Product Market Linkages and Managerial Risk Taking

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Abstract

A firm's customers and suppliers make relationship-specific investments (RSI) whose value reduces if the firm undertakes risky investments. We hypothesize that the risk-taking incentives in the firm CEO's compensation will lower the RSI by firms up and down in the vertical channel. We provide significant evidence that customer/supplier RSI declines with the risk-taking incentives of the firm's CEO. Moreover, we find that RSI is more sensitive to the CEO's risk-taking incentives when they are more likely to increase the firm's cash flow volatility. Our findings are robust to correcting for endogeneity and several measures for RSI and risk taking.

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Product Markets and Managerial Risk Taking

The decisions that a firm makes can have significant value effects on other firms that are economically linked to it, especially those up and down in the supply chain. For example, Quintiles, the firm which was conducting Phase III clinical trials of Eli Lily's Alzheimer's drug, reportedly lost $300 million when Eli Lilly announced on August 10, 2010 that it was dropping the pursuit of the drug.[2] In November, 2007, Gertrag Transmission, a supplier to Chrysler Motors, placed its Indiana plant in bankruptcy protection reportedly because Chrysler terminated an exclusive contract. Thus, firms should take into account the factors that affect the decision making of firms to which they are economically linked. We examine how an important factor affecting the investment decisions of a firm affects the investment levels of firms that are economically linked to it. Specifically, we empirically investigate the relation between the level of risk-taking incentives in a CEO's compensation and investment by supplier/customer firms that are economically linked to the firm.

Lately, the risk-taking incentives in a firm CEO's compensation have received considerable attention in the media and the academic literature.[3] The primary focus in the academic literature is on how managerial risk taking (MRI) affects the operating and financial policies and performance of the firm. On the one hand, giving the CEO incentives for taking risk can be valuable as it induces a risk-averse CEO to undertake risky but positive NPV projects. However, if these incentives result in "excessive" risk taking, they can be detrimental to the value of the firm.. We argue that a CEO's risk-taking incentives should be of considerable

[2] By the end of the month, Eli Lilly lost approximately $2 billion in equity value. We do note here that, despite these losses, as of September, 2012, Eli Lilly and Quintiles are still working together, but have substantially modified the subsequent structure of their relationship (Ohnesorge, 2012).

[3] Some have attributed the recent financial crisis, in large part, to such incentives. The SEC Commissioner Mary Shapiro has in fact suggested that firms should disclose in its financial statements "how compensation impacts risk taking." ("Risk vs Executive Reward", by Cari Tuna and Joann S. Lublin, Wall Street Journal June 15, 2009)

concern to the firm's supplier/customer firms. This is especially true if the economic linkages among the firms in the vertical chain entail significant relationship specific investments (RSI), which have much lower value outside the relationship. When the firm undertakes risky projects that increase the likelihood of financial distress, it undermines the value of RSI undertaken by its customers and suppliers. Consequently, the firm's customers and suppliers will make lower RSI if the risk-taking incentives given to the firm's CEO are high. In this paper, we study how a firm's customers and suppliers adjust their levels of RSI to its CEO's risk-taking incentives. We find that greater risk-taking incentives in the firm CEO's compensation are associated with lower RSI by supplier/customer firms. We also provide evidence that firms take this negative effect of higher MRI on supplier/customer RSI into account when they determine the level of MRI in the CEO's salary.

We examine the relation between a firm CEO's risk-taking incentives and the RSI by the firm's customer and supplier firms at *both the firm and the industry level*. For the firm-level analysis, we use the Compustat Segment data to construct a firm-level dataset of the major customers of the firms, as firms are required to identify all major customers who account for more than 10% of sales. Since Compustat does not provide supplier identities, our firm-level analysis is limited to the relation between a firm CEO's risk-taking incentives and the level of its customer firm RSI. For the industry-level analysis, we use the Input-Output tables provided by the Bureau of Economic Analysis to identify a firm's customer and supplier industries. This industry-level dataset is larger, allows us to analyze the relation between a firm CEO's risk-taking incentives and supplier RSI, and also mitigates some concerns of endogeneity that may arise in the firm-level analysis of customers.

In the firm-level analysis, we find that RSI by customers declines as risk-taking incentives of the firm's CEO increase. This effect of CEO risk-taking incentives on customer firm RSI appears to be economically significant; a one standard deviation increase in the CEO's risk-taking incentives decreases customer RSI by 28% to 34% depending on the measure of risk-taking incentives used. The negative relation between managerial risk taking and customer RSI varies by firm characteristics. For example, CEO incentives for risk taking have a greater impact in firms undertaking relatively larger R&D investments and/or capital expenditures and in manufacturing and focused firms, where RSI is likely to be important. We find similar results in the analysis at the industry level; higher risk-taking incentives in CEO compensation are associated with lower RSI in customer and supplier industries.

The credibility of the negative relation between CEO risk-taking incentives and customer/supplier RSI depends on its robustness to three concerns, namely, measurement of RSI and risk-taking incentives, direction of causality, and latent variables that affect the levels of both risk-taking incentives and supplier/customer/RSI. We address all the three concerns in the analysis and show that the negative relation between CEO risk-taking incentives and customer/supplier RSI holds when we adjust our analysis to these considerations.

First, RSI by suppliers/customers is a crucial variable in our hypotheses but, in the literature, there is no generally accepted empirically observable variable to measure RSI. Therefore, we show that risk taking is negatively associated with several measures of RSI. To begin, consistent with a large body of literature, we use a firm's R&D intensity as a measure of RSI.[4] The second measure of RSI is the R&D intensity of only those customers whose R&D is

[4] R&D intensity is often used as a proxy for RSI in empirical literature on transactions cost economics; see Boerner and Macher (2001) for a review. Levy (1985) posits that research-intensive industries have specialized inputs and require RSI by suppliers. Allen and Philips (2000) suggest that research-intensive industries are more likely to create

likely to be relationship specific. We isolate such customers by using the NBER data on patent citation. We include the R&D of customer and suppliers only if their patents cite the patents of the firm or if supplier/customer patents are cited in patents filed by the firm. The cross-citation of patents indicates the presence of communication between the scientists of both firms and is evidence of the integration between the firms (see Jaffe, Tratjtenberf and Fogarty (2000)). Therefore, R&D intensity is likely to be a less noisy proxy of RSI for these firms. Our third RSI measure is advertising intensity since it proxies for product uniqueness and, hence, is likely to be associated with RSI (Titman and Wessels (1988)). We find a negative relation with risk-taking incentives for all three measures of RSI.

We also show that our findings are robust to alternate measures of managerial risk taking. Consistent with the extant literature, we use CEO's option "vega" to capture risk-taking incentives and include option delta to control for pay for performance incentives. Secondly, as the correlation between vega and delta incentives of a firm is large (0.94) and significant, we construct a new variable, managerial risk-taking incentives or *MRI*, which is the ratio of vega to delta incentives. Intuitively, *MRI* captures the vega incentives per unit of delta incentives or the relative strength of the risk-taking incentive.[5] Since *MRI* is independent of the magnitude of the CEO's option compensation, we construct a third variable by multiplying *MRI* by the number of options granted to the CEO to capture the overall effect of the CEO's risk-taking incentives. Lastly, we estimate the *MRI* of total compensation – not just option compensation, which also captures risk-taking incentives from stock grants and stock ownership. Our results are qualitatively similar for all measures of the risk-taking incentives.

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relationship-specific assets. Armour and Teece (1980) propose that vertical chains that are R&D-intensive are likely to have complex inter stage interdependencies that lead to higher RSI.

[5] The variable *MRI* to measure managerial risk-taking incentives is in the spirit of the variable suggested by the theoretical framework of Dittmann and Yu (2010).

Second, it is likely that managerial risk-taking incentives and customer RSI are jointly determined.[6] If customers respond to managerial risk-taking incentives by reducing their RSI, then the firm would take this into account when deciding on the structure of CEO compensation. Therefore, we estimate a simultaneous equation model that treats both customer RSI and risk-taking incentives as endogenous and jointly determined and find that the direction of causality does indeed work in both directions but the effect of customer RSI on CEO compensation is statistically weaker.

Third, the observed negative association between risk-taking incentives and customer RSI may be due to unobserved firm characteristics associated with both high managerial risk-taking incentives and lower customer RSI. For example, suppliers and customers could endogenously match based on existing or expected compensation and risk characteristics, creating a spurious correlation. We address such potential endogeneity in two ways. In the first set of tests, we use instruments for managerial risk taking and show that the significant negative relation between managerial risk taking and customer RSI continues to obtain. The second set of tests is based on the intuition in Philips and Sertsios (2011), who argue that firms experiencing sustained negative shocks have the incentive to renege on their implicit contracts. In support, these authors present evidence that service quality decreases when (airline) firms enter financial

[6] CEO risk-taking incentives are determined in equilibrium depending on firm characteristics. Edmans and Gabaix (2010) demonstrate that risk-averse CEOs will be given compensation contracts with greater risk-taking incentives to induce them to accept high-risk positive NPV projects. In such a setting, compensation contracts with high risk-taking incentives may signal risk-averse CEOs, and the prediction would be a non-negative association between risk-taking incentives and RSI. Therefore, the negative effect of risk-taking incentives on RSI that we find likely underestimates the effect of the mechanism we propose. Furthermore, in equilibrium, the determination of the risk-taking incentives to be given to the CEO should also take into account the negative effect these incentives have on RSI by customers and suppliers.

distress.[7] In the setting of our paper, firms that require customers to undertake RSI implicitly commit to lower levels of risk taking by giving fewer risk-taking incentives to their CEO. Then, if these firms experience sustained negative shocks, they will likely have the incentive to renege on this implicit contract and begin to offer greater risk-taking incentives to their CEO. Consistent with this notion, we find that firms facing sustained low growth and with high customer investment in relationship specific assets in place reverse their implicit commitment by increasing the CEO's risk-taking incentives.

Our paper is related to several strands of the literature. The first consists of studies on product markets and especially the role of relationship specific investment. These include research on the existence of RSI and asset specificity (Williamson (1975, 1978), Crawford and Alchian (1978) and Hart and Moore (1990)); and the effect of RSI on financial policy (Haugen and Senbet (1978, 1988), Titman (1984), Maksimovic and Titman (1991), Mackay and Philips (2005) and Kale and Shahrur (2007)); the effect of RSI on earnings management and trade credit policies (Raman and Shahrur (2008) and Dass, Kale, and Nanda (2011)). We contribute to this strand of literature by documenting that customers and suppliers respond to the risk-taking incentives implied in the firm CEO's compensation by adjusting their RSI levels.

The stream of compensation literature that is closely related to our work examines the effect of stock option usage on the risk-taking incentives of the CEO. Guay (1999) and Cohen, Hall and Viceria (2000) document that executive stock options are associated with increased firm risk. Coles, Daniel, and Naveen (2007) find that compensation structures with higher vega incentives are associated with riskier investment policy as captured by increased R&D, increased

[7] In a similar vein, Kale, Meneghetti, and Shahrur (2012) show that product warranty-offering firms have lower debt levels than those who do not. However, following long-term negative growth, warranty-offering firms issue more debt than non-warranty firms.

focus and reduced PP&E. We use the results of these papers, i.e., that risk-taking incentives in executive compensation translates into increased firm risk and riskier investments by the firm, to motivate our hypothesis. Specifically, when customers and suppliers observe risk-taking incentives embedded in CEO compensation they anticipate increased firm risk and consequently reduce their RSI in the vertical channel. In a similar vein, Brockman, Martin and Unlu (2008) examine the implication of increased risk taking for debt holders and find that debt holders reduce debt maturity in the presence of large vega incentives.[8]

The literature described above examines the effects of CEO compensation on a host of firm decisions. The contribution of our paper is in examining the effects of a firm's compensation policy on entities outside the firm. Aggarwal and Samwick (1999) are among the first to examine potential externalities from CEO compensation by studying how CEO delta incentives mitigate competition in the firm's industry. We complement their study by documenting that the compensation policy of a firm influences the investment decisions of customer and supplier firms. By showing significant externalities of compensation, our results impart a different and important perspective to the debate on executive compensation. As the investments made by customers and suppliers are integral to the long-term growth of the firm, our paper underscores the importance of understanding all channels by which stock options can impact the value of the firm. It also highlights that a firm's compensation policies can have important externalities as they affect investment decisions up and down the vertical channel.

[8] There is considerable literature on the effects of pay for performance or "delta" incentives on firm decisions including takeover premiums (Hartzell, Ofek and Yermack (2004)), earnings management (Bergstresser and Philippon (2006) and Burns and Kedia (2006)), and firm investment policy (Benmelech, Kandel and Veronesi (2008)). Therefore, we estimate (as in Yermack (1995), Core and Guay (1999), and Mehran (1995)) and control for a CEO's "delta" incentives in our analysis..

The rest of the paper is organized as follows. Section II describes the data, and Section III lays out the basic analysis, examines cross sectional differences in the impact of *MRI* and alternate proxies for relationship specific investment. Section IV controls for endogeneity, examines simultaneity and includes robustness tests. Section V discusses industry level analysis and Section VI concludes.

II. Data and Sample Description

We begin with all firms in Execucomp over the 1994 to 2006 period from which we exclude utilities and financial firms (SIC codes between 4900 and 4999, and 6000 and 6999, respectively) and obtain a sample of 17,661 firm-years.[9] We then identify key customers for this sample using the Compustat industry segment files, which provides names of key customers for public companies that are required by SFAS 14 and SFAS 131 to report customers who account for at least 10% of their annual sales.[10] We are able to find a customer firm for 4,224 firm years in our Execucomp sample. Thus, our sample size is comparable to the 9,452 firm-years with identifiable customer firms in *all* of Compustat over a 20-year period reported in Kale and Shahrur (2007). Since we require compensation data from Execucomp also for customer firms, our sample size is further reduced to 3,565 firm years.

A. Measures of CEO Incentives

Consistent with most of the existing literature, we calculate the option delta to capture pay for performance or effort incentives given to the CEO and use option vega to capture the

[9] The disclosure for executive compensation changed in 2006 making it difficult to estimate delta and vega for the CEO option grants. Therefore we do not use data after 2006 for tabulating results. For robustness, we have with elaborate assumptions estimated *VEGA* and *MRI* for the CEO option grants made over 2006 to 2009. Our main results do not change if we include the years after 2006 in our analysis.

[10] As the industry segment files identify customers by names, we match these names to *GVKEY* and other identifiers. Often, the customer names are the names of subsidiaries or are abbreviated, which necessitates manually identifying the customer in many cases. The technique is similar to Fee and Thomas (2004).

incentives for increased risk taking by the CEO. We use the Black–Scholes model adjusted for dividend payouts (Black and Scholes, 1973; Merton, 1973) to value the options.[11] To estimate the exercise prices of previously granted options, we subtract from the current stock price the ratio of the realizable value of previously granted options (the difference between the realizable values of all options less the realizable value of current options) and the number of previously granted options. The option delta (per option) is the partial derivative of the option value with respect to stock price. We compute the delta and the corresponding option sensitivity separately for newly granted options, vested options, and unvested options and a weighted average of these is the total option sensitivity.

Our main measure for the pay for performance incentives of CEO's option compensation is *DELTA*, which is the product of the above estimated per-option delta and the number of options owned by the CEO (see Core and Guay (2002)). This measure captures the change in the value of the options held by the CEO for a 1% change in stock price. We also use an alternate measure (see Jensen and Murphy (1990) and Yermack (1995)), which is the product of the per option delta and the ratio of the number of options owned by the CEO to the number of shares outstanding in the firm. This alternate measure captures the change in the value of options held by the CEO for a dollar change in firm value. All our results are robust to using either measure of delta incentives. As in Daniel, Coles and Naveen (2007) and Brockman, Martin and Unlu (2008), we capture the sensitivity of the CEO's option compensation to volatility with *VEGA*, which is the product of the per option vega and the number of options held by the CEO. Our results are

[11] As ExecuComp does not offer details on previously granted options, we make assumptions about T, the time to maturity, and X, the exercise price. If there are no option grants in the current year, we set T equal to nine years for unvested previously granted options and six years for previously vested options. If there are current option grants with T less than three years, we set the T for all previously vested options equal to the T for current options. For current option grants with T greater than or equal to three years, we set unvested previously granted options to T – 1, and vested previously granted options to T - 2.

robust to the alternate measure of risk-taking incentives, which is the product of the per option vega and the ratio of the number of options held by the CEO to shares outstanding.

We also compute another measure of risk taking, *MRI*, which is the ratio of *VEGA* to *DELTA*. The intuition underlying *MRI* is from a recent paper by Dittmann and Yu (2010) that models the endogeneity of risk and effort incentives and emphasizes that volatility has both a direct and an indirect effect on a manager's wealth. The direct effect is captured by *VEGA*, i.e., the effect of volatility on the value of the stock options. However, volatility also has an indirect effect: an increase in volatility increases firm value as more valuable risky projects are adopted. This increase in stock price then feeds through to managerial wealth via the manager's incentive pay, i.e., *DELTA*. Dittmann and Yu (2010) argue that whereas *VEGA* just captures the direct effect of volatility, *MRI* captures both the direct and the indirect effects.[12] The higher is the value of MRI the greater are the incentives provided to the CEO for risk taking.

Since the variable *MRI* is a ratio, it is independent of the level of the CEO's option compensation. Therefore, we construct another variable which is the product of *MRI* and the number of options granted to the CEO and use it as an alternative measure of risk-taking incentives. Finally, we calculate *Total Comp MRI*, which is the ratio of *VEGA* to *DELTA* but using both stock and option vega and delta. This captures the risk-taking incentives from total compensation as opposed to just from options.

B. Customer RSI and other characteristics

We use customer and supplier R&D intensity, defined as the ratio of R&D expenses to total assets, to capture their respective RSI levels (see Kale and Shahrur (2007)). For firms with

[12] More specifically, the theoretical measure derived by Dittman and Yu (2010) is the ratio of utility adjusted vega to utility adjusted delta.

multiple customers we use the percentage of the firm's sales to these customers as weights to construct customer level variables. We then construct the weighted average R&D of all customer firms where the weight is customer share in firm sales as defined above.[13] Later in the paper, we present results with alternate measures for RSI that are based on patent citations and advertising intensity.

While our main variable of interest in explaining customer RSI is the CEO's risk-taking incentives, we control for a number of other factors that are likely to impact customer RSI. These factors belong to three major groups: 1) compensation policy and CEO characteristics, 2) firm characteristics and 3) customer characteristics. We control for CEO compensation effects by including the delta incentives, cash compensation (*Log[CEO Cash Comp])*, and the CEO's equity ownership level (*CEO Ownership).* We also control for *CEO Tenure* and create a dummy that captures years of CEO turnover (*CEO Turnover Year)* as these years may be associated with a shift in compensation structure. Appendix A provides detailed descriptions of the variables we use in the analyses.

We control for several firm characteristics, namely, firm size or *Log[Total Assets]*, *Tobin's Q*, *Market Leverage*, firm profitability measured by *Firm ROA*, firm's own *R&D Intensity*, firm's *Sales Volatility*, and the firm's own two digit industry *Herfindahl Index* to control for own-industry competition. We also include several customer characteristics of the customer that might impact its research intensity, namely, customer firm CEO vega, customer leverage, and customer sales growth. When the firm has multiple customers, we construct

[13] Since firms generally do not report all customers, the weights do not sum to one for each firm-year. The results do not change if we change the data criteria. For example, not imposing the restriction that customers are covered in Execucomp or forcing the customer weights to sum to one does not change our results.

weighted average values of *Customer Leverage*, *Customer VEGA*, and *Customer Sales Growth* for each firm-year.

We present summary statistics of our sample firms in Table I. The average values in our sample are $201,540 for *DELTA*, $171,469 for *VEGA* and 0.53 for *Total Comp MRI*. The summary statistics for the other variables are similar to those documented in the literature. In Table II, we present the correlations among the variables of interest. Consistent with our hypothesis, the three measures of CEO risk-taking incentives, *VEGA*, *MRI*, and *Total Comp MRI*, are all negatively correlated with *Customer R&D*. As noted before the correlation between *DELTA* and *VEGA* is 0.94 and the correlation of *MRI* with *DELTA* and *VEGA* is 0.02 and 0.18, respectively.

III. Managerial Risk-Taking Incentives and RSI by Customer Firms

The identities of key customers in Compustat industry segment files enable us to analyze the effects of the risk-taking incentives of a firm's CEO on the RSI levels of its customer firms. Since identities of supplier firms are not available, we examine the relation between risk-taking incentives and RSI of suppliers at the industry level in a later section.[14]

A. Firm-Level Determinants of Customer RSI

We present finding from OLS regressions of customer firm RSI on the various measures of risk taking in Table III. The first column reports the results for the CEO's *DELTA* and *VEGA*, the incentive measures used in the existing literature. As higher *DELTA* aligns CEO incentives with those of shareholders, it is likely to be associated with-value enhancing firm decisions.

[14] Since some of the customers firms are listed as customers for more than one firm, therefore, for these firms, we can compute a firm-level measure of supplier R&D (see, Kale and Shahrur (2007)). The sample size, however, is small and the supplier are necessarily much smaller in size than customers. Therefore, we study the relation between risk-taking and supplier RSI only at the industry level.

Consequently, it should be associated with greater RSI from customers. *VEGA* is associated with increased risk taking and, therefore, we hypothesize that it should be associated with lower customer RSI. The coefficient on *DELTA* in column one is positive (0.0047, t-value = 1.93) and that on *VEGA* is negative (coefficient = -0.0073, t-value = -2.57). The significantly negative coefficient on *VEGA* indicates that for a firm with higher risk-taking incentives, customer firms will be reluctant to invest in relationship-specific assets. This effect of *VEGA* is economically significant – a one standard deviation increase in *VEGA* is associated with a 34% decline in customer RSI from its unconditional average.

To mitigate the effects of the high correlation between *VEGA* and *DELTA*, we next regress customer RSI on the variable *MRI*, which is the ratio of *VEGA* to *DELTA*. High values of *MRI* imply high *VEGA* incentives relative to *DELTA* incentives and should be associated with lower customer RSI. Since *MRI* captures the strength of the *VEGA* incentives relative to *DELTA* incentives but not the level of overall incentives, we also include the number of options held by the CEO in this specification. The findings from estimating this specification with *MRI* as the measure of the firm CEO's risk-taking incentives are in column 2 of Table III. Since *MRI* is not defined when *DELTA* is zero, the number of observations is lower when we introduce *MRI* in our estimation. The coefficient on *MRI* is negative and significantly different from zero (coefficient = -0.0068, t-value = -3.88), which is consistent with our primary hypothesis that greater risk-taking incentives are associated with lower customer RSI. The effect of *MRI* on customer RSI is economically significant; a one standard deviation increase in *MRI* results in a 27% decrease in customer *RSI*.

As an alternative method to control for the level of incentives, we include the product of *MRI* and the number of options held by the CEO.[15] The coefficient on *MRI x Number of options* is negative and significant at the 1% level (Model 3 in Table III). Our last measure *Total Comp MRI* includes risk-taking incentives from stock and option ownership and is the ratio of total compensation *DELTA* to total compensation *VEGA*. The coefficient on *Total Comp MRI* reported in column four is also significantly negative. Models 5 to 8 report the findings for specifications with industry fixed effects – the results are unchanged. The analysis with all the different measures of risk-taking incentives tells a consistent story – risk-taking incentives of the upstream firm's CEO are negatively associated with the level of RSI of the downstream firm.

As the findings in Table III indicate, all the results are qualitatively similar if we include industry fixed effects. Since one of the instrumental variables we use in the subsequent analysis is based on industry, it cannot be used with industry fixed effects. Therefore, henceforth we will report findings without industry fixed effects so that results are comparable across the paper.

B. Firm MRI and Customer RSI: Cross Sectional Differences

A CEO's ability to change the riskiness of the firm's cash flows will vary by firm characteristics. Therefore, the negative relation between customer RSI and risk-taking incentives should be "stronger" when the CEO is in a better position to alter the firm risk. We next examine the relation between customer RSI and CEO risk-taking incentives for subsamples formed on the basis of a CEO's ability to change firm risk.

When firms make no substantial investments, even CEOs with high risk-taking incentives will not be able to change the risk of firm cash flows. In contrast, CEOs in firms with high levels

[15] Note, that as *VEGA* is the product of the per option vega and the number of options held, it also controls for the level of incentives.

of investment can have a significant impact on the riskiness of the cash flows through their investment decisions. Therefore, we next examine whether the customers of high-investment firms are more sensitive to the firm CEO's risk-taking incentives. We use a firm's ratio of capital expenditure to total assets (*CAPEX*) and *R&D Intensity* as two measures of the extent to which firm risk can be changed.

To examine the differential impact of risk-taking incentives on customer RSI for high- and low-*CAPEX* firms, we create a dummy variable *High-CAPEX* that equals one if the firm is in the top tercile of the ratio of capital expenditures to total assets and zero otherwise; and the dummy variable *Low-CAPEX* that takes the value of one for the remaining firms. We first estimate the regression (for the whole sample) that includes all the independent variables and the product of each independent variable with the dummy *High-Capex*. The coefficients on the non-interacted independent variables in this specification represent the relation of these variables on *Customer R&D* for the *Low-CAPEX* group; and the coefficients on the interaction terms are the differences for the *High-Capex* group. We repeat this estimation procedure but this time interact the *Low-CAPEX* dummy with the independent variables. The non-interacted independent variables now capture the impact for the high *CAPEX* group and the coefficients on the interactions term capture the difference between the low- and high-*CAPEX* groups.[16]

We report the findings from the above analysis comparing low- and high-*CAPEX* firms in Panel A of Table IV. For brevity, we report the results for only the specifications with *VEGA* and *MRI*. We also only report the coefficients and t-statistics for risk-taking incentive measures for the two subsamples and the interaction of risk-taking incentives with the high-*CAPEX* dummy.

[16] This procedure allows the effects of all the independent variables to vary for the two subgroups as compared to the case where only the variable of interest, in this case risk-taking incentive, is interacted with the subgroup dummy, and all other independent variables are assumed to have the same impact across the subgroups.

The latter measures the direction and statistical significance of the difference between the coefficients of risk taking in the high- versus low-*CAPEX* subsamples. The coefficients on *VEGA* and *MRI* are negative and significant for both high- and low-*CAPEX* subsamples. The significant coefficient on the interaction term in column 2 implies that the effect of *MRI* for high-*CAPEX* firms (coefficient = -0.0107) is significantly more negative than that for low-*CAPEX* firms (coefficient = -0.0049). Though the effect of *VEGA* for high-*CAPEX* firms is also more negative than that for low-*CAPEX* firms (-0.0141 vs. -0.0052), the difference is not significant at conventional levels.

We follow a similar procedure to examine the differences in the relation of customer RSI with risk-taking incentives between firms with positive R&D and those with no R&D and report the findings in Panel B of Table IV. The coefficients of both *VEGA* and *MRI* are significantly negative only for positive R&D firms and, as the significant interaction term coefficients indicate, these negative effects are significantly greater than those for firms with no R&D. This finding suggests that the presence of greater *VEGA* or *MRI* leads customer firms to reduce their RSI significantly more for firms with R&D than for firms with no R&D.

Firms in manufacturing industries are more likely to require RSI by their customer firms and, therefore, we expect a higher impact of risk-taking incentives on customer RSI for the subsample of firms in manufacturing industries (two digit SIC 20 to 39). Consistent with our hypothesis, the results in Panel C of Table IV show that the coefficient on both *VEGA* and *MRI* are negative and significant only for the subsample of manufacturing firms. Further, the coefficients on the interaction term are highly significant implying that the impact of *VEGA* and *MRI* on customer RSI is significantly more negative for manufacturing firms relative to non-manufacturing firms.

When firms operate in concentrated industries, their customers may have few choices. In contrast, customers of firms operating in competitive industries have more choices of suppliers and consequently should react more strongly to higher risk-taking incentives by reducing their RSI. We classify industries as concentrated if their *Herfindahl Index* for sales is in the top tercile of all firms in the sample and present findings for the two subsamples in Panel D of Table IV. The coefficients on risk-taking incentives are negative in both the subsamples and the magnitude of the coefficient is greater when the firm operates in a more competitive industry. The coefficient on the interaction term, though in the right direction, is not significant.

Next, we examine the impact of risk-taking incentives in focused vs. diversified firms. As diversified firms operate in multiple industries, increased risk taking by the operating segment in one industry will likely have a smaller impact on firm-level volatility, and, therefore will lead to a smaller response by customer firms. Consistent with this conjecture, we find that there is a significantly higher impact of *MRI* on customer RSI in focused firms relative to diversified firms (Panel E of Table V). With *VEGA*, though the effect is stronger for focused firm the difference is not statistically significant.

In summary, the findings on various subsamples formed on the basis of firm characteristics tell a fairly consistent story. The negative effect of greater risk-taking incentives on customer RSI varies across firms; and that this negative effect is higher when risk-taking incentives are more easily translated into riskier firm cash flows. These findings provide additional support to our hypothesis that CEO's risk-taking incentives influence investments by customer firms in relationship-specific assets.

IV. Endogeneity, Simultaneity and Other Robustness Checks

A. Alternate RSI Measures

In the analysis thus far, the measure of customer RSI has been R&D intensity of all the key customers of the firm. However, the R&D of all customer firms is not likely to be relationship specific. Therefore, using data on patent citations, we next identify the customer firms whose R&D is more likely to be relationship specific. Citations of patents arise when technology from one patent is incorporated in the other product, or when the patent improves on the product concept, or when patents improve product feasibility. Presence of cross-citations between firms and their customers is, therefore, an indication of the degree of communication and integration between the two firms (Jaffe, Tratjtenberg and Fogarty (2000)). The higher the cross-citation of each other's patents, the greater is the likelihood of the presence of relationship-specific assets.

We obtain patent citation data from the NBER 2006 updated patent citation database.[17] The data file of interest is the patent citation file, *cite76_06*, which includes patent numbers of the citing patent and the cited patent. We trace each patent number (for both citing and cited patents) to NBER's unique patent assignee identifier, *PDPASS* using the patent assignee file, *patassg.* Next, we use the files *dynass* and *pdpcohdr* to map the patent identifier to Compustat. and merge this citing/cited data to the firms and customers in our sample from Compustat Segment Tapes.

We identify customers that cite the firm or customers that are cited by the firm in its patents over the past five years. We propose that these customers are more likely to have their R&D investments integrated with those of the firm, and therefore their R&D is more likely to be

[17] The data are available on Bronwyn Hall's website: http://elsa.berkeley.edu/~bhhall/patents.html.

representative of RSI. We then construct a sales-weighted average of R&D across *only* these "cited/ citing" customers and report the findings from using this proxy for RSI in column one of Table V. The coefficient of both *VEGA* and *MRI* are negative and significant, and this relation is robust to the inclusion of industry fixed effects (column 2).

If cross citation of patents captures relationship specificity of R&D expenditures, then it must be the case that the absence of cross citations implies that R&D is more likely to be generic. In these cases we should see no effect of risk-taking incentives on customer R&D intensity. Consistent with this prediction, the results from Models 3 and 4 in Table V show that the coefficient on *VEGA* is not significant in either specification, while that on *MRI* is significant in column 3 but insignificant in the specification with industry fixed effects. In summary, the result that risk-taking incentives are significantly negatively related to *Customer R&D* when patents are cross cited but not so when patents are not cross cited suggests that the negative relation to customer R&D is arising from the relationship specificity of R&D rather than through other channels.

Next, we consider a proxy for RSI that is not based on R&D expenses, namely, advertising intensity. Advertising Intensity tends to be higher in industries with differentiated goods with non standardized output that require higher RSI (Levy (1985)). Since advertising intensity may also be a proxy for product uniqueness (Titman and Wessels (1988)), we conjecture that it should be associated with RSI. We define *Advertising Intensity* as the ratio of SG&A expenses to sales and, as before, construct customer SG&A intensity as the sales-weighted value of *Advertising Intensity*. The results using *Advertising Intensity* as a measure of RSI are in column five of Table V. The coefficient on *MRI* is significantly negative and the negative relation is robust to the inclusion of industry fixed effects (column 6). The coefficient of

VEGA is negative as expected but not significant at conventional levels. Even with this significantly different proxy for RSI we get consistent results – customer RSI relates negatively to risk-taking incentives of the CEO of the upstream firm.

B. Testing and Correcting for Potential Endogeneity

The OLS results presented thus far suggest that customer investment in relationship-specific assets is negatively associated with risk-taking incentives. However, it is possible that the results are due to some unobservable firm characteristics that are associated with high firm risk-taking incentives and low customer RSI. For example, a supplier and customer may endogenously match based on risk characteristics. A CEO with high *MRI* attempts to offset this risky compensation by selecting customers with less-risky investment (lower R&D). In that case, the negative relation between CEO risk-taking incentives and customer RSI is not being driven by customers' responses to ex-ante CEO incentives, but rather a spurious relation driven by a risk-averse CEO attempting to "unwind" risk-taking incentives using product markets.

We control for this potential endogeneity by estimating a two-stage least squares (2SLS) model with identifying instruments for *VEGA* (*MRI)* that are likely to be correlated with *VEGA* (*MRI)* but not with the error term in the second-stage equation for customer RSI. The first instrument is the average industry *VEGA* (*MRI),* which is the average *VEGA* (*MRI)* for all firms in the same two-digit NAICS as the firm for that year. As compensation practices have a strong industry component we expect that industry-year *VEGA* (*MRI)* to be positively correlated with the firm *VEGA* (*MRI).* However, it is unlikely that the supplier industry-year *VEGA* (*MRI)* is related to the research intensities of individual customer firms. The second instrument is the average "moneyness" of the firm CEO's options. Increase in moneyness increases *DELTA* and generally decreases *VEGA,* which also implies that it is negatively associated with *MRI.*

However, there does not appear to be a reason for moneyness of the firm CEO's options to be systematically related to individual customer R&D intensity except through its relation with *VEGA* (*MRI)*. We measure moneyness (in dollars) as the average realizable value of options owned by the CEO.[18]

We estimate the above 2SLS and present the second stage estimation from the standard IV estimation in the first four columns and the second stage results from the iterated GMM estimation in the last four columns of Table V. We do not present the results for the first stage for space considerations but note that the instruments are highly significant in the first stage regression – the industry-year *MRI* is positively related and *Average Moneyness* is negatively related to *MRI*. When we use the predicted *VEGA* (*MRI)* from the first stage, we find that it continues to be significantly negatively related to customer RSI (See columns 1 and 2). The Hausman test, however, is not significant suggesting the lack of endogeneity given our instruments. The Hansen's J test of overidentifying restrictions is not significant pointing to the validity of the instruments used.[19]

When we use the other two measures of risk-taking incentives, *MRI x Number of Options* and *Total Comp MRI* the Hausman test is, however, significant. Overall, the results suggest that endogeneity may be a concern in these specifications. However, controlling for endogeneity again does not affect our results – we continue to find a significant negative relation between risk-taking incentives and customer RSI (See columns 3 and 4). The results using iterated GMM in Models 5 to 8 are similar.

[18] From results not reported in a table, we note that the mean moneyness for our sample is 0.94, that is, an average CEO option is about $1 in the money.

[19] The Hausman test is based on the reasoning that if there is no endogeneity, then the 2SLS and OLS estimators should differ only by sampling error. The presence of significant differences implies endogeneity (Wooldridge (2002)). 2SLS estimators in the presence of overidentifying restrictions can cause finite sample problems and rejection of the Hansen J test of overidentifying restrictions casts doubts on the validity of the estimates.

C. Are Risk-taking Incentives and RSI Jointly Determined? Our results thus far indicate that a customer firm responds to risk-taking incentives of the upstream firm. However, the RSI by the customer firms is likely to be critical to the long-term growth of the firm and, therefore, the firm will take into account the response of its customers when deciding on the compensation of its CEO. In other words, RSI by customer firms and risk-taking incentives may be jointly determined. To examine this possibility, following Mackay and Phillips (2005) and Kale and Shahrur (2007), we estimate a 2SLS simultaneous equation model for each measure of risk-taking incentives. For brevity, we discuss in detail only the model using MRI as the proxy for risk-taking incentives. Specifically, we estimate

$$MRI = \delta_0 + \delta_1 Customer\ RSI + \lambda Y + \mu \qquad (1)$$

$$Customer\ RSI = \beta_0 + \beta_1 MRI + \gamma X + \varepsilon \qquad (2)$$

where *MRI* and customer RSI are as defined before. In equation (2), we instrument *MRI* with *Average Moneyness* and industry level *MRI* and X represents all variables that influence customer RSI as in prior sections. In equation (1), we instrument customer RSI using the log of customer assets, customer leverage, and percentage of customer's industry with non-zero R&D expenses. When we use *VEGA* as a measure of the risk-taking incentives, we estimate a system with three jointly determined endogenous variables, i.e., *Customer RSI, VEGA* and *DELTA.*

We report the findings from the above analysis in Table VII, which presents the results from the second-stage estimation. In system I, which uses *VEGA* for risk-taking incentives, we find that whereas *VEGA* has a significantly negative effect on *Customer RSI* in line with prior results (column 1), *customer RSI* does not affect *VEGA* (column 2) or *DELTA* (column 3). In this specification, there is little evidence that customer RSI and risk-taking incentives are jointly

determined. In system II, which uses *MRI* for risk-taking incentives, however there is evidence of joint determination. *MRI* is negatively related to *Customer RSI* and *Customer RSI* is negatively related to *MRI*. In summary, there continues to be significant evidence that risk-taking incentives are associated with lower customer RSI. However there is only weak evidence that customer RSI is significant in determining the CEO's risk-taking incentives.

D. Further Tests on the Relation between Risk-taking Incentives and Customer RSI

In this section we address endogeneity and the underlying relationship between risk taking and customer RSI using an alternative empirical strategy.

Since risk-taking incentives and customer RSI are simultaneously determined, firms who need customers to invest in relationship specific assets will reduce the risk-taking incentives provided to their CEO. This implicit commitment to reduced risk taking implied by lowering the CEOs *MRI* or *VEGA* is what induces customer firms to increase RSI. However, if a firm faces sustained negative shock that significantly increase the firm's financial distress; it has less incentive to stay in this commitment equilibrium. Thus, since customer RSI is likely fixed in the short term, a distressed firm may opportunistically increase CEO risk taking to reap short-term benefits. In other words, firms that have kept their CEO's risk-taking incentives low to bolster customer RSI are likely to increase them for higher short-term profits since customer RSI is committed in the short term. We now test for the above implication of the linkage between risk-taking incentives and customer RSI.[20]

To capture firms that face financial difficulties we calculate the average annual sales growth in a firm's four-digit NAICS industry over the period t-10 to t-1. If the industry sales

[20] This methodology of examining how firms undo equilibrium behavior when subject to distress has also been used by Philips and Sertsios (2011), Kale, Meneghetti and Shahrur (2012), and Gopalan and Xie (2011).

growth is in the lowest decile, the dummy variable *LowGrowth* equals one and is zero otherwise. Among these firms in *LowGrowth* industries, firms for whom customer RSI is important would have (in the past) reduced the CEO's risk-taking incentives. We conjecture that these firms, now facing financial difficulties, are likely to exploit the customer RSI in place by increasing their CEO's risk-taking incentives. Therefore, whereas *LowGrowth* should be negatively related to increases in risk-taking incentives, the interaction of *LowGrowth* and *Customer R&D* should be positively related to the increase in risk-taking incentives.

We present evidence consistent with the above predictions in Table VIII. The total annual percent change in the risk-taking incentives from year t to t+4, as captured by *MRI* times the number of options over this period, is negatively related to the *LowGrowth* dummy and significantly positively related to the interaction of *LowGrowth* with *Customer R&D* (See Column 1). The coefficient of *Customer R&D* is negative and in line with prior results in the simultaneous equations results. The findings are similar if we measure increased risk-taking incentives given to the CEO with the Black-Scholes value of the options (Column 2), or the total number of option grants from year t to t+4 (Column 3). These results, that a firm facing financial difficulties and whose customers have high R&D (i.e., customers have invested in relationship assets) reverse their behavior and increase risk-taking incentives provide further support for the underlying relationship between a CEO's risk-taking incentives and customer RSI.

E. Other Robustness

Next, we first present findings from estimating the relation between customer RSI and risk-taking incentives separately for large and small customers, examining whether the effects on customer RSI are due to cross-sectional or time-series variations in risk-taking incentives, and estimating a Tobit rather than the OLS specification used in the earlier sections.

In the analysis thus far, we have identified the major customers of firms and find that on average they respond to increased risk taking by reducing their RSI. However, some of these customers may be so large (e.g., Walmart) that only a small fraction of their total R&D expenses is specific to a particular supplier and, therefore, their overall R&D intensity may not change much in response to increased risk taking by an individual supplier. To examine whether the effect of risk-taking incentives is stronger when customers are smaller firms, we define the relative size of all customers as the ratio of the customer assets to firm assets. We classify all customers with relative size greater than the year-median as large customers, the remaining as small customers, and compute the weighted *Customer R&D* separately for these large and small customers. The findings from analyzing the effect on RSI by small and large customers are in the first two columns of Table IX. The coefficient on both *VEGA* and *MRI* are significantly negative for small customers (column one), but not for large customers (column two). This finding is consistent with expectations and suggests that the effect of *VEGA* and *MRI* is not due to omitted firm-level characteristics that impact both small and large customers in a similar way.

For any given firm, compensation contracts are likely to show substantial changes only when a new CEO is hired and/or there are significant changes in the operating and governance environment of the firm. As these events are relatively infrequent, we expect that a substantial variation in the risk-taking incentives arises due to differences between firms rather than differences over time for a given firm. We examine this conjecture by estimating a between effects specification and a within effects estimator. The findings from these estimations are in columns three and four of Table IX, respectively. As expected, the *MRI* coefficient is negative and significant only in the between effects specification implying that most of the effect of risk incentives on customer RSI is seen in the cross section rather than in the time series. The

coefficient of *VEGA* is negative as expected in the between effects specification but not significant at conventional levels.

Lastly, as our dependent variable is the weighted average R&D intensity for all customers, it takes the value of zero if none of the customer firms report R&D expenses. In order to ensure that our results are not affected by issues relating to truncation, we also estimate a Tobit Model. From the results in the last column of Table IX we find that this modification has no material impact on our results.

V. Industry Level Identification of Customers and Suppliers

Our analysis thus far examines the relation between risk-taking incentives and RSI by customer firms. Since supplier firms cannot be identified from Compustat, we construct an industry-level dataset to examine the relation between a firm's risk-taking incentives and the RSI in supplier and customer industries. We use all firms in the supplier (customer) industry to create Supplier-level (customer-level) variables. Using customer and supplier R&D intensity at the industry level may mitigate some of the endogeneity concerns that arise from identifying individual customer firms.

With the help of the "Use" tables from the Benchmark Input-Output accounts, we identify the customer and supplier industries for all firms covered in Execucomp over the period 1994-2006. We employ the 1997 Use tables for the years 1994-1999, and the 2002 Use tables for the years 2000-2006. Recent versions of the IO tables are organized by NAICS codes (as opposed to SIC codes) due to a change by the Bureau of Economic Analysis. As a result, all of our industry-level analysis is performed by 4-digit historical NAICS codes, which are available in Compustat. After merging our 21,935 Execucomp firm-years with the IO tables by NAICS,

our sample drops to 10,008 firm-years. Excluding financial and utility firms further reduces the sample to 8,733 firm-years.

The other variables used in the industry-level analysis include *Industry R&D*, which is the sum of R&D expense for all firms in that industry that are covered in Compustat divided by the total industry book assets as given in Compustat. *Industry Sales Growt*h is the sales growth of the median firm in the industry, *Industry Leverage* is the sum of book value of debt divided by the total assets of the industry, and *Industry Herfindahl Index* is the sales Herfindahl index for the two. We use the IO tables to construct a weighted-average *Customer* and *Supplier Industry R&D, Customer* and *Supplier Sales Herfindahl Index*, *Customer* and *Supplier Sales Growth*, and *Customer* and *Supplier Leverage*. Summary statistics for this much larger industry dataset are in Table X. The average *DELTA* and *VEGA* are similar to the firm level dataset. There are some differences between customer and supplier industries. The average R&D intensity of customer industry is 2.87%, which is higher than the 0.65% for suppliers. Customer industries also appear to be more concentrated, have higher sales growth and lower leverage than supplier industries.

We estimate the OLS specification on this industry-level dataset and report the findings in Table XI. The first two columns present the findings for customer industry RSI and columns three and four the findings for supplier industry RSI for the entire sample. The next four columns present the results for the sub-sample of firms that report positive R&D expenses. The coefficient on *MRI* is negative and highly significant in all specifications. In the Customer industry RSI regression in column 2, the coefficient of *MRI* is -0.0075 (t-statistic = -12.86) and is similar to the coefficient of -0.0068 estimated in the firm level dataset. More importantly, we find that *MRI* is negatively related to supplier RSI as well. The coefficient on *MRI* in column four is -0.0013 (t-statistic = -4.83), which suggests that suppliers also significantly reduce their

RSI when the CEO of the firm has high risk-taking incentives. The results are qualitatively similar when we use *VEGA* though weaker for supplier industries.

VI. Conclusions

In this paper, we find a significant negative impact of managerial risk-taking incentives on relationship-specific investments by both customer and supplier firms. Further, this negative impact of CEO's risk-taking incentives on RSI by customers is significantly higher for firms with high R&D and high capital expenditures, as well as, for firms in manufacturing industries. As these are precisely firms where risk-taking incentives can have a large impact on the volatility of cash flow, a significantly larger reduction in customer RSI further supports our hypothesis.

The analysis at the industry level not only corroborates the results of a reduction in customer RSI in a much larger dataset but also shows that they are applicable to RSI by suppliers. As RSI by customers and suppliers is crucial for the long term growth of the firm, the results in this paper suggest that though managerial risk-taking incentives may have the desired short-term effect of increased risk taking, they may have a long-term detrimental effect of undermining the implicit contracts with customers and suppliers and reducing their investment in the vertical channel. The results in our paper underscore how compensation structures designed to impact managerial behavior within a firm can have strong externalities and affect the operating decision of other entities that the firm interacts with in the economy.

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Appendix 1
Description of Variables

Log[CEO Cash Comp]: Log of CEO cash compensation. Cash compensation is defined as salary + bonus.

CEO Tenure: Number of years as CEO

CEO Turnover Year: A dummy that takes the value 1 in the year of CEO turnover

CEO Ownership: Number of shares owned by the CEO, including restricted stock divided by shares outstanding.

*Customer Leverage***:** Weighted average of customer market leverage. Market leverage is the ratio of book value of debt to market value of the firm and weights are the share of sales to the customer.

*Customer R&D***:** Weighted average R&D intensity of customers. R&D intensity is the ratio of R&D expenses to total assets. The weights are the share of sales to the customers.

*Customer Sales Growth***:** The weighted average sales growth of all customers. Sales growth is the annual increase in sales and the weights are the share of sales to customers.

Customer VEGA: The weighted average vega of all the customers of the firms. Each customer vega is the per option vega multiplied by the number of options held by the CEO. The weights used are the sales to customer divided by total firm sales and need not sum to one as all customers of the firm are not identified.

DELTA: The product of per option delta and the number of options held by the CEO.

Herfindahl Index: is the sum of squared market shares (in sales) of the firm's two digit NAICS industry.

MRI: Managerial risk taking, i.e., the ratio of delta to vega.

Market Leverage: is the ratio of book value of debt to market value of the firm. Market value of the firm is the sum of book value of debt and the market value of equity.

*R&D Intensity***:** The ratio of R&D expenses to total assets. This has been assigned a value of zero when the firm does not report any R&D expenses.

ROA: The ratio of net income to Total Assets. We use the lagged value of ROA.

Sales Volatility: The standard deviation of prior three years of sales.

Tobin's Q: The ratio of the market value of the firm to book value of the firm.

VEGA: The product of per option vega and the number of options held by the CEO.

Table I
Summary Statistics

The dataset is constructed from Execucomp over the period 1994-2006. *DELTA* (*VEGA*) is the product of per option delta (vega) with the number of options owned by the CEO (in 000'). *MRI* is the ratio of option vega to option delta. *Total Comp MRI* is the ratio of CEO portfolio vega to portfolio delta. *Log[# of Options]* is the natural logarithm of the total number of options held by the CEO. *Log[Total Assets]* is the natural logarithm of total book assets. *Tobin's Q* is market value of the firm divided by the book value of the firm. *Market Leverage* is the book value of debt divided by the market value of the firm. *R&D Intensity* is firm R&D expense divided by total assets. *Firm ROA* is prior year net income divided by total assets. *Sales Volatility* is the standard deviation of prior three years' sales intensity. *CEO Ownership* is percentage of outstanding shares held by the CEO. *CEO Tenure* is the number of years the CEO has held the position. *CEO Turnover Year* is a dummy = 1 if it is the year of CEO turnover. *Log[CEO Cash Comp]* is the natural logarithm of CEO Salary + Bonus. *Herfindahl Index* is the firm's two-digit NAICS industry concentration. *Customer R&D* is the weighted average of all identifiable customers' *R&D Intensity* (weighted by % of total sales). *Customer VEGA* is the weighted average of all identifiable customers' *VEGA* (weighted by % of sales). *Customer Leverage* and *Customer Sales Growth* are similarly defined. Customer weights are not required to sum to one. All variables are winsorized at the 1st and 99th percentile.

	Mean	StD	Min	Max	Observations
DELTA (in thousands)	201.54	372.48	0.00	2592.12	3604
VEGA (in thousands)	171.47	326.52	0.00	2363.67	3604
MRI	0.84	0.29	0.00	2.10	3230
Total Comp MRI	0.53	0.32	0.00	1.47	3230
Log[# of Options]	6.27	1.26	0.00	10.67	3358
Log[Total Assets]	6.98	1.53	1.77	12.60	3604
Tobin's Q	2.13	1.50	0.70	8.98	3599
Market Leverage	0.19	0.20	0.00	0.93	3599
Firm ROA	0.02	0.15	-0.70	0.28	3603
R&D Intensity	0.05	0.07	0.00	0.38	3604
Sales Volatility	0.13	0.13	0.01	0.65	3600
CEO Ownership	0.03	0.06	0.00	0.33	3451
CEO Tenure	8.04	7.45	0.00	52.00	3604
CEO Turnover Year	0.12	0.32	0.00	1.00	3604
Log[CEO Cash Comp]	6.73	0.87	-6.91	9.68	3593
Customer R&D	0.01	0.01	0.00	0.08	3604
Customer VEGA (thousands)	158.34	0.21	0.00	1914.38	3604
Customer Leverage	0.06	0.08	0.00	0.49	3600
Customer Sales Growth	0.00	0.00	0.00	0.00	3604
Herfindahl Index	0.03	0.02	0.01	0.35	3604

Table II
Correlation Structure of Selected Variables

This table reports correlations in a sample consisting of Execucomp firms with identifiable customer data from 1994-2006. Financial firms and utilities are excluded. *Customer R&D* is the weighted average of all identifiable customers' R&D Intensity (weighted by % of total sales). *DELTA* is the product of per option delta with the number of options shares owned by the CEO. *VEGA* is the product of per option vega with the number of options owned by the CEO and represents the dollar increase in CEO wealth (in thousands) for a 1% increase in stock volatility. *MRI* is *VEGA*/*DELTA*. *Total Comp MRI* is the ratio of CEO portfolio vega to portfolio delta. *Log[CEO Cash Comp]* is equal to the natural logarithm of CEO Salary + Bonus. *CEO Ownership* is percentage of outstanding shares held by the CEO. *R&D Intensity* is firm R&D expense divided by total assets. Customer weights are not required to sum to one. All compensation variables are lagged. All variables are winsorized at the 1st and 99th percentile.

	Customer R&D	DELTA	VEGA	MRI	Total Comp MRI	Log[CEO Cash Comp]	CEO ownership	R&D Intensity
Customer R&D	1.00							
DELTA	-0.05	1.00						
VEGA	-0.10	0.94	1.00					
MRI	-0.30	0.02	0.18	1.00				
Total Comp MRI	-0.13	0.24	0.32	0.48	1.00			
Log[CEO Cash Comp]	-0.18	0.30	0.35	0.28	0.29	1.00		
CEO Ownership	-0.01	-0.07	-0.09	-0.07	-0.46	-0.13	1.00	
R&D Intensity	0.33	0.11	-0.38	-0.38	-0.06	-0.16	-0.11	1.00

Table III
Firm Level Determinants of Customer R&D Intensity

The table reports OLS estimation where the dependent variable is *Customer R&D*. This is the weighted average of all identifiable customers' *R&D Intensity*. *R&D Intensity* is R&D/Total Assets (zero if missing). *DELTA* (*VEGA*) is the product of per option delta (vega) with the number of options owned by the CEO. *MRI* is the ratio of option vega to option delta. *Total Comp MRI* is the ratio of CEO portfolio vega to portfolio delta. *Log[# of Options]* is the natural logarithm of the total number of options held by the CEO. *Log[Total Assets]* is the natural logarithm of total book assets. *Tobin's Q* is market value of the firm divided by the book value of the firm. *Market Leverage* is the book value of debt divided by the market value of the firm. *Firm ROA* is prior year net income divided by total assets. *Sales Volatility* is the standard deviation of prior three years' sales intensity. *CEO Ownership* is percentage of outstanding shares held by the CEO. *CEO Tenure* is the number of years the CEO has held the position. *CEO Turnover Year* is a dummy = 1 if it is the year of CEO turnover. *Log[CEO Cash Comp]* is the natural logarithm of CEO Salary + Bonus. *Herfindahl Index* is the firm's two-digit NAICS industry concentration. *Customer R&D* is the weighted average of all identifiable customers' *R&D Intensity* (weighted by % of total sales). *Customer VEGA* is the weighted average of all identifiable customers' *VEGA* (weighted by % of sales). *Customer Leverage* and *Customer Sales Growth* are similarly defined. Customer weights are not required to sum to one. Compensation variables are lagged. All variables are winsorized at the 1st and 99th percentile. T-statistics are from robust standard errors clustered by firm and reported in parentheses.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
VEGA	-0.0073**				-0.0052*			
	(-2.57)				(-1.87)			
MRI		-0.0068***				-0.0065***		
		(-3.88)				(-4.09)		
MRI x # of Options			-0.0011***				-0.0008**	
			(-3.07)				(-2.16)	
Total Comp MRI				-0.0027**				-0.0030**
				(-2.03)				(-2.49)
DELTA	0.0047*				0.0033			
	(1.93)				(1.42)			
Log[# of Options]		-0.0001	0.0009**	0.0003		-0.0000	0.0007	0.0004
		(-0.44)	(1.97)	(0.84)		(-0.14)	(1.61)	(1.05)
Firm Characteristics								
Log[Total Assets]	-0.0007**	-0.0007**	-0.0009**	-0.0010***	-0.0009***	-0.0008**	-0.0010***	-0.0011***
	(-2.43)	(-1.99)	(-2.42)	(-2.92)	(-2.69)	(-2.33)	(-2.65)	(-3.02)
Tobin's Q	-0.0003	-0.0004	-0.0004	-0.0004	-0.0002	-0.0003	-0.0003	-0.0003
	(-1.11)	(-1.34)	(-1.28)	(-1.30)	(-0.79)	(-1.22)	(-1.05)	(-1.06)
Market Leverage	-0.0024	-0.0024	-0.0029	-0.0026	-0.0018	-0.0025	-0.0025	-0.0024
	(-1.10)	(-0.96)	(-1.15)	(-1.05)	(-0.86)	(-1.04)	(-1.05)	(-1.00)
Firm ROA			-0					
	-0.0053*	-0.0051*	.0066**	-0.0064**	-0.0057**	-0.0051*	-0.0067**	-0.0063**
	(-1.90)	(-1.67)	(-2.15)	(-2.10)	(-2.04)	(-1.67)	(-2.20)	(-2.06)

Table III **(**Continued)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
R&D Intensity	0.0472***	0.0397***	0.0437***	0.0432***	0.0312***	0.0250***	0.0278***	0.0269***
	(6.37)	(5.15)	(5.85)	(5.70)	(3.83)	(2.92)	(3.29)	(3.16)
Sales Volatility	0.0015	0.0002	0.0013	0.0009	0.0020	0.0004	0.0010	0.0007
	(0.53)	(0.07)	(0.42)	(0.30)	(0.76)	(0.13)	(0.33)	(0.24)
Herfindahl Index	-0.0222	-0.0231	-0.0296	-0.0300	0.0336	0.0438*	0.0324	0.0349
	(-1.50)	(-1.12)	(-1.60)	(-1.62)	(1.45)	(1.92)	(1.37)	(1.48)
CEO Characteristics								
CEO Ownership	-0.0107*	-0.0065	-0.0028	-0.0098	-0.0117*	-0.0026	0.0016	-0.0059
	(-1.96)	(-0.97)	(-0.41)	(-1.20)	(-1.85)	(-0.40)	(0.25)	(-0.79)
CEO Tenure	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
	(1.27)	(0.63)	(0.67)	(0.14)	(1.31)	(0.58)	(0.50)	(0.02)
CEO Turnover Year	0.0001	0.0002	0.0004	-0.0000	0.0002	0.0002	0.0003	-0.0001
	(0.18)	(0.30)	(0.55)	(-0.06)	(0.26)	(0.35)	(0.39)	(-0.08)
Log[CEO Cash Comp]	-0.0006	-0.0006	-0.0008*	-0.0007	-0.0005	-0.0005	-0.0006	-0.0005
	(-1.60)	(-1.26)	(-1.67)	(-1.39)	(-1.25)	(-1.10)	(-1.33)	(-1.18)
Customer Characteristics								
Customer VEGA	0.0113***	0.0104***	0.0110***	0.0108***	0.0107***	0.0096***	0.0102***	0.0100***
	(3.96)	(3.79)	(3.96)	(3.86)	(3.73)	(3.39)	(3.57)	(3.49)
Customer Leverage	0.0094*	0.0104*	0.0102*	0.0102*	0.0073	0.0079	0.0082	0.0079
	(1.72)	(1.78)	(1.81)	(1.75)	(1.18)	(1.22)	(1.26)	(1.20)
Customer Sales Growth	1.5301*	1.6348**	1.7413**	1.7252**	1.3786*	1.4326*	1.5568*	1.5146*
	(1.88)	(1.97)	(2.06)	(2.04)	(1.79)	(1.82)	(1.93)	(1.89)
Constant	0.0122***	0.0190***	0.0103**	0.0152***	0.0131***	0.0210***	0.0126***	0.0164***
	(3.64)	(4.91)	(2.47)	(4.13)	(3.58)	(4.92)	(2.82)	(4.09)
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Ind Fixed Effects	NO	NO	NO	NO	YES	YES	YES	YES
N observations	3428	3088	3088	3088	3424	3084	3084	3084
R Squared	0.20	0.21	0.20	0.20	0.26	0.27	0.26	0.26

Table IV
Cross sectional tests of the Impact on Customer R&D Intensity

This table reports selected coefficients from the OLS regression where the dependent variable is the sales weighted *Customer R&D* intensity. *R&D Intensity* is the ratio of R&D expenses to total assets. Other variables included but not reported are *Log[# of Options], Log[Total Assets], Tobin's Q, Market Leverage, Firm ROA, R&D Intensity, Sales Volatility, Herfindahl Index, CEO Ownership, CEO Tenure, CEO Turnover Year, Log[CEO Cash Comp]*. Also included are *Customer VEGA, Customer Leverage,* and *Customer Sales Growth*. All compensation variables are lagged. In panel A, a firm is defined as high *CAPEX* if the firm's Capital expenditure to total assets ratio is in the top tercile of all firms. All other firms are in the low *CAPEX* group. For Panel B, firms with a positive R&D (zero) expense are in the positive (no) R&D group. For panel C, manufacturing firms are defined as having a two-digit SIC code between 20 and 39 with all other in the non-manufacturing group. For panel D, high HI firms are those with main industry *Herfindahl Index* in the top tercile with all other in the other group. For Panel G firms in the High Q are those with *Tobin's Q* in the top tercile and all others are in the low Q group. All variables are winsorized at the 1st and 99th percentile. All estimations included year fixed effects. All vega estimates have 3428 observations and all MRI estimates have 3088 observations.

	Coefficient of VEGA	Coeffient of MRI
Panel A: Differences between Low and High Capex		
Low CAPEX	-0.0052*	-0.0049***
High CAPEX	-0.0141**	-0.0107***
Difference	0.0089	0.0058*
t-stat	(1.31)	(1.84)
Panel B: Differences between R&D and No R&D Firms		
No R&D Firms	-0.0008	-0.0015
Positive R&D Firms	-0.0074**	-0.0089***
Difference	0.0067*	0.0074***
t-stat	(1.735)	(2.88)
Panel C: Differences between Manufacturing and Non-Manufacturing Firms		
No Manufacturing Firm	0.0002	0.0005
Manufacturing Firms	-0.0099**	-0.0102***
Difference	0.0101**	0.0108***
t-stat	(2.159)	(4.306)
Panel D: Differences between High and Low Herfindahl Industry		
High Herfindahl Index "HI" Firms	-0.0055	-0.0038***
Low "HI" Firms	-0.0070*	-0.0093***
Difference	0.0015	0.0055
t-stat	(0.244)	(1.63)
Panel E: Differences between Focused and Diversified Firms		
Focused Firms	-0.0091**	-0.0091***
Diversified Firms	-0.0045*	-0.0024**
Difference	0.0047	0.0067**
t-stat	(0.94)	(2.55)

Table V
Robustness: Different Proxies for Relationship Specific Investments

This table reports coefficients from the OLS regression where the dependent variable is the customer sales weighted *Advertising Intensity*(Models 1 and 2). *Advertising Invensity* is the selling, general and administrative expenses to sales. Model 3 and 4, the dependent variable is the customer sales weighted R&D intensities (*Customer R&D*) but only customers that have patents that cite the firm or are cited by the firm are included. For Model 5 and 6, the dependent variable is the sales weighted customer R&D intensities (*Customer R&D*) but only for customers that have no patent cross citations with the firm. *MRI* is *VEGA*/*DELTA*. Other control variables included in the estimation but not displayed in the table due to brevity are *Log[Total Assets], Tobin's Q* (market value over book value of the firm), *Market Leverage* (book value of debt by the market value of the firm), *R&D Intensity* (firm R&D expense by total assets), *Firm ROA* (prior year net income by total assets), *Sales Volatility* (the standard deviation of prior three years' sales intensity), *CEO Ownership* (percentage of shares held by the CEO), *CEO Tenure* (number of years the CEO has held the position), *CEO Turnover Year* (a dummy = 1 if a turnover occurred in the year), *Log[CEO Cash Comp]* (Log of CEO Salary + Bonus), *Herfindahl Index (*firm's industry concentration), and *Customer VEGA* (weighted average of all identifiable customers' *VEGA* (weighted by % of sales)), *Customer Leverage* and *Customer Sales Growth*. Customer weights are not required to sum to one. All compensation variables are lagged. All variables are winsorized at the 1st and 99th percentile. T-statistics are calculated from robust standard errors clustered by firm and reported in parentheses.

	Customer R&D in case of Cross Citation		Customer R&D when no Cross citation		Advertising Intensity	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
VEGA	-0.0073***	-0.0051*	-0.0016	-0.0013	-0.0111	-0.0176
	(-2.760)	(-1.924)	(-0.756)	(-0.549)	(-1.07)	(-1.63)
MRI	-0.0051***	-0.0052***	-0.0015*	-0.0013	-0.0114**	-0.0155***
	(-3.241)	(-3.738)	(-1.799)	(-1.353)	(-2.25)	(-2.79)
Control Variables included but not displayed						
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Ind Fixed Effects	NO	YES	NO	YES	NO	YES
N observations - VEGA	3428	3424	3428	3424	3428	3424
N observations - MRI	3088	3084	3088	3084	3088	3084

Table VI
Controlling for Potential Endogeneity

The table displays estimation of the second stage. Dependent variable in the first stage are the compensation measures, which are either *DELTA* and *VEGA*, *MRI*, *MRI*# of Options*, and *Total Comp MRI*. Dependent variable in the second stage is *Customer R&D intensity* which is the sales weighted R&D Intensity of all customers. R&D Intensity is the ratio of R&D expenses to total assets. *Tobin's Q* is the ratio of market value to book value of the firm. *Market Leverage* is the book value of debt divided by the market value of the firm. *Firm ROA* is lagged and is the ratio of net income to total assets. *Sales Volatility* is the standard deviation of prior three years' sales intensity. *CEO Ownership* is percentage of outstanding shares held by the CEO. *CEO Tenure* is the number of years the CEO has held the position. *CEO Turnover Year* is a dummy = 1 in the year of turnover. *Log[CEO Cash Comp]* is the Log of CEO Salary + Bonus. *Herfindahl Index* is reference firm's industry concentration. *Customer VEGA*, *Leverage*, and *Sales Growt*h are the sales weighted average of all identifiable customers' *VEGA*, leverage, and sales growth respectively. Variables are winsorized at the 1st and 99th percentile. T-statistics are from robust standard errors and in parentheses.

	Standard IV estimation				Iterated GMM IV estimation			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
VEGA	-0.0176**				-0.0172**			
	(-2.18)				(-2.15)			
MRI		-0.0079***				-0.0076***		
		(-2.75)				(-2.71)		
MRI x # of Options			-0.0038**				-0.0039**	
			(-2.33)				(-2.40)	
Total Comp MRI				-0.0168**				-0.0165**
				(-1.99)				(-1.96)
DELTA	0.0117				0.0123			
	(1.21)				(1.28)			
Log[# of Options]	0.0004	-0.0003	0.0027**	0.0011	0.0003	-0.0003	0.0027**	0.0010
	(0.52)	(-0.79)	(2.20)	(1.58)	(0.45)	(-0.77)	(2.28)	(1.57)
Firm Characteristics								
Log[Total Assets]	-0.0005	-0.0006	-0.0003	-0.0006	-0.0006	-0.0006	-0.0003	-0.0007
	(-0.54)	(-1.61)	(-0.63)	(-1.56)	(-0.64)	(-1.64)	(-0.58)	(-1.59)
Tobin's Q	-0.0002	-0.0004	-0.0003	-0.0003	-0.0002	-0.0004	-0.0003	-0.0003
	(-0.42)	(-1.29)	(-1.11)	(-1.07)	(-0.49)	(-1.24)	(-1.08)	(-1.01)
Market Leverage	-0.0028	-0.0025	-0.0036	-0.0031	-0.0026	-0.0025	-0.0034	-0.0030
	(-0.94)	(-0.99)	(-1.41)	(-1.18)	(-0.88)	(-1.02)	(-1.35)	(-1.17)
Firm ROA	-0.0051	-0.0049	-0.0060*	-0.0044	-0.0051	-0.0050	-0.0059*	-0.0043
	(-1.49)	(-1.55)	(-1.94)	(-1.29)	(-1.48)	(-1.61)	(-1.90)	(-1.28)
R&D Intensity	0.0435***	0.0391***	0.0423***	0.0374***	0.0429***	0.0396***	0.0425***	0.0368***
	(5.41)	(4.81)	(5.55)	(4.09)	(5.45)	(4.92)	(5.60)	(4.05)

Table VI (continued)

Sales Volatility	0.0017	0.0008	0.0019	-0.0001	0.0016	0.0009	0.0016	-0.0002
	(0.65)	(0.30)	(0.66)	(-0.05)	(0.61)	(0.31)	(0.58)	(-0.07)
Herfindahl Index	-0.0313*	-0.0223	-0.0322*	-0.0376*	-0.0299	-0.0225	-0.0311*	-0.0361*
	(-1.68)	(-1.07)	(-1.70)	(-1.96)	(-1.64)	(-1.08)	(-1.65)	(-1.90)
CEO Characteristics								
CEO Ownership	-0.0064	-0.0067	-0.0003	-0.0411**	-0.0067	-0.0063	-0.0001	-0.0411**
	(-0.90)	(-0.99)	(-0.04)	(-2.01)	(-0.96)	(-0.94)	(-0.02)	(-2.01)
CEO Tenure	0.0001	0.0000	0.0001	-0.0001	0.0001	0.0000	0.0001	-0.0001
	(0.74)	(0.63)	(1.15)	(-1.06)	(0.69)	(0.67)	(1.13)	(-1.01)
CEO Turnover Year	0.0004	0.0002	0.0010	-0.0007	0.0003	0.0002	0.0010	-0.0007
	(0.50)	(0.25)	(1.33)	(-0.96)	(0.49)	(0.24)	(1.39)	(-0.90)
Log[CEO Cash Comp]	-0.0008*	-0.0005	-0.0010*	-0.0003	-0.0008*	-0.0005	-0.0011*	-0.0003
	(-1.68)	(-1.20)	(-1.76)	(-0.55)	(-1.69)	(-1.30)	(-1.81)	(-0.56)
Customer Characteristics								
Customer VEGA	0.0121***	0.0101***	0.0111***	0.0101***	0.0119***	0.0101***	0.0111***	0.0099***
	(3.70)	(3.70)	(4.06)	(3.57)	(3.69)	(3.69)	(4.11)	(3.53)
Customer Leverage	0.0090	0.0107*	0.0103*	0.0104*	0.0091	0.0109*	0.0099*	0.0105*
	(1.43)	(1.84)	(1.93)	(1.72)	(1.46)	(1.88)	(1.88)	(1.76)
Cust. Sales Growth	1.4012*	1.6167*	1.6852**	1.5110*	1.4442*	1.6373*	1.6683**	1.6677**
	(1.79)	(1.92)	(1.99)	(1.75)	(1.86)	(1.95)	(1.97)	(2.00)
Constant	0.0090	0.0190***	-0.0021	0.0140***	0.0099	0.0189***	-0.0025	0.0138***
	(0.88)	(4.46)	(-0.31)	(3.77)	(0.99)	(4.44)	(-0.37)	(3.78)
N observations	3209	3088	3088	3088	3209	3088	3088	3088
Hansen J	0.13	0.24	0.18	0.46	0.13	0.24	0.18	0.46
Hausman Statistic	2.07	0.23	4.51**	4.02**	2.07	0.23	4.51**	4.02**
Instruments Used	Average Moneyness Industry-Year VEGA Industry-Year DELTA	Average Moneyness Industry-Year MRI	Average Moneyness Ind. Year MRI*Options Industry-Year DELTA	Average Moneyness Industry-Year VEGA	Average Moneyness Industry-Year VEGA Industry-Year DELTA	Average Moneyness Industry-Year MRI	Average Moneyness Ind. –Year MRI*Options Industry-Year DELTA	Average Moneyness Industry-Year VEGA

Table VII
Simultaneous Equations Model

The table displays results of simultaneous equation models estimated using 2SLS. The dependent variable in each system is (1) *Customer R&D* and (2) the incentive measure (*VEGA*/*DELTA*, *MRI*). Each incentive measure is instrumented by *Average Moneyness* of CEO options and industry-year median value of each incentive measure. *Customer R&D* is instrumented by *Ln[Customer Assets]*, *Customer Leverage*, and percentage of customer's industry with R&D activity (Customer Ind % RD). *Customer R&D* is the weighted average of all identifiable customers' R&D Intensity (weighted by % of total sales). R&D Intensity is R&D/Total Assets (zero if missing). *MRI* is *VEGA*/*DELTA* and is lagged in the first specification and contemporaneous in the second specification. *Log[Total Assets]* is the Log of Book Assets. *Tobin's Q* is market value of the firm divided by the book value of the firm. Market Leverage is the book value of debt divided by the market value of the firm. *Firm ROA* is prior year net income divided by total assets. Sales Volatility is the standard deviation of prior three years' sales intensity. *CEO Ownership* is percentage of outstanding shares held by the CEO. *CEO Tenure* is the number of years the CEO has held the position. *CEO Turnover Year* is a dummy = 1 if a turnover occurred in the observation year. *Log[CEO Cash Comp]* is equal to the Log of CEO Salary + Bonus. *Herfindahl Index* is reference firm's industry concentration. *Customer VEGA (Sales Growth)* is the weighted average of all identifiable customers' vega (Sales Growth) (weighted by % of sales). Customer weights are not required to sum to one. All variables are winsorized at the 1st and 99th percentile. T-statistics are calculated from robust standard errors and reported in parentheses.

	System 1			**System 2**	
Dependent Variable	Customer R&D	VEGA	DELTA	Customer R&D	MRI
VEGA	-0.0178**		0.9719***		
	(-2.00)		(14.33)		
MRI				-0.0108***	
				(-4.31)	
Customer R&D		-0.1604	0.1752		-1.4783**
		(-0.63)	(0.60)		(-2.27)
Average Moneyness		-0.0041**	0.0037*		-0.0051***
		(-2.12)	(1.65)		(-2.62)
Customer Ind % R&D	0.0534***			0.0545***	
	(12.65)			(15.29)	
Ln[Customer Assets]	0.0021***			0.0021***	
	(4.86)			(5.36)	
Customer Leverage	-0.0587***			-0.0594***	
	(-7.70)			(-8.51)	
Ind-Median VEGA		0.2447***			
		(4.00)			
Ind-Median DELTA			-0.1086**		
			(-2.20)		
Ind-Median MRI					0.6073***
					(14.13)
DELTA	0.0176*	0.8839***			
	(1.83)	(16.61)			

Table VII (continued)

Firm Characteristics					
Log[Total Assets]	-0.0006	0.0044	0.0110	0.0001	0.0289***
	(-1.14)	(0.73)	(1.52)	(0.40)	(5.32)
Tobin's Q	-0.0006	-0.0136	0.0266***	-0.0003	-0.0038
	(-1.28)	(-1.63)	(3.07)	(-1.30)	(-0.87)
Market Leverage	-0.0017	0.0109	-0.0463**	-0.0024	-0.0985**
	(-0.87)	(0.60)	(-2.18)	(-1.50)	(-1.97)
Firm ROA	-0.0034	0.0597**	-0.0576**	0.0014	0.2834***
	(-1.35)	(2.56)	(-2.27)	(0.72)	(6.79)
R&D Intensity	0.0200***	-0.0817*	0.1423**	0.0101*	-0.5419***
	(3.21)	(-1.68)	(2.48)	(1.75)	(-5.19)
Sales Volatility	0.0015	-0.0292	0.0383	0.0003	-0.1318***
	(0.67)	(-0.90)	(1.13)	(0.16)	(-2.82)
Herfindahl Index	-0.0097	0.0668	-0.1162	-0.0067	0.4207
	(-0.60)	(0.61)	(-0.98)	(-0.33)	(0.49)
CEO Characteristics					
CEO Ownership	-0.0013	-0.1095*	0.0990	-0.0031	-0.3114***
	(-0.24)	(-1.89)	(1.28)	(-0.65)	(-2.98)
CEO Tenure	-0.0001	0.0006	0.0005	-0.0001	0.0002
	(-1.59)	(1.17)	(0.90)	(-1.35)	(0.27)
CEO Turnover Year	0.0003	-0.0005	-0.0058	-0.0001	-0.0149
	(0.46)	(-0.08)	(-0.79)	(-0.27)	(-1.12)
Log[CEO Cash Comp]	0.0001	0.0127**	-0.0120**	-0.0000	0.0091
	(0.24)	(2.07)	(-1.98)	(-0.08)	(1.40)
Customer Characteristics					
Customer VEGA	-0.0178***	-0.0036	0.0120	-0.0181***	-0.0558*
	(-4.83)	(-0.24)	(0.78)	(-5.67)	(-1.94)
Customer Sales Growth	-1.5775**	0.9509	-1.6394	-1.6921**	-12.4178
	(-2.02)	(0.25)	(-0.38)	(-2.44)	(-1.54)
Constant	0.0054	-0.0838	-0.0718	0.0136***	0.3559***
	(1.12)	(-1.19)	(-0.84)	(4.07)	(4.59)
N observations	2340	2340	2340	2783	2783

Table VIII
Economically distressed industries and subsequent option grants

The table reports OLS estimations. The dependent variables are four-year sums of Black and Scholes values of (number of) option grants, or the four-year sum of annual (percentage) changes in MRIx#ofOptions. *DELTA* (*VEGA*) is the product of per option delta (vega) with the number of options owned by the CEO. MRI is the ratio of option vega to option delta. LowGrowth is an indicator variable equal to one if the average annual sales growth for a firm's 4 digit NAICS industry is in the lowest year-decile from *t-10*, *t-1*. Customer R&D which is the weighted average of all identifiable customers' R&D Intensity. R&D Intensity is R&D/Total Assets (zero if missing). Log[# of Options] is the natural logarithm of the total number of options held by the CEO. Log[Total Assets] is the natural logarithm of total book assets. Tobin's Q is market value of the firm divided by the book value of the firm. Market Leverage is the book value of debt divided by the market value of the firm. Firm ROA is prior year net income divided by total assets. Sales Volatility is the standard deviation of prior three years' sales intensity. CEO Ownership is percentage of outstanding shares held by the CEO. CEO Tenure is the number of years the CEO has held the position. CEO Turnover Year is a dummy = 1 if it is the year of CEO turnover. Log[CEO Cash Comp] is the natural logarithm of CEO Salary + Bonus. Herfindahl Index is the firm's two-digit NAICS industry concentration. Customer R&D is the weighted average of all identifiable customers' R&D Intensity (weighted by % of total sales). Customer VEGA is the weighted average of all identifiable customers' *VEGA* (weighted by % of sales). Customer Leverage and Customer Sales Growth are similarly defined. Customer weights are not required to sum to one. All variables are winsorized at the 1st and 99th percentile. T-statistics are calculated from robust standard errors clustered by firm and reported in parentheses.

	(1)	(2)	(3)
	Total Annual % Change in MRIx Number of Options, T to t+4	Total B-S Value of Option Grants, t to t+3	Total Number of Options Granted, t to t+3
CustomerRDxLowGrowth, *t-10* to *t-1*	28.37**	56,691.7**	9,345.01***
	(2.23)	(2.23)	(3.21)
Customer R&D	-9.44	-38,626.9*	-1,326.5
	(-1.17)	(-1.84)	(-0.57)
LowGrowth, *t-10* to *t-1*	-0.85***	-1,626.6***	-140.27***
	(-3.04)	(-2.69)	(-2.71)
Firm Characteristics			
Log[Total Assets]	0.06	2,825.4***	214.58***
	(0.56)	(7.87)	(5.94)
Tobin's Q	-0.02	1,086.01***	36.71**
	(-0.27)	(4.04)	(2.22)
Market Leverage	-0.49	-6,036.6***	-371.50***
	(-0.76)	(-4.26)	(-3.34)

	(continued)	**Table VIII**	
Firm ROA	-1.57	4,095.5*	126.65
	(-1.43)	(1.71)	(0.64)
R&D Intensity	-2.19	24,448.5***	2,264.31***
	(-0.88)	(4.52)	(4.30)
Sales Volatility	1.67	1,135.75	293.95*
	(1.46)	(0.78)	(1.69)
Herfindahl Index	-10.06	-8,204.22	727.03
	(-1.44)	(-0.59)	(0.48)
CEO Characteristics			
CEO Ownership	0.004	-6,288.00	-284.94
	(0.00)	(-1.44)	(-0.73)
CEO Tenure	-0.0030	24.0197	1.43
	(-0.18)	(0.64)	(0.50)
CEO Turnover Year	0.1857	689.07	74.88
	(0.50)	(1.04)	(1.25)
Log[CEO Cash Comp]	-0.0241	-525.26	-50.22
	(-0.24)	(-1.05)	(-0.86)
Customer Characteristics			
Customer VEGA	0.8562	552.75	-10.03
	(0.85)	(0.31)	(-0.06)
Customer Leverage	-2.85*	2,372.5	206.58
	(-1.87)	(0.92)	(0.94)
Customer Sales Growth	223.76	857,291.4**	35,719.8
	(1.08)	(2.04)	(1.18)
Constant	1.204	-13,312.7***	-881.19***
	(1.16)	(-4.30)	(-2.71)
Year Fixed Effects	YES	YES	YES
Ind Fixed Effects	NO	NO	NO
Observations	1,656	1,656	1,656
R-squared	0.348	0.029	0.267

Table IX
Robustness: Customer R&D and Alternative Estimators

The table reports alternative constructs of *Customer R&D* by size as well as alternative econometric estimates. We define customers as "Small" ("Large") if the ratio of customer assets to supplier assets is less than (greater than) the year-median. We then create separate weighted average Customer R&D variables for both small and large customers. Small Customer R&D is the dependent variable in the first model, and Large Customer R&D is the dependent variable in the second model. We use the original dependent variable, *Customer R&D*, which is the weighted average of all identifiable customers' R&D Intensity for the third, fourth, and fifth models. These models contain between effects and within effects estimators, and a Tobit estimate, respectively. *R&D Intensity* is R&D/Total Assets (zero if missing). *DELTA* (*VEGA*) is the product of per option delta (vega) with the number of options owned by the CEO. *MRI* the ratio of vega to delta. *Tobin's Q* is the ratio of market value to book value of the firm. *Market Leverage* is the book value of debt divided by the market value of the firm. *Firm ROA* is lagged and is the ratio of net income to total assets. *Sales Volatility* is the standard deviation of prior three years' sales intensity. *CEO Ownership* is percentage of outstanding shares held by the CEO. *CEO Tenure* is the number of years as CEO. *CEO Turnover Year* is a dummy = 1 if it is the year of CEO turnover. *Log[CEO Cash Comp]* is equal to the Log of CEO Salary + Bonus. *Herfindahl Index* is reference firm's industry concentration. *Customer VEGA* (*Leverage*, *Sales Growth*) is the weighted average of all identifiable customers' *VEGA* (Leverage, Sales Growth). All compensation variables are lagged. All variables are winsorized at the 1st and 99th percentile. T-statistics are calculated from robust standard errors clustered by firm and reported in parentheses. The constant term is included but not reported for brevity. The Small Customers, Large Customers, and Tobit specifications include year fixed effects. Number of Gvkeys for the Between and Within Effects estimates are 741 for the specifications with VEGA and 709 for the other specifications.

	Small Customers	Large Customers	Between Effects	Within Effects	Tobit
	Model 1	Model 2	Model 3	Model 4	Model 5
VEGA	-0.0099***	0.0021**	-0.0075	0.0009	-0.0209***
	(-3.67)	(2.15)	(-1.52)	(0.57)	(-3.78)
MRI	-0.0067***	0.0002	-0.0038**	-0.0001	-0.0133***
	(-4.33)	(0.36)	(-2.39)	(-0.16)	(-4.03)
	Control variables included but not displayed				
Year Fixed Effects	YES	YES	N/A	N/A	YES
N observations - VEGA	3428	3428	3428	3428	3428
N observations - MRI	3088	3088	3088	3088	3088

Table X
Summary Statistics for Industry Level Data

DELTA (*VEGA*) is the product of per option delta (vega) with the number of options held. *MRI* is the ratio of *VEGA* to *DELTA*. *R&D Intensity* is R&D/Total Assets (zero if missing). *Log[# of Options]* is the number of options held by the CEO. *Log[Total Assets]* is the natural logarithm of Book Assets. *Tobin's Q* is market value of the firm divided by the book value of the firm. *Market Leverage* is the book value of debt divided by the market value of the firm. *Firm ROA* is prior year net income divided by total assets. *Sales Volatility* is the standard deviation of prior three years' sales intensity. *CEO Ownership* is percentage of outstanding shares held by the CEO. *CEO Tenure* is the number of years the CEO has held the position. *CEO Turnover Yea*r is a dummy = 1 if a turnover occurred in the observation year. *Log[CEO Cash Comp]* is equal to the Log of CEO Salary + Bonus. *Herfindahl Index* is reference firm's industry concentration. *Supplier* and *Customer R&D* is the weighted average of all Supplier and Customer industries' *R&D Intensity* (weighted by % of total sales). *Supplier* and *Customer Q (HI)* is the weighted average of all Supplier and Customer industries' *Tobin's Q* (HI or *Herfindahl Index*). All variables are winsorized at the 1st and 99th percentile.

	Mean	StD	Min	Max	Observations
DELTA (in thousands)	236.0139	418.9971	0	2592.12	8718
VEGA (in thousands)	204.5259	374.7355	0	2362.674	8718
MRI or VEGA/DELTA	0.8524	0.276	0	2.1028	7906
Log[# of Options]	6.3473	1.249	-2.3026	11.3007	8162
Log[Total Assets]	7.0644	1.638	0.0667	13.0814	8710
Tobin's Q	2.3512	1.6241	0.7699	10.1321	8710
Market Leverage	0.165	0.1841	0	0.8419	8707
Firm ROA	0.0246	0.1495	-0.7743	0.2824	8712
R&D Intensity	0.0588	0.075	0	0.4049	8710
Sales Volatility	0.1083	0.1027	0.0053	0.5578	8691
CEO ownership	0.0257	0.0591	0	0.3336	8352
CEO Tenure	7.8618	7.5283	0	57	8718
CEO Turnover year	0.128	0.3341	0	1	8733
CEO Cash Comp	6.7373	1.0012	-6.9078	10.6808	8669
Customer R&D	0.0287	0.0235	0	0.0671	8718
Customer HI	0.1839	0.1136	0	0.6589	8718
Customer Leverage	0.0581	0.0517	0.0002	0.2284	8718
Customer Sales Growth	0.0547	0.03	-0.0113	0.1736	8718
Supplier R&D	0.0065	0.0064	0.0004	0.0331	8718
Supplier HI	0.1009	0.0103	0.0085	0.3675	8718
Supplier Leverage	0.0853	0.042	0.0182	0.2232	8718
Supplier Sales Growth	0.0298	0.0524	-0.0185	0.3689	8718
Herfindahl Index	0.1205	0.0945	0.0109	1	8718

Table XI
Industry level identification of Customer and Supplier R&D Intensity

The table reports OLS estimation where the dependent variable is *Customer R&D* for Model 1 and 3 and *Supplier R&D* for model 2 and 4. *Customer* (*Supplier*) *R&D* is the weighted average of all identifiable customers' (suppliers') *R&D Intensity* (weighted by % of total sales). *R&D Intensity* is R&D/Total Assets (zero if missing). *MRI* is the ratio of *VEGA* to *DELTA*. *Log[# of Options]* is the number of options held by the CEO. *Tobin's Q* is market value of the firm divided by the book value of the firm. *Market Leverage* is the book value of debt divided by the market value of the firm. *Firm ROA* is prior year net income divided by total assets. *Sales Volatility* is the standard deviation of prior three years' sales intensity. CEO Ownership is the percentage of outstanding shares held by the CEO. CEO Tenure is the number of years the CEO has held the position. CEO Turnover Year is a dummy = 1 if it is the year of CEO turnover. *Log[CEO Cash Comp]* is the Log of CEO Salary + Bonus. *Herfindahl Index* is the reference firm's industry concentration. *Customer VEGA (HI, Leverage, Sales Growth*) is the weighted average of all identifiable customers' *VEGA* (*Herfindahl Index, Leverage, Sales Growth*) where the weights are fraction of industry sales. Supplier variables are similarly defined. All compensation variables are lagged. All variables are winsorized at the 1st and 99th percentile. Model 5-8 include only firms with positive R&D. T-statistics are calculated from robust standard errors clustered by firm and reported in parentheses.

	Customer Industry R&D		Supplier Industry R&D		Customer Industry R&D		Supplier Industry R&D	
	All Firms		All Firms		Only R&D Firms		Only R&D Firms	
VEGA	-15.4824***		-1.0517*		-14.0246***		-0.5985	
	(-12.37)		(-1.796)		(-10.88)		(-1.021)	
MRI		-0.0075***		-0.0013***		-0.0085***		-0.0014***
		(-12.858)		(-4.833)		(-12.28)		(-4.578)
DELTA	13.1428***		1.3883**		11.6938***		1.2208**	
	(11.46)		(2.554)		(10.02)		(2.301)	
Ln[# of Options]	0.0001	-0.0001	-0.0000	0.0000	0.0003*	0.0001	-0.0001	0.0000
	(0.37)	(-0.759)	(-0.434)	(0.752)	(1.76)	(0.91)	(-1.126)	(0.351)
Log[Total Assets]	-0.0002	-0.0000	0.0002***	0.0003***	-0.0002	-0.0000	0.0002***	0.0003***
	(-1.52)	(-0.378)	(4.752)	(6.830)	(-1.63)	(-0.29)	(3.183)	(5.790)
Tobin's Q	-0.0010***	-0.0011***	-0.0002***	-0.0002***	-0.0009***	-0.0009***	-0.0002***	-0.0001***
	(-9.94)	(-10.288)	(-4.863)	(-4.497)	(-8.34)	(-8.91)	(-3.995)	(-3.372)
Market Leverage	-0.0036***	-0.0031***	-0.0028***	-0.0028***	-0.0015	-0.0008	-0.0026***	-0.0025***
	(-3.72)	(-3.070)	(-8.074)	(-7.833)	(-1.39)	(-0.73)	(-5.777)	(-5.525)
Firm ROA	0.0113***	0.0133***	0.0008*	0.0011**	0.0100***	0.0118***	0.0010**	0.0014***
	(10.68)	(12.293)	(1.767)	(2.487)	(8.76)	(10.26)	(2.198)	(2.971)
R&D Intensity	0.0302***	0.0260***	0.0103***	0.0095***	0.0114***	0.0065**	0.0093***	0.0084***
	(12.10)	(10.171)	(11.010)	(9.956)	(4.27)	(2.38)	(9.538)	(8.597)

Table XI (Continued)

Sales Volatility	0.0037**	0.0019	0.0030***	0.0028***	0.0078***	0.0057***	0.0037***	0.0033***
	(2.57)	(1.278)	(5.494)	(5.056)	(4.66)	(3.20)	(5.645)	(4.933)
CEO Ownership	-0.0111***	-0.0141***	-0.0022**	-0.0021*	-0.0057	-0.0107**	-0.0024*	-0.0024*
	(-3.32)	(-4.118)	(-2.004)	(-1.865)	(-1.33)	(-2.47)	(-1.808)	(-1.806)
CEO Tenure	0.0001**	0.0000**	-0.0000	-0.0000	0.0000*	0.0000	-0.0000	0.0000
	(2.47)	(2.220)	(-0.367)	(-0.282)	(1.66)	(1.36)	(-0.076)	(0.112)
CEO Turnover Year	0.0009**	0.0006	0.0003*	0.0004**	0.0011**	0.0009*	0.0003	0.0003
	(1.98)	(1.412)	(1.863)	(1.991)	(2.25)	(1.73)	(1.390)	(1.553)
Log[CEO Cash Comp]	-0.0005***	-0.0005***	-0.0003***	-0.0003***	-0.0004***	-0.0004***	-0.0002***	-0.0002***
	(-3.82)	(-3.570)	(-3.195)	(-3.396)	(-3.48)	(-3.03)	(-2.728)	(-3.016)
Herfindahl Index	-0.0117***	-0.0110***	0.0013**	0.0016**	-0.0165***	-0.0149***	0.0034***	0.0035***
	(-8.09)	(-7.617)	(2.087)	(2.429)	(-8.65)	(-7.92)	(3.359)	(3.396)
Customer HI	0.1597***	0.1600***			0.1624***	0.1629***		
	(63.33)	(63.200)			(53.37)	(54.04)		
Customer Leverage	-0.1058***	-0.1023***			-0.0952***	-0.0903***		
	(-27.23)	(-26.538)			(-20.91)	(-20.62)		
Customer Sales Growth	-0.0081	-0.0082			0.0007	-0.0016		
	(-1.02)	(-1.018)			(0.07)	(-0.16)		
Supplier HI			0.1134***	0.1132***			0.1418***	0.1409***
			(34.408)	(33.945)			(46.193)	(45.416)
Supplier Leverage			-0.0250***	-0.0239***			-0.0263***	-0.0249***
			(-10.501)	(-9.655)			(-11.364)	(-10.385)
Supplier Sales Growth			0.0224***	0.0237***			0.0278***	0.0294***
			(8.355)	(8.167)			(10.439)	(10.539)
Constant	0.0122***	0.0186***	-0.0035***	-0.0035***	0.0112***	0.0178***	-0.0062***	-0.0065***
	(8.26)	(12.964)	(-4.949)	(-5.562)	(6.53)	(11.01)	(-7.880)	(-9.538)
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
N observations	7785	7543	7785	7543	6056	5885	6056	5885
R Squared	0.74	0.742	0.469	0.473	0.74	0.75	0.519	0.522