# Board composition and contracting frictions: Evidence on suppliers and customers

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## Abstract

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JEL Classification: G34; L14

Keywords: Relationship-specific investment; board composition; contracting friction; supplier; customer; information asymmetry; financial distress.

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## **1. Introduction**

A firm's transactions with suppliers and customers are often governed by incomplete contracts. As a consequence, the outcomes from such transactions depend on governance mechanisms that mitigate incentive problems between firms and their suppliers/customers. While the literature highlights the role of mechanisms such as vertical integration, equity ownership, and long-term contracts in alleviating conflicts of interest along the supply chain, much less is understood about the contribution of another prominent governance mechanism, the board of directors, in enabling firms and their non-financial stakeholders to overcome potential conflicts due to incomplete contracts.<sup>2</sup> In this study, we examine the association between the firm's choice to include a supplier/customer on the board and the extent to which contracting frictions are likely to permeate the relationship.<sup>3</sup>

We capture variation in contracting frictions along the supply chain using the level of relationship-specific investment undertaken by the supplier/customer, given that such investments are uniquely tied to the relationship and hence are exposed to risks arising from incomplete contracts (Williamson, 1975). Fee, Hadlock, and Thomas (2006) is one of the earliest studies to recognize the importance of board directorships in alleviating contracting frictions between customers and suppliers. While the focus of their study is on equity ownership stakes, Fee et al. find that buyers are more likely to serve on the boards of suppliers in relationships where buyers hold equity stakes in the suppliers. More recently, Dass, Kini, Nanda, Onal, and Wang (2013) find that a firm appoints suppliers or customers as directors in

<sup>&</sup>lt;sup>2</sup> For instance, see Williamson, 1975; Grossman and Hart, 1986; Joskow (1987); Hart, 1988; Hart and Moore, 1990; Dasgupta and Tao, 2000; Baiman and Rajan, 2002b; and Fee, Hadlock, and Thomas, 2006.

<sup>&</sup>lt;sup>3</sup> Throughout the paper, we state that a customer (supplier) serves on the firm's board if an officer/director of the customer (supplier) serves on the firm's board.

order to mitigate its *own* information challenges by obtaining information about industry conditions and trends from these related industry directors.

While the insights in prior research help us understand the firm's motives to appoint supply chain partners to its board, important questions from a stakeholder's perspective remain unanswered. First, given that multiple suppliers may exist in a given industry, what factors determine the inclusion of a specific supplier on the firm's board? Second, how does the supplier benefit from inclusion on the board and from providing valuable information to the firm? Third, what factors determine the inclusion of a specific customer on the firm's board and how does the customer benefit from inclusion in the board? We address these questions by focusing on decisions by suppliers and customers to invest in relationship-specific assets. As the decision to invest in relationship-specific assets and inclusion on the firm's board are likely to be jointly endogenous, our identification strategy is to use instrumental variables with two-stage probit least squares estimation, following the approach outlined in Maddala (1983).

In our sample, about 5 percent of the firms include a customer on the board and about 4 percent of firms include a supplier on the board. These frequencies are comparable but higher than those reported in Dass, et al. (2013), who find that about 1.2 percent of firms in their sample appoint an actual supplier/customer as a director. As a comparison, Fee, et al. (2006) report that equity ownership stakes by buyers are observed in 3.31 percent of their sample, and alliance agreements represent about 5.09 percent of their sample. Notwithstanding these relatively small frequencies, examining the role of interlocked boards in supply chain relationships is important as it provides insight into a potential mechanism through which to alleviate contracting frictions.

The literature suggests that including a supply chain partner on the board could adversely impact the firm during negotiations because sharing proprietary information increases the risk that the supplier/customer could misappropriate the information by behaving opportunistically (Baiman and Rajan, 2002a; Drake and Haka, 2008). Moreover, the disclosure of proprietary information jeopardizes the firm's competitive position because the information could be revealed to the firm's rivals either directly by the supply chain partner or could be inferred by the rivals through the actions of the supplier/customer (Li, 2002; Zhang, 2002; Li and Zhang, 2008). As these costs of including a supplier/customer on the board are likely to increase with the size of the relationship-specific investment, we propose the *stakeholder exclusion hypothesis* as follows: a firm is less likely to include a supplier/customer on the board if the supplier/customer invests more in relationship-specific assets.

On the other hand, including a supply chain partner on the board could enable the firm to exchange detailed information and mitigate the information asymmetry faced by the partner (Schoorman, et al., 1981; Haunschild and Beckman, 1998; Gulati and Westphal, 1999; Dass, et al., 2013). As a consequence, the supply chain partner is likely to avoid underinvestment in relationship-specific assets, which in turn increases the surplus available to be shared by the firm and the supply chain partner. Furthermore, repeated boardroom interactions between the firm and the supplier/customer could build greater trust between the transacting parties, promote inter-firm cooperation, and create an informal (relational) contract that limits opportunistic behavior by either party (Gulati, 1995; Baker, Gibbons, and Murphy, 2002). As the benefits are likely to increase with the size of relationship-specific investments, we propose the *stakeholder inclusion hypothesis* as follows: a firm is more likely to include a supplier/customer on the board if the supplier/customer invests more in relationship-specific assets.

We empirically test these two-sided hypotheses using a large sample of publicly traded U.S. firms during the period 2001 to 2009. Following the literature, we use the supplier's (or

customer's) R&D intensity and Advertising intensity as alternate empirical proxies to capture environments in which relationship-specific investments are likely to be prevalent. As described later, we also conduct additional tests to verify the robustness of our conclusions.

Controlling for the firm's own level of R&D intensity (or Advertising intensity) and for other economic factors identified in the literature, we find that firms are more likely to include a supplier on their board if the level of R&D intensity (or Advertising intensity) by the supplier is higher. We also find these results for the firm's customer. In addition, we find that suppliers (or customers) invest more in relationship-specific assets if they are more likely to serve on the firm's board. Collectively, these findings support the *stakeholder inclusion hypothesis*, and suggest that firms design the composition of their boards by taking into account the incentives of their supply chain partners to invest in relationship-specific assets.

While R&D and advertising intensities have been used in the literature to estimate the presence of relationship-specific investments, we conduct additional tests to verify the robustness of our conclusions. We find that the results are more pronounced in sub-samples where (a) the firm and its supplier/customer have a larger number of citations of each other's patents, and (b) the customer (supplier) faces a high concentration of suppliers (customers). Given that these sub-samples are likely to capture environments where investments by suppliers and customers are more likely to be relationship-specific and where contracting frictions could arise, the findings suggest that interlocking directorships play an important role in alleviating potential conflicts between firms and their supply chain partners. Furthermore, the results are robust in a sub-sample where the firm itself does not invest in relationship-specific assets, it still benefits from the inclusion of a supply chain partner on the board because the directorship enhances the

partner's incentive to undertake relationship-specific investments, which creates a surplus for both the firm and the partner.

Additionally, the positive relation between the likelihood of a supplier/customer serving on the firm's board and the size of relationship-specific investments undertaken by the supplier/customer is more pronounced if the firm: (i) is characterized by poorer financial reporting quality, (ii) has wider bid-ask spreads, and (iii) is in a different industry from that of the supplier/customer. These findings suggest that one benefit of including a stakeholder on the board is to reduce information asymmetry for the stakeholder, and thereby enhance the stakeholder's incentive to invest in relationship-specific assets.

Furthermore, controlling for the level of information asymmetry, we find that the positive relation between the inclusion of a supply chain partner on the board and the level of relationship-specific investment by the partner is more pronounced if the firm is more financially distressed. Given that the incentive to behave opportunistically is likely to increase with the degree of financial distress, as suggested by Titman (1984) and others, this finding suggests that including a supply chain partner on the firm's board builds trust and strengthens the informal relational contract between the firm and its partner, and thereby mitigates the firm's incentive to engage in opportunistic behavior particularly in situations where the firm may have few incentives to invest in reputation.

The results are robust with respect to (i) the use of alternate measures of relationshipspecific investments (R&D intensity and Advertising intensity), (ii) excluding zero R&D firms from the analysis, and controlling for outside board relationships between the firm and its supplier/customer.

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Our study contributes to different strands of literatures. The literature on transactions cost economics identifies mechanisms such as vertical integration, equity ownership, and the choice of capital structure to mitigate the potentially adverse consequences of contracting frictions between firms and their non-financial stakeholders (e.g., Fee, Hadlock, and Thomas, 2006; Kale and Shahrur, 2007). At the same time, prior research on boards identifies various economic factors that determine firms' choice of board composition (e.g., Hermalin and Weisbach, 1988; Linck, Netter, and Yang, 2008; Coles, Daniel, and Naveen, 2008). Our study brings together these two strands of research by recognizing the role of board composition in improving information flow along the supply chain, and thereby alleviating the uncertainties associated with relationship-specific investments. In doing so, our results identify relationshipspecific investments by the firm's suppliers/customers as an important determinant of the firm's board structure and thus adds to the insights in Dass, et al. (2013). Our study also adds new insight to a vast stream of research on interlocked boards (e.g., Haunschild, 1993; Haunschild and Beckman, 1998; Gulati and Westphal, 1999). While these studies shed light on the role of interlocked boards in information transfers across firms, we specifically focus on investment decisions by firms along the supply chain and find that board interlocks between supply chain partners play a valuable role in mitigating contracting frictions by enhancing the incentives of suppliers and customers to invest in relationship-specific assets.

The rest of the paper is structured as follows. We develop the hypotheses and discuss related literature in Section 2. We describe the sample formation and key variables in Section 3. In Section 4, we discuss the two-stage research design. Section 5 presents a discussion of the empirical results, including the findings from robustness checks. Section 6 concludes the study.

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#### 2. Hypotheses

In a market with complete contracts, there is no uncertainty about the terms of transactions because future states of the world are known with certainty and hence future outcomes can be fully described and incorporated into the contract (Fudenberg and Tirole, 1990; Tirole, 1999). However, in product markets with incomplete contracts (where the outcomes are not perfectly describable ex-ante, and hence are not contractible), firms have incentives to behave opportunistically and expropriate rents from their supply chain partners because the value of relationship-specific investments undertaken by suppliers/customers is lower outside the relationship (Williamson 1975).

The ability to access information about the firm affects the ex-ante incentives of its supply chain partners to invest in relationship-specific assets because the ex-post share of surplus (from the investment) gained by stakeholders depends on their relative bargaining power in negotiations with the firm (Grossman and Hart, 1986; Hart, 1988; Hart and Moore, 1990; Baiman and Rajan, 2002b). Given that interlocked boards facilitate the transfer of information from one firm to another, we propose that the firm's decision to include a supply chain partner on its board depends on the tradeoff between the adverse consequences of revealing proprietary information to the supply chain partner versus the benefits of sharing information and facilitating relationship-specific investments. In this section, we present a two-sided hypothesis relating the likelihood of a firm including a supplier/customer on its board and the level of relationship-specific investments undertaken by the supplier/customer.

### 2.1. Stakeholder exclusion hypothesis

Baiman and Rajan (2002a) suggest that a firm puts itself at a competitive disadvantage by providing information to its supply chain partner because the partner could misappropriate the information. In particular, the firm could potentially lose a share of the surplus generated from relationship-specific investments as the proprietary information revealed by the firm increases the relative bargaining power of the supplier/customer. The drawback of including a supply chain partner on the board is especially pronounced in environments where firms exchange complicated, technical, and proprietary information (e.g., information regarding R&D) because the adverse consequences of information misappropriation by the partner cannot be specified ahead of time and hence are not contractible ex-ante. Consistent with this view, Drake and Haka (2008) find that buyers and suppliers are less likely to share fine, detailed information (such as activity based costing information) with each other because of the risk that the information revealed could lead to an inequitable outcome for the provider of the information.

Moreover, a firm risks losing its competitive position in the industry by sharing information along the supply chain because of two possible effects (Li, 2002; Zhang, 2002; Li and Zhang, 2008). First, a supplier/customer receiving the proprietary information could change its strategy in its dealings with the firm. Second, proprietary information could be leaked indirectly to the firm's competitors as they could infer the information from the actions of the firm's partner. Given the technical nature of the information generally associated with relationship-specific investments (Armour and Teece, 1980), firms face potentially high costs by including a supplier/customer on their boards and thereby revealing proprietary information to their stakeholder. As the potential costs of revealing information increase with the size of the relationship-specific investment, we propose the *stakeholder exclusion hypothesis* as follows:

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H1: A firm is less likely to include a supplier/customer on its board if the supplier/customer invests more in relationship-specific assets.

#### 2.2. Stakeholder inclusion hypothesis

A board directorship has at least three consequences that contribute positively to the supplier/customer's incentive to invest. First, boardroom networks between the firm and its stakeholder reduce information asymmetry through the sharing of information, and thereby lead to more efficient contracting between the two parties (Schoorman et al., 1981; Larcker, So, and Wang, 2013). In addition, a vast literature on interlocked boards suggests that director interlocks are an important source of information transfer between firms (Davis, 1991; Haunschild, 1993, 1994; Mizruchi, 1996; Haunschild and Beckman, 1998; Gulati, 1998; Gulati and Westphal, 1999; Dass, et al., 2013). Given the high degree of uncertainty surrounding the outcomes from relationship-specific investments, the exchange of information through a seat on the firm's board could reduce information asymmetry faced by the supplier/customer, and thereby mitigate the risk associated with the relationship-specific investment.

Second, access to information through a directorship increases the supplier/customer's relative bargaining power in negotiations with the firm. The increase in relative bargaining power results in a higher expected share of the surplus from relationship-specific investments, and thereby increases the supplier/customer's incentive to invest in such assets (Grossman and Hart, 1986). The firm has an incentive to provide additional bargaining power to the stakeholder in order to promote investment in relationship-specific assets (Baiman and Rajan, 2002b).

Third, by having a seat on the firm's board, the supplier/customer is likely to have repeated interactions with the firm's inside directors. One consequence of such repeated interactions is the potential for the firm and its supply chain partner to build trust in each other (Gulati, 1995). In a similar vein, theories of board interlocks suggest that interlocks promote inter-firm cooperation (Koenig, Gogel, and Sonquist, 1979; Burt, 1983). Moreover, repeated boardroom interactions between the firm and its supplier/customer could strengthen the informal (relational) contract between the parties and thereby limit opportunistic behavior by either party (Baker, Gibbons, and Murphy, 2002). Thus, by enhancing the likelihood of cooperation, a board seat mitigates the supplier/customer's vulnerability to losses from expropriation, and hence improves its incentive to invest in relationship-specific assets.

As the benefits of having a supplier/customer on the board increase with the size of the relationship-specific investment, we could expect a positive relation between the likelihood of the firm including the supplier/customer on the board and the level of relationship-specific investments by the supplier/customer. Accordingly, we propose the following hypothesis:

H2: A firm is more likely to include a supplier/customer on its board if the supplier/customer invests more in relationship-specific assets.

## 3. Sample and key variables

In this study, we identify the firm's actual suppliers or customers as opposed to the overall industry to which the suppliers or customers belong for two reasons. First, our objective is to explain why a firm chooses to include a specific supplier or a specific customer on the board. Second, we are interested in understanding the specific benefit to an individual supplier

or customer from serving on the firm's board. Thus, our research design is structured to examine how a given supplier's (or customer's) decision to invest in relationship-specific assets is associated with the same supplier's (or customer's) inclusion on the firm's board.

#### 3.1. Sample construction

To build our customer-supplier relationship database, we start with all firms covered by the Compustat Customer file in the Compustat Segment Database from 2001 to 2009. We focus on this period because it coincides with the time period for which data is available in the BoardEx dataset. In accordance with FASB Accounting Standards Codification, ASC 280-10-50-42, public firms may disclose the identity of any customer whose purchases represent more than ten percent of the firm's total revenues, although they are not mandated to disclose the identity of such customers.<sup>4</sup> The procedure we follow to identify the customer firms is similar to that used in Fee and Thomas (2004) and Raman and Shahrur (2008) and is described in detail in the appendix. To assemble the data required for our study, we first identify 5,962 unique supplier-customer relationships and 15,006 firm-year observations between 2001 and 2009 where both the supplier and customer have a GVKEY and are listed in Compustat.

In the next step, we use BoardEx data to determine whether the executives or directors of the customer have a seat on the supplier's board, and vice versa. Thus, for an observation to remain in our final sample, both the customer and supplier have to be covered in BoardEx for a given year. This requirement results in 5,516 customer-supplier-year observations and 1,733 unique customer supplier relationships.

Table 1 shows the breakout of our sample. In Panel A, we show the yearly breakout of customer-supplier pairs with both Boardex and Compustat data. Panel B shows the breakdown

<sup>&</sup>lt;sup>4</sup> Previously known to as SFAS 131, the statement of ASC 280-10-50-42 is reproduced in the Appendix.

of industries using the Fama French 12 industry classification (note that we use the Fama French 49 industries as actual controls in our analysis, but report FF12 for brevity). Over 36% of our customer companies are in the retail sector (FF Industry 9), followed by 20% in business equipment industry (FF Industry 6). We also find that 30% of the suppliers are in the business equipment industry, followed by 14% in the healthcare industry.

Descriptive statistics on firm- and industry-characteristics used in our tests are provided in Table 2, Panel A; their definitions are provided in Appendix B. Consistent with the literature, we find that the customers in our sample are substantially larger and older than the suppliers, and have higher leverage, ROA and sales growth. The suppliers have higher cash ratios, returns and riskiness of returns, and are reliant on the customers for sales (mean *CSALE ratio* of 0.33 and a median of 0.12). We also find that 73% of the customers, and 69% of the suppliers, have a dual CEO/Chair, and that customers have larger boards with more independent directors.

#### 3.2. Identifying customer and supplier board relationships

To identify which customers and suppliers are on each other's boards, for each year that a relationship exists between the customer and supplier, we verify whether the executive team and directors for the customer company also hold a board seat on the supplier company during that same year. We create an indicator variable that equals one if at least one executive or director employed by the customer is on the supplier's board, and zero otherwise (*Cust on Firm Bd*). We follow the same process to identify whether executives or directors employed by the supplier are on the customer's board (*Sup on Firm Bd*).<sup>5</sup> Panel A of Table 2 shows the univariate statistics

<sup>&</sup>lt;sup>5</sup> We also distinguish between executive and non-executive directors on the other board. Our results do not differ qualitatively when we do this. Therefore, we report the combined *Cust on Firm Bd* variable (where either executives or non-executive directors of the customer are on the supplier's board), and the combined *Sup on Firm Bd* variable (where either executives or non-executive directors of the supplier are on the customer's board). We

for these relationships. We find that significantly more customers have a seat on the firm's board (5.1%) than do suppliers (4%). These statistics are somewhat higher than the frequency reported in Dass et al. (2013), who find that about 1.2% of firms include an actual supplier or customer on the board. A potential explanation for these differences could be that large firms, having larger boards than small firms, are likely to have a greater capacity to accommodate a supplier or customer on the board. The median value of assets in our sample is \$551 million for suppliers and \$28,187 million for customers, which is larger than the overall sample median of \$169 million reported in Dass, et al. (2013). Also, our sample construction requires that firms are listed in the Compustat Segment Database and in the BoardEx database. As these data sources tend to cover larger firms on average, it is not surprising that the average firm in our sample is relatively large.

We also further refine the board relationship measure by identifying the board committees on which these directors serve. Following Faleye, Hoitash, and Hoitash (2010), we classify board committees based on the role of the directors as either monitoring or advising. As noted in Faleye, et al., the most common standing committees and their primary functions are the audit (monitoring), compensation (monitoring), nominating/governance (monitoring), finance/investment/strategy (mostly advising), and executive (mostly advising) committees. We create indicator variables (*Cust on Bd Monitor* and *Cust on Bd Advis*) that equal one if any of the customer's agents are on a monitoring committee or an advising committee of the firm's board. We similarly create the variables, *Sup on Bd Monitor* and *Sup on Bd Advis*, by identifying if any of the supplier's agents are on monitoring or advising committees of the firm's board.

also use the number of relationships instead of an indicator variable for any relationship, and find that the results are qualitatively similar to those reported in the study.

In Table 2, Panel B, we find that slightly more customers (5%) than suppliers (4%) serve on firms' monitoring committees, but a similar frequency of customers and suppliers are on advising committees (both 3%). In addition, using BoardEx, we identify whether any of the executives or directors of both the customer and supplier are on the same boards of some outside alternative company in the year of the customer-supplier relationship. We create an indicator variable that is equal to one if an outside relationship exists, and zero otherwise. Panel A of Table 2 shows that 3% of the customers and suppliers are on outside boards together.

### 3.3. Variables to identify relationship-specific investments

Following the transaction cost economics literature, we use two proxies to measure relationship-specific investments: (i) R&D intensity, and (ii) Advertising intensity.<sup>6</sup> Levy (1985) and Allen and Phillips (2000) argue that firms in research-intensive industries are likely to have specialized inputs that require transaction-specific investments by suppliers. Accordingly, research intensive industries are likely to be associated with investments in relationship-specific assets. Likewise, Armour and Teece (1980) suggest that R&D activities generally involve complex interdependent stages of production, and hence entail relationship-specific investments. Moreover, the incomplete nature of R&D contracts often leads to frictions between transacting parties whereby the relationship-specific investments of one party could indirectly benefit the other party in ways that are outside the scope of the contract (Aghion and Tirole, 1997; Fee, Hadlock, and Thomas, 2006).

These studies suggest that the variation in R&D intensity is likely to capture environments (at least partially) in which the firm's customers or suppliers might undertake

<sup>&</sup>lt;sup>6</sup> Following the literature, we measure advertising intensity as selling, general, and administrative expense (SGA) scaled by total assets, and assume that the firm spends zero dollars on R&D (or on SGA) if the expense is missing for the firm.

relationship-specific investments (see also, Kale and Shahrur, 2007; Banerjee, Dasgupta, and Kim, 2008; Raman and Shahrur, 2008). In addition, Titman and Wessels (1988) and Hui, Klasa, and Yeung (2012) suggest that firms with unique or specialized products are expected to incur higher selling and advertising expenses. Hence, we use *Advertising intensity* as an additional proxy for relationship-specific investments. Table 2, Panel C shows the univaritate analysis for our relationship specific investments. Consistent with Fee, Hadlock and Thomas (2006) and Banerjee, Dasgupta, and Kim (2008), we find that suppliers have higher levels of relationship-specific investment than customers (*R&D intensity* is 6.1% vs. 2.5%, and *Advertising intensity* is 5.8% vs. 1% for suppliers vs. customers, respectively).

In addition to the above variables, we also attempt to capture the prevalence of relationship-specific investments using the number of times that firms and their supplier (or customer) cite each other's patents. We suggest that R&D intensity (or Advertising intensity) is even more likely to represent relationship-specific investments in supply chain relationships characterized by a large number of cross-citations of patents. We discuss the data on patent citations and the corresponding variables in more detail later in the paper.

#### 4. Research design

Given that the level of relationship specific investments and a directorship on the firm's board are likely to be inter-dependent decisions, we account for two issues that would affect the estimation of the empirical relations predicted by the hypotheses. First, these decisions are likely to be determined jointly, requiring simultaneous estimation of the coefficients of interest. Second, whether the supplier/customer serves on the firm's board or not is measured as a dichotomous variable, whereas the supplier/customer's level of relationship-specific investment (measured by R&D intensity or Advertising intensity) is a continuous variable. Thus, we follow the approach in Maddala (1983) and estimate coefficients from a simultaneous equation twostage probit least squares model in which one of the variables is continuous and the other is dichotomous. The model specification for the set of simultaneous equations is:

Cust or Sup on Firm 
$$Bd_{i,t+1} = \gamma_{10+}\gamma_{11}RSI_{i,t+1} + \beta'_{1}X_{1t} + Yr FE + Ind FE + \mu_{1}$$
 (1)

$$RSI_{i,t+1} = \gamma_{20+}\gamma_{21}Cust \text{ or } Sup \text{ on } Firm Bd_{i,t+1} + \beta'_2X_{2t} + Yr FE + Ind FE + \mu_2$$
(2)

The dependent variables in equations (1) and (2) above are the indicator variable (*Cust or Sup on Firm Bd*, which is either *Cust on Firm Bd* or *Sup on Firm Bd*) and the relationship specific investment variable (*RSI*, which is either R&D Intensity or Ad Intensity). Equation (1) is estimated via probit and equation (2) via OLS. Based on the reduced-form first stage estimates, the predicted values from each model are used in the second stage. The endogenous variables (*RSI* in equation (1)) and (*Cust or Sup on Firm Bd* in equation (2)) are replaced by their respective fitted values.  $X_1$  and  $X_2$  are the vectors of controls (including the instruments) in equations (1) and (2) respectively.  $\gamma_{11}$  and  $\gamma_{21}$  are the parameters of the endogenous variables (fitted *RSI* and fitted *Cust or Sup on Firm Bd*) in equations (1) and (2). *Yr FE* and *Ind FE* represent the year and industry fixed effects.

In equation (1), based on the findings in prior research (e.g., Darrough and Rangan, 2005; Coles, Daniel, and Naveen, 2006), the identifying variables (instruments) used to estimate the fitted values of the customer's RSI are the customer's: Industry RSI, Book to Market, Cash Ratio, Capex Ratio, and the one-year Sales Growth. Likewise, we estimate the fitted values of RSI for the supplier using the corresponding variables for the supplier. Similarly, based on the findings in Dass, et al. (2013), in equation (2), the identifying variables used to estimate the fitted values of *Cust on Firm Bd* and *Sup on Firm Bd* are the firm's: RSI, duality of CEO/Chair, board size, and percent of independent directors.

Following prior research (e.g., Darrough and Rangan, 2005; Coles, Daniel, and Naveen, 2006; Kale and Shahrur, 2007; Raman and Shahrur, 2008), the control variables for equation (2) with the customer's RSI as the dependent variable include *Customer Assets/Firm Assets*, *Leverage Ratio Firm, Return SD Firm, CSALE/Total Firm Sales, Ln(Assets) Customer, Average Returns Customer, ROA Customer, Leverage Ratio Customer, Firm Age Customer, and Return SD Customer.* Similarly, the supplier estimations include the above variables for suppliers.

Table 3 reports the customer and supplier characteristics and their correlations. Panel A shows the correlations of the customer specific variables and Panel B shows the correlations of the supplier specific variables. We note that multicollinearity due to high correlations is unlikely to affect the conclusions as none of the variables in our sample have significant correlations.

#### 5. Multivariate empirical results

In Table 4, we present the coefficients from the second stage of the simultaneous equations model described above. Panel A presents the results for customers while Panel B presents the results for suppliers. In column 1, the coefficients are based on a specification where the dependent variable equals one if the customer is on the firm's board, and is zero otherwise. The key independent variable of interest in this column is the R&D Intensity of the customer. In column 2, we report the coefficients with the customer's R&D Intensity as the dependent variable, and the main independent variable in this specification is the likelihood that the customer is on the firm's board. In columns 3 and 4, we measure relationship-specific

investments using *Advertising Intensity*. The model in column 3 corresponds to the specification in column 1 and that in column 4 corresponds to the model in column 2.

## 5.1. Board composition and relationship-specific investments: Results for customers

The results in column 1 of Panel A of Table 4 indicate a positive and significant coefficient on *Cust RD Intensity* (at the one percent level), controlling for other factors influencing the appointment of the customer on the firm's board. Moreover, in column 3, using *Cust Ad Intensity* as an alternate proxy for relationship-specific investments, we find a positive and significant coefficient (at the ten percent level). Consistent with the stakeholder inclusion hypothesis, the results suggest that accounting for the endogeneity of the investment decision, customers investing more in relationship-specific assets are more likely to be included on the firm's board.

Examining the customer's investment decision in column 2 of Panel A of Table 4, we find a positive and significant coefficient (at the one percent level) on *Cust on Firm Bd*, the predicted likelihood of the customer serving on the firm's board, suggesting that the customer invests more in relationship-specific assets if it is more likely to be included on the firm's board. The results in column 4, based on advertising intensity as the proxy for relationship-specific investments, also indicate a positive and significant coefficient (at the five percent level) on *Cust on Firm Bd*. These findings suggest that the inclusion of the customer on the firm's board enables the customer to avoid underinvestment in relationship-specific assets. The results are consistent with the explanation that inclusion on the firm's board provides the customer with access to firm-specific information, builds trust between the firm and the customer, and thereby

alleviates uncertainties surrounding the relationship-specific investment. We further examine this issue in the next section.

Among the control variables, we find a positive coefficient on the firm's own level of investment in unique products (*Firm RD Intensity* in column 1 and *Firm Ad Intensity* in column 3), and the coefficient in column 3 is significant at the five percent level. These findings are broadly consistent with the insight in Dass et al. (2013) that firms with unique and differentiated products are more likely to include their customer on the board in order to mitigate their own information challenges. In addition, we find that the likelihood of a customer on the firm's board is higher if (i) an executive or director of the firm is on the customer's board, (ii) the customer is larger, (iii) the firm is associated with higher levels of uncertainty (as measured by stock return standard deviation), and (iv) the customer is profitable, more leveraged, and older compared to other customers. Finally, the likelihood of a customer serving on the firm's board is higher if the firm has the same individual serving as chairman and CEO, and if the firm has a smaller proportion of independent directors.

Among the control variables in columns 2 and 4, we find that the customer invests more in R&D if an executive or director of the firm is not on the customer's board. The coefficients of the other control variables in column 2 and 4 are generally intuitive and consistent with the results in the literature. For instance, we find higher R&D intensities for customers that are smaller, more levered, that have higher cash ratios, lower stock returns, lower book-to-market ratios, and for firms in R&D intensive industries (see, e.g., Darrough and Rangan, 2005; Coles, Daniel, and Naveen, 2006; Raman and Shahrur, 2008).

#### 5.2. Board composition and relationship-specific investments: Results for suppliers

Panel B of Table 4 presents the results for suppliers. In column 1 of Panel B, we find a positive and significant coefficient on *R&D Intensity* of the supplier (at the one percent level). Similarly, in column 3 of Panel B, we find a positive and significant coefficient on the *Advertising Intensity* of the supplier (at the ten percent level). Consistent with the stakeholder inclusion hypothesis, these findings suggest that firms design the composition of their boards by taking into account the incentives of their suppliers to invest in assets that have little or no value outside the relationship with the firm.

Turning to the investment decision by suppliers, the results in column 2 of Panel B in Table 4 indicate a positive and significant relation (at the five percent level) between the likelihood of the supplier serving on the firm's board and the R&D intensity of the supplier. This result complements our findings for customers and suggests that suppliers invest more in relationship-specific assets if they are more likely to serve on the firm's board. We arrive at a similar conclusion based on the results in column 4, where we report a positive and significant coefficient (at the five percent level) with the supplier's advertising intensity as the dependent variable. These results support the stakeholder inclusion hypothesis.

#### 5.3. Does the type of board committee matter for customers and suppliers?

The literature suggests that membership on a monitoring committee of the board entails a tradeoff between the benefits of acquiring information through greater oversight of management and the costs of not receiving adequate information (from management) about the firm's competitive strategy (Holmstrom, 2005; Adams and Ferreira, 2007; Adams, 2009; Faleye, et al., 2011). One question arising from the findings in columns 1 through 4 in Panel A of Table 4 is

whether customers investing in relationship-specific assets are appointed to committees that are more likely to be associated with a monitoring role versus those with a more advisory function. We examine this question in Table 5. While the reported results are based on *R&D Intensity* as the proxy for relationship-specific investments, in untabulated results, we arrive at similar conclusions using *Advertising Intensity*.

As reported in Customer columns 1 and 3 in Table 5, we find a positive relation between the R&D intensity of the customer and the likelihood that the customer serves on a monitoring committee or on an advising committee of the firm's board. A test of the difference between the coefficients of *R&D Intensity* (6.017 versus 4.354) indicates that the customer's likelihood of serving on the monitoring committee is slightly greater (significant at the ten percent level) than that of serving on an advising committee. In addition, we find in columns 2 and 4 that the coefficient of the predicted likelihood of the customer serving on a monitoring committee and that of the customer serving on an advising committee are both positive and significant in regressions explaining the R&D intensity of the customer. These results suggest that information obtained by the customer from monitoring and advising committees of the firm's board are both useful in influencing the customer's decision to invest in relationship-specific assets.

In the Supplier columns 1 through 4, we find that both monitoring as well as advising roles appear to be equally important in influencing relationship-specific investments by suppliers. The results in columns 1 and 3 indicate that higher R&D intensities for the supplier are associated with higher likelihoods that the supplier is included on a monitoring committee or an advising committee of the firm's board. The magnitude of the coefficient of the *Predicted R&D Intensity* in column 1 (2.347) is slightly greater than that in column 3 (2.007). Among the control variables, we find that the likelihood of having a supplier on the firm's board is higher if

the firm is associated with more uncertainty (as measured by the stock return standard deviation), if the firm is represented on the supplier's board, and if the supplier is more profitable or older.

## 5.4. Environments where relationship-specific investments are more likely to exist

While the use of variables such as R&D intensity and Advertising intensity is likely to capture environments where relationship-specific investments are prevalent, we conduct additional tests to ascertain the robustness of our conclusions with respect to the role of relationship-specific investments in explaining the choice of board composition at firms along the supply chain. Specifically, we separately interact R&D intensity and Advertising intensity with two different variables that are likely to capture the presence of relationship-specific investments by the customer: (a) log of the number of times that a firm and its customer cite each other's patents, and (b) supplier concentration, i.e., one over the number of suppliers for a given customer. We similarly construct the corresponding variables for the firm's suppliers.

We obtain data on patent citations by firms and identify the number of times a firm and its customer cite each other's patents. We similarly construct data on cross-citations of patents by the firm and its supplier. The data on patent citations are obtained from NBER.<sup>7</sup> Given that cross-citation of patents reflects the degree of knowledge spillover between the firms, as suggested by Jaffe, Trajtenberg, and Fogarty (2000), R&D intensity and advertising intensity are likely to represent less noisy proxies of relationship-specific investments in supply chains characterized by a large number of patent cross-citations between a firm and its customer (or supplier). Likewise, for a given customer, a higher concentration of suppliers would indicate greater reliance by the customer on the suppliers, and hence, the R&D (or advertising intensity)

<sup>&</sup>lt;sup>7</sup> The data on patent citations are obtained from <u>http://www.nber.org/patents/</u>. See Hall, Jaffe, and Trajtenberg (2001) for details regarding the data.

investments by this customer are more likely to be relationship-specific in this sub-sample. Thus, we interact the R&D intensity of the customer with (a) the (log of) number of crosscitations between a firm and its customer, and (b) supplier concentration. We similarly construct the corresponding interaction terms for the supplier. While the results presented in Table 6 are based on R&D intensity as the proxy for relationship-specific investments, we arrive at a similar conclusion using advertising intensity (not tabulated for brevity).

The results in Table 6 indicate a positive and statistically significant coefficient on the interaction term in seven of the eight models. These findings indicate that the positive relation between the R&D intensity of a customer (supplier) and the likelihood of inclusion on the firm's board is stronger in supply chain relationships where: (a) the number of cross-citations between the customer (supplier) and the firm is higher, and (b) the customer (supplier) relies more on the firm for its business. The results reinforce the inferences drawn earlier based on the main results in Table 4, that relationship-specific investments by a firm's suppliers or customers play an important role in influencing the firm's decision to include the supply chain partner on the board.

#### 5.5. Sub-sample of firms with no relationship-specific investments

A key distinction between our study and that of Dass et al. (2013) is that we examine whether the firm's decision to include a supplier/customer on the board is influenced by the supplier/customer's investment in relationship-specific assets (as opposed to being influenced by the firm's own investment in such assets, as in Dass et al.). While the specifications in Table 4 control for the firm's own level of relationship-specific investments, we conduct an additional test to ascertain that what we find is distinct from the insight in Dass et al. (2013). Specifically, we examine a sub-sample of firms with zero R&D and test whether such firms would still appoint a supply chain partner to the board if the partner invests in relationship-specific assets.

The results in Model (1) of Table 7 indicate a positive and significant coefficient on *Cust RD Intensity*, suggesting that firms with no R&D intensity are likely to include a customer on the board if the customer invests more in relationship-specific assets. In addition, in Model (2) of Table 7, we report a positive and significant coefficient on the predicted likelihood of the customer serving on the firm's board. These results suggest that even if the firm does not invest in relationship-specific assets, it still benefits from the inclusion of a customer on the board because the directorship improves the customer's incentive to undertake relationship-specific investments, and thereby enhances the surplus available to be shared by the firm and its customer. In Models (3) and (4), we arrive at a similar conclusion with respect to the firm's board, the suppliers. Collectively, these results suggest that by serving on the firm's board, the suppliers/customers benefit from mitigating underinvestment in relationship-specific assets and that this benefit for suppliers/customers appears to be distinct from the informational benefits derived by the firm as noted in Dass et al. (2013).

#### 5.6. Role of information asymmetry

One benefit for supply chain partners from serving on the firm's board is that they could alleviate some of the risks associated with relationship-specific investments by gaining access to information about the firm's future strategies and prospects. We expect these informational benefits for suppliers/customers to be larger if the firms on whose boards they serve are associated with more severe information asymmetries. In this section, we examine whether the strength of the results reported above varies according to the level of information asymmetry faced by suppliers/customers. In Table 8, we report the two-stage least squares coefficients for interaction terms comprising of the main independent variable of interest (either relationship-specific investment or the likelihood of supplier/customer on the board) and a proxy for information asymmetry associated with the firm on whose board the supplier or customer serves.

#### 5.6.1. Information asymmetry variables

We use three different variables to estimate the degree of information asymmetry between the firm and its supplier/customer: bid-ask spread (*Firm Spread*), accounting quality (*Firm Acct. Qual*), and an indicator variable that equals one if the firm and its supplier/customer belong to different industries (*Diff Ind*). Although the bid-ask spread may be a potentially noisy proxy, it broadly captures information asymmetry (Stoll, 1989; George, Kaul, & Nimalendran, 1991; Huang & Stoll 1997). Bhattacharya, Desai, and Venkataraman (2013) find that poor accounting quality is associated with higher information asymmetry. We follow Lee and Masulis (2009) and estimate accounting quality using the Dechow and Dichev (2002) method as modified by McNichols (2002).<sup>8</sup> A higher value for this variable implies poorer accounting quality and hence greater information asymmetry. Given that firms are likely to be better informed about the conditions and factors affecting their own industry, we suggest that a customer or supplier would face greater information asymmetry about the firm if the firm operates in a different industry from that of the customer or supplier.

<sup>&</sup>lt;sup>8</sup> We measure accounting quality as the mapping of accruals into cash flows: the weaker the mapping, the poorer the quality of information. For each year and Fama-French industry combination, we regress the firm's total current accruals in year *t* on the firm's cash from operations in year *t*-1, *t*, and *t*+1, the change in total revenue, and the gross property, plant, and equipment, with all variables scaled by average total assets (average over years *t* and *t*-1). These variables are measured as in Lee and Masulis (2009, Equation 2, page 447). We winsorize each of these variables at the one and ninety-nine percentile values before estimating the above regression. These annual cross-sectional estimations yield firm- and year-specific residuals. We measure accounting quality for firm *i* in year *t* as the standard deviation of firm *i*'s residuals over years *t*-4 through *t*.

As shown in Panel A of Table 8, the mean (median) value of *Acct. Qual* is 0.07 (0.06) for suppliers, compared to a mean (median) of 0.04 (0.04) for customers, indicating greater information asymmetry surrounding suppliers relative to customers. These statistics are consistent with the results in prior studies. For instance, Lee and Masulis (2009) report a median of 0.0438 for their sample of seasoned equity issuers, and Raman, Shivakumar, and Tamayo (2013) report a median of 0.041 for their sample of target firms. Likewise, the mean and median values of *Spread* are also higher for suppliers relative to customers, consistent with the results using accounting quality.

## 5.6.2. Results on the role of information asymmetry

Panel B of Table 8 reports the coefficients for customers. We find that the coefficient of the interaction term in column 1 is positive and significant, indicating that the positive relation between the customer's investment in relationship-specific assets and the likelihood of the customer serving on the firm's board is more pronounced if the firm is associated with higher levels of information asymmetry. The results in column 2 indicate a positive and significant coefficient on the interaction term with *Cust RD Intensity* as the dependent variable. This finding suggests that the benefits of customers' directorships (i.e., investment in relationship-specific assets) are more pronounced in environments where the customers face more severe information asymmetry.

In columns 3 through 6, we find that the conclusions are robust if we categorize the severity of information asymmetry based on accounting quality or on industry membership. Notably, these alternate proxies for information asymmetries are not perfectly correlated with

each other.<sup>9</sup> Given the imperfect correlations between these proxies, the consistency of results in Panel B of Table 8 imply robustness in the conclusion that directorships enable the firm's customers to reduce information asymmetry, and thereby avoid underinvestment in relationship-specific assets.

The results in Panel C of Table 8 indicate that the coefficients of the interaction terms for suppliers are positive and significant in all specifications. The results in column 1 indicate that the likelihood of a supplier with high R&D intensity serving on the firm's board is stronger if the firm is characterized by more severe information asymmetry (based on the firm's bid-ask spread). We also find in column 2 that the positive relation between directorships for suppliers and their relationship-specific investments is more pronounced if the firm is associated with high information asymmetry.

Furthermore, these results are robust with respect to alternate proxies for information asymmetry. Finally, in untabulated results, our conclusions from Table 8 (Panel B and Panel C) are unchanged if we use *Advertising Intensity* instead of *R&D Intensity* as the proxy for relationship-specific investments.

#### 5.7. Role of directorships in relational contracting

Besides gaining access to firm-specific information, another channel through which suppliers and customers could benefit from directorships is by strengthening their level of trust and their informal (relational) contract with the firm. Baker, Gibbons, and Murphy (2002) show that relational contracts between firms are particularly effective when the outcomes are difficult to specify ex ante and are observed ex post by only the contracting parties. To understand the

<sup>&</sup>lt;sup>9</sup> For instance, the correlation between bid-ask spread and accounting quality is 0.19 for suppliers and is 0.16 for customers.

role of directorships in supporting relational contracts between firms and their suppliers/customers, we identify firms that are likely to have incentives to engage in opportunistic behavior and expropriate rents from suppliers/customers. We specifically focus on firms in severe financial distress because these firms are less likely to care about their reputation, and because suppliers and customers are unlikely to invest in assets that are specifically tied to relationships with distressed firms (e.g., Titman, 1984; Maksimovic and Titman, 1991; Kale and Shahrur, 2007; Hertzel, Li, Officer, and Rodgers, 2008).

We create interaction terms using the key independent variables of interest and an indicator variable, *Firm Zscore*, that equals one if the firm is in the bottom quartile of the distribution of Altman's Z and zero otherwise.<sup>10</sup> We note that lower values of Altman's Z indicate more severe financial distress. If directorships enable suppliers/customers to enhance their trust and relationship with the firm, and thereby result in effective relational contracts, we would expect a positive coefficient on the interaction terms as directorships for suppliers and customers would play an important role in the sub-sample of financially distressed firms.

The results, presented in Table 9, indicate a positive and significant coefficient for the interaction term in three of the four columns. In all specifications shown in Table 9, we control for the information asymmetry of the firm. The results indicate that customers are willing to invest more in assets tied to their relationships with distressed firms if they are more likely to serve on the distressed firm's board. The results in column (3) indicate that although a supplier investing in relationship-specific assets is in general more likely to be included on the firm's board, this likelihood is stronger if the firm is financially distressed. Finally, the results in

<sup>&</sup>lt;sup>10</sup> Altman' Z is computed as  $3.3*oiadp/at + 1.2*(act-lct)/at + sale/at + 0.6*prcc_f*csho/(dltt+dlc) + 1.4*re/at. We assign the value at the 99th percentile of Altman's Z for firms with zero debt (dltt+dlc = 0). We find that defining Zscore based on the median Altman's Z yields similar results.$ 

column (4) indicate that suppliers that are likely to be included on the firm's board invest more in relationship-specific assets if the firm is financially distressed.

The results in Table 9 suggest that controlling for the firm's level of information asymmetry, the benefits of directorships for suppliers and customers are more pronounced in settings where they are likely to be most susceptible to opportunistic behavior by the firm. Given that relational contracts are expected to overcome the transactional difficulties arising from incomplete contracts, the results are consistent with the theory in Baker, Gibbons, and Murphy (2002) and suggest that directorships awarded to the firm's suppliers and customers could effectively serve as a relational contracting mechanism and improve the incentives of suppliers and customers to invest in relationship-specific assets.

#### 5.8. Additional robustness tests

In this section, we discuss additional tests conducted to assess the robustness of our conclusions. First, a potential explanation for the positive relation between the likelihood of suppliers/customers serving on the firm's board and relationship-specific investments by suppliers/customers is that the officers or directors of the supplier/customer and those of the firm are known to each other through a network outside of the existing business relationship. For instance, these officers or directors may know each other from serving on other boards together. Thus, we examine whether relationship-specific investments explain the presence of suppliers/customers on the firm's board once we control for the existence of outside relationships between individuals at the firm and those at the supplier/customer.

The results, reported in Table 10, indicate that the presence of outside relationships between the firm and its supplier/customer significantly increases the likelihood of the

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supplier/customer getting included on the firm's board. More importantly, our primary conclusions of a positive relation between the likelihood of a supplier/customer on the firm's board and the level of relationship-specific investment by the supplier/customer, based on the results in Table 4, are unchanged when we control for the presence of outside relationships.

Second, we re-examine the results reported in Table 4 using OLS regression instead of the two-stage approach. The results from the OLS specification for customers (not tabulated for brevity) are consistent with those reported in Panel A of Table 4. Furthermore, the OLS results for suppliers are also consistent with the findings in Panel B of Table 4 except for the specification in column (3) of Panel B of Table 4. In the OLS specification, we find the coefficient of the supplier's *Advertising Intensity* to be positive but insignificant in explaining the likelihood of the supplier serving on the firm's board. Third, we arrive at a similar conclusion as that reported in the paper if we only include in our analysis the sub-sample of suppliers or customers with non-zero R&D intensities (results not tabulated for brevity).

## 6. Conclusion

We examine whether firms consider the relationship-specific investments made by their suppliers and customers in designing the composition of their boards. Examining a large sample of actual suppliers and customers of U.S. firms between 2001 and 2009 and using a two-stage probit least squares approach to control for the endogeneity of the joint decision by firms and their suppliers/customers, we find that a firm is more likely to include a supply chain partner on the board if the partner invests more in relationship-specific assets. We also find that suppliers/customers invest larger amounts of capital in relationship-specific assets if they are more likely to serve on the firm's board.

The results are stronger among relationships where the firm and its supplier/customer cite each other's patents more, and if the customer (or supplier) is more dependent on the firm. Furthermore, the findings are robust even in a sub-sample where the firm itself does not invest in relationship-specific assets. These results suggest that directorships enable firms and their supply chain partners to overcome the contracting frictions inherent in the relationships.

The results are also more pronounced if the firm has wider bid-ask spreads, poorer accounting quality, and is in a different industry from that of the supply chain partner, suggesting that the inclusion of a supplier/customer on the board mitigates the information asymmetry faced by the stakeholder and thereby reduces the stakeholder's risk of investing in relationship-specific assets. We also find that the results are also stronger if the firm is more financially distressed. Given that the propensity to engage in opportunistic behavior is likely to increase with the degree of financial distress, the results are consistent with the idea that the inclusion of a supplier/customer on the board strengthens the informal relational contract between the firm and its stakeholder, and thereby reduces the risks associated with relationship-specific investments.

Collectively, the findings suggest that directorships enable suppliers/customers to avoid underinvestment in relationship-specific assets by mitigating the risks arising from asymmetric information and by strengthening their informal (relational) contracting relationship with the firm. The study contributes to the literature by identifying the board of directors as a mechanism to alleviate contracting frictions between firms along the supply chain.

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#### Appendix A

#### Procedure to identify customer-supplier relationships

Previously known to as SFAS 131, ASC 280-10-50-42 requires firms to disclose information about their major customers. Specifically, the standards require that: "A public entity shall provide information about the extent of its reliance on its major customers. If revenues from transactions with a single external customer amount to 10 percent or more of a public entity's revenues, the public entity shall disclose that fact, the total amount of revenues from each such customer, and the identity of the segment or segments reporting the revenues. The public entity need not disclose the identity of a major customer or the amount of revenues that each segment reports from that customer. For the purposes of this Subtopic, a group of entities known to a reporting public entity to be under common control shall be considered as a single customer, and the federal government, a state government, a local government (for example, a county or municipality), or a foreign government each shall be considered as a single customer (see Example 3, Case E [paragraph 280-10-55-52])."

The Compustat Customer file in the Segment database only reports the name of firms' major customers, not the identifiers (such as GVKEY). More importantly, the customer names reported in the database are not standardized. As a result, a given customer name may be abbreviated in multiple ways across firms reporting in the database, and even across years by the same reporting firm. In order to obtain a unique identifier (e.g., GVKEY) for each reported customer, we first use an algorithm that compares the order and number of letters in the reported customer name with all company names in the Merged CRSP/Compustat file for the year in which the company is named as a customer.

In the next step, we only include those customer names from the Compustat Segment database that are an exact match with the name reported in the Merged CRSP/Compustat database. For the remaining customer names, where the letters in the Segment database do not precisely match the letters in the Merged CRSP/Compustat file, we manually inspect every customer name to ascertain whether the abbreviated name in the Segment database corresponds to the name in the Merged CRSP/Compustat file.

If a match is found, we merge the customer with the appropriate match in the Merged CRSP/Compustat file and obtain the corresponding GVKEY. In those cases where it is doubtful that the abbreviated name matches the name of the firm listed in the Merged CRSP/Compustat file, we treat the observation as though they do not match. Thus, we follow a very conservative approach and identify a firm as a major customer only if we are sure that it is the customer in question. If a customer in a given year (e.g., Sam's Club) is a subsidiary of a public parent firm (in this case, Wal-Mart), we consider the parent company to be the customer for that year.

# Appendix B

Variable	Definition	Source
1-Yr Sales Growth	One-year growth in 'sale'	Compustat
Accounting quality	Measured as in Lee and Masulis (2009);	
	described in more detail in the paper.	
Advertising Intensity	sga/at, if sga is missing, we set it =0	Compustat
Average Monthly Returns	Fiscal year stock return	CRSP
Board Size	The number of directors on the board	BoardEx
Book to Market	at / ((prcc_f*cshpri)+at-ceq)	Compustat
Capex Ratio	capx/at	Compustat
Cash Ratio	che/at	Compustat
CSALE	Dollar value of sales from supplier to the	Compustat
	customer	-
CSALE/Total Firm Sales	CSALE/sale	Compustat
		-
Cust on Bd Advis	Customer has a seat on suppliers' advising	BoardEx
	committee	
Cust on Bd Monitor	Customer has a seat on suppliers' monitoring	BoardEx
	committee	
Cust on Firm Bd	Customer has a seat on suppliers' board	BoardEx
Diff Industry	Indicator variable that is equal to one if the	
-	customer (supplier) and firm are in different	
	industries and zero otherwise	
Dual CEO/Chair	Indicator equal to one if the CEO is also	BoardEx
	Chair, and zero otherwise	
Financing Cash Flow	fincf/at	Compustat
	If 'fincf' is missing, then Financing Cash	
	Flow is defined as:	
	sstk - prstkc - dv + dltis - dltr + dlcch	
Firm age	Age of the firm	CRSP
Industry AD	Sum of 'sga' for all firms in the same 4-digit	Compustat
	SIC divided by the sum of 'at' for the same	
	firms.	
	If sga is missing, we set $sga = 0$	
Industry R&D	Sum of 'xrd' for all firms in the same 4-digit	Compustat
	SIC divided by the sum of 'at' for the same	
	firms.	
	If $R\&D$ is missing, we set $R\&D = 0$	
Leverage Ratio	(dltt+dlc)/at	Compustat
LN(Assets)	Log(at)	Compustat
Outside relationship	Indicator variable equal to one if the supplier	BoardEx
	and customer have executives or directors	
	who sit on outside boards together	

# Appendix B (continued)

Variable	Definition	Source
Pct Indep	The percent of independent directors on the	BoardEx
_	board	
Profit Margin	ni/sale	Compustat
R&D Intensity	xrd/at, If R&D is missing, we set $R\&D = 0$	Compustat
Return SD	Standard deviation of daily stock returns	CRSP
	during fiscal year	
ROA	oibdp/at	Compustat
Spread	Average of (ask-bid/close) stock price during	CRSP
	fiscal year.	
Sup on Bd Advis	Supplier has a seat on customer's advising	BoardEx
	committee	
Sup on Bd Monitor	Supplier has a seat on customer's	BoardEx
	monitoring committee	
Sup on Firm Bd	Supplier has a seat on customer's board	BoardEx
Total Assets	Total Assets in MM, (at)	Compustat

#### **Table 1 Customer and Supplier Relationships**

Panel A shows the breakout of the customer supplier relationships in our sample from 2001 to 2009. Panel B shows the Fama French 12 industry breakdown of the sample for both customers and suppliers. FF Industry 1 is Consumer NonDurables (Food, Tobacco, Textiles, Apparel, Leather, and Toys); 2 is Consumer Durables (Cars, TV's, Furniture, and Household Appliances); 3 is Manufacturing (Machinery, Trucks, Planes, Off Furn, Paper, and Commercial Printing); 4 is Energy (Oil, Gas, and Coal Extraction and Products); 5 is Chemicals and Allied Products; 6 is Business Equipment (Computers, Software, and Electronic Equipment ); 7 is Telephone and Television Transmission; 8 is Utilities; 9 is Shops (Wholesale, Retail, and Some Services likeLaundries, Repair Shops); 10 is Healthcare, Medical Equipment, and Drugs; 11 is Finance ; and 12 is Other (Mines, Constr, BldMt, Trans, Hotels, Bus Serv, Entertainment).

	Panel A : Year Breakdown										
Year	Relationships										
2001	296										
2002	393										
2003	710										
2004	629										
2005	708										
2006	680										
2007	755										
2008	771										
2009	574										
Total	5,516										

	Panel B : Industry Breakdown using Fama French 12 Industry Classification													
							Custo	mer						
Supplier	1	2	3	4	5	6	7	8	9	10	11	12	Total	
1	20	4	0	4	7	13	0	0	419	2	3	2	474	
2	8	140	11	0	0	8	6	0	39	0	0	3	215	
3	27	100	187	13	15	74	7	1	149	14	3	7	597	
4	1	1	0	153	3	0	0	84	0	0	0	14	256	
5	4	4	24	2	0	5	0	0	87	10	0	0	136	
6	5	45	127	3	0	857	193	6	294	54	65	20	1,669	
7	0	0	1	0	0	18	82	0	4	3	0	2	110	
8	0	0	0	15	1	0	0	3	0	0	0	0	19	
9	14	4	9	6	0	14	3	2	252	5	8	2	319	
10	0	1	0	0	11	4	0	0	477	227	30	10	760	
11	9	0	5	4	3	27	10	0	196	34	31	26	345	
12	35	33	34	35	33	65	60	27	110	82	48	54	616	
Total	123	332	398	235	73	1,085	361	123	2,027	431	188	140	5,516	

# **Table 2: Univariate Statistics**

This table shows the descriptive statistics of key variables for suppliers and customers. All variables are defined in the appendix. Matched pair t-test is used to examine the significance of differences between the mean values for customers and suppliers. \*\*\*,\*\*,\* denote significance at the 1,5,and 10% levels respectively.

Panel A: Firm Characteristics											
	Relatior	nship Specit	fic Investmen	t							
	Supj	plier	Cust	omer	Significance						
Variable	Mean	Median	Mean	Median	Matched pair t-test						
	Accounting an	nd Stock Ma	arket Charact	eristics							
Total Assets	2,935.67	551.17	82,889.36	28,187.37	***						
Firm Age	16.91	12.00	36.74	33.00	***						
Leverage Ratio	0.19	0.11	0.22	0.21	*						
Book to Market	0.68	0.66	0.64	0.63							
ROA	0.05	0.10	0.13	0.13	***						
1-Yr Sales Growth	0.04	0.05	0.08	0.06	***						
Profit Margin	-0.08	0.02	0.14	0.04	*						
Capex Ratio	0.04	0.03	0.05	0.04							
Cash Ratio	0.23	0.15	0.12	0.07	***						
Financing CF	0.01	0.00	-0.04	-0.03	*						
Average Monthly Returns	0.01	0.01	0.00	0.00	***						
Return SD	0.13	0.11	0.09	0.07	*						
CSALE Ratio	0.33	0.12	0.22	0.00	***						
	Bo	oard Charac	cteristics								
Dual CEO/Chair	0.69	1.00	0.73	1.00	*						
Board Size	7.98	8.00	11.52	11.00	***						
Pct Indep	0.71	0.70	0.76	0.74	**						
	Panel B: R	elationship	o Characteri	stics							
	Customer-S	Supplier Bo	ard Relations	hips							
	Supp	plier	Cust	omer	Significance						
Variable	Mean	Median	Mean	Median	Matched pair t-test						
Sup/Cust on Firm Bd	0.04	0.00	0.05	0.00	***						
Sup/Cust on Bd Monitor	0.04	0.00	0.05	0.00	***						
Sup/Cust on Bd Advis	0.03	0.00	0.03	0.00							
Outside relationship	0.03	0.00	0.03	0.00	NA						
Panel	C: Relationshi	p Specific l	Investment (	Characteristic	s						
	Supj	plier	Cust	omer	Significance						
Variable	Mean	Median	Mean	Median	Matched pair t-test						
RD Intensity	0.061	0.003	0.025	0.000	***						
Ad Intensity	0.058	0.012	0.009	0.003	***						

	Panel A Customer Correlations																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	RD Int	1.00																			
2	Ad Int	0.33	1.00																		
3	Board Rel	0.03	0.00	1.00																	
4	Dual CEO/Chr	-0.12	-0.05	0.03	1.00																
5	Board Size	-0.05	-0.04	0.00	0.19	1.00															
6	Pct Indep	-0.02	-0.01	0.02	0.14	-0.15	1.00														
7	Total Assets	-0.04	-0.02	0.01	0.11	0.36	-0.05	1.00													
8	LN(Assets)	-0.21	-0.13	0.00	0.13	0.49	-0.09	0.51	1.00												
9	Book to Mkt	-0.20	-0.07	-0.03	0.04	-0.06	0.05	-0.03	0.01	1.00											
10	Av Ret	-0.03	-0.01	0.01	-0.03	-0.01	-0.05	-0.02	-0.03	-0.28	1.00										
11	Spread	0.04	0.07	-0.01	-0.06	-0.17	0.08	-0.11	-0.42	0.20	0.03	1.00									
12	Cash Ratio	0.39	0.10	0.01	-0.12	-0.17	-0.02	-0.12	-0.34	-0.30	0.01	-0.01	1.00								
13	Capex	-0.06	-0.02	-0.01	-0.02	-0.06	-0.02	-0.04	0.01	0.01	-0.02	-0.03	-0.16	1.00							
14	ROA	-0.55	-0.27	-0.01	0.10	0.10	-0.02	0.07	0.28	0.02	0.09	-0.19	-0.23	0.06	1.00						
15	1-Yr Sales G	0.02	0.00	0.00	0.02	0.01	0.03	-0.01	-0.03	-0.06	0.02	0.00	0.04	-0.04	-0.01	1.00					
16	Lev	0.02	0.00	-0.02	-0.01	0.15	0.01	0.09	0.29	0.00	-0.06	-0.08	-0.26	0.00	-0.08	-0.01	1.00				
17	Firm Age	-0.11	-0.04	-0.01	0.15	0.38	-0.07	0.37	0.35	0.02	-0.01	-0.09	-0.23	-0.06	0.13	0.01	0.05	1.00			
18	Profit Margin	-0.18	-0.11	0.00	0.04	0.02	0.04	0.01	0.05	0.05	0.00	0.00	-0.10	0.02	0.18	0.00	-0.01	0.04	1.00		
21	Return SD	0.19	0.04	0.01	-0.06	-0.13	0.01	-0.09	-0.17	0.07	0.17	0.18	0.15	0.01	-0.15	0.00	0.13	-0.17	-0.05	1.00	
22	Acct Quality	0.12	0.07	0.00	-0.05	-0.12	0.00	-0.11	-0.32	-0.10	0.01	0.16	0.14	-0.04	-0.19	0.00	-0.11	-0.14	0.00	0.06	1.00

Table 3: Correlations

This table shows the correlations of the variables used in the estimations for both suppliers and customers. The Variables are defined in the appendix.

	railer D Supplier Colletations																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	RD Int	1.00																			
2	Ad Int	0.13	1.00																		
3	Board Rel	0.05	0.01	1.00																	
4	Dual CEO/Chr	0.02	-0.02	0.02	1.00																
5	Board Size	-0.16	-0.11	-0.02	0.01	1.00															
6	Pct Indep	0.03	0.02	0.02	0.05	-0.19	1.00														
7	Total Assets	-0.12	-0.06	-0.03	-0.04	0.28	-0.03	1.00													
8	LN(Assets)	-0.21	-0.31	-0.04	-0.09	0.44	-0.10	0.59	1.00												
9	Book to Mkt	-0.28	0.02	-0.03	0.08	0.05	0.00	0.21	0.04	1.00											
10	Av Ret	-0.05	0.02	0.00	0.02	-0.05	-0.03	-0.03	-0.08	-0.15	1.00										
11	Spread	0.09	0.36	0.01	-0.02	-0.10	0.09	-0.07	-0.25	0.15	-0.05	1.00									
12	Cash Ratio	0.60	0.16	0.05	0.02	-0.20	0.07	-0.11	-0.26	-0.32	0.04	0.01	1.00								
13	Capex	-0.17	0.04	-0.06	-0.15	0.02	0.00	-0.07	-0.01	-0.12	-0.09	0.04	-0.24	1.00							
14	ROA	-0.22	-0.13	-0.01	-0.04	0.03	-0.04	-0.14	0.08	-0.49	0.07	-0.20	-0.10	0.27	1.00						
15	1-Yr Sales G	0.01	0.03	0.06	-0.03	-0.04	0.03	-0.01	-0.07	0.01	-0.04	0.04	0.04	0.03	-0.07	1.00					
16	Lev	-0.22	-0.05	0.00	-0.04	0.17	0.01	0.28	0.21	0.31	-0.06	0.15	-0.35	0.15	-0.14	-0.03	1.00				
17	Firm Age	0.01	-0.12	0.00	0.08	0.24	-0.15	0.20	0.42	0.00	-0.02	-0.10	-0.16	-0.02	0.13	-0.07	0.17	1.00			
18	Profit Margin	-0.07	-0.12	-0.06	0.01	0.02	0.00	0.01	0.04	0.01	-0.03	-0.03	-0.04	-0.01	0.10	-0.02	0.02	0.03	1.00		
19	Return SD	-0.21	0.01	-0.05	-0.04	0.01	0.04	-0.09	-0.15	0.02	0.01	0.00	-0.09	0.20	0.18	-0.03	-0.01	-0.04	0.01	1.00	
20	Acct Quality	0.22	0.14	0.01	0.08	-0.10	0.01	0.02	-0.27	0.18	0.02	0.19	0.24	-0.25	-0.31	0.02	-0.01	-0.16	-0.03	-0.09	1.00

Panel B Supplier Correlations

#### Table 4: Second stage coefficients from customer and supplier simultaneous estimations

This table reports the second stage coefficients from the simultaneous probit least squares estimations of R&D (Ad) intensity and board relationships. Panel A reports coefficients for cutomers and Panel B presents the results for suppliers. The dependent variable in columns 1 and 3 equals one if an executive or director of the customer (supplier in Panel B) is on the firm's board in year t+1, and zero otherwise. In Panel A (Panel B), column 2 uses the R&D intensity of the customer (supplier) at t+1 as the dependent variable; column 4 uses the advertising intensity of the customer (supplier in Panel B) at t+1. In Panel A, the independent variables, Cust RD Intensity, Cust on Firm Bd, and Cust Ad Intensity represent the fitted values from the first stage. The corresponding supplier variables in Panel B similarly represent fitted values from the first stage. The estimations control for year and industry fixed effects. \*\*\*,\*\*,\* denote significance at the 1,5,and 10% levels respectively.

<u> </u>	Panel A - Customer E	stimations		
	(1)	(2)	(3)	(4)
-	5 7	Cust RD	× 7	Cust Ad
	Cust on Firm Bd	Intensity	Cust on Firm Bd	Intensity
Cust RD Intensity	6.183***			
	(0.00)	0 000***		0.001**
Cust on Firm Bd		0.008***		0.001**
		(0.00)	4.040*	(0.02)
Cust Ad Intensity			4.849*	
Firm DD Intensity	0.016		(0.07)	
Film KD Intensity	(0.010)			
Firm Ad Intensity	(0.40)		2 800**	
Thin Ad Intensity			(0.02)	
Firm on Cust Bd	1 696***	-0.012***	1 695***	-0.001
Thin on Cust Du	(0.00)	(0.012)	(0.00)	(0.67)
Leverage Ratio Firm	-0.047	-0.003*	-0.111	0.001
	(0.74)	(0.003)	(0.45)	(0.15)
Return SD Firm	0 740***	0.015***	0.817***	0.001
	(0.01)	(0.01)	(0.01)	(0.14)
CSALE/Total Cust COGS	-0 514	0.005***	-0.382	0.001
CSALL Total Cast COOS	(0.27)	(0,00)	(0.302	(0.28)
CSALE/Total Firm Sales	0.002	0.001	(0.57)	0.001
CS/ LL/ Total T IIII Sales	(0.83)	(0.11)	(0.82)	(0.81)
In (Assets) Customer	0.052*	-0.002***	0.025*	-0.001***
En (Assets) Eustomer	(0.032)	(0.002)	(0.06)	(0.001)
Ln (Assets) Firm	0.050**	-0.002***	0.038**	-0.001***
	(0.02)	(0,00)	(0.01)	(0,00)
Average Returns Customer	0.850	-0.072***	0.232	-0.001
riverage retains customer	(0.36)	(0,00)	(0.80)	(0.27)
ROA Customer	0.720*	-0.143***	0.479	-0.001***
	(0.07)	(0,00)	(0.35)	(0,00)
Leverage Ratio Customer	0.453**	0.015***	0.009	0.001
20 for age rando Castonier	(0.04)	(0.00)	(0.97)	(0.53)
Firm Age Customer	0.002*	0.001***	0.004**	0.001*
	(0.11)	(0.00)	(0.02)	(0.07)
Return SD Customer	0.382	0.055***	0.154	0.001***
	(0.49)	(0.00)	(0.81)	(0.00)
Industry RD Customer	(0.13)	0.362***	(0.0-)	(0100)
		(0.00)		
Book to Market Customer		-0.039***		-0.001
		(0.00)		(0.13)
Cash Ratio Customer		0.073***		0.001***
		(0.00)		(0.00)
Capex Ratio Customer		0.068***		0.002***
		(0.00)		(0.00)
1-Yr Sales Growth Customer		-0.003***		-0.001
		(0.00)		(0.66)
Dual CEO/Chair Firm	0.161**	` '	0.149**	× /
	(0.03)		(0.04)	
Board Size Firm	-0.002		-0.002	

	(0.92)		(0.89)	
Pct Indep Firm	-1.247***		-1.266***	
	(0.00)		(0.00)	
Industry Ad Customer				-0.001
				(0.52)
Constant	-2.521***	0.092***	-2.469***	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Observations	5516	5516	5516	5516
Adjusted R-squared		0.555		0.144
Pseudo R-squared	0.181		0.168	

	Panel B - Supplier Es	timations		
	(1)	(2)	(3)	(4)
		Sup RD		Sup Ad
	Sup on Firm Bd	Intensity	Sup on Firm Bd	Intensity
Sup RD Intensity	2.278***			
	(0.00)			
Sup on Firm Bd		0.027**		0.003**
		(0.03)	4 505*	(0.03)
Sup Ad Intensity			4.505*	
Firm PD Intensity	0.003		(0.03)	
Firm KD Intensity	(0.72)			
Firm Ad Intensity	(0.72)		16 366***	
			(0.00)	
Firm on Sup Bd	1.563***	0.035	1.647***	0.008
•	(0.00)	(0.42)	(0.00)	(0.26)
Leverage Ratio Firm	0.215	0.015	0.122	0.003
	(0.35)	(0.23)	(0.60)	(0.73)
Return SD Firm	1.200**	0.073*	1.329**	0.022
	(0.02)	(0.10)	(0.02)	(0.25)
CSALE/Total Cust COGS	0.514	0.013	0.575	0.002
	(0.38)	(0.31)	(0.36)	(0.34)
CSALE/Total Supplier Sales	0.016	0.001*	0.002	0.001
La (Assata) Samalian	(0.89)	(0.06)	(0.91)	(0.18)
Ln (Assets) Supplier	0.029	(0.82)	0.043	$0.002^{***}$
In (Assets) Firm	0.20)	(0.82)	(0.12) 0.003	0.00)
	(0.27)	(0.77)	(0.92)	(0.002)
Average Returns Supplier	0.313	0.071*	0.152	0.012
i i orage records suppror	(0.63)	(0.05)	(0.82)	(0.57)
ROA Supplier	0.506**	0.262***	0.135	0.069***
	(0.01)	(0.00)	(0.80)	(0.00)
Leverage Ratio Supplier	0.182	0.006	0.154	0.004
	(0.22)	(0.61)	(0.33)	(0.39)
Firm Age Supplier	0.005**	0.001	0.003	0.001
	(0.04)	(0.99)	(0.18)	(0.22)
Return SD Supplier	0.600	0.112***	0.151	0.006
In devetors DD Sourcelling	(0.12)	(0.00)	(0.68)	(0.58)
Industry RD Supplier		0.484***		
Rock to Market Supplier		(0.00)		0.015***
Book to Market Supplier		(0.000)		$(0.01)^{-1}$
Cash Ratio Supplier		0.110***		0.001
		(0.00)		(0.81)
Capex Ratio Supplier		0.044		0.003
		(0.20)		(0.85)
1-Yr Sales Growth Supplier		0.001		0.001
		(0.56)		(0.62)
Dual CEO/Chair Firm	0.035		0.001	
	(0.66)		(0.99)	
Board Size Firm	0.017		0.013	
	(0.18)		(0.33)	
Pct Indep Firm	0.329		0.386	
	(0.38)		(0.31)	0.061
moustry AD Supplier				(0.55)
Constant	2 161***	0 111*	7 587***	0.55)
Constant	(0,00)	(0.07)	(0,00)	(0.00)
Observations	5516	5516	5516	5516
Adjusted R-squared		0.448		0.084
Pseudo R-squared	0.189	-	0.202	

#### **Table 5: Monitoring and Advising Roles**

This table reports the second stage coefficients from the simultaneous probit least squares estimations of R&D (Ad) intensity and board relationships. In column 1, the dependent variable is one if the customer (supplier) is on a monitoring committee in year t+1, and in column 3, the dependent variable equals one if the customer (supplier) is on an advising committee of the firm's board in year t+1. In columns 6, and 8 use the R&D intensity of the customer (supplier) at t+1 as the dependent variable. The independent variables, Cust RD Intensity, and Cust on Firm Bd represent the fitted values from the first stage. The corresponding supplier variables similarly represent fitted values from the first stage. The estimations control for year and industry fixed effects. \*\*\*,\*\*,\* denote significance at the 1,5,and 10% levels respectively.

	(1)	(2)	(3)	(4)		(1)	(2)	(3)	(4)
	Cust on	Cust RD	Cust on	Cust RD		Sup on	Sup RD	Sup on	Sup RD
	Bd Monitor	Intensity	Bd Advis	Intensity	_	Bd Monitor	Intensity	Bd Advis	Intensity
Cust RD Intensity	6.017***		4.354***		Sup RD Intensity	2.347***		2.007***	
	(0.00)		(0.00)			(0.00)		(0.00)	
Cust on Firm Bd		0.008***		0.005***	Sup on Firm Bd		0.027**		0.053*
		(0.00)		(0.00)			(0.03)		(0.06)
Cust Ad Intensity					Sup Ad Intensity				
Firm RD Intensity	0.017		0.031		Firm RD Intensity	0.003		0.003	
	(0.40)		(0.32)			(0.72)		(0.74)	
Firm Ad Intensity					Firm Ad Intensity				
Firm on Cust Bd	1.680***	-0.012***	1.333***	-0.004	Firm on Sup Bd	1.547***	0.033	1.330***	0.072*
	(0.00)	(0.00)	(0.00)	(0.14)		(0.00)	(0.43)	(0.00)	(0.07)
Constant	-2.543***	0.092***	-2.053***	0.081***	Constant	2.453***	0.109*	2.534***	0.174***
	(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.06)	(0.00)	(0.01)
Controls as in Table					Controls as in Table				
4 Panel A	Yes	Yes	Yes	Yes	4 Panel A	Yes	Yes	Yes	Yes
Industry and Year					Industry and Year				
Fixed Effects	Yes	Yes	Yes	Yes	Fixed Effects	Yes	Yes	Yes	Yes
Observations	5,516	5,516	5,516	5,516	Observations	5,516	5,516	5,516	5,516
Adj R-squared		0.555		0.555	Adj R-squared		0.448		0.448
Pseudo R-squared	0.176		0.117		Pseudo R-squared	0.184		0.109	

#### Table 6: Role of patent citations and customer/supplier concentration

This table reports the second stage coefficients from the simultaneous probit least squares estimations of R&D intensity and board relationships. The specifications, dependent variables, and control variables for customers (suppliers) are the same as in Table 4 Panel A (Panel B). The table presents the coefficients of interactions of the predicted variables with the log of cross patent citations in estimations (1-2), and the inverse of the number of suppliers (customers) for a given customer (supplier) in a given year in estimations (3-4) The independent variables, Cust RD Intensity and Cust on Firm Bd represent fitted values from the first stage. The corresponding supplier variables similarly represent fitted values from the first stage. The estimations control for year and industry fixed effects. \*\*\*,\*\*,\* denote significance at the 1,5,and 10% levels respectively. We only report the variables of interest for brevity.

	(1)	(2)	(3)	(4)		(1)	(2)	(3)	(4)
	Cust on	Cust RD	Cust on	Cust RD		Sup on	Sup RD	Sup on	Sup RD
	Firm Bd	Intensity	Firm Bd	Intensity		Firm Bd	Intensity	Firm Bd	Intensity
Cust RD Intensity	2.875**		7.253***		Sup RD Intensity	1.832***		1.591*	
-	(0.02)		(0.00)			(0.00)		(0.09)	
Cust on Firm Bd		0.014***		0.013***	Sup on Firm Bd		0.050***		0.051***
		(0.00)		(0.00)			(0.00)		(0.00)
Cust RD Intensity * Patent	0.068**				Sup RD Intensity * Patent	0.111**			
	(0.04)					(0.01)			
Cust on Firm Bd * Patent		0.001*			Sup on Firm Bd * Patent		0.001*		
		(0.08)					(0.08)		
Cust RD Intensity * Sup conc.			6.197**		Supp RD Intensity * Cust conc.			0.614	
			(0.02)					(0.55)	
Cust on Firm Bd * Sup conc.				0.006***	Sup on Firm Bd * Cust conc.				0.021*
				(0.00)					(0.10)
Patents	0.059***	0.001			Patents	0.003	0.004		
	(0.00)	(0.32)				(0.89)	(0.27)		
Sup conc.			-0.183	0.014***	Cust conc.			0.105	0.034
			(0.27)	(0.00)				(0.44)	(0.19)
Constant	-1.764***	0.100***	-1.395***	0.088***	Constant	-2.496***	-0.062***	-2.620***	-0.060***
	(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.01)
Controls as in Table 4 Panel A	Yes	Yes	Yes	Yes	Controls as in Table 4 Panel A	Yes	Yes	Yes	Yes
Industry and Year Fixed					Industry and Year Fixed				
Effects	Yes	Yes	Yes	Yes	Effects	Yes	Yes	Yes	Yes
Observations	5,516	5,516	5,516	5,516	Observations	5,516	5,516	5,516	5,516
Adj R-squared		0.555		0.556	Adj R-squared		0.453		0.453
Psuedo R-squared	0.131			0.124	Psuedo R-squared	0.110		0.111	

## Table 7: Second stage coefficients for customers and suppliers of firms with no RD

This table shows the coefficients from the second stage of the probit least squares simultaneous estimations for R&D intensity and board relationships. The specifications and control variables are the same as in Table 4 Panel A for customers, and Table 4 Panel B for suppliers. The regressions are only estimated for cases where the firm's R&D intensity is equal to zero. The independent variables, Cust RD Intensity and Cust on Firm Bd represent fitted values from the first stage. The corresponding supplier variables similarly represent fitted values from the first stage. The estimations control for year and industry fixed effects. \*\*\*,\*\*,\* denote significance at the 1,5,and 10% levels respectively.

	Customer ]	Estimations		Supplier Estimations		
	(1)	(2)		(3)	(4)	
	Cust on	Cust RD		Sup on	Sup RD	
	Firm Bd	Intensity		Firm Bd	Intensity	
Cust RD Intensity	2.500**		Sup RD Intensity	0.385**		
	(0.05)			(0.01)		
Cust on Firm Bd		0.008**	Sup on Firm Bd		0.012**	
		(0.06)			(0.04)	
Constant	-1.970**	0.064***	Constant	-3.492***	-0.038	
	(0.03)	(0.00)		(0.00)	(0.85)	
Controls as in Table 4 Panel A	Yes	Yes	Controls as in Table 4 Panel A	Yes	Yes	
Industry and Year Fixed Effects	Yes	Yes	Industry and Year Fixed Effects	Yes	Yes	
Observations	2043	2043	Observations	2631	2631	
Adj R-squared		0.614	Adj R-squared		0.521	
Pseudo R-squared	0.342		Pseudo R-squared	0.341		

#### **Table 8: Role of information asymmetry**

This table reports the second stage coefficients from the simultaneous probit least squares estimations of R&D intensity and board relationships. Panel A presents descriptive statistics. Panel B reports coefficients for cutomers and Panel C presents the results for suppliers. The specifications and dependent variables in Panel B (Panel C) are the same as in Table 4 Panel A (Panel B). Columns 1 and 2 present the coefficients of interactions of the predicted variables with Firm Spread (bid-ask spread). Columns 3 and 4 present coefficients of interactions with the firm's accounting quality (Firm Acct. Qual). Columns 5 and 6 present the coefficients of interactions with an indicator variable, Diff Ind, which equals one if the firm and the customer (or supplier in Panel B) are in different industries, and zero otherwise. The independent variables in Panel B, Cust RD Intensity and Cust on Firm Bd represent fitted values from the first stage. The corresponding supplier variables in Panel C similarly represent fitted values from the first stage. The estimations control for year and industry fixed effects. \*\*\*,\*\*,\* denote significance at the 1,5,and 10% levels respectively.

	Panel A: Information asymmetry characteristics								
	Su	Supplier		stomer	Significance				
	Mean	Median	Mean	Median	Matched pair t-test				
Firm Spread	0.007	0.003	0.002	0.001	***				
Firm Acct. Qual	0.07	0.06	0.04	0.04	***				
Diff Ind	0.64	0.00	0.64	0.00	NA				

	Panel B: Customer Estimations						
	(1)	(2)	(3)	(4)	(5)	(6)	
	Cust on	Cust RD	Cust on	Cust RD	Cust on	Cust RD	
	Firm Bd	Intensity	Firm Bd	Intensity	Firm Bd	Intensity	
Cust RD Intensity	3.078**		5.728***		3.055**		
	(0.03)		(0.00)		(0.04)		
Cust on Firm Bd		0.014***		0.014***		0.015***	
		(0.00)		(0.00)		(0.00)	
Cust RD Intensity * Firm Spread	3.071*						
	(0.09)						
Cust on Firm Bd * Firm Spread		0.006**					
		(0.01)					
Cust RD Intensity * Firm Acct. Qual			3.566*				
			(0.06)				
Cust on Firm Bd * Firm Acct. Qual.				0.002**			
				(0.03)			
Cust RD Intensity * Diff Ind					0.424**		
					(0.03)		
Cust on Firm Bd * Diff Ind						0.005***	
						(0.01)	
Firm Spread	-0.050*	-0.009*					
	-0.07	-0.05					
Firm Acct. Qual			0.206**	-0.005*			
			(0.05)	-0.09			
Diff Ind					-0.301***	-0.017***	
					(0.00)	(0.00)	
Constant	-2.129***	0.096***	-2.144***	0.097***	-1.700***	0.106***	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
Controls as in Table 4 Panel A	Yes	Yes	Yes	Yes	Yes	Yes	
Industry and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	5,516	5,516	5,516	5,516	5,516	5,516	
Adjusted R-squared		0.551		0.551		0.555	
Pseudo R-squared	0.119		0.119		0.125		

	Panel C: Supplier Estimations						
	(1)	(2)	(3)	(4)	(5)	(6)	
	Sup on	Sup RD	Sup on	Sup RD	Sup on	Sup RD	
	Firm Bd	Intensity	Firm Bd	Intensity	Firm Bd	Intensity	
Sup RD Intensity	2.332***		2.074***		2.326***		
	(0.00)		(0.00)		(0.00)		
Sup on Firm Bd		0.051***		0.051***		0.051***	
		(0.00)		(0.00)		(0.00)	
Sup RD Intensity * Firm Spread	1.075*						
	(0.05)						
Sup on Firm Bd * Firm Spread		0.001**					
		(0.02)					
Sup RD Intensity * Firm Acct. Qual			0.078*				
			(0.89)				
Sup on Firm Bd * Firm Acct. Qual.				0.001*			
				(0.08)			
Sup RD Intensity * Diff Ind					0.497**		
					(0.02)		
Sup on Firm Bd * Diff Ind						0.003*	
						(0.05)	
Firm Spread	0.021	0.039**					
	(0.83)	(0.02)					
Firm Acct. Qual			0.117	0.127***			
			(0.21)	(0.00)			
Diff Ind					0.103	0.037**	
					(0.25)	(0.02)	
Constant	-2.492***	-0.067***	-2.519***	-0.068***	-2.594***	-0.057***	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	
Controls as in Table 4 Panel B	Yes	Yes	Yes	Yes	Yes	Yes	
Industry and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	5,516	5,516	5,516	5,516	5,516	5,516	
Adjusted R-squared		0.455		0.454		0.456	
Pseudo R-squared	0.191		0.190		0.190		

# Table 9: Role of financial distress

This table reports the second stage coefficients from the simultaneous probit least squares estimations of R&D intensity and board relationships. The specifications, dependent variables, and control variables for customers (suppliers) are the same as in Table 4 Panel A (Panel B). The table presents the coefficients of interactions of the predicted variables with Firm Zscore, which is an indicator variable that equals one if the firm's Altman Z-score is below the 25th percentile in value. Firm Spread is the firm's bid-ask spread. The independent variables, Cust RD Intensity and Cust on Firm Bd represent fitted values from the first stage. The corresponding supplier variables similarly represent fitted values from the first stage. The estimations control for year and industry fixed effects. \*\*\*,\*\*,\* denote significance at the 1,5,and 10% levels respectively. We only report the variables and interactions of interest for brevity.

	(1)	(2)		(3)	(4)
	Cust on	Cust RD		Sup on	Sup RD
	Firm Bd	Intensity		Firm Bd	Intensity
Cust RD Intensity	5.550***		Sup RD Intensity	2.575**	
	(0.01)			(0.01)	
Cust on Firm Bd		0.012***	Sup on Firm Bd		0.051***
		(0.00)			(0.00)
Cust RD Intensity * Firm Zscore	1.414		Sup RD Intensity * Firm Zscore	1.507**	
	(0.51)			(0.04)	
Cust on Firm Bd * Firm Zscore		0.006***	Sup on Firm Bd * Firm Zscore		0.005**
		(0.00)			(0.03)
Firm Zscore	-0.262**	-0.010***	Firm Zscore	-0.105*	-0.010*
	(0.04)	(0.00)		-0.1	(0.06)
Firm Spread	-0.131**	-0.002*	Firm Spread	0.08	0.004
	(0.02)	-0.06		(0.35)	(0.37)
Constant	-2.422***	0.094***	Constant	-2.143***	-0.066***
	(0.00)	(0.00)		(0.00)	(0.00)
Controls as in Table 4 Panel A	Yes	Yes	Controls as in Table 4 Panel B	Yes	Yes
Industry and Year Fixed Effects	Yes	Yes	Industry and Year Fixed Effects	Yes	Yes
Observations	5,516	5,516	Observations	5,516	5,516
Adjusted R-squared		0.552	Adjusted R-squared		0.455
Pseudo R-squared	0.180		Pseudo R-squared	0.190	

#### Table 10: Controlling for outside relationships between the firm and the customer/supplier

This table reports the second stage coefficients from the simultaneous probit least squares estimations of R&D intensity and board relationships. The specifications, dependent variables, and control variables for customers (suppliers) are the same as in Table 4 Panel A (Panel B). The table presents the coefficients of interactions of the predicted variables with two different variables. The first is Firm on Cust Bd (or Firm on Sup Bd), which equals one if an executive or director of the firm is on the board of its customer (or supplier), and zero otherwise. The second variable used in the interactions is Outside, which equals one if any of the executives or directors of both the firm and customer (or supplier) are on the same boards of some outside alternative company in the year of the relationship between the firm and the customer (or supplier). The independent variables, Cust RD Intensity and Cust on Firm Bd represent fitted values from the first stage. The estimations control for year and industry fixed effects. \*\*\*,\*\*,\* denote significance at the 1,5,and 10% levels respectively. We only report the variables of interest for brevity.

	Customer Estimations			Supplier Estimations					
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
	Cust on	Cust RD	Cust on	Cust RD		Sup on	Sup RD	Sup on	Sup RD
	Firm Bd	Intensity	Firm Bd	Intensity		Firm Bd	Intensity	Firm Bd	Intensity
Cust RD Intensity	6.097***		4.674***		Sup RD Intensity	2.230***		2.030***	
	(0.00)		(0.00)			(0.00)		(0.00)	
Cust on Firm Bd		$0.008^{***}$		0.007***	Sup on Firm Bd		0.027**		0.033**
		(0.00)		(0.00)			(0.03)		(0.04)
Cust on Firm Bd * Firm	0.944				Sup on Firm Bd * Firm	0.579			
	(0.24)					(0.50)			
Cust RD Intensity * Firm		0.002*			Sup RD Intensity * Firm		0.017**		
		(0.07)					(0.63)		
Cust RD Intensity * Outside			15.599***		Sup RD Intensity * Outside			0.794	
			(0.00)					(0.52)	
Cust on Firm Bd * Outside				0.001	Sup on Firm Bd * Outside				0.002
				(0.74)					(0.90)
Outside relationship			0.944***	-0.007**	Outside relationship			0.549***	0.004
			(0.00)	(0.04)				(0.00)	(0.86)
Firm on Cust Bd	1.711***	0.012***	1.477***	$0.008^{***}$	Firm on Sup Bd	1.495***	0.012***	1.379***	$0.008^{***}$
	(0.00)	(0.00)	(0.00)	(0.01)		(0.00)	(0.00)	(0.00)	(0.01)
Constant	-2.550***	0.092***	-2.534***	0.089***		-2.440***	0.109*	-2.401***	0.117**
	(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.06)	(0.00)	(0.04)
Controls as in Table 4 Panel	Yes	Yes	Yes	Yes	Controls as in Table 4 Panel	Yes	Yes	Yes	Yes
Industry and Year Fixed	Yes	Yes	Yes	Yes	Industry and Year Fixed	Yes	Yes	Yes	Yes
Observations	5,516	5,516	5,516	5,516	Observations	5,516	5,516	5,516	5,516
Adjusted R-squared		0.554		0.555	Adjusted R-squared		0.448		0.448
Pseudo R-squared	0.179		0.280		Pseudo R-squared	0.188		0.206	