

Suppliers in business-to-business settings are increasingly building a portfolio of multiple types of ties with individual customers. For example, in addition to supplying goods and services, a supplier may have a research-and-development alliance and a marketing alliance with a customer. This study investigates the effect of multiple types of ties with a customer on a supplier's performance with the customer. The findings from panel data on supplier–customer relationships suggest that an increase in the number of different types of ties with a customer results in an increase in supplier sales to the customer and a decrease in sales volatility to that customer. The effect of a change in relationship multiplexity (i.e., number of different types of ties) on the change in sales becomes weaker and its effect on the change in sales volatility becomes stronger as the competitive intensity in the customer's industry increases. The results also indicate that the effect of a change in the number of different types of ties on the change in sales volatility becomes stronger when the intangibles intensity in a customer's industry increases. The results are robust to alternative measures, alternative estimators, heteroskedasticity, and endogeneity, among other methodological concerns. These findings have clear implications for managing multiple types of ties with a customer and indicate that relationship multiplexity is a valuable nonfinancial metric.

Keywords: relationship multiplexity, multiple types of ties, financial performance, business-to-business customer relationships, sales growth, sales volatility

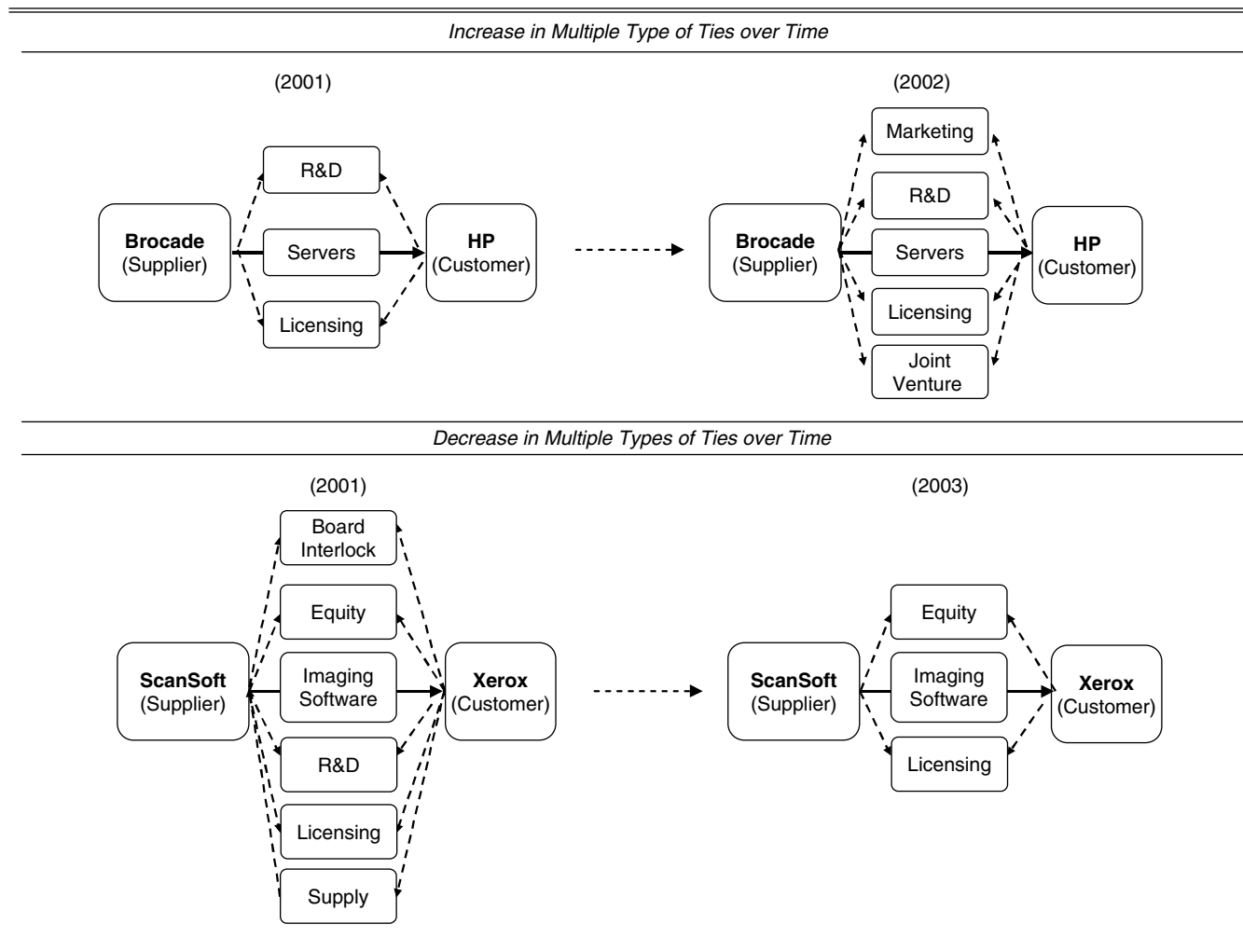
Ties That Bind: The Impact of Multiple Types of Ties with a Customer on Sales Growth and Sales Volatility

It is increasingly common for suppliers in business-to-business (B2B) settings to build multiple types of ties with

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their customers (e.g., Rindfleisch and Moorman 2001). For example, in 2002, Brocade Communications set up a marketing alliance and a joint venture with Hewlett–Packard (HP). This was in addition to its main business of selling servers to HP and a research-and-development (R&D) alliance and a licensing agreement with HP (see Figure 1). It can be argued that by increasing the number of different types of ties with a customer, a supplier can obtain useful private information about a customer (e.g., Uzzi 1997) and build a long-term focus, or solidarity, with a customer (e.g., Kilduff and Tsai 2003). However, there is little empirical evidence whether changes in the number of different types of ties with a customer result in changes in supplier performance with that customer. This is surprising because it takes significant resources to develop and maintain multiple types of ties with B2B customers (e.g., Heide 1994; Murry and Heide 1998).

Figure 1
CHANGES IN MULTIPLE TYPES OF TIES BETWEEN A SUPPLIER AND A CUSTOMER



The purpose of this study is to investigate the effects of changes in the number of different types of ties on changes in supplier performance with an individual customer. We draw on the resource-based view (RBV) of a firm to argue that presence of multiple types of ties—that is, “relationship multiplexity”—is a valuable resource for a supplier that is rare and difficult to imitate and/or substitute. In addition, we argue that the value of this resource varies with conditions in customer’s industry (see Wathne and Heide 2004). The study makes the following contributions.

First, whereas prior studies have investigated individual ties, such as R&D alliances (Rindfleisch and Moorman 2001) and marketing alliances (Murry and Heide 1998), this study examines the effect of a portfolio of diverse ties between a supplier and a customer on the supplier’s performance with the customer. In doing so, the study is responsive to calls to move from a focus on individual ties to multiplex relationships (e.g., Palmatier 2007; Ross and Robertson 2007).

Second, the current study is responsive to calls for examining the financial impact of customer relationships (e.g., Rust et al. 2004). We examine the effects of a change in the number of different types of ties on two key financial

metrics of supplier performance with a customer—change in sales (i.e., sales growth) and change in sales volatility. Sales growth to a customer is an important indicator of the health of a customer relationship, and managers are often evaluated on this metric. It is also viewed as a valuable metric by financial analysts as firms with higher sales growth receive higher valuations (e.g., Brailsford and Yeoh 2004). Volatility in sales to a customer reflects uncertainty of revenues from the customer and therefore is a relevant metric for sales managers (Miller 2006). Indeed, firms with high sales volatility are viewed as more risky by financial analysts (Srivastava, Shervani, and Fahey 1999). We find that an increase in the number of different types of ties with a customer results in an increase in sales to the customer and a decrease in sales volatility to the customer. Therefore, the presence of multiple types of ties with a customer, or relationship multiplexity, is a valuable “market-based asset” that can be used by financial analysts to assess the potential growth and volatility in sales of a firm (Srivastava, Shervani, and Fahey 1998).

Third, the study identifies customer industry-related contingencies that influence the effects of relationship multiplexity. We find that the effect of a change in relationship

multiplexity on the change in sales becomes weaker and its effect on the change in sales volatility becomes stronger as competitive intensity in the customer's industry increases. This suggests that suppliers should be cognizant of the trade-offs between sales growth and sales volatility to multiplex customers as competitive intensity in the customer's industry increases. We also find that the impact of changes in relationship multiplexity on changes in sales volatility becomes stronger as customer industry intangibles intensity increases. This suggests that suppliers should focus on forming multiple types of ties with customers in industries with increasing intangibles intensity, if the objective is to realize more stable revenues.

Fourth, to our knowledge, this study is the first to use panel data on customer relationships across multiple industries. Therefore, the study complements recent customer relationship panel studies of single firms (e.g., Ansari, Mela, and Neslin 2008). The panel data enable us to address issues of unobservable factors and endogeneity. Sensitivity analyses suggest that our results are robust to alternative measures of multiplexity, alternative model specifications, and concerns related to sample selection bias and heteroskedasticity.

Fifth, the study's results have important implications for reporting standards recommended by the Financial Accounting Standard Board (FASB) and the International Accounting Standards Board (IASB).¹ Firms are required to identify their large customers because firm performance is likely to be vulnerable to adverse decisions by such customers (see FASB statement No. 14 at www.fasb.org). However, our results suggest that increasing relationship multiplexity reduces vulnerability to such customers because it enhances sales growth and reduces sales volatility to these customers. Therefore, relationship multiplexity can be viewed as an intangible asset (FASB 2002) and possibly a relevant nonfinancial measure (IASB 2004; Ittner and Larcker 1998).

RELATIONSHIP MULTIPLEXITY: A RESOURCE-BASED PERSPECTIVE

Relationship multiplexity refers to the number of diverse types of ties between two firms (Carrington, Scott, and Wasserman 2005). Beyond selling goods/services, suppliers may have other ties, such as marketing alliances (e.g., Bucklin and Sengupta 1993), R&D alliances (e.g., Rindfleisch and Moorman 2001), equity ownerships, and board memberships (e.g., Fee, Hadlock, and Thomas 2006) with customers. However, a supplier that simply sells multiple offerings to a customer is not considered to have a multiplex relationship with it. This is because different offerings sold to a customer pertain to a single type of tie, that of a supplier–customer. In contrast, a supplier that sells goods/services to a customer and has an equity stake in it

is considered to have a multiplex relationship with the customer. This is because the supplier has two distinct roles, that of a seller and an investor (Ross and Robertson 2007).

Recent research suggests that the RBV is a theoretical framework that integrates theories on supplier–customer relationships, such as the commitment–trust theory, transaction cost economics, and relational norms (Palmatier, Dant, and Grewal 2007). We use the RBV framework to argue that relationship multiplexity is a valuable resource that is rare and difficult to imitate or substitute (Barney 1991). We argue that relationship multiplexity enhances supplier sales to a customer and lowers the volatility in sales to a customer, two metrics of high relevance to managers and financial analysts (Dobbs and Koller 2005).

Relationship Multiplexity, Sales Growth, and Sales Volatility

We draw on network theory in sociology, which indicates that relationship multiplexity leads to benefits of solidarity and private information. These benefits make relationship multiplexity a valuable resource as they enable a supplier to create more value for a customer.

Solidarity. Network theory suggests that multiplex relationships are more stable because it is more difficult to terminate a relationship comprising diverse ties in which each type of tie provides unique value for the partners (Kenis and Knoke 2002; Palmatier 2007). Therefore, firms in multiplex relationships are likely to focus on their mutual interests over the long run and have greater commitment and reciprocity toward each other (i.e., maintain solidarity with each other; see Kilduff and Tsai 2003; Uzzi 1997). Importantly, solidarity enables a supplier and a customer to collaborate and identify avenues for enhancing mutual benefits (Jap 1999). For example, recent work based on network theory suggests that a supplier and a customer with high solidarity are likely to codevelop offerings that are more likely to be purchased by the customer, thus increasing a supplier's sales to the customer (Palmatier 2007). Solidarity in a supplier–customer relationship can also lead to a coordination of their ordering processes, lowering their inventories and, therefore, cost of operations (e.g., Narus and Anderson 1996). In this way, solidarity in multiplex relationships enables a supplier to create superior value for the customer and is likely to result in an increase in sales to the customer.

Private information. Suppliers and customers in multiplex relationships also have access to broader set of information sources about each other, with each source corresponding to a different type of tie (Beckman and Haunschild 2002). Diversity of ties ensures that firms have access to nonredundant information, which may not be the case for firms with multiple but similar ties (Burt 1992). Thus, firms in multiplex relationships are more likely to obtain private information about each other, information that is not available in the public domain (Uzzi 1997).

A supplier can use private information about a customer to identify opportunities for creating value for the customer. Private information about a customer's operating environment can help a supplier understand the customer's idiosyncratic requirements and tailor its offerings to meet a customer's unique needs. Private information about

¹FASB establishes the standards for financial reporting and its recommendations are considered "authoritative" by the Securities and Exchange Commission and the American Institute of Certified Public Accountants. The IASB is FASB's global counterpart that establishes international financial reporting standards.

a customer's operating environment also increases a supplier's familiarity with the customer's demand patterns and therefore provides it an opportunity to anticipate a customer's requirements (Tuli, Kohli, and Bharadwaj 2007). This reduces the time and effort that a customer might expend in conveying and explaining its new requirements to a supplier (Srivastava, Shervani, and Fahey 1998). This is valuable for a customer because it enhances its ability to respond to new and/or unexpected developments in its markets. Finally, a supplier in a multiplex relationship can obtain private information about a customer's buying process and key purchase influences and criteria (e.g., Palmatier 2007). This is likely to enable a supplier to influence the preferences of key decision makers, thus increasing its odds of growing sales to a customer (Dhar, Menon, and Maach 2004).

Just as a supplier can take advantage of customer private information, a customer can also leverage private information about a supplier's capabilities to ensure that it purchases offerings that the supplier is capable of delivering well. Ability to procure better offerings is important because it can improve the quality of customer firm's offerings to its customers. In addition, it reduces the customer's procurement costs related to reworking and recovering from supplier offerings that are of poor quality or otherwise unsuitable (Heide 1994).

Relationship multiplexity is not only valuable but also a rare and difficult-to-imitate and/or -substitute resource. Not many suppliers and customers form multiplex relationships because of the substantial resources required to build multiple types of ties and the complexities involved in managing these ties. Indeed, in the sample collected for the current study, we find that approximately 65% relationships are not multiplex. Recent research in network theory also suggests that it is difficult to replicate multiplex relationships because each multiplex relationship has its own unique set of personnel from multiple functions and across hierarchical levels managing multiple types of ties (Palmatier 2007). In addition, solidarity between a supplier and a customer in a multiplex relationship is rare and difficult to imitate because of the relative paucity of customers interested in investing the resources necessary to develop solidarity (Dyer and Singh 1998; Palmatier, Dant, and Grewal 2007). Not surprisingly, relationships with high solidarity are viewed as entry barriers that are "almost impenetrable by rivals" (Srivastava, Shervani, and Fahey 1998, p. 7).

In summary, relationship multiplexity is a valuable resource that is rare and difficult for competitors to imitate or substitute. As multiplexity increases, it increases the benefits available to a supplier and a customer. The supplier is able to develop superior offerings and collaborate with a customer to identify and develop new offerings required by the customer. Therefore, a customer is likely to increase its purchases from a supplier as its relationship multiplexity with the supplier increases. Formally,

H₁: A positive change in relationship multiplexity with a customer results in a positive change in sales to that customer.

As multiplexity increases, the economic incentives (e.g., better offerings and lower inventories) for a customer to obtain more of its requirements from a supplier also increase. Therefore, the customer is less likely to switch to

other prospective suppliers to take advantage of marginally better products or prices (see Hutt and Speh 2001; Srivastava, Shervani, and Fahey 1998). As such, a supplier's sales to a customer with which it has multiplex relationships are likely to fluctuate to a lesser extent over time.

Solidarity in multiplex relationships also enables a supplier and a customer to make up for losses in a given transaction with offsetting gains in subsequent ones (Rokkan, Heide, and Wathne 2003). Therefore, as relationship multiplexity increases, suppliers and customers are less likely to bargain frequently about prices and terms of trade (e.g., Simester and Knez 2002). Instead, customers tend to work with suppliers to address their deficiencies rather than abandoning them for their competitors (Narayandas and Rangan 2004). This again suggests that a supplier's sales to a customer are likely to become more stable (i.e., less volatile) as relationship multiplexity increases. Thus:

H₂: A positive change in relationship multiplexity with a customer results in a negative change in sales volatility to that customer.

MODERATING EFFECTS OF CUSTOMER INDUSTRY CONDITIONS

Scholars of the RBV frequently underscore the need to identify industry conditions that affect the value of a resource (e.g., Barney 1991). For suppliers, it is important to assess the impact of conditions in a customer's industry because they can influence supplier performance with the customer (Wathne and Heide 2004). Therefore, we explore the effects of a change in relationship multiplexity on the change in sales and the change in sales volatility across two customer industry conditions suggested by RBV: competitive intensity and intangibles intensity.

Moderating Effect of Competitive Intensity in Customer Industry

As we discussed previously, an increase in relationship multiplexity increases the probability of a supplier offering superior products/services, thus providing greater economic incentives to buy from the supplier. These incentives are expected to be more valuable for a customer as competitive intensity in its industry increases. This is because increases in competitive intensity put greater pressure on customers to procure superior offerings and lower their procurement costs (Hastings 2004; Sánchez and Schmitz 2002). Therefore, as the competitive intensity in a customer's industry increases, it is likely to purchase more from a supplier with which it has a multiplex relationship. As such, we expect the following:

H₃: The association between a change in relationship multiplexity with a customer and the change in sales to that customer is more positive when the competitive intensity in the customer's industry increases.

As competitive intensity in a customer's industry increases, the customer has greater economic incentives to avoid switching purchases away from a supplier with which it has a multiplex relationship. This is because increasing

competitive intensity increases the pressure on the customer to procure better inputs and lower its procurement costs (Soberman and Gatignon 2005). Therefore, a customer facing increasing competitive intensity is less likely to switch to alternative suppliers that may offer short-term inducements, such as marginally better products or prices (see Srivastava, Shervani, and Fahey 1998). In turn, this is likely to make a multiplex supplier's sales to the customer more stable. Consequently,

- H₄: The association between a change in relationship multiplexity with a customer and the change in sales volatility to that customer is more negative when the competitive intensity in the customer's industry increases.

Moderating Effect of Intangibles Intensity in Customer Industry

Whereas some industries, such as pharmaceuticals, are characterized by a high level of intangible assets (e.g., intellectual property), other industries, such as manufacturing, entail a high level of tangible assets (e.g., plant, equipment). The creation and augmentation of intangible assets is subject to causal ambiguity (Dierickx and Cool 1989; Srivastava, Shervani, and Fahey 1999). That is, firms in industries with high intangibles intensity find it relatively difficult to identify inputs that lead to the creation of intangible assets (Slotegraaf, Moorman, and Inman 2003). Indeed, suppliers view customers in a high-intangibles-intensity industry as belonging to an "opaque industry" (see Morgan 2002). Therefore, as intangibles intensity in a customer's industry increases, it becomes more difficult for the customer to accurately predict the goods/services it will need and to articulate the same to a supplier (Bharadwaj, Varadarajan, and Fahy 1993).

As we noted previously, relationship multiplexity with a customer engenders solidarity and helps a supplier obtain private information about the customer. In turn, these enable the supplier to collaborate closely with the customer and complement the customer's knowledge of its business with the supplier's experience and knowledge (see also Tuli, Kohli, and Bharadwaj 2007). Such pooling of knowledge afforded by relationship multiplexity is more important for serving customers as the intangibles intensity in its industry increases. This is because it helps a supplier better anticipate the goods/services likely to be needed by customers and plan ahead to deliver the same and thus realize higher sales. In contrast, such close collaboration with a customer is less valuable when the intangibles intensity in a customer's industries decreases because these customers can now more readily articulate their needs to a supplier. Thus, a change in relationship multiplexity is likely to have a stronger positive effect on the change in supplier sales to customers as the intangibles intensity in customer's industry increases. Formally,

- H₅: The association between a change in relationship multiplexity with a customer and the change in sales to that customer is more positive when the intangibles intensity in the customer's industry increases.

In industries with low intangibles intensity, customers are able to articulate their requirements explicitly in requests

for proposals. Suppliers are required to meet these requirements and thus have limited latitude to differentiate their offerings. Therefore, customers are able to choose from a broader set of suppliers that all attempt to deliver the explicit requirements defined in the request for proposals. As the intangibles intensity in a customer's industry increases, it becomes more difficult for the customer to identify and develop alternative suppliers that can serve it as well as an incumbent supplier with which it has a multiplex relationship. This is because it is more difficult for prospective suppliers (that do not have the broad-based interaction and experience of the incumbent supplier) to understand the customer requirements when the intangibles intensity in a customer's industry increases (see Di Patti and Dell'Araccia 2004). In turn, this inhibits a customer from switching sales away from a supplier with which it has a multiplex relationship, resulting in lower sales volatility. Thus:

- H₆: The association between a change in relationship multiplexity with a customer and the change in sales volatility to that customer is more negative when the intangibles intensity in the customer's industry increases.

DATA COLLECTION AND MEASURES

Data Collection

The Securities and Exchange Commission (SEC) requires publicly listed firms to identify customers that contribute more than 10% of any of their operating segment's revenues.² In practice, firms tend to disclose sales to a customer for the prior three years, even if sales to the customer are less than 10% of the business unit's revenues in one or more of the three years. This behavior is consistent with theories and findings in the accounting literature suggesting that firms are better-off providing more information than is required by financial disclosure rules (e.g., Gu and Li 2007). Therefore, by tracking the SEC filings of publicly listed firms, it is possible to identify a supplier's customers and sales to these customers.

We manually obtained data for computing relationship multiplexity from multiple SEC filings of publicly listed firms: 10-K (annual report), 10-Q (quarterly report), DEF14-A (definitive proxy report containing information about board of directors and key equity holders), and 8-K (current reports about the firm). We supplement the SEC reports with data on formation and dissolution of supplier-customer ties from the Securities Data Company database, customer and supplier Web sites, and electronic databases

²An operating segment is defined as the components of an enterprise about which separate financial information is available and is regularly monitored by the chief operating decision maker of an organization (see FASB Statement No. 131 at www.fasb.org). Therefore, a firm operating in multiple operating segments is considered a highly diversified firm, while a firm operating in a single operating segment is not diversified.

Table 1
SUMMARY OF MEASURES AND DATA SOURCES

<i>Variable</i>	<i>Measure</i>	<i>Sources</i>
<i>Dependent Variables</i>		
1. Sales growth to a customer	$\log \left(\frac{\text{Sales to a Customer in Relationship } i \text{ at } t}{\text{Sales to a Customer in Relationship } i \text{ at } (t-1)} \right)$	•SEC Filings 10-K, 10-Q •COMPUSTAT
2. Sales volatility from a customer	$\log \left[\text{Coefficient of Variation} \left(\frac{\text{Sales to Customer}_{it},}{\text{Sales to Customer}_{i(t-1)},} \right) \right]$	•SEC Filings 10-K, 10-Q •COMPUSTAT
<i>Independent Variables</i>		
1. Relationship multiplexity	$\log (\text{Number of different ties between a supplier and a customer})$	•SEC Filings (10-K, 10-Q, 8-K, DEF 14A) •Electronic search •EBSCO, FACTIVA, ABI/INFORM •Supplier and customer Web site
2. Customer industry competitive intensity	$\log \left(\frac{(\text{Herfindahl Concentration Index at } t)}{(\text{Herfindahl Concentration Index at } t-1)} \right)$	•COMPUSTAT
3. Customer industry intangibles intensity	$\text{Industry Average} \left[\log \left(1 - \frac{(\text{Plant, Property, and Equipment at } t)}{(\text{Total Assets at } t)} \right) \right]$	•COMPUSTAT
<i>Control Variables</i>		
	Supplier power, supplier firm sales growth, supplier firm sales volatility, customer firm sales growth, customer firm sales volatility, supplier industry competitive intensity, supplier industry intangibles intensity, and year dummies	•COMPUSTAT

(e.g., EBSCO, Factiva). In addition, we use the COMPUSTAT database to obtain financial data on supplier and customer firms and to calculate the firm and industry level control variables.

We focus on supplier firms listed as having only a single operating segment. This enables us to include firm-level variables (e.g., a supplier's overall sales growth and sales volatility, supplier market share) as controls in the empirical estimation. This is important because data on a supplier's sales to a customer are available only at the operating segment level, whereas supplier financial information is available only at the overall firm level. Importantly, by focusing on firms with only one operating segment, we ensure that interpretation of growth and volatility results is not confounded by a supplier's performance in multiple operating segments (see Kalwani and Narayandas 1995). Therefore, we do not include a firm such as General Electric in our data because it has multiple operating segments. In addition, we include only observations in which the customer is also a publicly listed firm. This enables us to use the customer firm's financial data (e.g., a customer firm's overall sales growth) as control variables.

Overall, we obtain data on 200 supplier–customer relationships during the 1997–2004 period, for a total of 1195 relationship–year observations. Because some relationships were formed and others were dissolved during this period, the panel is unbalanced. Because we use multiple periods to calculate sales growth and sales volatility, along with lagged variables as controls, we have 790 observations for sales growth and 388 observations for sales volatility. The 200 relationships include 110 customer firms and 126 supplier firms operating in Standard Industrial Classification codes 28, 34–38, and 73, which include high technology, manufacturing, and services industries.

There are seven types of ties among suppliers and customers in this sample: licensing agreements (17%), marketing alliances (10%), customers who are also suppliers of goods/services to their suppliers (8%), R&D alliances (7%), equity investments by customers in suppliers (6%), board interlocks (i.e., a customer's employees serving on a supplier's board of directors) (5%), and joint ventures (2%). Overall, approximately 35% of relationships in the data are multiplex, with an average of 1.53 ties between suppliers and customers.

Measures

Table 1 lists the measures of the key variables used in the study. We log-transform the variables because it lowers the impact of extreme values (see Anderson, Fornell, and Rust 1997) and is consistent with prior work on sales growth models (e.g., Campello 2003).

Sales growth. We use the log of sales and calculate the changes in sales as the difference between the log of sales to a customer at time t and the log of sales to the customer at time $(t-1)$. This difference in log of current and lagged sales, or the log of the ratio of sales to a customer at time t to sales at $(t-1)$, gives us the sales growth to a customer (e.g., Campello 2003).³

Sales volatility. We measured sales volatility to a customer as the log of the coefficient of variation in sales over time z , which includes years t , $(t-1)$, and $(t-2)$. The coefficient of variation is the ratio of standard deviation of sales

³ $\text{Log}(\text{Sales to Customer})_t - \text{Log}(\text{Sales to Customer})_{(t-1)} = \text{Log}\{(\text{Sales to Customer})_t / (\text{Sales to Customer})_{(t-1)}\} = \text{Sales Growth to Customer at time } t.$

to the mean of sales, and it controls for the differences in standard deviation of sales to a customer due to the magnitude of sales to the customer.

Relationship multiplexity. We measured relationship multiplexity as the log of the number of different types of ties between a supplier and a customer (Kilduff and Tsai 2003). Recall that the sample includes the following types of supplier–customer ties: (1) board interlocks, (2) marketing alliances, (3) R&D alliances, (4) joint ventures, (5) equity investments, (6) licensing agreements, and (7) customer as a supplier. Thus, for example, relationship multiplexity between Brocade and HP in 2002 (see Figure 1) is log (5).

Customer industry competitive intensity. We measured competitive intensity in a customer's industry by the log of the ratio of the industry's Herfindahl concentration index at time t to the industry Herfindahl concentration index at $(t-1)$. This measure is suggested by organizational ecologists, who note that increases (decreases) in industry concentration reflect high (low) competitive intensity (Boone, Witteloostuijn, and Carroll 2002).

Customer industry intangibles intensity. The industry average ratio of physical assets (i.e., property, plant, and equipment) to gross total assets represents the extent to which tangible assets dominate an industry. The higher this ratio, the greater is the tangibles intensity in an industry. We subtract this ratio from 1 to measure the intangibles intensity in a customer's industry (see Di Patti and Dell'Araccia 2004).

Control variables. We include several control variables in our models. First, to control for the power structure in a relationship (see Anderson and Weitz 1992), we use the ratio of supplier market share to the customer market share. This ratio represents the relative power of a supplier over a customer and is motivated by prior research that argues that the market share of a firm confers it bargaining power (e.g., Szymanski, Bharadwaj, and Varadarajan 1993). We measure firm market share by the ratio of its sales to the total sales of all firms in its four-digit Standard Industrial Classification code. Second, we use the log of a supplier firm's overall sales growth (i.e., across all customers) and the log of a customer firm's sales growth to control for changes in sales to a customer due to changes in overall sales of the supplier and the customer. Similarly, we use supplier and customer sales volatility to control for changes in sales volatility to a customer due to changes in the overall sales volatility of the supplier and the customer. Third, to account for supplier industry factors, we include the supplier industry competitive intensity and intangibles intensity. Finally, we use year dummies to control for global shocks that can affect sales growth and volatility.

MODEL AND ESTIMATION PROCEDURE

Sales Growth Model

We describe our econometric procedure by starting with a level–level model in Equation 1 (e.g., Anderson, Fornell, and Rust 1997). It is termed a level–level model because it includes the level of sales as the dependent variable and the levels of relationship multiplexity, interaction terms, and the control variables as independent variables. We include the lag of the dependent variable in the model because it

accounts for inertia, persistence in sales to a customer, and different initial conditions (see Wooldridge 2006).

$$(1) \quad S_{it} = \beta_1 S_{i(t-1)} + \beta_2 M_{it} + \beta_3 CI_{it} + \beta_4 (M_{it} \times CI_{it}) + \beta_5 II_{it} \\ + \beta_6 (M_{it} \times II_{it}) + \beta_7 RSP_{it} + \beta_8 SSG_{it} + \beta_9 CSG_{it} \\ + \beta_{10} SCI_{it} + \beta_{11} SII_{it} + \beta_{12} YD_{it} + \eta_i + \varepsilon_{it},$$

where

S_{it} = log of sales to a customer in relationship i at time t ,

M_{it} = log of multiplexity in relationship i at time t ,

CI_{it} = log of customer industry competitive intensity for relationship i at time t ,

II_{it} = log of customer industry intangibles intensity for relationship i at time t ,

RSP_{it} = log of relative supplier power in relationship i at time t ,

SSG_{it} = log of supplier firm sales growth in relationship i at time t ,

CSG_{it} = log of customer firm sales growth in relationship i at time t ,

SCI_{it} = log of supplier industry competitive intensity for relationship i at time t ,

SII_{it} = log of supplier industry intangibles intensity for relationship i at time t ,

YD_{it} = year dummies for relationship i at time t ,

η_i = time invariant unobservable factors, and

ε_{it} = random error.

Time-invariant unobservable factors (η_i) include factors that are unlikely to change over time (e.g., colocation of supplier and customer manufacturing plants). Note that in Equation 1, η_i is correlated with $S_{i(t-1)}$.⁴ Thus, if we do not account for the effects of η_i , our results will be biased. Therefore, we follow precedent in econometrics and marketing and first-difference Equation 1—that is, we subtract its lagged value, $S_{i(t-1)}$, from it (e.g., Anderson, Fornell, and Rust 1997; Arellano and Bond 1991). This removes η_i and gives us the growth–growth model, in which a change in the log of sales (i.e., sales growth) is the dependent variable and a change in relationship multiplexity and control variables are independent variables:

$$(2) \quad \Delta S_{it} = \beta_1 (\Delta S_{i(t-1)}) + \beta_2 (\Delta M_{it}) + \dots + \Delta \varepsilon_{it},$$

where $\Delta S_{it} = S_{it} - S_{i(t-1)}$. Importantly, the growth–growth model is consistent with our hypotheses, which predict that changes in relationship multiplexity affect the changes in sales.

Sales Volatility Model

Similar to the sales growth model, we begin with a level–level model for sales volatility:

$$(3) \quad V_{iz} = \beta_{v1} V_{i(z-1)} + \beta_{v2} M_{iz} + \beta_{v3} CI_{iz} + \beta_{v4} (M_{iz} \times CI_{iz}) + \beta_{v5} II_{iz} \\ + \beta_{v6} (M_{iz} \times II_{iz}) + \beta_{v7} AG_{iz} + \beta_{v8} RSP_{iz} + \beta_{v9} SSV_{iz} \\ + \beta_{v10} CSV_{iz} + \beta_{v11} SCI_{iz} + \beta_{v12} SII_{iz} + \beta_{v13} YD_{iz} + \psi_i + \delta_{iz},$$

⁴This is because $S_{i(t-1)} = \alpha + \beta_1 S_{i(t-2)} + \dots + \eta_i + \varepsilon_{i(t-1)}$.

where

- V_{iz} = log of sales volatility to a customer in relationship i during time z ,
- M_{iz} = log of multiplexity in relationship i during time z ,
- CI_{iz} = log of customer industry competitive intensity for relationship i during time z ,
- II_{iz} = log of customer industry intangibles intensity for relationship i during time z ,
- AG_{iz} = absolute level of sales growth to customer in relationship i during time z ,
- RSP_{iz} = log of relative supplier power in relationship i during time z ,
- SSV_{iz} = log of supplier firm sales volatility in relationship i during time z ,
- CSV_{iz} = log of customer firm sales volatility in relationship i during time z ,
- SCI_{iz} = log of supplier industry competitive intensity for relationship i during time z ,
- SII_{iz} = log of supplier industry intangibles intensity for relationship i during time z ,
- YD_{iz} = year dummies for relationship i during time z ,
- ψ_i = time invariant unobservable factors, and
- δ_{iz} = random error.

Because we measure sales volatility over three years, we use the average of relationship multiplexity and other independent variables over three years in this model. We also include the absolute level of sales growth over three years (AG_{iz}) because sales volatility can increase due to an increase or decrease in sales growth. We first-difference Equation 3 to remove time-invariant unobservable factors (ψ_i). This gives us the following growth–growth model:

$$(4) \quad \Delta V_{iz} = \beta_{v1}(\Delta V_{i(z-1)}) + \beta_{v2}(\Delta M_{iz}) + \dots + \Delta \delta_{iz},$$

where $\Delta V_{iz} = V_{iz} - V_{i(z-1)}$. Again, this model is consistent with the proposed hypotheses.

Addressing Endogeneity

Lagged dependent variable. The lagged dependent variable in Equation 2 ($\Delta S_{i(t-1)}$) is correlated with the error term $\Delta \epsilon_{it}$. This is because $\epsilon_{i(t-1)}$ is in $\Delta \epsilon_{it}$ and is also a part of $\Delta S_{i(t-1)}$ per Equations 5 and 6:

$$(5) \quad \Delta S_{i(t-1)} = S_{i(t-1)} - S_{i(t-2)}, \text{ and}$$

$$(6) \quad S_{i(t-1)} = \beta_1(S_{i(t-2)}) + \beta_2 M_{i(t-1)} + \dots + \epsilon_{i(t-1)}.$$

Similarly, the lagged dependent variable in Equation 4, $\Delta V_{i(z-1)}$, is correlated with $\Delta \delta_{iz}$. Therefore, we need to take into account the endogeneity of $\Delta S_{i(t-1)}$ and $\Delta V_{i(z-1)}$.

Relationship multiplexity. Relationship multiplexity and its interaction terms are also endogenous in Equations 1 and 2. This is because variables such as trust and relationship duration are known to affect relationship performance and are also potentially correlated with relationship multiplexity (e.g., Bolton 1998; Kalwani and Narayandas 1995).

The general method of moments (GMM), which we describe subsequently, takes into account the endogeneity of the lagged dependent variable, relationship multiplexity,

and its interaction terms and obtains unbiased and consistent estimates. The method involves two steps: First, we use the first two lags of the endogenous variables, along with industry variables and year dummies as instruments for their first differences (for applications using lagged variables as instruments for first differences, see Mizik and Jacobson 2004; Narasimhan, Dutta, and Rajiv 2006). For example, $S_{i(t-2)}$ and $S_{i(t-3)}$ serve as instruments for $\Delta S_{i(t-1)}$ in Equation 2. Lagged values are valid instruments for the first differences under the assumption that error terms are not serially correlated (see Arellano and Bond 1991); that is,

$$(7) \quad E(\epsilon_{i(t)}, \epsilon_{i(t-1)}) = 0.$$

For example, consider $S_{i(t-2)}$:

$$(8) \quad S_{i(t-2)} = \beta_1(S_{i(t-3)}) + \beta_2 M_{i(t-2)} + \dots + \epsilon_{i(t-2)}.$$

Under the condition in Equation 7, $S_{i(t-2)}$ is a valid instrument for $\Delta S_{i(t-1)}$ because

1. It is correlated with $\Delta S_{i(t-1)}$, because $\Delta S_{i(t-1)} = S_{i(t-1)} - S_{i(t-2)}$, but
2. It is not correlated with the error term $\Delta \epsilon_{it}$, in Equation 2 because $\Delta \epsilon_{it} = \epsilon_{it} - \epsilon_{i(t-1)}$ —that is, it does not contain $\epsilon_{i(t-2)}$.

If ϵ_{it} is not serially correlated, the second-order differenced errors (AR II), $(\epsilon_{it} - \epsilon_{i(t-1)})$ and $(\epsilon_{i(t-2)} - \epsilon_{i(t-3)})$ should not be correlated. To test this assumption, we use the AR (II) test developed by Arellano and Bond (1991), in which the null hypothesis is that the differenced error terms are not correlated. We also use the Hansen test of overidentifying restrictions to test the validity of instruments. The null hypothesis is that the instruments are not valid (Roodman 2006).

Second, we use the valid instruments with the GMM estimator to obtain unbiased and consistent parameter estimates of both the sales growth and sales volatility model (see Arellano and Bond 1991). We use the GMM estimator because it does not require any assumptions about the distribution of the independent variables (Hansen and West 2002, pp. 462–63). This is important because the distribution of the relationship multiplexity contains a large number of zero values.

RESULTS

Table 2 provides the descriptive statistics and the correlation matrix of the key variables in the sales growth and the change in sales volatility models. Table 3 provides the results we obtained from estimating the sales growth and sales volatility models. As Table 3 notes, the results of the Hansen test and AR (II) tests indicate that the instruments used are valid. Parameter estimates for the sales growth and volatility models support H_1 and H_2 ; a positive change in relationship multiplexity results in a positive change in sales—that is, sales growth to a customer ($\beta_2 = .48$, $p < .05$)—and a negative change in sales volatility to a customer ($\beta_{v2} = -2.64$, $p < .05$).

H_3 and H_4 posit that the effect of a change in relationship multiplexity on the change in sales and the change in sales volatility is stronger when the competitive intensity in

Table 2
DESCRIPTIVE STATISTICS FOR SALES GROWTH AND CHANGE IN SALES VOLATILITY MODELS

<i>Correlation Matrix: Sales Growth</i>											
	<i>M</i>	<i>SD</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>
1. Δ Sales to a Customer _{it}	.06	.66	1.00								
2. Δ Relationship Multiplexity _{it}	.02	.20	.17	1.00							
3. Δ Supplier Power _{it}	.01	.47	.43	.02	1.00						
4. Δ Supplier Sales _{it}	.05	.42	.41	.04	.65	1.00					
5. Δ Supplier Industry Competitive Intensity _{it}	.00	.25	-.06	-.03	.06	-.06	1.00				
6. Δ Supplier Industry Intangibles Intensity _{it}	.00	.11	.13	-.02	.05	.19	.04	1.00			
7. Δ Customer Sales _{it}	.08	.27	.19	.11	-.39	.14	-.01	.19	1.00		
8. Δ Customer Industry Competitive Intensity _{it}	.00	.26	-.05	-.02	-.13	.01	.11	.02	-.04	1.00	
9. Δ Customer Industry Intangibles Intensity _{it}	.02	.38	-.07	.01	-.02	-.08	-.02	.03	-.02	.04	1.00

<i>Correlation Matrix: Change in Sales Volatility</i>											
	<i>M</i>	<i>SD</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>
1. Δ Sales Volatility to a Customer _{iz}	-.07	.77	1.00								
2. Δ Relationship Multiplexity _{iz}	.01	.11	-.08	1.00							
3. Δ Supplier Power _{iz}	.00	.28	-.15	.02	1.00						
4. Δ Supplier Sales Volatility _{iz}	-.08	.79	.19	.01	-.17	1.00					
5. Δ Supplier Industry Competitive Intensity _{iz}	.00	.09	.04	.00	.03	.00	1.00				
6. Δ Supplier Industry Intangibles Intensity _{iz}	-.01	.07	.06	-.02	.08	.06	.06	1.00			
7. Δ Customer Sales Volatility _{iz}	-.09	.75	.08	.02	.05	.02	-.10	.00	1.00		
8. Δ Customer Industry Competitive Intensity _{iz}	.00	.08	.07	-.05	-.15	.04	-.09	.01	.05	1.00	
9. Δ Customer Industry Intangibles Intensity _{iz}	.01	.16	.07	.06	.05	-.01	-.06	.03	.07	.17	1.00

Notes: The summary statistics for all variables indicate the values of their natural logarithm. Correlations in italics are significant at $p < .05$.

the customer's industry increases. We find that the change in the interaction of relationship multiplexity and customer industry competitive intensity lowers the change in sales ($\beta_4 = -.73$, $p < .05$) and the change in sales volatility

($\beta_{v4} = -6.39$, $p < .01$). Drawing on these results, we calculate the marginal effects of a change in relationship multiplexity on the change in sales and the change in sales volatility and plot it across changes in customer industry

Table 3
THE EFFECTS OF CHANGES IN RELATIONSHIP MULTIPLEXITY ON SALES GROWTH AND CHANGES IN SALES VOLATILITY TO A CUSTOMER

<i>Sales Growth Model</i>		<i>Sales Volatility Model</i>	
<i>Independent Variables</i>		<i>Independent Variables</i>	
H ₁ Δ Multiplexity _{it}	.48*	H ₂ Δ Multiplexity _{iz}	-2.64*
H ₃ Δ (Multiplexity $\times$ Customer Industry Competitive Intensity) _{it}	-.73*	H ₄ Δ (Multiplexity $\times$ Customer Industry Competitive Intensity) _{iz}	-6.39**
H ₅ Δ (Multiplexity $\times$ Customer Industry Intangibles Intensity) _{it}	-.03	H ₆ Δ (Multiplexity $\times$ Customer Industry Intangibles Intensity) _{iz}	-2.27*
<i>Control Variables</i>		<i>Control Variables</i>	
Δ Sales to a Customer _{it(t-1)}	.35**	Δ Sales Volatility to a Customer _{iz(t-1)}	-.03
Δ Customer Sales _{it}	.88**	Δ Customer Sales Volatility _{iz}	.13
Δ Customer Industry Competitive Intensity _{it}	.55*	Δ Customer Industry Competitive Intensity _{iz}	1.63
Δ Customer Industry Intangibles Intensity _{it}	-.11	Δ Customer Industry Intangibles Intensity _{iz}	2.57*
Δ Relative Supplier Power _{it}	.91**	Δ Relative Supplier Power _{iz}	-.23
Δ Supplier Sales _{it}	-.27	Δ Supplier Sales Volatility _{iz}	-.14
Δ Supplier Industry Competitive Intensity _{it}	-.32**	Δ Supplier Industry Competitive Intensity _{iz}	-.97
Δ Supplier Industry Intangibles Intensity _{it}	-.52	Δ Supplier Industry Intangibles Intensity _{iz}	-.90
		Δ Absolute Sales Growth _{iz}	1.46**
N = 790 (200)		N = 388 (159)	
Wald χ^2 (d.f.)	323.34 (17)	Wald χ^2 (d.f.)	115.48 (16)
Hansen test: χ^2 (d.f.)	32.49 (35)	Hansen test: χ^2 (d.f.)	8.99 (18)
AR (II) test	$z = -.49$	AR (II) test	$z = -1.60$

* $p < .05$.

** $p < .01$.

competitive intensity. As Figure 2 shows, the positive effect of a change in relationship multiplexity on the change in sales becomes weaker as customer industry competitive intensity increases, thus contradicting H_3 . However, the negative effect of a change in relationship multiplexity on the change in sales volatility becomes stronger as customer industry competitive intensity increases, in support of H_4 .

H_5 and H_6 posit that the effects of a change in relationship multiplexity on the change in sales and the change in sales volatility is stronger when intangibles intensity of a customers industry increases. We do not find support for H_5 ($\beta_5 = -.03$, $p < .80$). When we plot the marginal effects, it is evident that the effect of a change in relationship multiplexity on the change in sales remains consistent as customer industry intangibles intensity increases (see Figure 2). However, we find strong support for H_6 ($\beta_6 = -2.27$, $p < .05$). As is evident in Figure 2, the negative effect of a change in relationship multiplexity on the change in sales volatility becomes stronger as customer industry intangibles intensity increases.

To check whether multicollinearity is a concern, we computed the variance inflation factor for the two models. The highest variance inflation factor for the sales model is 3.11 and that for the sales volatility model is 2.70. These values are well below 10, suggesting that multicollinearity is unlikely to be a concern (see Mason and Perreault 1991).

Sensitivity Analyses

We conduct several sensitivity analyses to assess the robustness of our results (for further information, see the Web Appendix at <http://www.marketingpower.com/jmrfeb10>). We examine the sensitivity of our results to alternative measures of relationship multiplexity: a weighted measure, a grouped measure, and a measure that examines the effect of excluding a single type of tie. As Table 4 shows, our conclusions remain unchanged when we use these alternative measures.

We also examine the impact of using a different set of instruments because changing the number of instruments can potentially change conclusions (see Roodman 2006). In addition, we examine the effects of removing potential outliers (± 10 th and ± 15 th percentile of residuals). As we outline in Table 5, our results are robust to these alternative specifications. In addition, we assess the sensitivity of our conclusions to the use of Arellano and Bond's (1991) GMM estimator. As we show in Table 5, our results remain unchanged when we use the Windmeijer (2005) estimator, which controls for finite sample bias and heteroskedasticity.

A concern is that the errors of observations that include common suppliers and/or customers may be correlated. To check for the effect of this possibility, we construct panel data that are unlikely to have correlated error terms (for further information, see the Web Appendix

Figure 2

MARGINAL EFFECTS OF CHANGES IN RELATIONSHIP MULTIPLEXITY ON SALES GROWTH AND CHANGES IN SALES VOLATILITY ACROSS CHANGES IN CUSTOMER INDUSTRY FACTORS

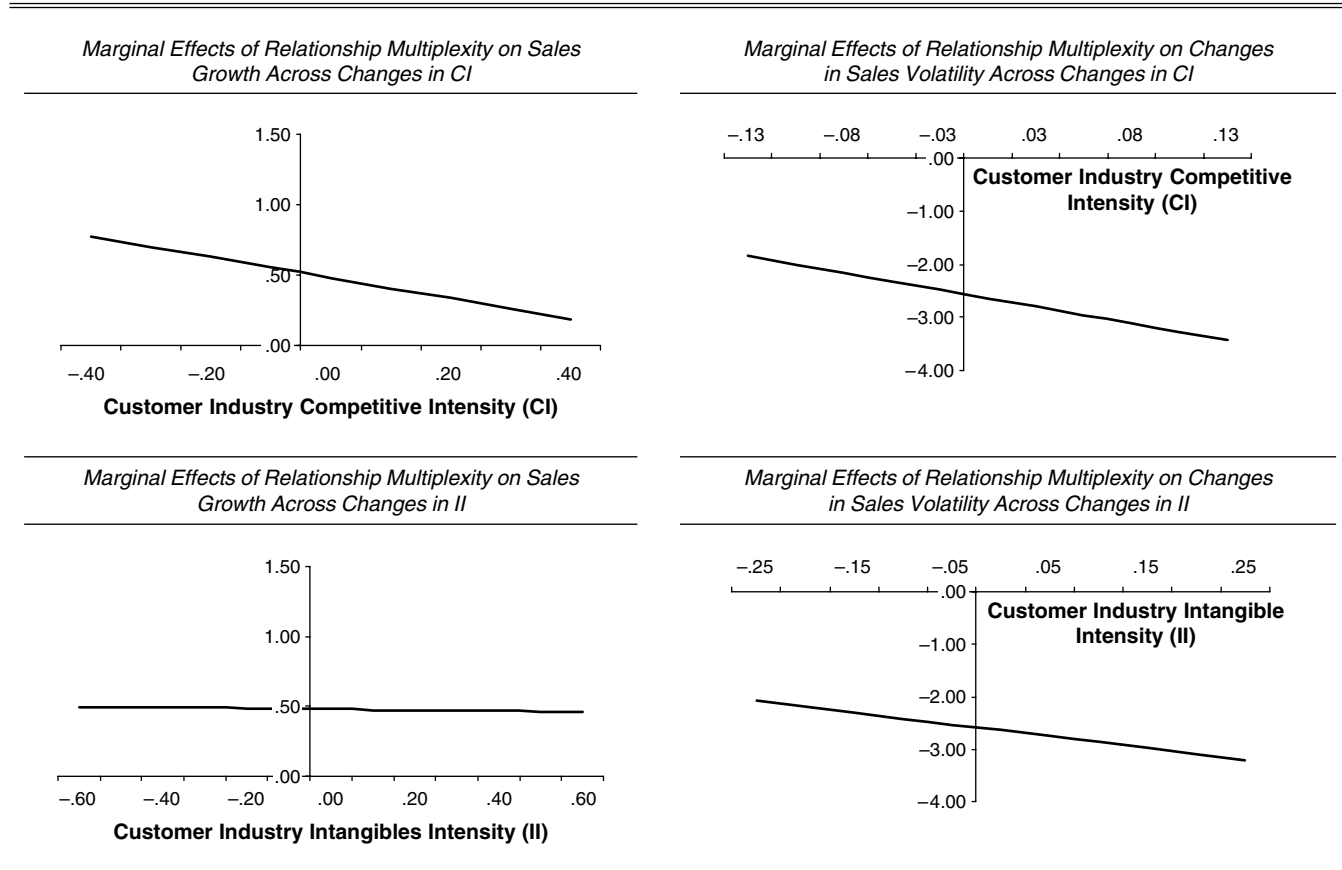


Table 4
SENSITIVITY ANALYSES USING ALTERNATIVE MEASURES OF RELATIONSHIP MULTIPLEXITY

<i>Sales Growth to a Customer During Time t</i>									
	<i>Weighted Measure</i>	<i>Grouped Measure</i>	<i>Measure Without Board Interlocks</i>	<i>Measure Without Equity Investment</i>	<i>Measure Without Licensing Agreement</i>	<i>Measure Without Marketing Alliances</i>	<i>Measure Without R&D Alliances</i>	<i>Measure Without Joint Venture Ties</i>	<i>Measure Without Customer as Supplier Tie</i>
1 $\Delta S_{it(t-1)}$	.34***	.36***	.35***	.37***	.34***	.36***	.36***	.34***	.34***
2 ΔM_{it}	.20*	.64**	.54**	.52**	.42**	.68***	.51***	.51**	.47*
3 $\Delta(M_{it} \times CI_{it})$	-.42**	-.83**	-.69**	-.63**	-.59**	-.83***	-.52*	-.79**	-.76**
4 $\Delta(M_{it} \times II_{it})$	-.03	.03	-.02	-.02	-.03	-.02	-.04	-.05	-.10
1 Hansen Test χ^2 (d.f.)	35.56 (35)	32.53 (35)	31.90 (35)	31.30 (35)	30.75 (35)	32.62 (35)	30.90 (35)	32.94 (35)	29.14 (35)
2 AR (II) Test	$z = -.28$	$z = -.47$	$z = -.54$	$z = .07$	$z = -.32$	$z = -.63$	$z = -.34$	$z = -.59$	$z = -.21$
<i>Change in Sales Volatility from a Customer During Time z</i>									
	<i>Weighted Measure</i>	<i>Grouped Measure</i>	<i>Measure Without Board Interlocks</i>	<i>Measure Without Equity Investment</i>	<i>Measure Without Licensing Agreement</i>	<i>Measure Without Marketing Alliances</i>	<i>Measure Without R&D Alliances</i>	<i>Measure Without Joint Venture Ties</i>	<i>Measure Without Customer as Supplier Tie</i>
1 $\Delta V_{iz(z-1)}$	.03	.09	-.03	-.01	-.03	-.01	.01	-.04	.01
2 ΔM_{iz}	-.92*	-8.36**	-1.87*	-2.26**	-2.18**	-2.22**	-2.69**	-2.53**	-1.74*
3 $\Delta(M_{iz} \times CI_{iz})$	-3.69***	-19.88**	-6.92***	-7.48***	-5.84**	-5.10**	-6.99**	-6.24**	-5.68**
4 $\Delta(M_{iz} \times II_{iz})$	-.98**	-5.02*	-1.63**	-2.19**	-1.82**	-1.60**	-2.66**	-2.05**	-1.66**
1 Hansen test χ^2 (d.f.)	8.24 (18)	10.92 (18)	10.06 (18)	8.46 (18)	5.13 (18)	8.31 (18)	12.91 (18)	9.51 (18)	14.69 (18)
2 AR (II) test	$z = -1.24$	$z = -.81$	$z = -1.25$	$z = -1.23$	$z = -1.10$	$z = -1.40$	$z = -1.40$	$z = -1.40$	$z = -1.21$

* $p < .10$.

** $p < .05$.

*** $p < .01$.

Notes: S_{it} = log sales to a customer in relationship i at time t , M_{it} = log multiplexity in relationship i at time t , CI_{it} = log customer industry competitive intensity for relationship i at time t , II_{it} = log customer industry intangibles intensity for relationship i at time t , V_{iz} = log sales volatility to a customer in relationship i during time z , M_{iz} = log multiplexity in relationship i during time z , CI_{iz} = log customer industry competitive intensity in relationship i during time z , and II_{iz} = log customer industry intangibles intensity in relationship i during time z .

at <http://www.marketingpower.com/jmrfeb10>). As we show in Table 5, our results remain unchanged when we use these data. We also assess the impact of other specifications, such as lagged and nonlinear effects. Our results are robust to these alternative specifications as well (for further information, see the Web Appendix at <http://www.marketingpower.com/jmrfeb10>).

DISCUSSION

The current study adds to the literature on customer relationships in the B2B context by exploring the effects of relationship multiplexity on the performance of a supplier with an individual customer. It focuses on two key financial metrics—sales growth and sales volatility—and thus adds to the literature on the impact of marketing on financial outcomes (e.g., Rust et al. 2004). The use of a panel data set is among the first investigations of supplier–customer relationships using a longitudinal approach. Importantly, the results are consistent across a broad range of sensitivity analyses and have several implications.

The study results indicate that relationship multiplexity with a customer is a valuable “market-based asset” that increases a supplier’s sales to a customer and reduces the volatility of sales to a customer (Srivastava, Shervani, and Fahey 1998). These findings are consistent with the argument that multiplex relationships with a customer help a

supplier gain access to private information about the customer, which in turn enables it to serve the customer better. These findings are also consistent with the argument that by forming multiplex ties with a customer, a supplier can collaborate with the customer to codevelop offerings that meet the customer’s unique requirements, thus providing an economic incentive for the customer to buy more from the supplier.

The current study also highlights the moderating role of customer industry factors. The results support the general proposition that conditions in a customer’s industry can influence the functioning of a supplier’s relationship with the customer (e.g., Wathne and Heide 2004). In addition, these findings are of direct importance to managers as they identify conditions under which it is more (or less) beneficial to form multiplex relationships with customers.

We find that increases in competitive intensity in a customer’s industry weaken the positive effect of a change in relationship multiplexity on a change in sales to a customer. This is contrary to expectations. A plausible explanation for this finding is that as competition in a customer’s industry increases, a customer expects its multiplexed suppliers to share more of its competitive burden. For example, a customer may ask a multiplex supplier for price concessions but in return purchase greater volumes, thus leading to greater number of units sold to a customer but not

Table 5
SENSITIVITY ANALYSES FOR THE EFFECTS OF CHANGES IN RELATIONSHIP MULTIPLEXITY ON
SALES GROWTH AND CHANGES IN SALES VOLATILITY

<i>Sales Growth to a Customer during Time t</i>						
	<i>Reduced Set of Instruments</i>	<i>±10th Percentile Residuals Removed</i>	<i>±15th Percentile Residuals Removed</i>	<i>Using Windmeijer's Correction</i>	<i>Removing Potentially Correlated Observations</i>	<i>Using Inverse Mills Ratio to Control for Sample Selection Bias</i>
1 $\Delta S_{it(t-1)}$	.36***	.31***	.37***	.30***	.21***	.32***
2 ΔM_{it}	.95**	.44**	.33**	.54*	.39**	.53**
3 $\Delta(M_{it} \times CI_{it})$	-1.16**	-.31**	-.37**	-.74**	-.77**	-.76**
4 $\Delta(M_{it} \times II_{it})$	-.07	-.05	-.04	.05	-.02	-.05
1 Hansen test χ^2 (d.f.)	8.60 (16)	29.40 (35)	29.66 (35)	33.91 (35)	34.76 (35)	33.87 (34)
2 AR (II) test	$z = -1.02$	$z = .36$	$z = .59$	$z = -.08$	$z = -.48$	$z = .90$
<i>Change in Sales Volatility from a Customer During Time z</i>						
	<i>Reduced Set of Instruments</i>	<i>±10th Percentile Residuals Removed</i>	<i>±15th Percentile Residuals Removed</i>	<i>Using Windmeijer's Correction</i>	<i>Removing Potentially Correlated Observations</i>	<i>Using Inverse Mills Ratio to Control for Sample Selection Bias</i>
1 $\Delta V_{iz(z-1)}$	-.18	.07	.09*	-.03	-.01	-.04
2 ΔM_{iz}	-4.13**	-3.39***	-3.15***	-2.97**	-3.21**	-2.68**
3 $\Delta(M_{iz} \times CI_{iz})$	-6.93**	-5.25***	-4.81***	-6.65***	-5.53**	-6.45***
4 $\Delta(M_{iz} \times II_{iz})$	-3.81**	-3.03***	-2.67***	-2.95***	-2.47**	-2.29**
1 Hansen test χ^2 (d.f.)	3.70 (7)	15.23 (18)	7.47 (18)	8.99 (18)	15.46 (18)	8.63 (18)
2 AR (II) test	$z = -1.43$	$z = -.24$	$z = -1.30$	$z = -1.38$	$z = -1.30$	$z = -1.47$

* $p < .10$.** $p < .05$.*** $p < .01$.

Notes: S_{it} = log sales to a customer in relationship i at time t , M_{it} = log multiplexity in relationship i at time t , CI_{it} = log customer industry competitive intensity for relationship i at time t , II_{it} = log customer industry intangibles intensity for relationship i at time t , V_{iz} = log sales volatility to a customer in relationship i during time z , M_{iz} = log multiplexity in relationship i during time z , CI_{iz} = log customer industry competitive intensity in relationship i during time z , and II_{iz} = log customer industry intangibles intensity in relationship i during time z .

greater revenues (Narayandas and Rangan 2004). Therefore, the effect of relationship multiplexity on sales growth is weaker.

Consistent with our expectations, we find that the impact of a change in relationship multiplexity on the change in sales volatility becomes stronger as the competitive intensity in the customer's industry increases. This result supports the idea that the economic incentives engendered by private information and solidarity in a multiplex relationship are of greater value to a customer when it is in a more competitive industry. Collectively, these findings suggest that multiplex relationships with a customer can lead to competing effects on sales growth and sales volatility as a customer's industry becomes more competitive.

We find that the effects of relationship multiplexity also vary with increases in intangibles intensity in a customer's industry. In particular, increase in intangibles intensity of a customer's industry moderates the effects of changes in relationship multiplexity on changes in sales volatility but not on changes in sales. As Figure 2 shows, the effect of changes in relationship multiplexity on sales growth is invariant to the changes in the intangibles intensity of customer industry. Thus, suppliers that increase their relationship multiplexity with a customer may not experience relatively greater sales as the intangibles intensity in a customer's industry increases. We observe that the negative effect of changes in relationship multiplexity on changes in

sales volatility become stronger as customer industry intangibles intensity increases. This result supports the argument that customer private information is more valuable for a supplier when the customer industry intangibles intensity increases, thus making it more difficult for a supplier to understand the customer's requirements. These findings suggest that managers should focus on forming multiplex relationships with customers in industries with increasing intangibles intensity if the objective is to realize stable revenues.

The current study also has important implications for financial analysts and the accounting standards recommended by the FASB and IASB. First, the effects of changes in relationship multiplexity on sales growth and changes in sales volatility are relevant for financial analysts. Sales growth is considered a valuable metric by financial analysts, as evidenced by the finding that firms with higher sales growth receive higher valuations for their capital expenditures (Brailsford and Yeoh 2004) and equity buyback initiatives (Ho, Liu, and Ramachandran 1997). Volatility in sales to a customer reflects uncertainty of revenues from the customer and, therefore, from a financial analyst's view, greater risk (see Srivastava, Shervani, and Fahey 1999). To the extent that changes in relationship multiplexity enhance sales growth and lower sales volatility to a customer, it is a valuable nonfinancial measure that can be used by financial analysts to assess a firm's potential sales growth and sales volatility.

Second, FASB Statement Nos. 14 and 131 (see www.fasb.org) require firms to identify customers that contribute more than 10% of their annual sales because a firm's financial performance is likely to be vulnerable to switching by such customers. However, our results suggest that suppliers can offset their vulnerability to such customers by increasing their relationship multiplexity with them. Therefore, to the extent that a firm's relationship multiplexity with a customer increases, it is less vulnerable to switching by these customers. This is valuable information for investors that firms perhaps should be required to reveal in their SEC filings.

Third, the results of the current study provide empirical support for FASB's recommendation that customer relationships should be viewed as intangible assets whose fair value should be stated by an acquirer when it discloses the details of valuation of a target firm (FASB 2002). As such, it may be useful for FASB to recommend the disclosure of a target firm's multiplex relationships with customers in disclosures related to acquisitions. This recommendation is consistent with other recent calls within and outside the marketing discipline (e.g., Barth, Kasznik, and McNichols 2001; Mizik and Jacobson 2008). Such disclosures serve as signals about the credibility of marketing actions and allow a firm to make relationship multiplexity-related investments with greater confidence.

LIMITATIONS AND FURTHER RESEARCH

While the current study provides empirical justification for supplier efforts to form multiplex ties with customers, these results do not imply that suppliers should maximize their ties with customers without consideration of the costs of forming and maintaining multiple types of ties. Further research could be directed at identifying such costs and understanding their effects on supplier and customer choice to form or terminate ties with each other. For example, further research could explore the different types of costs incurred by suppliers and customers. Suppliers and customers incur learning costs—time and effort expended in making sense of and adjusting to each other's operational and cultural environment. They also incur financial costs of investing in personnel, equipment, and facilities in course of managing different types of ties. Finally, multiplex relationships also imply opportunity costs for suppliers because significant investments in personnel and finance for multiplex relationships preclude them from investing in other projects, customers, and markets.

It would be of significant interest to identify how these learning, financial, and opportunity costs vary across industries. It would also be useful to study how the proportion of costs assumed by supplies and customers respectively varies across industries. For example, in industries characterized by high intangibles intensity, both parties may need to bear significant and perhaps similar amount of such costs. However, these are preliminary conjectures and more detailed work is required in this domain.

A possible limitation of this study stems from the use of SEC filings in which firms identify customers that contribute at least 10% of their revenues in a year. This results in a data set in which most of the customer relationships

examined consist of "large" customers. However, presumably due to the anticipated benefits of greater disclosure, firms tend to identify a customer's contribution to their revenues even in years when this contribution is less than 10% (see Gu and Li 2007). Indeed, approximately 15% of our data consist of observations in which a customer contributes less than 10% of a supplier's revenues. Not surprisingly, several studies in finance (e.g., Fee, Hadlock, and Thomas 2006) and accounting (e.g., Gosman et al. 2004) use this data source. We also empirically assess the effects of potential sample selection bias using the Heckman procedure (for further information, see the Web Appendix at <http://www.marketingpower.com/jmrfeb10>). As Table 5 shows, our substantive conclusions remain unchanged when we use the Heckman procedure, indicating an absence of selection bias.

The current study uses the growth-growth model because it is consistent with the hypotheses, controls for endogeneity, and removes the effects of time-invariant factors that researchers do not observe. However, a limitation of this model is that it does not estimate the extent to which time-invariant factors contribute to the variance in the dependent variables. Such an endeavor could be useful because it would enable researchers to compare the variance in dependent variables explained by relationship multiplexity with that of the time-invariant factors.

In the current study, we assess the impact of relationship multiplexity on two metrics that are relevant to managers: sales growth and sales volatility to a customer. Another relevant financial metric is customer profitability. Unfortunately, data on profits earned by a supplier from each of its customers are not publicly available. Such data may be collected through self-reported perceptual measures (e.g., Jap 1999) or activity-based costing studies (e.g., Niraj, Gupta, and Narasimhan 2001). However, conducting such a study for a large sample covering multiple industries and over multiple years is likely to be extremely challenging.

Nevertheless, we test a model that examines the impact of relationship multiplexity on the profit margin from a customer (i.e., the ratio of supplier operating income from a customer to sales to that customer). We obtained this metric by assuming that a supplier's profit margin from each customer is identical and proportional to the revenue from the customer. This implies that (1) a supplier's profit margin from a customer is the same as the supplier's overall profit margin and (2) if a customer contributes $x\%$ of a supplier's revenues, it contributes $x\%$ of the supplier's net income. We find that relationship multiplexity has a positive impact ($\beta = .46, p > .02$) on profit margins.⁵ This result addresses possible concerns that higher growth and lower volatility in sales may come at the expense of lower profit margins. That said, this result should be viewed as tentative because it is obtained under the assumption that profits margins across customers are constant, which is probably not the case (see Niraj, Gupta, and Narasimhan 2001).

Although the current study focuses on the outcomes of multiplex relationships, the antecedents of relationship

⁵We obtained operating income from the COMPUSTAT (Data 13). Because operating income can be both negative and positive, we do not log-transform the variables. We use the GMM estimation procedure used in this study.

multiplexity remain largely unexplored. Indeed, it could be argued that the relationship between multiplexity and sales growth and volatility is reciprocal. That is, high sales growth and low sales volatility with a customer are likely to lead to the formation of multiplex relationships. To assess this possibility, we test three models with relationship multiplexity as a dependent variable and using current, current and lagged, and future values of sales growth and sales volatility as independent variables (for further information, see the Web Appendix at <http://www.marketingpower.com/jmrfeb10>). However, we do not find any empirical support for the reverse causality argument. That said, multiplex relationships are a valuable market-based asset, and studies that identify the factors that affect their decline and/or termination would be valuable.

In summary, the domain of relationship multiplexity offers multiple avenues for further research. The current study is a first step that explores the theoretical foundations and identifies publicly available data that can be used in further research.

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