	0.309

Panel B. CEO general managerial ability

	Dependent variable: *Ln(1+Vega)*			
	Specialist CEO		Generalist CEO	
	(1)	(2)	(3)	(4)
Major customer sales	0.689***		0.058	
	(3.42)		(0.31)	
Customer HHI		1.664***		0.304
		(3.15)		(0.62)
All controls	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	9493	9493	9187	9187
Adjusted R^2	0.339	0.339	0.401	0.401

Table 10
Effect of supplier investment opportunities

This table examines whether the positive relation between customer concentration and supplier CEO vega varies with suppliers' investment opportunities. The measure of investment opportunities is *Tobin's Q*, computed as the sum of total assets plus market value of equity minus book value of equity divided by total assets. The sample partition is based on the sample median of *Tobin's Q*. 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. The same set of control variables and industry-year fixed effects as in our baseline models are 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.

	Dependent variable: *Ln(1+Vega)*			
	High growth		Low growth	
	(1)	(2)	(3)	(4)
Major customer sales	0.379***		0.120	
	(2.72)		(0.81)	
Customer HHI		0.847***		0.389
		(3.32)		(1.17)
All controls	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	19,183	19,183	19,183	19,183
Adjusted R^2	0.293	0.293	0.347	0.347

Table 11
Effect of customer switching costs

This table examines whether the positive relation between customer concentration and supplier CEO vega varies with customers' costs of switching to other suppliers. Customer switching costs are measured using *Supplier market share*, defined as the supplier firm's sales scaled by total three-digit SIC industry sales. The sample partition is based on the sample median of *Supplier market share*. 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. The same set of control variables and industry-year fixed effects as in our baseline models are 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.

	Dependent variable: *Ln(1+Vega)*			
	Low supplier market share		High supplier market share	
	(1)	(2)	(3)	(4)
Major customer sales	0.290**		-0.031	
	(2.13)		(-0.15)	
Customer HHI		0.755***		0.021
		(3.22)		(0.05)
All controls	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	19,183	19,183	19,183	19,183
Adjusted R^2	0.348	0.349	0.307	0.307

Table 12
Effect of relationship-specific investments

This table examines whether the positive relation between customer concentration and supplier CEO vega varies with relationship-specific investments made by suppliers. We measure relationship-specific investments with the supplier's *R&D intensity*, defined as R&D expenditures scaled by total assets. The sample partition is based on the sample median of *R&D intensity*. 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. The same set of control variables and industry-year fixed effects as in our baseline models are 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.

	Dependent variable: *Ln(1+Vega)*			
	High R&D intensity		Low R&D intensity	
	(1)	(2)	(3)	(4)
Major customer sales	0.360***		0.168	
	(2.79)		(0.80)	
Customer HHI		1.040***		0.414
		(4.50)		(0.93)
All controls	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	15,912	15,912	22,454	22,454
Adjusted R^2	0.323	0.324	0.312	0.312

Table 13
Government customer concentration and CEO vega

This table examines the impact of government customer concentration on risk-taking incentives in the CEO's compensation package. 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. *Customer HHI* is the corporate customer sales-based Herfindahl-Hirschman Index. *Government customer HHI* is the government 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. *Major government sales* is the fraction of a firm's total sales to all government customers that account for at least 10% of total sales. The same set of control variables and industry-year fixed effects as in our baseline models are 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.

	Dependent variable: *Ln(1+Vega)*	
	(1)	(2)
Major customer sales	0.343***	
	(2.98)	
Major government sales	-0.442**	
	(-2.23)	
Customer HHI		0.927***
		(4.18)
Government customer HHI		-0.996***
		(-3.09)
All controls	Yes	Yes
Industry-Year FE	Yes	Yes
N	38,366	38,366
Adjusted R^2	0.318	0.319

Appendix
Variable definitions

Variable	Definition	Data source
Customer concentration measures		
Major customer sales	The fraction of a firm's total sales to all corporate customers that account for at least 10% of total sales.	Compustat Segments
Customer HHI	Customer sales-based Herfindahl-Hirschman Index calculated by summing the squares of the ratios of major corporate customer sales to the supplier's total sales.	Compustat Segments
Major government sales	The fraction of a firm's total sales to all government customers that account for at least 10% of total sales.	Compustat Segments
Government customer HHI	Government customer sales-based Herfindahl-Hirschman Index calculated by summing the squares of the ratios of major government customer sales to the supplier's total sales.	Compustat Segments
Major customer	An indicator variable set to one if a firm has at least one corporate customer that accounts for at least 10% of its total sales, and zero otherwise.	Compustat Segments
Major customer max	Highest percentage sales to major corporate customers.	Compustat Segments
Major customer count	Total number of a firm's major corporate customers.	Compustat Segments
Risk incentive measures		
Ln(1 + Vega)	Natural logarithm of one plus vega, where vega is defined as the change 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.	ExecuComp; CRSP
Ln(1 + Augmented vega_S)	Natural logarithm of one plus *Augmented vega_S*, where *Augmented vega_S* is the augmented vega after incorporating the pay convexity arising from p-v stock awards.	ExecuComp; ISS Incentive Lab
Ln(1 + Augmented vega_SC)	Natural logarithm of one plus *Augmented vega_SC*, where *Augmented vega_SC* is the augmented vega after incorporating the pay convexity arising from both p-v stock and p-v cash awards.	ExecuComp; ISS Incentive Lab
Option pay ratio	The fraction of total compensation paid in options.	ExecuComp

Control variables		
Ln(Sales)	Natural logarithm of sales.	Compustat
ROA	Earnings before interest and taxes divided by total assets.	Compustat
Tobin's Q	Sum of total assets plus market value of equity minus book value of equity divided by total assets.	Compustat
Leverage	Sum of debt in current liabilities plus long-term debts and divided by total assets.	Compustat
Volatility	Annualized standard deviation of monthly stock return over the past three years.	CRSP
Stock return	Annual stock returns over the past year.	CRSP
Age	Age of CEO in years.	ExecuComp
Tenure	Number of years as CEO in the current position.	ExecuComp
CEO ownership	An indicator variable set to one if the percentage of stock ownership held by the CEO is greater than 5%.	ExecuComp
CEO duality	An indicator variable set to one if the CEO serves as the chairman of the board, and zero otherwise.	ExecuComp

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 μ_i ($i = A$ or P) and σ_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 ξ.

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, τ. 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 τ. 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 τ. 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 ξ 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_τ and P_τ. Using the predicted A_τ, P_τ, 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