

# COLLABORATING WITH COMPLEMENTORS: WHAT DO FIRMS DO?

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## ABSTRACT

*The study considers the interdependencies between complementors in the business ecosystem and explores the nature of collaborative interactions between them. It sheds light on the organizational and the strategic contexts in which such interactions take place, and shows how they may influence the pattern and the benefits of collaboration. The evidence presented is based on fieldwork followed by a detailed survey instrument administered to firms in the semiconductor industry. The findings, while reinforcing the shift in the locus of value creation from focal firms to collaborative business ecosystems characterized by information sharing and joint action among complementors, illustrate the organizational and the competitive challenges that firms face in their pursuit of joint value creation.*

## INTRODUCTION

Over the last two decades, strategy scholars have increasingly viewed firms' ability to create value as critically dependent on complementors in the business ecosystem (Adner, 2012; Brandenburger & Nalebuff, 1996; Iansiti & Levien, 2004). The emerging literature stream has begun to systematically examine how firms manage their interdependence with complementors (e.g., Ethiraj, 2007; Gawer & Henderson, 2007; Kapoor & Lee, 2013) and how complementors shape firms' value creation (Adner and Kapoor, 2010). The emphasis so far has been on recognizing the coordination and technological challenges associated with complements, and linking them to firm boundary choices and technology investment decisions. While interorganizational collaboration is an important driver of firms' value creation (Dyer & Singh, 1998; Powell & Grodal, 2005), the literature has yet to offer an account of the collaborative interactions that exist between firms and their complementors and the challenges that accompany such interactions.

The study attempts to address this gap by shedding light on the different ways in which firms collaborate with complementors, and by exploring how the nature and the benefits of collaboration are influenced by the organizational and strategic contexts underlying firm-complementor relationships. Specifically, it considers the organizational context through the choice of the organizational unit that firms may use to manage their relationships with complementors (Dyer, Kale, & Singh, 2001; Kale, Dyer, & Singh, 2002). It considers the strategic context through the nature of the co-opetitive interactions that characterize firm-complementor relationships (Brandenburger & Nalebuff, 1996; Casadesus-Masanell & Yoffie, 2007).

The evidence presented in this study is based on fieldwork followed by a survey of firms in the semiconductor industry. The importance of complementors to firms' value creation has been well documented in the semiconductor industry (e.g., Ethiraj, 2007; Gawer & Henderson, 2007). Key complementors to these firms include software firms and other semiconductor firms whose products are used with the focal firm's product in a given end-user application such as a cell phone or a personal computer.

The findings suggest that firms in the semiconductor industry interact with their complementors most extensively by sharing information on R&D and markets, joint product development, and customizing their products to the complementor's offering. Hence, exchanging knowledge and combining complementary resources and capabilities seem to be key drivers of joint value creation among complementors (Dyer & Singh, 1998).

Firms pursue a variety of organizational designs to manage relationships with their most important complementors. The majority of relationships were managed through engineering or marketing departments, whereas some were managed through a dedicated organizational unit. While the survey data is somewhat limited in drawing causal inference, the extent of collaborative interactions was found to be highest when the relationship was managed through a dedicated organizational unit, lowest when managed through the engineering department, and moderate when managed through the marketing department.

The empirical context also enabled an exploration of how the extent of collaboration with complementors is shaped by the duality of value creation and value appropriation (Brandenburger & Nalebuff, 1996). The fieldwork allowed for mapping a given complementor according to the relative opportunity for value creation and the relative threat of value appropriation that is shaped by the complementor's business model and capabilities. It was found that the extent of collaboration was highest with software complementors that were characterized by high opportunity for value creation and low competitive threat of complementors moving into the focal firm's product market, lowest with general purpose semiconductor complementors which entailed constrained opportunity for value creation and a high threat of complementors expanding into focal firm's product market, and intermediate with application-specific semiconductor complementors which represented high opportunity for value creation as well as a high threat of competition.

Finally, the study also attempted to reveal the different types of benefits that firms derive from their relationships with complementors. Based on managers' evaluations, it was found that collaboration with complementors was most beneficial in improving the performance of focal firms' products, moderately beneficial in increasing sales or gaining customers in existing market segments, and least beneficial in gaining customers in new market segments. The data also confirmed the high value creation potential of software and application-specific semiconductor complementors. However, the superiority of the dedicated organizational unit in facilitating collaboration did not seem to correspond to high value creation. This mixed finding points to the organizational design challenges that firms may face in pursuing collaborative innovation with complementors. Complementors are neither buyers nor suppliers to the firm. While a dedicated organizational interface may facilitate interorganizational collaboration with complementors, extracting benefits from such interactions requires intra-organizational collaboration among upstream and downstream units.

Hence, beyond creating a dedicated organizational entity, firms may need to redesign their internal organization to facilitate both inter- and intra-organizational collaboration.

The findings reinforce the shift in the locus of value creation from focal firms to collaborative business ecosystems characterized by information sharing and joint action among complementors. However, the results also illustrate the organizational and the co-opetitive challenges that firms may face in leveraging complementarities and pursuing joint value creation.

## RESEARCH SETTING AND METHODOLOGY

The findings reported in this study are based on fieldwork, followed by a detailed survey of senior managers at firms in the semiconductor industry. The systemic nature of the semiconductor industry with strong interdependencies between focal firms and their complementors makes it an ideal setting in which to explore the nature and extent of collaboration among these actors. Several scholars have studied ecosystem-level interactions among firms in the semiconductor industry. For example, [Casadesu-Masanell and Yoffie \(2007\)](#) use the case of Intel and its complementor, Microsoft, to develop a formal model that captures the tension between value creation and appropriation. They show how Microsoft's dependence on the existing installed base of PCs and Intel's dependence on the sale of new PCs create conflict over their pricing and incentives to invest in new product generations. [Gawer and Henderson \(2007\)](#) provide a rich case study of how Intel selectively enters and subsidizes complementary markets so as to balance control over the key complements with incentives for new entrants to push the Intel microprocessor platform forward. [Ethiraj \(2007\)](#) explores how firms in different segments of the semiconductor industry (microprocessors, memory, etc.) pursued R&D investments in complements so as to manage technology bottlenecks in the PC ecosystem. None of these studies have, however, explored the nature of collaborative interactions between semiconductor firms and their complementors.

In order to identify survey participants and facilitate their participation, the survey was conducted in partnership with two industry organizations – an industry trade association (Global Semiconductor Alliance, GSA) and an industry consulting firm (ATREG, Inc.) – who expressed strong interest in the research. These partners were also chosen because of their relationships with distinct segments of the semiconductor industry. The semiconductor industry comprises integrated device manufacturing (IDM) firms that



design, manufacture, and sell semiconductor chips, and fabless firms that design and sell semiconductor chips but who rely on external suppliers for manufacturing (Kapoor, 2013). GSA is a leading industry trade organization focusing on the needs of the fabless firms since 1994. ATREG is a leading global advisory firm specializing in semiconductor manufacturing since 2000, with strong links to the IDM segment of the industry.

Prior to designing the survey, I conducted exploratory interviews with executives at GSA and ATREG as well as with 11 managers at fabless and IDM semiconductor firms. The interviews were semi-structured and lasted an hour on average. These interviews helped me identify the different types of complementors to the semiconductor firms, the different types of collaborative interactions among them, and the nature of benefits that firms derive from collaborating with complementors. Based on the understanding developed from the interviews and a review of the academic literature on interorganizational relationships, I designed the initial survey, paying particular attention to the vocabulary with which managers in the industry are familiar. I then sought feedback from academic colleagues and pre-tested the survey with managers from both fabless and IDM firms. After the final revisions were made, the survey was administered to all fabless and IDM firms that were either publicly traded or considered to be firms with established product lines (as opposed to the many privately held startups that have yet to achieve successful commercialization) by GSA or ATREG. This was done to ensure that the responses were based on a somewhat stable set of interdependencies and relationships between firms and their complementors.

I used the key informant approach for the survey, which has been commonly used in the literature on buyer-supplier relationships, alliances, and outsourcing (e.g., Heide & John, 1990; Kale et al., 2002; Parmigiani & Mitchell, 2009). The informants were corporate executives, business-unit heads, or senior marketing executives who have detailed knowledge of their firms' relationships with complementors. These informants were identified by GSA and ATREG or by their contacts within the semiconductor firms. Each informant was asked to provide information for two of the key complementors that their firm or the business unit was dependent on. For almost every firm, the initial survey request was followed up with emails and phone calls to clarify the objectives of the research and to encourage survey participation.

In order to ensure that survey participants did not mistake complementors for other actors (i.e., suppliers or customers), the introduction to the survey included the following text – “Complementors are companies that

provide complementary products to your customers such that your company's products and complementors' products are used together in the customer's application. For example, hardware and software firms are complementors to each other. In the semiconductor industry, complementors could be other semiconductor firms providing integrated circuits (ICs) that are used by your customers together with your company's products. They could also include firms that develop software or provide other products or services that are used by your customers together with your company's products."

Completed surveys were received from senior managers at 36 fabless and 15 IDM firms, for an overall response rate of 37%. The response rate is consistent with the typical response rate for surveys of top managers (Anseel, Lievens, Schollaert, & Choragwicka, 2010; Baruch & Holtom, 2008). Nonresponse bias was evaluated by comparing firms' sales and number of employees, and no significant difference was found. The median firm in the sample had 679 employees and sales of US\$340 million in 2011. The average firm in the sample had 9,072 employees and sales of US\$2,236 million in 2011. Of the respondents, 20 firms are headquartered in North America, 15 in Asia, and the rest in Europe. The final sample was composed of detailed information on 99 firm-complementor dyadic relationships from 51 firms.

## **NATURE OF COLLABORATIVE INTERACTIONS BETWEEN FIRMS AND THEIR COMPLEMENTORS**

To measure the nature of collaborative relationships between firms and their complementors, respondents were asked to rate on a scale of 1 (not at all) to 7 (very great extent) the extent to which their firm interacts with complementors in different ways. The nature of interactions included (1) share information on R&D plans and technology roadmaps; (2) share information on a specific market or application; (3) joint product development; (4) joint marketing; (5) setting standards; (6) licensing; (7) customizing products to the complementor; and (8) investing in the complementor.

Firms in the semiconductor industry seem to interact most extensively with their complementors by sharing information on a specific market or application (mean = 4.45), and on R&D plans and technology roadmaps (mean = 4.12). Given that such "horizontal" information sharing helps complementors to coordinate their activities and products with the least

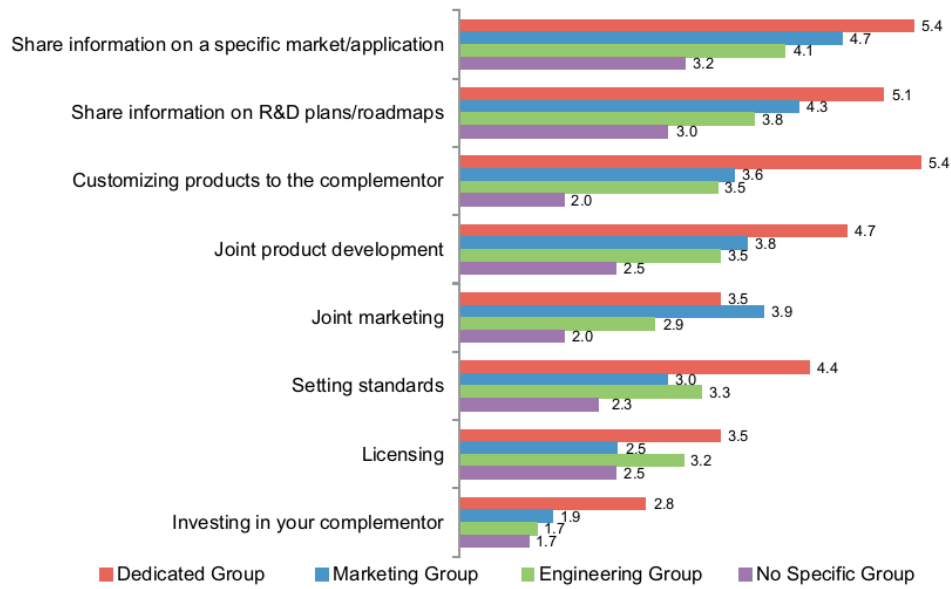
amount of strategic commitment, this preponderance is expected. Customizing products to the complementor (mean=3.73) and joint product development (mean=3.71), both of which require a greater commitment on behalf of the complementors, represent the next most intense set of interactions. As argued by Dyer and Singh (1998), interorganizational collaborative interactions that entail knowledge exchange and combination of complementary resources and capabilities are key drivers of joint value creation. These collaborative interactions are followed by joint marketing (mean=3.32), setting standards (mean=3.29), licensing (mean=2.91), and investing in complementors (mean=1.95), which are more likely to be a function of firm-specific interdependencies and opportunities.<sup>1</sup>

## **ORGANIZATIONAL AND STRATEGIC INFLUENCES ON COLLABORATIVE INTERACTIONS**

### *Organizational Influence*

To learn how these interactions were affected by the organizational context in which firms managed their complementor relationships, survey respondents were asked to identify the department that was primarily responsible for coordinating activities with a given complementor. Available responses included the following: (1) dedicated department or corporate executive; (2) engineering department; (3) marketing department; (4) no specific department or executive. Fourteen percent of the relationships in the sample were managed through a dedicated department or executive, 41% through the engineering department, 39% through the marketing department, and 6% did not seem to be managed by any specific department or executive. While the organizational interfaces are well-specified with respect to vertical relationships – procurement departments manage suppliers and marketing departments manage customers – the simultaneous existence of technology-level and market-level interdependencies seems to create ambiguity within firms regarding how to best manage their relationships with complementors. Some firms have created a dedicated organizational unit, while most others are leveraging their existing organizational structures to manage interdependence with complementors.

Fig. 1 presents a summary of the results for the different types of firm-complementor interactions by the organizational interface that firms use to



*Fig. 1.* Mean Values for the Different Types of Collaborative Interaction between Firms and Complementors, by Organizational Unit That Is Primarily Responsible for Coordinating Activities with the Complementor (Scale: 1 – Not At All, 7 – Very Great Extent).

manage these relationships. Complementor relationships that are managed through a dedicated department or executive exhibited the highest degree of collaboration for the most intensely occurring interactions (information sharing, joint product development, and product customization). This was followed by the marketing department, then by the engineering department, and finally, by the case in which no specific department was identified as the primary organizational interface. Not surprisingly, as compared to complementor relationships managed through engineering departments, those managed through marketing departments were characterized by a higher degree of joint marketing-based interactions and a lower degree of licensing-based interactions. Relationships managed through dedicated departments also outranked other departments in the level of interaction with respect to setting standards and investing in complementors.<sup>2</sup>

The higher level of collaboration associated with the dedicated organizational unit is consistent with the evidence from the alliance literature. For example, [Kale et al. \(2002\)](#) found that firms that created a dedicated alliance function were able to realize greater success with strategic alliances, as measured through stock market returns following alliance announcements and managers' evaluations of alliance performance. Given that the



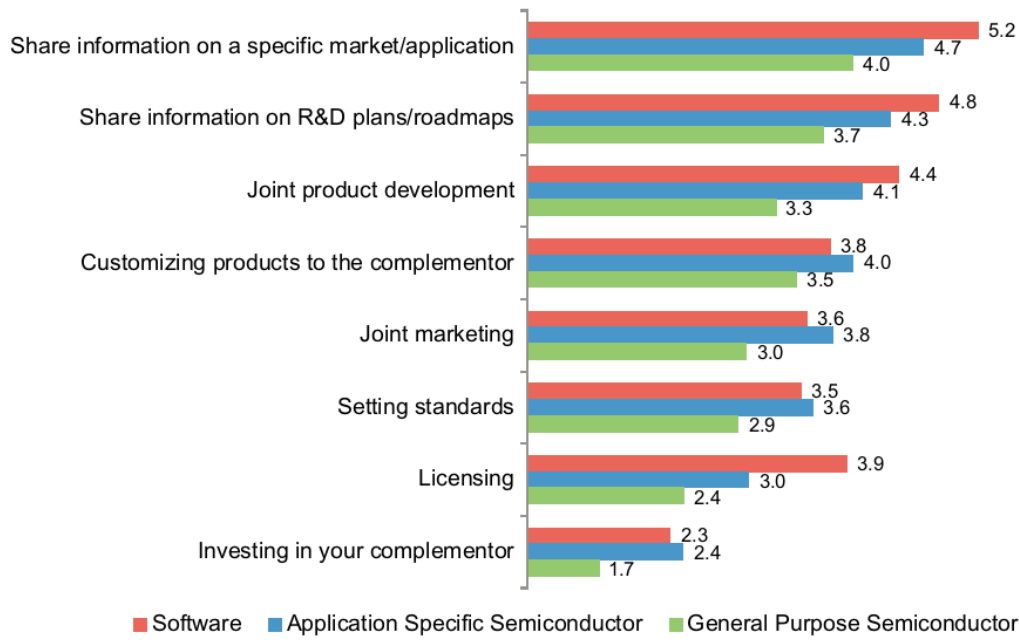
interdependence between complementors entails cooperation and coordination across both R&D and marketing functions, a dedicated organizational unit is likely to be more effective in accessing information, coordinating tasks across the different functions, and ensuring that firms and their complementors pursue joint value creation.

### *Strategic Influence*

Scholars have argued that relationships between complementors can be characterized by both cooperation for value creation and competition for value appropriation (Brandenburger & Nalebuff, 1996). Complementors may differ in the extent of complementarity as well as in the threat of competition. These differences may shape incentives to collaborate. For example, Casadesus-Masanell and Yoffie (2007) show how complementors' incentives to cooperate can be impacted by the degree of complementarity.

The fieldwork facilitated developing an understanding of the different types of complementors to semiconductor firms. A typical end-user application (e.g., television, networking equipment, cell phone, and computer) comprises many complementary semiconductor and software products. Hence, key complementors to semiconductor firms could include software firms or other semiconductor firms focusing on a different electronic function within the same end-user application. In order to learn how firm-complementor collaborative interactions were shaped by the industry context surrounding their relationships, survey respondents were asked to identify whether the complementor's product was software, a general purpose semiconductor, or an application-specific semiconductor. General purpose semiconductor products include analog ICs, memory ICs, microprocessors, microcontrollers, and discrete devices which can be used in a variety of end-user applications such as communications and computing. An application-specific semiconductor product is designed for a specific end-user application. Semiconductor industry analysts typically use this categorization to document industry sales and trends (e.g., Olsson, 2003).

Fig. 2 presents the mean values for the different types of collaborative interactions by the nature of the complement. Firms tend to exhibit the greatest degree of collaboration with software firms, followed by application-specific semiconductor firms, and finally with general purpose semiconductor firms. Over the last two decades, the semiconductor industry has gradually shifted away from the PC-dominated application to a variety of consumer- and communication-based applications. This shift has not only resulted in



*Fig. 2.* Mean Values for the Different Types of Collaborative Interaction between Firms and Complementors, by Type of Complement. (Scale: 1 – Not At All, 7 – Very Great Extent).

an increase in the share of application-specific products but also in an increase in the importance of software toward semiconductor firms' value creation (Grimblatt, 2002; Linden, Brown, & Appleyard, 2004). In the interviews, many industry executives reinforced their semiconductor firm's dependence on software for their firm's ability to differentiate from their rivals and offer a superior "integrated system" to their customer.

Collaborating with other semiconductor firms was also deemed useful, as partners could better manage and coordinate their technical and marketing activities. However, the interviewees discussed how these relationships are characterized by appropriability hazards, as partners with similar capabilities could encroach on each other's markets relatively easily. Given that application-specific semiconductor complements tend to be more tightly coupled with the end product than are general purpose semiconductor products, there is a greater benefit to collaborating with application-specific semiconductor firms than with the general purpose semiconductor firms. Hence, the three categories of complements in the industry present an important contrast with regard to focal firms' opportunities for value creation and threats of value appropriation. The opportunities for value

creation are greater with complementors who are either software or application-specific semiconductor firms than those who are general purpose semiconductor firms. The challenges for value appropriation are greater with semiconductor complementors, who are more likely than software complementors to expand into focal firm's product market. Jointly, these findings provide initial evidence regarding how differences in the opportunities for value creation and in the threats of value appropriation between complementors may shape the pattern of collaboration.

### *Regression Analysis*

Table 1 presents the results of the regression analysis on the different types of collaborative interactions. In addition to the type of organizational interface and the type of complement, the model includes controls for firm size as measured by the log of number of employees in 2011, whether the firm is an IDM firm, and whether it is headquartered in North America. The baseline category for organizational interface is the engineering department and for the type of complement is the general purpose semiconductor product.

The findings from the regression analysis are consistent with the descriptive evidence. As compared to complementor relationships managed through the engineering department, those managed through the dedicated department or corporate executive are characterized by greater levels of information sharing on R&D (Model 1) and market applications (Model 2), joint product development (Model 3), and product customization (Model 4). The difference between the coefficients for the dedicated department and the marketing department for these most common forms of collaborative interactions was found to be statistically significant using the Wald test. Hence, managing complementor relationships through a dedicated organizational entity seems to be correlated with higher levels of collaboration rather than through engineering or marketing functions. As expected, compared to relationships managed through the engineering department, those managed through the marketing department are characterized by greater collaborative interactions through information sharing on specific applications or market segments (Model 2) as well as through joint marketing activities (Model 5). Relationships managed through dedicated departments also have greater interactions with respect to setting standards (Model 7) and firms making investments in their complementors (Model 8).

**Table 1.** Regression Estimates for the Different Types of Collaborative Interactions between Firms and Their Complementors.<sup>a</sup>

	(1) Information Sharing (R&D)	(2) Information Sharing (Marketing)	(3) Joint Product Devt.	(4) Product Customization	(5) Joint Marketing	(6) Licensing	(7) Setting Standards	(8) Investing
<i>Type of complementor</i>								
Software	1.405** (0.536)	1.473*** (0.374)	1.259** (0.483)	0.461 (0.497)	0.890** (0.438)	1.375** (0.593)	0.254 (0.589)	0.357 (0.478)
Application-specific semiconductor	0.843** (0.357)	0.972*** (0.303)	0.937** (0.442)	0.766** (0.348)	1.032** (0.453)	0.640 (0.512)	0.491 (0.478)	0.302 (0.498)
<i>Type of organizational interface</i>								
Dedicated department	1.321*** (0.472)	1.555*** (0.442)	1.427*** (0.504)	1.482** (0.655)	0.950 (0.599)	0.646 (0.717)	1.298* (0.653)	1.196* (0.648)
Marketing department	0.528 (0.406)	0.792* (0.443)	0.437 (0.388)	-0.064 (0.415)	1.089*** (0.372)	-0.546 (0.475)	-0.041 (0.486)	0.072 (0.307)
No specific department	-0.735 (0.642)	-0.577 (0.554)	-0.681 (0.582)	-1.331* (0.671)	-0.636 (0.502)	-0.182 (0.923)	-0.726 (0.756)	0.190 (0.637)
<i>Controls</i>								
North American firm	0.674** (0.325)	0.705* (0.376)	0.334 (0.413)	0.819** (0.310)	0.288 (0.419)	0.315 (0.483)	-0.486 (0.476)	-0.823* (0.448)
Integrated firm	0.234 (0.420)	0.742 (0.577)	1.046 (0.646)	1.289** (0.519)	0.932 (0.570)	1.492** (0.637)	0.314 (0.647)	1.298** (0.510)
Firm size (log employees)	-0.127 (0.078)	-0.090 (0.077)	-0.181* (0.096)	-0.263*** (0.093)	-0.161* (0.095)	-0.241* (0.124)	0.064 (0.141)	-0.247** (0.115)
Constant	2.705*** (0.479)	2.658*** (0.440)	2.342*** (0.574)	2.318*** (0.421)	1.869*** (0.551)	1.904*** (0.612)	3.210*** (0.582)	1.738*** (0.568)
Observations	90	90	89	90	89	90	89	89
R <sup>2</sup>	0.26	0.29	0.26	0.27	0.23	0.20	0.13	0.31

*Notes:* Baseline categories are General Purpose Semiconductor Complementor and Engineering Department. Robust standard errors in parentheses, clustered by firm.

<sup>a</sup>Missing data on the types of complements and for some types of collaborative interactions resulted in the exclusion of some observations.

\*Significant at 10%.

\*\*Significant at 5%.

\*\*\*Significant at 1%.



As compared to general purpose semiconductor complementors, the higher intensity of collaboration with software complementors and application-specific semiconductor complementors is also confirmed in the regression models. The coefficient for software is positive and significant for information sharing (Models 1, 2), joint product development (Model 3), joint marketing (Model 5), and licensing (Model 6). The coefficient for application-specific semiconductor is positive and significant for information sharing (Models 1, 2), joint product development (Model 3), product customization (Model 4), and joint marketing (Model 5). The coefficient estimates for application-specific semiconductor complementors are lower than those for software complementors for information sharing, joint product development, and licensing interactions. However, the difference between the two coefficients is only statistically significant for licensing ( $F=3.49$ ,  $p<0.10$ ) and marginally insignificant for information sharing on market applications ( $F=2.43$ ,  $p=0.12$ ).

## NATURE OF VALUE CREATION

Finally, the survey instrument evaluated the nature and the extent of firms' value creation from collaborating with complementors. Respondents indicated on a scale of 1 (not at all) to 7 (very great extent), the extent to which their firm's relationship with the complementor has helped their firm to (1) gain new customers in existing market segments; (2) gain customers in new market segments; (3) increase their firm's sales to existing customers; and (4) improve the performance of their products. The results indicate that firms in the semiconductor industry benefit most from their collaborative interactions with complementors through improving the performance of their products (mean = 4.44) and the least through gaining customers in new market segments (mean = 3.64). Increasing sales within existing market segments represented an intermediate level of benefits (mean value is 3.90 for increasing sales to existing customers and is 3.81 for gaining new customers).<sup>3</sup> Thus, collaboration with complementors seems to be paying the most dividends in managing technological interdependencies to improve product performance that likely also has an effect of increasing sales to existing customers and new customers. These results also reaffirm that firm-complementor interactions in the semiconductor industry tend to be much more targeted at a specific application or market segment.

In exploring how organizational choices and types of complements are correlated with performance outcomes, Table 2 reports the regression

**Table 2.** Regression Estimates for the Different Types of Benefits that Firms Derive from Their Relationships with Complementors.

	(1) Product Performance	(2) Sales to Existing Customers	(3) New Customers in Existing Market Segments	(4) Customers in New Market Segments
<i>Type of complementor</i>				
Software	0.629* (0.340)	0.952** (0.385)	1.604*** (0.361)	1.342*** (0.415)
Application-specific semiconductor	-0.100 (0.435)	0.808** (0.342)	1.282*** (0.409)	0.711* (0.409)
<i>Type of organizational interface</i>				
Dedicated department	1.479** (0.621)	0.666 (0.612)	0.334 (0.731)	0.957 (0.607)
Marketing department	0.315 (0.524)	1.035*** (0.364)	0.466 (0.423)	0.915** (0.448)
No specific department	-1.476** (0.686)	-0.678 (0.679)	-0.604 (0.554)	0.248 (0.714)
<i>Controls</i>				
North American firm	0.080 (0.332)	0.849** (0.347)	0.843* (0.453)	0.830* (0.472)
Integrated firm	0.395 (0.471)	0.756 (0.547)	1.118 (0.678)	0.851 (0.661)
Firm size (log employees)	0.036 (0.124)	-0.088 (0.109)	-0.077 (0.124)	-0.023 (0.119)
Constant	3.869*** (0.480)	2.138*** (0.474)	1.975*** (0.547)	1.726*** (0.574)
Observations	89	90	89	90
R <sup>2</sup>	0.22	0.25	0.23	0.19

Notes: Baseline categories are General Purpose Semiconductor Complementor and Engineering Department. Robust standard errors in parentheses, clustered by firm.

\*Significant at 10%.

\*\*Significant at 5%.

\*\*\*Significant at 1%.

estimates. Among the different types of complementors, collaboration with software complementors is associated with the greatest value creation, followed by collaboration with application-specific semiconductor complementors, and finally by collaboration with general purpose semiconductor complementors. As compared to general purpose semiconductor complementors, collaboration with software complementors has a significant impact on semiconductor firms' improving their products (Model

1) and increasing sales in both new (Model 4) and existing market segments (Models 2-3). Collaborating with other application-specific semiconductor firms also facilitated value creation, primarily through increasing sales in existing market segments (Models 2-3), suggesting that value appropriation threat from these complementors is likely to be lower than that from general purpose semiconductor firms. These results reinforce the understanding, developed through the fieldwork, that the potential for value creation is greater with software and application-specific semiconductor complementors than with general purpose semiconductor complementors.

The results with regard to the effect of organizational units managing the firm-complementor relationships are somewhat puzzling. On the one hand, while dedicated groups facilitated extensive collaborative interaction (information sharing, product customization, joint product development), their effect on firms' value creation, as compared to the engineering group, is only significant for improving product performance (Model 1). On the other hand, as compared to complementor relationships managed through the engineering group, those managed through the marketing group seem to be more advantageous in increasing sales to existing customers (Model 2) and gaining customers in new market segments (Model 4). Why is it that relationships managed through dedicated groups characterized by the highest levels of collaboration between firms and their complementors (just as was the case with software complementors) did not seem to result in greater value creation? Although the current analysis cannot provide any definitive answers, it does point to the organizational design complexity of both managing external relationships with complementors for joint value creation and leveraging internal resources and functions to realize that value. While marketing and engineering departments may not be as effective as dedicated departments in facilitating collaboration with complementors, they are critical to realizing the gains from these collaborations. It is possible that a more externally oriented organizational interface may be constrained in its ability to leverage internal resources and capabilities for firms to benefit from their collaboration with complementors.

## **DISCUSSION**

The study considers the interdependencies between complementors in the business ecosystem and explores the nature of collaborative interactions between them. It sheds light on the organizational and strategic contexts in which such interactions take place, and shows how they may influence

the pattern and the benefits of collaboration. Just as the shift from integrated enterprises toward collaborative supply chains in the 1980s and 1990s presented new opportunities for scholars to understand value creation in buyer-supplier relationships (e.g., Cusumano & Takeishi, 2006; Dyer, 1997; Helper, MacDuffie, & Sabel, 2000), so too does the recent shift from supply chains to business ecosystems present new opportunities for scholars to expand beyond the traditional buyer-supplier relationships to also consider relationships between complementors. A primary objective of this study is to initiate that research trajectory by providing some evidence regarding the different ways in which firms collaborate with their complementors, and to identify how organizational and strategic factors may shape joint value creation.

The evidence presented is based on fieldwork followed by a detailed survey instrument administered to large established firms in the semiconductor industry. Key complementors to these firms include software and other semiconductor firms whose products are used in the same end-user application as the focal firms' products. Firms in the semiconductor industry seem to interact with their complementors most extensively through sharing information on R&D plans and market applications, joint product development, and customizing their products to complementors' products. As discussed in the literature on interorganizational collaboration, these types of interactions that entail knowledge exchange and combining complementary resources and capabilities are key drivers of joint value creation (Dyer & Singh, 1998). While firms also interact with their complementors through joint marketing, standards setting, licensing, and making financial investments, these interactions tend to be much more specific to a given firm-complementor dyad.

An important consideration for the relationship with complementors is the choice of the organizational interface that is used to manage the relationship. Given that interdependencies between complementors entail both technological and commercialization elements, there was no clear consensus within the survey sample as to how these relationships are to be managed. Although some firms have a dedicated organizational interface (a department or a corporate executive), the majority of firms in the sample seem to manage it through existing engineering and marketing departments. The complementor relationships that were managed through a dedicated organizational interface were characterized by the highest levels of collaboration. The level of collaboration was lowest for relationships managed through engineering departments or when no specific department had the primary responsibility to manage the relationship.



Another important consideration for collaborative interactions is the duality of value creation and appropriation between firms and their complementors. Scholars have argued how differences in the nature of complementors may shape firms' incentives to collaborate (Brandenburger & Nalebuff, 1996; Casadesus-Masanell & Yoffie, 2007). The greater the benefits from complements (higher degree of complementarity) and the lower the appropriability hazards, the greater the firms' incentives to collaborate. The three different types of complements identified in the semiconductor industry (software, application-specific semiconductor, and general purpose semiconductor) presented a unique opportunity to tease out the effects of complementarity and appropriability. The benefits from collaborating with software and application-specific semiconductor firms are greater than those from collaborating with general purpose semiconductor firms. The competitive threats are greatest from other semiconductor complementors with similar capabilities who would find it much easier than software complementors to expand into focal firms' product markets. As a result, the intensity of collaboration was found to be greatest when the complementor was a software firm, lowest when the complementor was a general purpose semiconductor product firm, and moderate when the complementor was an application-specific semiconductor product firm.

Finally, the survey explored the nature of benefits that firms derive from their relationship with complementors. These relationships seem to be most beneficial in improving the performance of focal firms' products, moderately beneficial in increasing sales or gaining customers in existing market segments, and least beneficial in gaining customers in new market segments. These findings are consistent with the view that value creation with complementors in the semiconductor industry is increasingly pursued in the context of a given market segment or application, and that managing technological interdependencies to improve product performance and sales to existing customers are important motivations underlying these relationships. This analysis also reinforced the high value creation potential of software complementors, followed by that of application-specific semiconductor complementors. Somewhat surprisingly, while complementor relationships managed through dedicated organizational units consistently exhibited a high degree of collaboration, this did not seem to match the managers' evaluation of the benefits from these relationships. The mixed finding regarding the impact of dedicated organizational units on the extent of collaboration and value creation points to the organizational challenges that underlie firm-complementor relationships. Although cultivating collaborative linkages with complementors may require dedicated organizational

interface, extracting benefits from such linkages requires cooperation and coordination among internal organizational units. Hence, simply creating a new organizational entity without redesigning the organization to support that entity may not allow firms to realize the potential value from such relationships.

These findings, while reinforcing the relational view of the firm characterized by collaboration between the firm and partners in its ecosystem, shed light on the important differences between the management of buyer-supplier and that of firm-complementor relationships. Traditional organizational designs within firms have been created to manage buyer-supplier relationships either through procurement or marketing functions. Complementors are neither buyers nor suppliers to the firm. This “indirect” interdependence that entails both supply-side and demand-side interactions raises the organizational design complexity that is required to manage complementor relationships. An organizational design for managing complementors needs to account for not only interorganizational interdependence between firms and complementors but also the intra-organizational interdependence between upstream (i.e., R&D) and downstream (i.e., marketing) tasks that underlie firms’ value creation. Also, while firms’ collaborative interactions with suppliers and complementors are characterized by information sharing, joint action, and specialized investments, there are significant differences in the nature of the challenges across those relationships. Often, an important concern with a given supplier relationship is whether the firm may be held up by the supplier due to high transaction costs and what may be an appropriate governance mechanism to manage such a relationship (e.g., [Poppo & Zenger, 2002](#); [Williamson, 1985](#)). In contrast, an important concern with a given complementor relationship is the somewhat inevitable conflict over who appropriates more value and whether the complementor may intrude into the focal firm’s product market becoming its direct competitor ([Gawer & Henderson, 2007](#); [Yoffie & Kwak, 2006](#)). The strategic interaction between Apple Inc. and Google Inc. is a case in point in which once highly collaborative complementors turned to direct competitors. Different types of complementors may vary both in the degree of complementarity (based on the nature of technological interdependence and the value creation potential) and in the extent of appropriability hazards (based on the differences in firms’ business models and capabilities). As the findings illustrate, these differences have an important impact on the nature of firm-complementor interactions. The study not only asserts that complementors present an important opportunity for management scholars to look beyond supply-chain interactions in the business ecosystem but also

underscores that such an opportunity entails an explicit consideration of the different types of challenges that firms may face between managing suppliers and managing complementors.

By focusing on interorganizational relationships between firms and their complementors, the study also contributes to the literature on alliances, which have traditionally tended to characterize such relationships based on the alliance function (i.e., R&D and marketing) rather than the role played by the alliance partners in the business ecosystem (e.g., [Gulati & Singh, 1998](#); [Lavie & Rosenkopf, 2006](#); [Mowery, Oxley, & Silverman, 1996](#)). Future research focusing on interorganizational alliances and firms' alliance portfolios could build on these findings by being explicit about the different roles that partners play in a collaborative business ecosystem (e.g., suppliers, complementors, and customers), and how these differences interact with firms' capabilities, alliance strategies, and performance outcomes. In many industries, there has been a significant increase in the norm of inter-organizational collaboration and open innovation, providing an institutional monitoring and reputation system, and making it possible for firms to benefit from less-hierarchical forms of collaboration ([Frankort, 2013](#)). It would be interesting to see how such institutional drivers shape collaboration and coordination in business ecosystems.

The methodology employed in this study, while allowing for a rich description of the nature of collaborative interactions between firms and their complementors, has several limitations. First, the research is carried out in the context of a single industry and the generalizability of these findings would need to be established through explorations in other empirical contexts. For example, in software-based industries, firms typically depend on a large number and variety of complementors. Beyond managing dyadic relationships, this would also require building and orchestrating an extensive network of complementors, and potentially increasing the organizational design complexity and the intensity of co-competitive interactions in the ecosystem (e.g., [West & Wood, 2013](#)). Similarly, in new emerging contexts such as the one studied by [Li and Garnsey \(2013\)](#), entrepreneurial firms face additional challenges of identifying complementors and offering them with a joint value proposition so as to mitigate the different types of risks in the ecosystem. Second, the observed relationship between the choice of the organizational unit that is used to coordinate activities with complementors and the extent of the collaborative interactions is best treated as correlation rather than causation. It is possible that firms may assign a corporate executive or create a dedicated organizational unit to manage more collaborative relationships. Whether the choice of



the organizational unit is a result of firms' sorting of partners into different organizational interfaces based on the scope and the intensity of collaboration or whether this choice impacts the extent of interorganizational collaborative interaction remains an important avenue for future research. Finally, the degree and the benefits of collaboration with complementors were evaluated based on the focal firm's perspective. Although this approach is somewhat typical of the literature on interorganizational relationships, it is possible that focal firms and complementors may have different perceptions of the collaboration and the measures may be subject to informant bias. Scholars could build on these findings by observing both sides of the interorganizational relationships and how they evolve over time.

## CONCLUSION

The study has attempted to shed light on the collaborative linkages that exist between firms and complementors within the business ecosystem, and how the nature and extent of their collaboration are shaped by the organizational and strategic contexts underlying these linkages. While scholars have considered the criticality of complementors to the firms' value creation (e.g., Adner & Kapoor, 2010; Brandenburger & Nalebuff, 1996; Gawer & Henderson, 2007) and the existence of collaborative linkages between these actors (Kapoor & Lee, 2013; Mitchell & Singh, 1996), our understanding of what goes on within these interorganizational relationships and how firms benefit from them is relatively limited. The analyses presented in this paper offer new insights on how firms collaborate with complementors and on the organizational and competitive challenges that underlie joint value creation.

## NOTES

1. Sharing information on a specific market or application is significantly greater than sharing information on R&D plans and technology roadmaps ( $t=3.32$ ,  $p<0.01$ ). Sharing information on R&D plans and technology roadmaps is significantly greater than customizing products to the complementor ( $t=2.67$ ,  $p<0.01$ ). Customizing products to the complementor and joint product development are significantly greater than joint marketing ( $t=2.02$ ,  $p<0.05$ ;  $t=2.58$ ,  $p<0.01$ ). Joint marketing and setting standards are significantly greater than licensing



( $t = 1.90$ ,  $p < 0.05$ ;  $t = 1.98$ ,  $p < 0.05$ ). Finally, licensing is significantly greater than investing ( $t = 5.44$ ,  $p < 0.01$ ).

2. It is possible that the firms' choice of the organizational interface is driven by the nature and the scope of the collaboration with complementors. For example, firms may be more likely to choose a dedicated organizational interface to manage complementor relationships with greater collaboration requirements. It is also possible that the choice between marketing and engineering departments may be influenced by whether the relationship focuses on marketing or on R&D activities. Note, however, that respondents were asked to provide inputs on two of the key complementors on which their firms or business units were dependent. Hence, given the strong dependence, the scope of collaboration is unlikely to be confined to either marketing or R&D tasks.

3. Improving product performance is significantly greater than increasing sales to existing customers ( $t = 3.29$ ,  $p < 0.01$ ), and as well as gaining customers in existing market segments ( $t = 4.71$ ,  $p < 0.01$ ). Increasing sales to existing customers and gaining customers in existing market segments are significantly greater than gaining customers in new market segments ( $t = 1.66$ ,  $p < 0.05$ ;  $t = 1.27$ ,  $p < 0.10$ ).

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