The Effect of CEO's Risk-Taking Incentives on Relationship-Specific Investments by Customers and Suppliers

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Abstract

Customers and suppliers often make relationship-specific investments (RSI) whose value is undermined if the firm undertakes risky investments. We hypothesize that the risk-taking incentives in the compensation of a firm's CEO will be associated with lower RSI by firms up and down in the vertical channel. Our empirical analysis offers significant evidence that customer and supplier RSI declines with the risk-taking incentives of the firm's CEO. Moreover, we find that customer firms are more sensitive to the CEO's risk-taking incentives when these incentives are more likely to increase the firm's cash flow volatility. Our findings are robust to correction for endogeneity, inclusion of a wide array of controls, and different proxies for RSI. By showing significant externalities of CEO compensation, on investments decisions of supplier and customer firms, our results impart a different and important perspective to the debate on executive compensation.

The Effect of CEO's Risk-Taking Incentives on Relationship-Specific Investments by Customers and Suppliers

The risk-taking incentives given to the CEO have received significant attention in the media lately. In particular, the negative effects of excessive risk-taking by financial firms brought to light by the recent financial crisis has prompted the Securities and Exchange Commissioner, Mary Schapiro, to consider requiring firms to disclose "how compensation impacts risk-taking" in their annual proxy statements.[2] The risk-taking incentives of a CEO have been studied in considerable detail in the literature but primarily in the context of how they affect the policies and performance of the firm itself. A CEO's incentives for taking risk can be valuable if they cause a risk-averse CEO to undertake risky but positive NPV projects. Increased risk taking by the firm, however, can be detrimental to the non-financial stakeholders that interact with the firm.

We argue that a CEO's risk-taking incentives should be of considerable concern to the firm's supplier and 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 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 the firm CEO's incentives, in particular the risk-taking incentives.

[2] "Risk vs Executive Reward", by Cari Tuna and Joann S. Lublin in Wall Street Journal June 15, 2009.

There are numerous real examples that illustrate how firms can lose considerable sums of money owing to decisions made by downstream firms. The recent episode involving two firms in the life sciences industry, Eli Lily and Quintiles, provide a good example. Firms in the life sciences industries (e.g., pharmaceuticals) are increasingly focused on core competencies and, as a result, outsource important functions like clinical drug trials to third parties in the vertical channel. These upstream firms invest considerable resources (in the millions of dollars) in setting up and conducting clinical trials that are, by definition, specific to the particular drug that the downstream firm is dveloping. On August 10, 2010 Eli Lily announced that it was "dropping" the pursuit of its Alzheimer's drug which was in Phase III of clinical trials. Eli Lilly's decision adversely affected not only Eli Lilly but also its research contractor Quintiles, who purportedly lost $300m.[3] In addition to the life science industries, examples of RSI range from building specialized plants and/or building them at sites that are close to the firm. For example, in the automobile industry, auto parts maker Getrag Transmission put its unfinished Indiana plant into bankruptcy protection, blaming Chrysler's termination of an exclusive contract.[4]

These examples highlight that customer and supplier firms often invest in relationship-specific assets whose value is higher within the relationship. As the value of these relationship-specific assets depends crucially on the decisions taken by the firm, customers and suppliers are likely to be keenly aware of CEO incentives that may lead to a significant impact on the value of these relationship-specific assets. We propose that if the CEO of a firm has high risk-taking incentives, the firm's supplier and customer firms will be reluctant to invest in relationship-

[3] See http://newsroom.lilly.com/releasedetail.cfm?releaseid=499794 for Eli Lilly's press release announcing the halted development. For a discussion of Quintiles investment, see "Big pharma needs private capital", by Robert Armstrong in the Wall Street Journal, January 26, 2011.

[4] "Getrag Puts Plant in Chapter 11, Blames Chrysler Dispute" By Jeff Bennet, 17th November 2008, Dow Jones News Wire.

specific assets for fear of greater likelihood of losing these investments – the $300 million loss by Quintiles is a stark case in point.[5]

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 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 not only larger but also mitigates some concerns of endogeneity that arise with the study of individual customer firms. Further, industry-level data also allows us to analyze the relation between a firm CEO's risk-taking incentives and supplier RSI.

In the firm-level analysis, we find that RSI by the firm's 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. 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. Further, we find that this negative relation between managerial risk-taking and customer RSI varies by firm characteristics. CEO incentives for risk-taking have

[5] We do not know or claim that Eli Lilly's CEO decision to bring the drug into phase III was "risky"; we simply wish to point out that the loss for the upstream contractor Quintiles was significant. However, we note here that our measure of risk-taking incentives for Eli Lilly's CEO is in the 90th percentile of our sample.

a greater impact on the riskiness of investments and cash flows in firms undertaking relatively larger R&D investments and/or capital expenditures. Consistent with this, we find that customers of firms with greater R&D and capital expenditures tend to reduce their RSI more in the presence of greater CEO incentives for risk-taking. We also find that customers of firms where RSI is likely to be important, such as manufacturing and focused firms, are more sensitive to managerial risk taking.

An alternative explanation for the observed negative association between risk-taking and customer RSI may be that unobserved firm characteristics associated with high managerial risk-taking incentives are also related to lower customer RSI. To control for this potential endogeneity, we identify two instruments for managerial risk taking and estimate a two stage least squares model and show that our results hold – we continue to find a significant negative relation between managerial risk taking and customer RSI.

It is also likely that, if customers respond to managerial risk-taking incentives by reducing their RSI, then a firm's board of directors would take this aspect into account when deciding on the structure of CEO compensation. In other words, managerial risk-taking incentives and customer RSI are likely to be jointly determined. We test this possibility by estimating a simultaneous equation model that treats customer RSI and risk-taking incentives as being endogenous and jointly determined. The results from estimating the simultaneous equation model indicate that managerial risk-taking negatively effects customer RSI. The evidence for customer RSI affecting on CEO compensation is, however, mixed – it negative but not always statistically significant.

We use several measures to capture the RSI by a firm's customers and suppliers. First, consistent with a large empirical literature in transactions cost economics (see Boerner and

Macher (2001) for a recent review of this literature), we use a firm's R&D intensity as a proxy for RSI. The use of R&D intensity as a proxy for RSI is also supported by Levy (1985) who posits that research-intensive industries have specialized inputs and require transaction-specific investments by suppliers. Allen and Philips (2000) also argue that research-intensive industries are more likely to create relationship-specific assets. In addition, Armour and Teece (1980) argue that vertical chains that are R&D-intensive are likely to have complex inter stage interdependencies that lead to higher RSI.

Since the R&D by all firms is not likely to be relationship-specific, we next use the NBER data on patent citation to isolate the firm whose R&D that is likely to be relationship-specific. For our second RSI measure, we include the R&D of customer and suppliers only if the patents of customers and suppliers cite patents of the firm or 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)) and, 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 associated with RSI (Titman and Wessels (1988)). Despite using such significantly different measures to proxy for RSI, we consistently obtain the result that customer firm RSI decreases as the risk-taking incentives of the upstream firm increase.

We also use several measures of managerial risk taking. Consistent with the extant literature, we use 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 in our sample is very large (0.94) and highly significant, we constrcut 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. 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). 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 options, which captures risk-taking incentives from stock grants as well as stock ownership. Our results are qualitatively similar for all measures of the risk taking incentives.

Our paper is among the first to find that a firm's compensation policy has important implications for entities outside the firm. An exception is Aggarwal and Samwick (1999) that examines the role of CEO delta incentives in mitigating 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.

The rest of the paper is organized as follows. Section II reviews the literature, Section III describes the data, and Section IV lays out the basic analysis, controls for different types of

endogeneity, and examines cross sectional differences in the impact of *MRI* and alternate proxies for relationship specific investment. Section V includes robustness tests and examines simultaneity. Section VI discusses industry level analysis and finally Section VII concludes.

II. Literature Review

Our paper is related to two strands of the literature. The first consists of the body of work that studies RSI. The issues associated with the existence of RSI and asset specificity have been the subject of extensive work (See Williamson (1975, 1978), Crawford and Alchian (1978) and Hart and Moore (1990) among others). The effect of RSI on financial policy has been studied in the context of capital structure decisions in theory papers (e.g., Haugen and Senbet (1978, 1988), Titman (1984) and Maksimovic and Titman (1991)) and, more recently, Kale and Shahrur (2007) empirically find a negative association between the customer/supplier RSI and firm leverage. The presence of RSI has also been shown to impact earnings management and trade credit policies – Raman and Shahrur (2008) show that firms manage earnings opportunistically to manipulate the perceptions of suppliers and customers to ensure their RSI, and Dass, Kale, and Nanda (2011) present a theoretical framework (and empirical evidence) in which trade credit arises as the mechanism used by upstream firms to commit to optimal levels of RSI. 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.

Secondly, our paper relates to the large literature on executive compensation that documents significant effects of pay for performance or "delta" incentives on firm decisions. For example, these delta incentives have been shown to have significant effects on takeover premiums paid to target shareholders in acquisitions (see Hartzell, Ofek and Yermack (2004)), earnings management (Bergstresser and Philippon (2006), and Burns and Kedia (2006)), or firm

investment policy (Benmelech, Kandel and Veronesi (2008)). Consistent with this research, we estimate (as in Yermack (1995), Core and Guay (1999), and Mehran (1995)) and control for a CEO's "delta" incentives in our analysis.

A 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 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.

Though it is clear from existing literature that CEO compensation has a significant effect on a host of firm decisions, it is less clear if it has any effect at all outside the firm. Aggarwal and Samwick (1999) are among the first to examine potential externalities from CEO compensation when they study its role in softening product market competition among rivals in competitive industries. We contribute to this literature by showing that CEO compensation significantly impacts the behavior of customers and suppliers. Moreover, as this effect takes the form of reduced investment in the vertical channel it is likely to impact firm value over the long term.

The literature discussed above takes CEO risk-taking incentives as given, but these incentives they are determined in equilibrium depending on firm characteristics. The theoretical framework in Edmans and Gabaix (2010), for example, predicts 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 *MRI* 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. We examine this possibility by estimating the firm CEO's MRI and customer firm's RSI jointly and discuss the results in Section 5.

III. Data and Sample Description

We exclude utilities and financial firms (SIC codes between 4900 and 4999, and 6000 and 6999, respectively) from the firms covered in Execucomp over the 1994 to 2006 period, which yields a sample of 17,661 firm-years. 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. As the industry segment files identify customers by names, we match these names to *GVKEY* and other identifiers.[6] We are able to find a customer firm for 4,224 firm years in our Execucomp sample. Our sample size is comparable to the 9,452 firm-

[6] 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).

years with identifiable customer firms in *all* of Compustat over a 20-year period reported in Kale and Shahrur (2007). Since we also need compensation data for each customer firm, we lose observations where the customer firm is not covered under Execucomp, which leaves us with a sample of 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 incentives for increased risk-taking by the CEO. The option delta (per option) is the partial derivative of the option value with respect to stock price. We use the Black–Scholes model adjusted for dividend payouts (Black and Scholes, 1973; Merton, 1973) to value the options.[7] We obtain the "moneyness" of previously granted options by finding the realizable value of previously granted options (the difference between the realizable value of all options less the realizable value of current options), and then divide it by the number of previously granted options. We estimate the exercise prices of previously granted options by subtracting this calculated moneyness from the current 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, referred to as *Delta*, is the product of the above estimated per-option delta with the number of options owned by the CEO. This measure, used by Core and Guay (2002), captures the change in

[7] 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.

the value of the options held by the CEO for a 1% change in stock price. We repeat our analysis with an alternate measure, which is the product of the per option delta with the ratio of the number of options owned by the CEO to the number of shares outstanding in the firm. This alternate measure was used by Jensen and Murphy (1990) and Yermack (1995) and 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 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.

As seen in Table I, the average *Delta* is $201,540, implying that the value of CEO options changes by $201,540 for every 1% change in stock price, and the mean value of *Vega* is $171,469, which implies that the value of CEO options changes by $171,469 for a 0.01 increase in the standard deviation of the firm's stock returns. Table II presents correlations between selected compensation variables. We note that the correlation between *Delta* and *Vega* is 0.94 and highly significant. In view of this high correlation, we construct another variable to capture the firm CEO's risk-taking incentives. This variable is the ratio of *Vega* to *Delta* and we denote this measure of the managerial risk-taking incentives as *MRI*.

Our measure of risk-taking, *MRI*, has been explored recently by Dittmann and Yu (2010), who model the endogeneity between risk and effort incentives and emphasize 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.[8] Therefore, we use *MRI* as our measure to capture the risk-taking incentives provided to the CEO. The higher is the value of MRI the greater are the incentives provided for risk taking. The mean value of *MRI* is 0.844 and its correlation with *Delta* and *Vega* is low (See Table II).

Since the variable *MRI* is a ratio, it is independent of the level of the CEO's otion 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. The mean value of *Total Comp MRI* is 0.53 and its correlation with *Delta* and *Vega* is also low (Table II).

B. Customer RSI and other characteristics

As discussed above, 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. For firms with multiple customers, we use the percentage of the firm's sales to these customers as weights to construct customer level variables. Note that because firms generally do not report all customers, the weights are not required to sum to one for each firm-year.[9] We then construct the weighted

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

[9] The results do not change if we change these 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.

average R&D of all customer firms where the weight is customer share in firm sales as defined above. This construction is similar to Kale and Shahrur (2007) and uses the ratio of R&D to total assets to capture *Customer R&D*. 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 *MRI*, 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*, and firm profitability as proxied by *Firm ROA*. We also control for the firm's research intensity by the ratio of R&D expenses to total assets (*R&D Intensity)* to control for high research intensity of the vertical channel. The higher is the investment in research by the firm, the more likely are customers to increase their RSI. We also include *Sales Volatility*, as this might be associated with greater distress and therefore lower RSI, and the firm's own two digit industry *Herfindahl Index* to control for own-industry competition.

Lastly, we control for characteristics of the customer that might impact its research intensity. Customer research intensity will be affected by the incentives given to its own CEO. In particular, if the CEO of the customer firm holds options with high vega, then this CEO has the

incentive to increase the riskiness of firm cash flows, which are likely to affect the customer firm's research intensity. We also control for customer leverage and customer sales growth. When the firm has multiple customers, we use the process described above for the firm to construct weighted average values of *Customer Leverage*, *Customer Vega*, and *Customer Sales Growth* for each firm-year.

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

The Compustat industry segment files provide the identities of key customer firms and, therefore, enable us to analyze the effects of the risk-taking incentives of a firm's CEO on the RSI levels of its customer firms. Identities of a firm's supplier firms are not available and, therefore, we are not able to study supplier RSI at the firm level.[10] However, in a later section, we examine the effect of a firm's *MRI* on its customers and suppliers at the industry level.

A. Firm-Level Determinants of Customer RSI

We first estimate OLS specifications where we regress customer firm RSI on the various measure of risk taking and present the results in Table III. We begin with the incentive measures used in the existing literature, namely, the CEO's *Delta* and *Vega*. As higher delta incentives align CEO incentives with those of shareholders, they are likely to be associated with-value enhancing firm decisions. Consequently, they should be associated with greater RSI from customers. As vega incentives are associated with increased risk taking, therefore, we hypothesize that they should be associated with lower customer RSI. As seen in Model 1, the coefficient of *Delta* is positive and that of *Vega* is negative. The coefficient on *Vega* is negative

[10] Firms do not directly report names of suppliers, but some suppliers can be inferred by inverting the dataset. However, since firms report only major customers we are able to identify only small suppliers of large firms through this inversion. Therefore, we do not study suppliers at the firm level but construct an industry-level dataset, discussed later in the paper, to examine the effect on supplier RSI.

and significantly different from zero (coefficient = -0.0073, t-value = -2.57), which is consistent with our hypothesis that if the firm is likely to take risks, 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). This finding is consistent with our primary hypothesis that the larger are the managerial risk-taking incentives the smaller is the customer firm's investment in relationship-specific assets. The effect of *MRI* on customer RSI is also economically significant. We find that a one standard deviation increase in *MRI* is associated with a 27% decrease in *Customer R&D*.

Though we have included number of options as a control, to further control for the level of incentives we create a third measure which is the product of *MRI* and the number of options held by the CEO. 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. 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 arising from stock ownership and from stock options and is computed as the ratio of total compensation delta to total compensation Vega. The coefficient on *Total Comp MRI* is also significantly negative. Models 5 to 8 in Table III 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, we report all results without industry fixed effects so that results are comparable across the paper.

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 some unobservable firm characteristics are associated with high firm risk taking incentive and low customer RSI, which might account for the observed negative association between customer RSI and firm risk taking incentives.

To test and control for this potential endogeneity we estimate a two-stage least squares (2SLS) model by identifying instruments for *Vega* (*MRI)* that are likely to be correlated with *Vega* (*MRI)* but not with the error term in the 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 SIC 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)*. The industry year *Vega* (*MRI)* should not be 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 decreases *Vega*, which 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. 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.

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 IV. 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 correlated 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.[11]

[11] 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.

When we use the other two measuress of risk taking incentives, *MRI x Number of Options* and *Total Comp MRI* the Hausman test is, however, significant suggesting endogeneity. 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.

C. Firm MRI and Customer RSI: Cross Sectional Differences

Results in the previous section suggest that when the CEO's risk-taking incentives are large, customers reduce RSI. However, a CEO's ability to change the riskiness of the firm's cash flows will also vary by firm characteristics. As a result, we should see a "stronger" negative relation between customer RSI and firm risk-taking incentives when the CEO is in a better position to alter the firm risk. We now examine and compare the strength of the relation between risk-taking incentives and customer RSI for various 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 of investment can have a significant impact on the riskiness of the cash flows through their investment decisions. Therefore, the customers of high-investment firms are likely to be more sensitive to the firm CEO's risk-taking incentives. We test this prediction by examining whether customers of firms with large investments are more likely to reduce their RSI when the firm's CEO has greater 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 illustrate the differential impact of risk taking incentives on customer RSI for the two groups, high- and low-*CAPEX* firms, we implement the following procedure. 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 interact each independent variable with the *High-CAPEX* dummy and include these interaction terms in addition to the independent variables in the regression. The coefficients for the non-interacted independent variables in this specification capture the impact for the low *CAPEX* group (the dummy is zero and, therefore, so are the interaction terms). Then we repeat the above 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. The coefficients on the interactions term capture the difference between the low- and high-*CAPEX* groups.

The above procedure is an efficient way to estimate the impact of risk-taking incentives on customer RSI separately for the two subgroups, i.e., that with high and low capital expenditures. As this estimation allows the impact of all other independent variables to vary for the two subgroups, it dominates the estimation where only the variables of interest, in this case ris- taking incentives, are interacted with the subgroup dummy, and all other independent variables are assumed to have the same impact across the subgroups

We report the findings from the above analysis comparing low- and high-*CAPEX* firms in Panel A of Table V. For space reasons, we report the results for only the two 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. 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. As seen in panel B of Table V, both *Vega* and *MRI* have a greater negative impact on customer RSI for firms with positive R&D; and this negative effect is significantly higher for firms with R&D relative to those 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 *MRI* on customer RSI for the subsample of firms in manufacturing industries. We estimate the relation of RSI with risk-taking for firms in manufacturing (two digit SIC 20 to 39) and non-manufacturing industries. Consistent with our hypothesis, the results in Panel C of Table V 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 sales *Herfindahl Index* is in the top tercile of all firms in the sample and present findings for the two subsamples in Panel D of Table V. 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.

Lastly, we examine the difference between high and low *Tobin's Q* firms. As high Q firms have more growth options, risk taking incentives should be associated with a greater impact of risk taking incentives on customer RSI. As seen in Panel F of Table V, though high-Q firms exhibit a more negative effect, this effect is not significantly different from that for low-Q firms. One possibility is that High-Q firms have positive NPV projects that increase firm value and, as a result, the firm is less likely to enter financial distress. Up- and downstream firms may, therefore, be less concerned about losing their RSI. As a result, there is no significant difference on the MRI coefficient for High- and Low-Q firms.

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.

D. Alternate RSI Measures and Risk Taking Incentives

In this section, we examine the robustness of the negative relation between risk-taking incentives and customer RSI for alternative measures for RSI. Our measure of customer RSI has been customer R&D intensity. However, the R&D investment undertaken by all customer firms is not likely to be relationship specific. We determine which customer firms' R&D is more likely to be relationship specific by patterns in cross-citation of patents. 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, Tratjtenberf 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.[12] 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.

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

We then merge this citing/cited data to the firms and customers in our dataset from Compustat Segment Tapes.

We use the citation data to identify customers that cite the firm or customers that are cited by the firm in its patents over the past five years. 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 representative of RSI. We then construct a sales-weighted average of R&D across these "cited/ citing" customers. We report the findings from using this proxy for RSI in column one of Table VI. The coefficient of both *Vega* and *MRI* are negative and highly 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 VI show little evidence that risk-taking incentives are related to customer R&D for firm-customer pairs with no cross-citation of patents. More specifically, the coefficient of *Vega* is not significant in either specification, while that of *MRI* is significant in column 3 but becomes insignificant after the inclusion of industry 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.[13]

[13] Joint Ventures between firms and customers may also proxy for the existence of relationship-specific assets. Joint ventures are very large commitments and are likely to be rare, and we find too few incidences of joint ventures between our sample firms over this time period to use this as a measure of RSI.

Next, we explore an entirely different proxy for relationship specific investments, i.e., 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 displayed in column five of Table VI. 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 firm RSI relates negatively to risk-taking incentives of the CEO of the upstream firm.

V. Other Robustness Checks, and Simultaneity

In this section, we first present findings from estimating the relation between customer RSI and risk-taking incentives separately for large and small customers. We then examine whether the effects on customer RSI are due to cross-sectional or time-series variations in risk taking incentives. Next, we show that our results obtain when we estimate a Tobit rather than the OLS specification used in the earlier sections. Finally, we control for the possibility that firms take into account the negative effect of CEO risk-taking incentives on customer RSI levels and use this association in determining the compensation of the CEO.

A. Small vs. Large Customers, Between-Effects, Firm Fixed Effects, and Tobit Specifications

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 VII. 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 VII, 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 and from the results in the last column of Table VII and find that this modification has no material impact on our results.

B. Are MRI and RSI Jointly Determined?

Thus far, we have examined how a customer firm responds to risk-taking incentives in the supplier firm. However, it is likely that if RSI by the customer firms is critical to the long-term growth of the firm, then 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 VIII, 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.

VI. Industry Level Identification of Customers and Suppliers

Given that we have firm-level data only for customers, we have restricted our analysis to examining the relation between a firm's risk-taking incentives and the level of RSI by customer firms. Since supplier firms cannot be identified from Compustat, we next 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 customer's industry to create customer-level variables and, similarly, use all firms in the supplier industry to create supplier-level variables. Since our customer and supplier R&D intensity is at the industry level rather than firm

level, it also likely mitigates 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 IX. The average *Delta* and *Vega* are similar to the firm level dataset, but 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 X. The first two columns present the findings for customer industry RSI and columns three and four the findings for and 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.

VII. 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	0.03	1.00	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
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 IV (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 V
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)
Panel F: Differences between High and Low Q Firms		
High Q	-0.0066	-0.0076***
Low Q	-0.0074**	-0.0062***
Difference	0.0008	-0.0014
t-stat	(0.15)	(-0.43)

Table VI
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 VII
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 VIII
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 Log[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)	
Customer Ln[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 VIII (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 IX
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 X
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)

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