

Influence of Firm and Partner Resources on Firm Performance in the Alliance Portfolio

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Abstract. Although a firm benefits from the resource endowment of the partners in its alliance portfolio, research has so far concentrated on partners. This study proposes that mutual conditions of network resources between a firm and its partners – the compatibility of underlying resources, including physical and R&D resources, strategy, status, and the complementarity of technology – have a positive relationship to the firm's economic performance in its alliance portfolio. By analyzing alliances within the global semiconductor industry, this study shows that a firm's economic performance increases when the compatibility and complementarity of network resources are high.

The effect of partners' resources and attributes on firm performance has become an important theme in alliance portfolio research. An alliance portfolio is a focal firm's set of all direct alliances, which take a variety of forms and occur across both vertical and horizontal boundaries (Baum, Calabrese, & Silverman, 2000; Hoffmann, 2007; Lavie, 2007; Wassmer, 2010). Scholars have argued that improvement of a firm's performance by constructing an alliance portfolio is largely attributable to the partners' principal network resources, defined as the alliance partners' heterogeneous resources and characteristics that are available to the focal firm in its set of direct alliances (Baum et al., 2000; Gulati, 1998; Powell, Koput, & Simth-Doerr, 1996). For instance, the technological and commercial prominence of partners as well as relationships with prestigious venture capital firms influence startups' innovation rate, sales growth, and IPO performance (Gulati & Higgins, 2003; Stuart, Hoang, & Hybels, 1999; Stuart, 2000). A key argument is that the most valuable aspect of composing the portfolio and improving performance is allying with partners who are well endowed with network resources. Partners' resources are critical to the composition of the alliance portfolio, because they are pivotal components of both value creation in a firm's alliances and improvement of firm performance (Baum et al., 2000; Stuart, 2000). While this research stream has contributed significantly to alliance portfolio research, it has focused on the inherent and prominent attributes of partners rather than on the properties of the portfolio's network structure. Consequently, alliance portfolio researchers increasingly focus on partners' resource endowment as a critical factor in the pursuit of performance improvement (Stuart, 2000).

This paper is motivated by a gap in the literature. Although the key resources and attributes of partners are likely to be important, how much a focal firm's resource condition influences the partners' contribution to performance is unclear. Rather, current research offers a deterministic account of performance improvement, in which partners with attractive resources or capabilities are able to improve firm economic performance (Baum et al., 2000; Stuart, 2000). However, this "rich get richer" account presents mixed evidence on the performance implications of partner endowment. For instance, some studies have

found no direct effect of partner attributes on profitability (Hagedoorn & Schakenraad, 1994), and even report a negative effect on economic performance (Goerzen & Beamish, 2005). Alliance research has recognized that understanding a firm's alliance activities inherently requires looking not only at partners' resource endowments but also at the focal firm's resource conditions, which should be compatible with such endowments (Walker, Kogut, & Shan, 1997). That is, the composition and consequences of an alliance portfolio depend on the firm-specific attributes and resources of both the focal firm and its partners. Thus, how the resources of a firm and its partners influence the focal firm's performance remains a puzzle.

In contrast, an emerging stream of alliance research explores resource matching (Vissa, 2011). Mitsunashi & Greve (2009: 976), citing Logan (1996), state that "a theory of relationship needs to simultaneously address all parties' preference, opportunities, and constraints by using data on the characteristics or resources that each side value in the other." Although this view advances an understanding of the role of both the firm's and its partners' resources, the empirical evidence has generally concentrated on alliance formation at the dyadic level. Put differently, portfolio studies on performance implications have been slow to embrace this important concern, and have provided limited guidance on how to better ensure the composition of alliance portfolios and the impact of resources on both the firm and the partners. Therefore, an understanding of the effect of network resources in alliance portfolios remains incomplete. This paper addresses these gaps by asking how the conditions of the network resources of a firm and its partners influence the focal firm's economic performance in its alliance portfolio. This investigation focuses on the performance implications of the network resources by proposing and testing two resource conditions: compatibility and complementarity. Some strategic alliance research emphasizes that partner compatibility allows firms to leverage alliances because of partner uncertainty (Podolny, 1994; Porter & Fuller, 1986), while other studies stress that complementarity between the firm and its partners facilitates alliance formation because of direct synergy (Chung, Singh, & Lee, 2000). This paper proposes that increasing the compatibility of the underlying network resources – physical and R&D resources, strategy, and status – and the complementarity of technologies between the firm and its partners has a positive effect on the focal firm's economic performance. This study tests the hypotheses by using data on alliance portfolios of firms in the semiconductor industry, which is characterized by rapid technology change and numerous alliances with heterogeneous partners.

This research contributes to the alliance portfolio literature on resource endowment of partners by highlighting the resource conditions of both the firm and its partners and the resource conditions' performance implications in alliance portfolios. Alliance research has pointed out that mutual conditions of resources are more or less suitable for understanding a firm's alliance formation (Mitsunashi & Greve, 2009). This paper extends this observation to alliance portfolios and argues that understanding the performance implications of alliance portfolios requires a fit of network resources between firm and partners.

THEORETICAL BACKGROUND AND HYPOTHESES

PERFORMANCE AND NETWORK RESOURCES IN ALLIANCE PORTFOLIOS

Understanding the relationship between alliances and performance is a long-standing goal of alliance research. Indeed, researchers have considered this relationship to be an essential pursuit of strategic alliance research (Child, Faulkner, & Tallman, 2005). Performance can be viewed from two distinct

perspectives: system performance linked to alliance performance and goal performance related to the influence of alliances on firm performance (Seashore & Yuchtman, 1967). While alliance performance relates to the extent to which an alliance performs well as a business unit, goal performance relates to the extent to which the objectives of each firm in an alliance are realized in practice. This paper examines performance associated with the asymmetric objectives of each firm, and the term “firm performance” refers to a focal firm’s performance at the firm level.

The system performance perspective, which focuses on joint ventures as separate legal entities, argues that some alliances are more successful than others because they are characterized by a high level of interfirm trust, strategic and organizational compatibility, knowledge exchange, or adaptive governance (Dussauge, Garrette, & Mitchell, 2000; Dyer & Singh, 1998; Dyer & Nobeoka, 2000; Madhok & Tallman, 1998; Kale, Dyer, & Singh, 2002; Khanna, Gulati, & Nohria, 1998). In contrast, the goal performance perspective holds that performance should be measured independently to maintain the objectives of each firm, because firms form alliances for a variety of reasons and alliance members may have asymmetric objectives. Heterogeneity of partnerships can affect firm outcomes differently, as firms enter alliances at distinct points in their value chains, with very different entities and for widely different reasons (Gulati & Kletter, 2004). Failure of an alliance in terms of one party’s goal attainment does not necessarily mean that the alliance has failed in terms of another party’s criteria (Child et al., 2005).

However, those perspectives do not fully explain the performance of alliances, and this is for three reasons. First, the analysis of performance has often been conducted at the dyadic level, with each firm’s alliance considered to be an isolated event rather than an interdependent element (Hoffmann, 2007; Ozcan & Eisenhardt, 2009). Put differently, research has neglected the simultaneous and interdependent effects of other alliances in a firm’s set of alliances. Furthermore, inferring alliance contributions to firm performance from alliance success is difficult because the value appropriated by the alliance partners is asymmetric (Khanna et al., 1998). Finally, the majority of research focuses on joint ventures rather than on the more common non-equity alliances (Lavie, 2007).

Drawing on social network theory, several alliance studies have overcome these limitations by focusing on the composition of alliances and attributes of partners, using terms such as multilateral alliance (Doz & Hamel, 1998) or alliance constellation (Gomes-Casseres, 1994). In particular, by expanding the unit of analysis to the focal firm and all its direct partners, research has examined the direct contribution to firm performance of a focal firm’s alliance configuration, called the ego-centric alliance network (Ahuja, 2000a; Bae & Gargiulo, 2004; Powell et al., 1996) or alliance portfolio (Baum et al., 2000; Hoffmann, 2007; Lavie, 2007; Stuart, 2000; Wassmer, 2010). The underlying argument is that the effects of alliance portfolio composition on firm performance depend on partner firms’ resources and attributes as network resources. As Gulati (2007) notes, firms can build very distinct network resource bases which are contingent on their partners and the relative efficacies of these entities. Network resources involve several partners’ resources and attributes, such as relational capabilities, technological knowledge, social position, or organizational resources, including both tangible and intangible resources: physical assets, financial resources, human resources, and R&D investment (Baum et al., 2000; Lavie, 2007; Stuart, 2000). When alliance partners have high-quality resources, capabilities, technological expertise, or social status, a firm is likely to improve its performance by leveraging the resource endowment and benefit from spillover (Baum et al., 2000; Chung et al., 2000; Gulati & Higgins, 2003; Gulati & Gargiulo, 1999; Stuart et al., 1999).

Recent research has examined the performance implications of network resources using various performance measures, such as innovation, new product development, number of patents obtained, revenue growth, market share, and market value (Ahuja, 2000a; Baum et al., 2000; Goerzen & Beamish, 2005; Lavie, 2007; Shipilov, 2009; Stuart, 2000). For example, by entering into technology alliances with larger firms which possess superior resource attributes in innovativeness and size, a firm improves innovation output in terms of its patent rate (Hagedoorn & Schakenraad, 1994). As another example, in the biotech industry, the technological and commercial superiority of alliance partners affects the IPO performance of startups (Stuart et al., 1999). The argument is that startups that have exchange partners with prominent technological and commercial resources and skills perform better than ventures without endorsements. Similarly, relationships with prestigious venture capital firms and underwriters contribute to IPO performance (Gulati & Higgins, 2003). For startup firms in the U.S. semiconductor industry, for instance, firm performance derived from an alliance portfolio is determined by the partners' revenues and technological and innovation capabilities, implying that the advantage of having an alliance portfolio is driven by the partner firms' characteristics (Stuart, 2000). In a similar vein, recent studies have argued that not only technology-related characteristics but also partners' other firm-specific factors have an impact on performance. Powell et al. (1996) showed that U.S. biotechnology firms have grown more rapidly in revenue and sales by establishing a more diverse set of partnering activities than other firms. Other studies showed that startups can enhance their initial performance by building efficient strategic alliances with technologically and commercially prominent partners, thus providing diverse information and capabilities and offering more opportunities for learning (Baum et al., 2000).

Although research has examined the impact of partners' resource endowments, performance implications also depend on several other factors, such as the focal firm's characteristics or the industry context (Ahuja, 2000b; Dussauge et al., 2000; Hansen, 1999; Owen-Smith & Powell, 2004). Of particular importance are both the partners' resource aspects and the focal firm's resource condition (Walker et al., 1997), and recent research has suggested that complementarity and compatibility of firm-partner aspects in an alliance are not parts of a trade-off. Rothaermel and Boeker (2008) found that a pharmaceutical firm and a biotechnological firm are more likely to enter into an alliance based on complementarities and similarities between partners. Mitsunashi and Greve (2009) found that firms' alliances in the shipping industry are associated with market complementarity and resource compatibility. However, empirical evidence on the contribution of resources has been limited to alliance formation at the dyadic level.

This study argues that a focal firm might improve its performance when its alliance portfolio strikes a balance between complementary and compatible resources. To evaluate whether the complementarity and compatibility of network resources between the firm and its partners influence firm performance, this investigation examines the effects of five key resources that have been prominently used in prior research: physical resources, R&D resources, strategy, status, and technology (Chatterjee & Wernerfelt, 1991; Chung et al., 2000; Lavie, 2007; Mitsunashi & Greve, 2009). These network resources may have a more direct impact than other resources on alliance portfolio composition and firm performance in high-tech industries (Gulati & Higgins, 2003; Podolny & Stuart, 1995; Stuart et al., 1999). The following sections develop and examine distinct hypotheses for each of these resources.

COMPATIBILITY OF NETWORK RESOURCES

Research on alliance formation suggests that asymmetric or imperfect information about potential partners' capabilities, reliability, and motives is a critical factor in building interfirm relationships (Kogut, 1988; Oxley, 1999; Podolny, 1994). When asymmetry of information raises transaction costs, firms are more likely to build partnerships with firms that are compatible in terms of organizational structure, size, and resources (Mitsuhashi & Greve, 2009; Porter & Fuller, 1986). In managing a number of alliances, a firm may incur heavy coordination costs. Organization scholars predicted long ago that the greater the coordination efforts by mutual adjustment, the heavier the communication burden and decision costs in the relationships (Thompson, 2007). Thus, firms will seek to minimize coordination costs by forming reciprocal relationships with similar partner firms. Because alliances require ongoing coordination that involves management time and money (Porter & Fuller, 1986), when interests between parties are divergent and separate, the process of value creation becomes complicated, raising the cost of alliance activity. Thus, the extent of coordination costs depends on how similar the partners' interests are. Indeed, recent studies suggest that increasing the diversity within an alliance portfolio may constrain firm outcomes owing to greater complexity of resource management, coordination costs, or potential interfirm conflicts (Ahuja & Lampert, 2001; Bae & Gargiulo, 2004; Goerzen & Beamish, 2005). Therefore, when firms seek business opportunities and improved performance by building alliances, the compatibility of underlying network resources influences the composition of the alliance portfolio and firm outcomes.

Physical and R&D resources. A widely held assumption is that firms in highly capital-intensive primary manufacturing industries are more likely to seek external alliance partners with similar underlying resources and characteristics, such as standardization, process innovation, and engineering breakthroughs (Harrison, Hitt, Hoskisson, & Ireland, 2001) because they expect greater synergies from partnerships with similar goals for engineering quality products and comparable managerial approaches for allocating resources. According to the resource-based view (Wernerfelt, 1984), firms could enjoy greater performance improvement when they are at the same stage in the value chain and have similar resource allocation patterns in critical areas. For example, the capital-intensive semiconductor industry is characterized by an emphasis on commodity products, standardized maximization of the number of products, low-cost products, a line-driven organization structure, process innovation, a strong emphasis on a capital budget, a high level of technological know-how, and functional emphasis on manufacturing and engineering (Galbraith & Kazanjian, 1986). Thus, building alliances between firms with similar resource allocation strategies based on similar capital and investment requirements is more likely to facilitate both effective management and skill and knowledge transfer, leading to performance improvement. This argument leads us to posit the following hypotheses:

Hypothesis 1a. A firm's economic performance is positively related to the level of compatibility of capital resources in its alliance portfolio.

Hypothesis 1b. A firm's economic performance is positively related to the level of compatibility of R&D resources in its alliance portfolio.

Strategy. Firms considering alliances assess their potential partners' strategy for aspects of compatibility. Strategy researchers argue that firms following similar strategies are likely to ally with each other. For example, Porter (1980) points out that when the strategies of interfirm relationships are far apart, tacit coordination

becomes more difficult, resulting in strong competition in the industry. That is, firms with strategic distance are more likely to impede interfirm coordination. Newman (1978) also argues that differences in firms' strategies may lead to incongruent goals, potentially reducing firms' ability to tacitly collude. To the extent that interfirm coordination links to firms' ability to develop and commercialize new products in the future, a similarity of strategy is likely to influence firm outcomes. Thus, firms are more likely to collaborate with others with compatible strategies, leading to performance improvement.

Hypothesis 2. A firm's economic performance is positively related to the level of compatibility of strategy in its alliance portfolio.

Status. A firm's status has been viewed as a key network resource in leveraging alliances and improving organizational outcomes (Pfeffer, 1992). Status is defined as the perceived quality of a producer's products relative to the products of similar others or the products of its competitors (Podolny, 1993). To lower uncertainty as to a partner's quality, firms use the status of potential partners as a cue for determining the underlying quality of their products (Podolny, 1993, 1994). Status is also a signal relevant audiences use to decrease the uncertainty surrounding the quality of a partner's products and services (Podolny & Stuart, 1995). For example, a high-status potential partner is likely to receive more media coverage than partners with lower or no status, reducing a firm's search costs for an acceptable partner. In other words, a high-status partner can be monitored and evaluated more easily because it is more visible and its performance is more public, thus lessening the probability of opportunistic actions.

Firms with comparable status tend to associate more readily with one another than with firms of a different status (Benjamin & Podolny, 1999), a characteristic referred to as "compatibility of status" (McPherson, Smith-Lovin, & Cook, 2001). Alliances are likely to reflect compatibility of status for two reasons (Chung et al., 2000). First, the signaling effect encourages firms to collaborate with others of similar status when transaction results are uncertain (Podolny, 1994). Partnerships with low-status partners will be detrimental to high-status firms because other relevant audiences could perceive that the high-status firm endorses the quality of the products manufactured by the low-status partners, resulting in leakage of the high-status firm's status. Second, similar status increases the likelihood that both parties will share the costs and benefits of an alliance with higher levels of fairness and commitment, because in unequal alliances the higher-status partner is less likely to commit resources of the same caliber as those of the lower-status partner (Chung et al., 2000; Shipilov & Li, 2008).

A firm's high status in its industry also has performance implications. As a firm's status rises, its advertising costs decline, and more customers flock to it (Podolny, 1993). A study of interfirm relationships of biotech startups found that startups with higher-status equity investors and underwriters had a higher rate of initial public offering and market capitalization because of the venture capitalist firms' close relationship with leading investment banks, demonstrating that higher-status interfirm relationships attracted other prestigious relationships (Stuart et al., 1999). Similarly, a study of the U.K. investment banking industry showed that a firm's accumulated status in an interfirm network relates positively to the firm's market performance (Shipilov & Li, 2008). In this sense, compatible status between the firm and its partners is likely to contribute to an increase in the firm's organizational outcomes such as revenue or net benefit in the context of alliance portfolio. In the same vein, this investigation tests the impact of the compatibility of status in a firm's alliance portfolio in the specific setting of

semiconductor firms. The above discussion leads to the presumption of a positive effect of compatible status between a firm and its partners in an alliance portfolio:

Hypothesis 3. A firm's economic performance is positively related to the level of compatibility of status in its alliance portfolio.

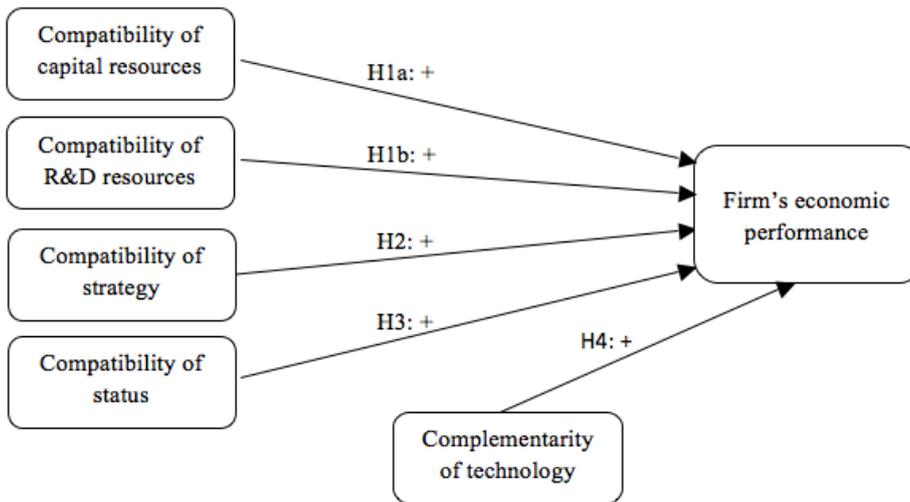
COMPLEMENTARITY OF TECHNOLOGY

While firms assess the compatibility of the underlying network resources of partners as a basis for alliance formation, strategic alliance research has long emphasized that firms' profile of complementarity is also an important component of the alliance formation process, having a direct impact on alliance purpose and firm outcomes (Chung et al., 2000; Gulati, 1995; Gulati, Nohria, & Zaheer, 2000; Lavie, 2007). Teece (1986) argues that because for high-tech firms knowledge is the primary resource for building competitive advantage, firms in high-growth industries are more likely to form alliances with partners with complementary knowledge and skill to ensure timely product introduction and to marshal a full array of capabilities. High complementarity of partners' expertise or specific knowledge increases the relative novelty of the knowledge a firm can access, because knowledge diversity adds to the variety of possible knowledge combinations and the potential for novel knowledge creation (Fleming, 2001). When alliance partners have a high level of complementary technologies, a firm can improve its performance by leveraging partner firms' resource endowment and learning (Baum et al., 2000; Burt, 1992; Gulati, 1998; Lavie, 2007; Stuart et al., 1999). For instance, alliance portfolios can provide a repository of accumulated experience and novel technological knowledge as their composition becomes more diverse and complementary (Anand & Khanna, 2000; Powell et al., 1996). In technology-intensive industries, complementarity of technology is an essential element in partner selection because it directly influences firm performance (Rothaermel, 2001). Since benefits derived from alliances in a high-tech industry hinge mostly on technological and innovation capabilities that partners bring to the alliance, the extent to which an alliance portfolio is built by a broad set of technological resources on the part of partners determines a firm's innovation and economic performance (Stuart, 2000). For instance, a firm may address technological challenges and possible solutions by creating an alliance portfolio with partners that possess different technologies and knowledge. Complementary technologies provide the opportunity to benchmark technologies, to combine knowledge, and to integrate best solutions that originate from those alliances (Lavie, Lechner, & Singh, 2007).

Several empirical studies have assessed the effect of partners' complementarity. For example, Saxenian (1994) found that partnerships with complementary technologies rapidly improved innovation, commercialization, and revenue generation, because complementarity increases the efficacy of combining both the firm's and the partners' resources for achieving strategic goals. Powell et al. (1996) found evidence that U.S. biotechnology firms in technology- and information-rich locations grew more rapidly when they established a more diverse set of activities than of other firms. Thus, this study suggests that the greater the complementarity of technology between a focal firm and its partners, the higher the probability of improving the firm's economic performance.

Hypothesis 4. A firm's economic performance is positively related to the level of complementarity of technology in its alliance portfolio.

Figure 1. Proposed theoretical model

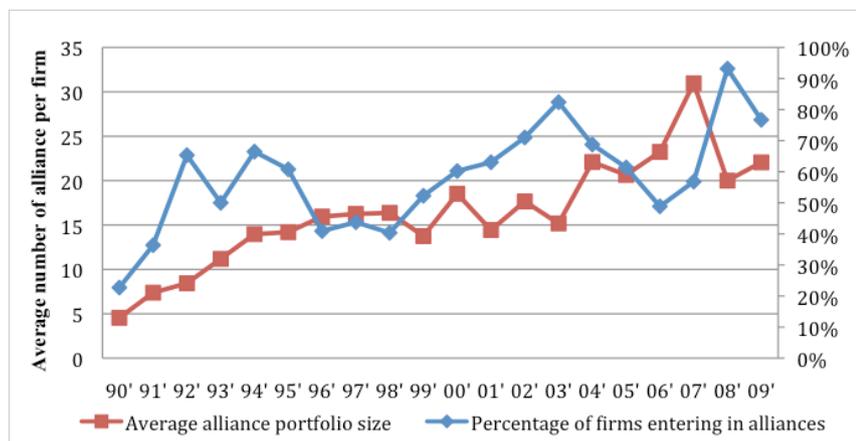


METHOD

SAMPLE

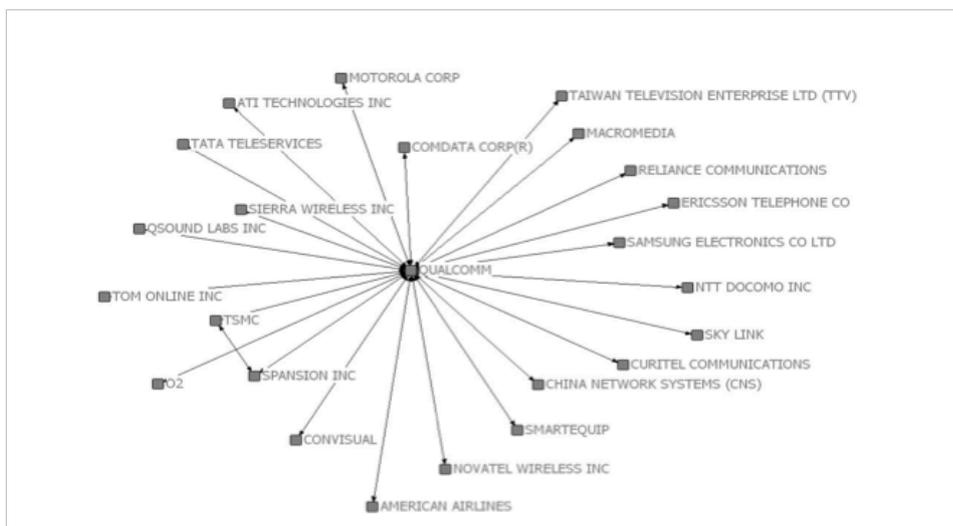
Figure 1 presents the theoretical model. The empirical context for this study is the global semiconductor industry (SIC 3674), and data on firms and alliances in the industry were collected during the period 1997-2007. Two reasons motivated the choice of semiconductor firms as the focus for the study. First, interfirm collaboration is common in that industry. As the semiconductor industry was experiencing rapid evolution in technologies, business models, and organizational types during the period under study, firms entered a large number of alliances (Park, Chen, & Gallagher, 2002; Stuart, 2000); according to the SDC database, between 1990 and 2009 the percentage of publicly traded semiconductor firms engaging in alliances increased from 23% to 93% and the average number of alliances per firm rose from five to more than 30 (Figure 2).

Figure 2. Percentage of firms entering alliances and average alliance portfolio size per firm (semiconductor firms publicly traded in the U.S. stock market exchange)



Second, semiconductor firms enter into alliances with heterogeneous other firms that vary in terms of size, technology, and value chain and provide complementary resources, assets, or knowledge, affecting the firm's technological and financial performance (Gomes-Casseres, 1994; Powell et al., 1996). For instance, Qualcomm, a leading company in the design of modem chipsets and microprocessors, has built its alliance portfolio with a number of firms, including Hitachi, Lucent, Motorola, Panasonic, Qsound, Samsung, Sharp, Sony, TSMC, and UMC (Figure 3). By building multiple alliances across its value chain, Qualcomm has been able to capitalize on learning from many market segments, such as computer manufacturing and telecommunications services. Within such multiple partnerships with integrated circuit design firms, original equipment manufacturer firms, and competitors that provide their own resources and skills, Qualcomm and its partner firms share R&D costs, marketing costs, financial resources, engineering support, and new products that are important for strategic purposes and financial performance. Such characteristics allow an examination of how the heterogeneous resources and characteristics of a focal firm and its partners influence firm economic performance. Thus, the semiconductor industry is an appropriate empirical setting for this study, which tests the resource conditions of a firm and the partners in its alliance portfolio.

Figure 3. Alliance portfolio of Qualcomm in 2007



The sample comprised semiconductor firms that design, produce, and market integrated circuits, including memory chips and microprocessors. From an initial list of firms from the Bloomberg database, a sample was selected according to four criteria. First, firms must design and manufacture integrated circuits. This criterion excluded firms that test integrated chips and trade them in the secondary market. Second, to meet this paper's objective of explaining variations in resource conditions and performance effects from alliances, firms must have been engaged in at least two alliances with other semiconductor firms between 1997-2007. Third, firms must be publicly traded on U.S. stock exchanges. Fourth, firms must have at least five sets of annual financial records. The third and fourth criteria were driven by the availability and reliability of data on private or foreign firms operating in the U.S. market. For these selected firms, the SDC Platinum database yielded records of alliances formed by each semiconductor firm. To ensure complete coverage of publicly announced alliances, the SDC data were complemented by alliance announcements in the Factiva database. Within the observation period, each sample firm entered an average of 10.5 alliances, but

significant variation in alliance activity occurred across firms. A few organizations entered up to 85 alliances, whereas some entered only two or three. The Bloomberg and Datamonitor databases, as well as firms' websites, were used to collect both firm-specific and partner-specific data, including financial records and technology information. In accordance with prior research (Stuart, 2000), the alliances examined were limited to those involving technology development or exchange, manufacturing, and marketing, because this study's theory concerned the compatibility and complementarity of resources. Unilateral licensing and distribution contracts were excluded.

These sampling criteria resulted in a sample of 115 firms and 386 firm-year observations. To construct a firm's alliance portfolio, a four-year moving period was adopted, including alliances formed in the previous three years (e.g., 1994-97, 1995-98, 1996-99, etc.). This approach is common practice in alliance research to account for the lag structure of learning and the cooperative strategy of each alliance (Stuart, 2000).

MEASURES

Firms' economic performance. A firm's economic performance is measured as its rate of return on assets (ROA), which managers widely use to evaluate their annual operations. In addition, previous studies have employed this measure to assess firm performance (Melynk, Stewart, & Swink, 2004; Sørensen, 2002) and it is useful for comparing corporate performance within the same industry. This study employed the three-year average of both measures with a one-year lag. Three years of data overlap were chosen because some resources may have immediate effects on economic performance, while in the case of others it may take a number of years for their effects to be fully realized (Palmer & Wiseman, 1999).

Compatibility of capital resources. A firm that makes a consistent commitment to capital expenditures is continually building tangible resources involving its property, plant, and equipment (Chatterjee & Wernerfelt, 1991). A high level of availability of such physical assets and resources can improve the productivity of an alliance, influencing the firm's profitability. This study operationalized capital intensity as capital expenditure divided by sales in year $t-1$.

Compatibility of R&D resources. A firm's R&D expenditure, which is investment in the development of technological knowledge, contributes to its innovation and new product development, improving its economic performance. R&D intensity was calculated by dividing R&D expenses by sales in year $t-1$.

Compatibility of strategy. According to Stinchcombe (1965), firms originating in a given period are "imprinted" by the prevailing environment and choose their structures and strategies accordingly. If Stinchcombe's hypothesis is correct, the date of founding can serve as a unidimensional proxy for strategy, and firms that are similar in the year of founding (i.e., firms that experienced similar environments at their founding dates) are likely to follow similar strategies (Gimeno & Woo, 1996). Following Gimeno and Woo (1996), this investigation used founding year to measure strategy.

Compatibility of status. Status can be one of several valuable intangible network resources which firms possess. Because status depends on social rank and generates social esteem or privileges, it can afford firms better access to scarce resources (Burt, 1992; Washington & Zajac, 2005). Bonacich's centrality, which has been interpreted as a status score, served as a measure of the status of each firm (Bonacich, 1987; Podolny, 1993; Rowley, Greve, Rao, & Baum,

2005). Bonacich argues that an actor's power and centrality are a function of the number of connections of the actor to others and the number of connections these others have in their neighborhood. That is, the more connections the firm's partners have, the more central the firm is. However, the fewer the connections the firm's partners have, the more powerful the firm is. Status was calculated by constructing annual asymmetric network data in UCINET (Borgatti, Everett, & Freeman, 1999). In accordance with Gulati & Gargiulo (1999), standardization of this variable across different years resulted from dividing the centrality of each firm and partner in each year by the maximum firm centrality observed in that year.

The dyadic compatibility of network resources was calculated as 1 minus the difference between a focal firm and a partner for each of these organizational resources by normalizing to a zero-to-one range (Gimeno & Woo, 1996). Greater value indicated higher compatibility between a firm and a partner. The compatibility scores were aggregated by calculating the average compatibility in an alliance portfolio:

$$\text{Dyadic compatibility} = 1 - \left| \text{Resource}_{(i,t-1)} - \text{Resource}_{(j,t-1)} \right|, \quad (1)$$

$$\text{Average compatibility} = \frac{\sum \text{Dyadic compatibility}}{\text{Number of alliance}_{i,t}}, \quad (2)$$

where Resource (i, t-1) is the focal firm i's organizational attribute and Resource (j, t-1) is a partner j's organizational attribute at year t-1.

Complementarity of technology. The scope of a firm's technology was used to determine the complementarity of technology (Park et al., 2002). The categories of semiconductor products in the Datamonitor database comprise eight distinctive technological areas: application-specific integrated circuit memory, analog, microcomponent, telecommunication, discrete component, digital signal processing, gallium arsenide, and optoelectronics. These areas differ in technical concepts, product designs, and manufacturing systems. The complementarity of these technologies in a semiconductor firm's alliance portfolio enables the firm to leverage technological synergy with other partner firms by meeting the firm's need for different technological resources to produce each product type (Stuart, 2000). Complementarity of technologies was measured as the sum of the count of the complement of the technologies divided by the union of the technologies the firms and partners have (Mitsubishi & Greve, 2009). Thus, if firm i has three technologies, including two technologies which firm j also has, and firm j has four technologies, including two technologies which firm i also has, then the union of their technologies is $3 + 4 - 2 = 5$ technologies. The complement technologies are $3 - 2 + 4 - 2 = 3$. Complementarity would then be $3 / 5 = 0.6$. The dyadic complementarity was aggregated by calculating the average complementarity score in an alliance portfolio.

Control variables. The study included a number of control variables that may affect a firm's performance in building its alliance portfolio. Control variables at the focal firm level were firm age and firm size, measured as the natural logarithm of the number of employees. To control for prior alliance activities that might affect current alliances (Ahuja, 2000a; Baum et al., 2000; Stuart et al., 1999), a focal firm's prior partnership with partners involved in the firm's alliance was counted (0 = no prior alliance, 1 = otherwise). The alliance experience was calculated by taking the number of prior alliances in the past 10 years. The proportion of joint ventures in the alliance portfolio was used to control for governance structure. Equity joint ventures are assumed to be effective

governance mechanisms for interfirm learning and knowledge transfer, reducing transaction costs (Kogut, 1988), and the proportion of joint ventures was computed out of the total number of alliances in firm *i*'s alliance portfolio. Internationalization of the alliance portfolio was controlled by the percentage of foreign partners in a firm *i*'s set of alliances in year *t*. Geographical and cultural distances are assumed to have both negative and positive effects on firm performance in that they make an alliance portfolio more difficult to manage but also provide efficiency of production cost. The study also controlled for portfolio size, as having more alliance partners can provide a firm with access to more diverse resources and knowledge, enhancing firm outcomes. Portfolio size was computed using the natural log of the number of alliance partners for firm *i* in year *t*. Market uncertainty was controlled for using the mean monthly stock price volatility of all sampled firms in year *t*-1 (Beckman, Haunschild, & Phillips, 2004), which is calculated as the mean monthly price coefficient of variation for all firms in the S&P 500 index for the representative year. If a firm's stock price varies widely relative to its average, the firm is experiencing high uncertainty. In this study, uncertainty was measured in year *t*-1 and alliances were examined in year *t*. Finally, market share was controlled for by capturing the extent to which firms control the share of their respective integrated circuit markets. A firm's high market share is likely to be associated with its economic performance. Table 1 summarizes the variables and measurement.

Table 1. Variables and measurement

Variables	Hypotheses	Measurement
Dependent variable		
Firm's economic performance		ROA
Main effects		
Compatibility of capital resources	H1a+	Capital intensity
Compatibility of R&D resources	H1b+	R&D intensity
Compatibility of strategy	H2+	Founding year
Compatibility of status	H3+	Bonacich's power and centrality
Complementarity of technology	H4+	Count of complement technologies
Control variables		
Firm age		Number of years since establishment
Firm size		Logarithm of the number of employees
Prior partnership		Dummy variable for prior alliance with partners
Alliance experience		Number of prior alliances in the past 10 years
Joint venture		Proportion of joint venture out of the total alliances
Internationalization		Percentage of foreign partners
Portfolio size		Logarithm of the number of partners
Market uncertainty		Mean of monthly stock prices of all sampled firms
Market share		Market share of integrated circuit market

Table 2. Descriptive statistics and correlation

Variables	Mean	s.d.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1. ROA	0.0	0.1	-0.6	0.4															
2. Firm age	28.7	27.5	0	131	0.02														
3. Log firm size	8.6	2.2	2.3	12.8	0.10	0.65													
4. Prior partnership	2.4	1.8	1	12	0.11	-0.13	0.07												
5. Alliance experience	91.3	138.1	1	994	0.18	0.32	0.36	0.14											
6. Joint venture	0.2	0.4	0	1	-0.05	0.04	0.05	0.08	0.03										
7. Internationalization	0.7	0.2	0.2	1.3	-0.19	0.02	0.01	0.01	-0.02	-0.05									
8. Portfolio size	4.6	2.2	1	11	0.24	-0.01	0.16	0.29	0.39	0.00	-0.09								
9. Market uncertainty	0.3	0.3	0	3.2	-0.17	-0.04	-0.07	0.03	-0.10	0.00	0.11	-0.09							
10. Market share	0.0	0.0	0	0.3	0.09	-0.04	-0.06	0.29	0.01	-0.03	0.00	-0.02	0.00						
10. Compatibility of physical resources	0.1	0.1	0	0.9	0.02	0.02	0.06	-0.09	-0.01	-0.10	0.03	-0.11	-0.07	0.12					
11. Compatibility of R&D resources	0.6	0.3	0	1	0.21	-0.02	0.02	-0.02	0.03	-0.09	-0.07	0.06	-0.10	0.03	-0.01				
13. Compatibility of strategy	0.6	0.2	0	1	0.12	0.04	-0.01	-0.01	-0.08	-0.02	-0.02	0.02	0.02	0.02	0.08	0.05			
13. Compatibility of status	0.7	0.2	0	1	0.07	-0.01	-0.14	-0.25	-0.21	-0.02	-0.07	-0.09	-0.02	-0.10	0.03	0.13	0.09		
15. Compatibility of technology	0.7	0.4	0	3.8	0.16	-0.06	-0.06	0.12	0.03	0.08	-0.07	0.18	-0.02	-0.02	0.02	0.04	-0.06	-0.05	

All correlations greater than +/- 0.1 are significant at p<0.05.

ANALYSIS AND RESULTS

Hypotheses were tested using ordinary least squares (OLS) multivariate regression models, and the standard errors of regression coefficients were adjusted using the robust estimates of standard errors clustered by firm. Table 2 presents descriptive statistics and correlations of the variables used in the regression analysis. The overall level of multicollinearity is low, as is evident from the maximum variance inflation factor in the final model of 1.28, which is well below the threshold of 10. Heckman's two-step procedure (1979) was used to correct for possible sample selection bias: if a firm's decision to enter an alliance is endogenous and correlated with the residuals of economic performance, estimates for economic performance might suffer from sample selection bias. As in previous work on sample selection (Bae & Gargiulo, 2004), studies on aspiration theory were followed to specify the selection equation. According to aspiration theory (Baum, Rowley, Shipilov, & Chuang, 2005; Greve, 2003), organizations are motivated to improve future performance by identifying problems and searching for solutions. To promote performance, a firm first decides on clear performance goals (e.g., sales goal or ROA) and sets an ambitious aspiration level based on historical performance and/or comparable others' performance. This assertion suggests that firms are more likely to enter alliances to access resources when their performance is below their social aspiration level (Baum et al., 2005; Bae & Gargiulo, 2004). Bae and Gargiulo (2004) specify two assumptions in addressing the sample selection bias. First, a firm whose performance is below its aspiration level is more likely to enter an alliance. Second, firms with small market shares are more likely to enter alliances. In this study, aspiration level was measured as an increasing function of the difference between a firm's ROA and the global industry-average performance in a given year. To test for the effect on performance above and below a firm's social aspiration level, performance was specified as the spline function (Greene, 2003). The results of the Heckman procedure were consistent with the reported findings, and this information was used to examine the effects of entering an alliance on the firm's economic performance. Table 3 shows logit estimates for a firm's decision to enter an alliance. In the selection equation, the dichotomous dependent variable was set to 1 if a firm entered an alliance during the 10-year observation period. The estimates provide negative and positive differences for the aspiration level, corresponding to levels above and below the level of performance aspiration. The results show that firms whose performance is low compared to others are more likely to enter alliances to access resources that may help them improve their performance. In addition, firms with small market shares are more likely to enter alliances, suggesting that firms may have an incentive to expand their market share through alliances.

Table 3. Logit estimates for a firm's entering an alliance

Variables	Probability of entering an alliance	
Constant	-0.356*	(0.094)
ROA relative to social aspiration, high performance	-0.455***	(0.036)
ROA relative to social aspiration, low performance	0.170***	(0.020)
Firm's market share	-4.545*	(2.316)
- log likelihood	886.27135	
χ^2 (3 df)	440.02***	

Note: † $p < 0.1$; * $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$. Standard errors are in parentheses

Table 4 shows the results of OLS regression analyses. Model 1 represents the base model, which includes control variables only, while Model 2 adds all the main effects for testing the impact of compatibility and complementarity of resources on a firm's economic performance. Models 1 and 2 show that alliance experience is positively related to firm's economic performance ($p < 0.1$). This finding is consistent with the interfirm network perspective (Gulati, 1995), wherein alliance experience enhances the collaborative capability of a firm, which facilitates interfirm knowledge transfer or acquisition. The firm's economic performance declines with increases in environmental volatility in the alliance portfolio, as indicated by the market uncertainty effect ($p < 0.05$). This finding shows the influence of uncertainty as a constraint in alliance activities (Carson, Madhok, & Wu, 2006), wherein volatile market conditions may decrease the interfirm trust and norms of reciprocity that may impede the coordination between the firm and its partners. Additionally, the firm's performance is positively related to portfolio size ($p < 0.1$), which captures the number of alliance partners. This finding is consistent with previous studies, showing that the size of the portfolio positively affects firm performance (Ahuja, 2000b; Baum et al., 2000). Prior partnership control shows no significant effect. Recent network studies, however, suggest the possibility that the performance effect by repeated ties depends on firm-specific factors (Shipilov, 2006; Zaheer & Bell, 2005). Participation in a joint venture is not significantly related to a firm's economic performance. This finding may be ascribed to the general intent to build multiple partnerships that effectively exploit knowledge and information across the value chain (Ahuja, 2000b; Baum et al., 2000; Stuart, 2000). Portfolio internationalization shows no significant effect on performance, a result that may be attributed to cultural conflict and communication problems that may diminish the effect of interfirm collaboration and learning. Finally, market share is not significantly related to a firm's economic performance. According to several alliance studies, a firm's strong bargaining position may decrease for an alliance period as a partner attempts to increase its organizational and resource commitment (Isobe, Makino, & Montgomery, 2000; Kwon, 2008).

Model 2 shows the direct effects of main variables. Hypothesis 1a predicts that a firm will be more likely to improve its economic performance as the compatible physical resource increases, and Hypothesis 1b predicts a positive relationship between a firm's economic performance and compatible R&D resources. Model 2 shows that the effect of compatible physical resources on firm performance is positive but not significant for ROA. The positive coefficient for compatible R&D resources in Model 2 presents support for Hypothesis 1b (ROA: $\beta = 0.070$, $p < 0.1$), suggesting that a firm is more likely to improve its economic performance as the compatible R&D resource increases in its alliance portfolio. According to Hypothesis 2, compatible strategy between a firm and its partners should have a positive effect on a firm's economic performance. The results of Model 2 show support for Hypothesis 2. More specifically, compatibility of strategy is significant and positively related to ROA ($\beta = 0.065$, $p < 0.01$). Hypothesis 3 proposes that compatibility of status is positively related to a firm's economic performance. Model 2 also shows support for Hypothesis 3, as compatibility of status is significant and positively related to ROA ($\beta = 0.060$, $p < 0.1$). These results suggest that a firm is more likely to improve its economic performance as it builds alliances with partners of similar strategic direction and social status in its alliance portfolio. Finally, Hypothesis 4 predicts that complementarity of technology has a positive relationship with a firm's economic performance in its alliance portfolio. The results of Model 2 show that complementary technology is significant and positively related to ROA ($\beta = 0.046$, $p < 0.05$). The results provide support for this hypothesis, suggesting that increased technological compatibility is more likely to improve the firm's economic performance.

Table 4. Regression results

Variables	ROA	
	Model 1	Model 2
Constant	0.034 (0.043)	-0.135* (0.056)
Firm age	0.000 (0.000)	0.000 (0.000)
Log firm size	0.004 (0.005)	0.006 (0.005)
Prior partnership	0.001 (0.004)	0.002 (0.004)
Alliance experience	0.000 (0.000)	0.000† (0.000)
Joint venture	-0.022 (0.017)	-0.019 (0.016)
Portfolio internationalization	-0.093 (0.057)	-0.080 (0.053)
Portfolio size	0.010† (0.005)	0.008 (0.005)
Market uncertainty	-0.060* (0.028)	-0.053* (0.026)
Market share	0.304 (0.263)	0.308 (0.250)
Compatibility of physical resources		0.000 (0.047)
Compatibility of R&D resources		0.070† (0.036)
Compatibility of strategy		0.065** (0.024)
Compatibility of status		0.060† (0.030)
Complementarity of technology		0.046* (0.018)
Model F	2.843	7.036
R2	0.128	0.192
N	386	386

Note: † $p < 0.1$; * $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$. Robust standard errors adjusted for 115 firm. Clusters are in parentheses.

DISCUSSION AND CONCLUSION

Despite growing interest in a firm's multiple alliances, the link between network resources in an alliance portfolio and the firm's performance remains poorly understood and subject to continuing debate (e.g., Baum et al., 2000; Lavie, 2007; Stuart, 2000). Even though researchers have reached a consensus about the benefits that firms can obtain from partners' key endowments in the alliance portfolio, an important question is still unanswered: what resource conditions of a firm and its partners might have performance implications for a firm's alliance portfolio? Since a firm's purpose in forming an alliance portfolio is to leverage different resources and capabilities of heterogeneous partners, the basic focus of the portfolio composition may be the matching of the condition of resources between them.

Thus, by addressing the question of how the resource conditions of a firm and its partners influence the focal firm's economic performance in its alliance portfolio, this paper investigates the impact of network resources on firm performance. Specifically, it examines the compatibility of physical and R&D resources, strategy, and status as well as the complementarity of technologies used in prior research as influential firm resources and attributes. The hypotheses

are tested with a sample of the global semiconductor firms during the period 1997-2007 by using OLS multivariate regression models. This study's results show that resource conditions between the firm and its partners influence the economic performance of semiconductor firms. Compatibility of R&D resources, strategy, and status between the firm and its partners affects the focal firm's economic performance, and increasing the complementarity of technologies between them influences the firm's economic performance. These findings show that resource fit between a focal firm and its partners is a key factor not only in facilitating the formation of alliances (Chung et al., 2000; Mitsunashi & Greve, 2009; Rothaermel & Boeker, 2008), but also in contributing to firm performance.

IMPLICATIONS FOR THEORY AND RESEARCH

This investigation contributes to the alliance portfolio literature examining the effect of partner attributes on firm performance, in particular by providing insights into resource conditions that influence a firm's economic performance in its alliance portfolio. This study tested mutual resource conditions of a firm and its partners to capture the performance effect. This approach is the first to theorize and test the link between a firm's and its partners' resources to understand the performance effect of resources in an alliance portfolio.

Previous studies have stressed the effect of portfolio resources derived from partners' resource endowment (Baum et al., 2000; Stuart et al., 1999; Stuart, 2000). Because firms can draw on synergies by pooling or leveraging the resource endowment of partners, portfolio composition with different resource-rich partners is assumed to have positive implications for the focal firm's performance. However, this body of research tends to overlook the effect of a resource match between a firm and its partners. It does not explain the effect of a firm's own resources in contributing to its economic performance in alliances. The findings in this study show that the compatibility of network resources between a firm and its partners contributes to the firm's performance improvement. That is, a firm can maximize its performance improvement when two or more firms are useful to each other in leveraging resources. Therefore, a firm can reasonably focus on resource conditions between itself and its partners rather than on the absolute amount of network resources that partners hold.

Ultimately, this paper proposes that alliance portfolio research should examine not just the resource endowment of partners but also a focal firm's resource conditions that correspond to such endowment. Such consideration for resource conditions of both the firm and its partners results in a more comprehensive understanding of the performance effect of the alliance portfolio and also allows redirection of alliance portfolio research toward examining the focal firm's own resource conditions contributing to firm performance beyond the partner endowment.

The findings complement recent studies on interfirm cooperation that recognize and explain the performance effect of an alliance that could be contingent upon resource fit between a firm and its partner, such as market complementarity and resource compatibility (Mitsunashi & Greve, 2009), as well as complementarity of technology (Rothaermel & Boeker, 2008). These investigations show that the benefits of the compatibility and complementarity of resource characteristics are mutually supplementary in an alliance. The findings of this study reinforce and complement the argument of those earlier studies by showing that both compatibility and complementarity affect a firm's economic performance in its alliance portfolio.

The results of this study also confirm and extend recent alliance portfolio studies by differentiating resource types and conditions. Stuart (2000) shows that partners' revenue and technologies increase a focal firm's sales growth. Lavie (2007) finds that partner resources, such as marketing resources, financial

resources, and human resources, could improve a firm's market performance. The current findings demonstrate that a firm's economic performance is also contingent on several other assets, such as capital resources, R&D resources, strategy, status, and technological resources. In particular, as discussed earlier, whether a firm improves its economic performance through alliances is determined by the resource conditions between the firm and its partners. That is, performance improvement may depend on what you have.

The findings of this study are in line with previous studies showing that success in leveraging multiple partnerships is a function of firm-specific characteristics (Shipilov, 2009; Srivastava & Gnyawali, 2011; Vasudeva & Anand, 2011; Zaheer & Bell, 2005). For example, the performance effect of diverse network resources could be contingent on a firm's specific attributes, such as absorptive capacity, multimarket experience, status accumulation, and network position (Lavie, 2006; Shipilov, 2006), reflecting the benefits of idiosyncratic organizational resources, knowledge stocks, and organizational routine (Cohen & Levinthal, 1990). The findings also showed that a firm can improve economic performance by leveraging its strategy and status as firm-specific characteristics.

IMPLICATIONS FOR MANAGERS

The results of this investigation hold two implications for managers. First, recent studies suggest that a firm can improve its performance by leveraging its partners' technologically and commercially prominent resources. The findings of this study show that managers seeking to establish multiple alliances should be on the alert for resources that increase synergy with resources of their alliance partners, because resource fit between a firm and its partners may yield a unique combination that is valuable for building the competencies needed to succeed in market competition. Given that resource fit plays a critical role in alliance formation and performance assessment, a firm will fail to exploit its alliances effectively if its alliances depend on the prominent resources of partners. Thus, managers should pay attention not just to partners' absolute or superior resource conditions but also to whether their firm's resource conditions are compatible with and complementary to partners' resources.

Second, the results suggest that firm-specific resources and characteristics may contribute to economic performance in alliances. To maximize the economic performance effects of potential alliances, managers need to increase the breadth of their firm's resources and characteristics by developing new resources, skills, and technologies and by building status (Podolny, 1993), reputation (Stuart, 1998), and managerial experience (Dussauge et al., 2000). Improved firm-specific resources and characteristics allow the firm to form partnerships with more value-adding partners that may provide better resource conditions and may increase the potential for synergy.

LIMITATIONS AND FUTURE RESEARCH

This study exhibits a number of limitations that offer opportunities for future research. First, although this investigation explicitly theorizes about the impact that the compatibility and complementarity of the resources of a firm and partners may have on a firm's performance, the data set does not allow for the direct measurement of different facets of resources. Furthermore, the findings impose no specialization on each of the technologies measured in the complementarity of technology. Qualitative or survey research designs are better equipped to unravel the complexities associated with resource exchange, a distinction among adopted technologies, and fit in an alliance portfolio.

Second, to demonstrate the utility of conceptualizing resource conditions in multiple alliances, this paper considers only four types of network resources. However, a firm's competitive resources could include other firm-specific attributes, such as multimarket contact and scope of experience (Shipilov, 2009). Additional studies examining the relationship between firm resources and performance might incorporate other dimensions of network resources into theoretical and empirical models. For example, larger partner firms might have more power vis-à-vis a firm, and greater power of partners may impose unfavorable conditions of cooperation on the firm (Pfeffer & Salancik, 2003). By exploiting internal firm attributes or portfolio-level characteristics, a focal firm may limit the bargaining power of its stronger partners, appropriating more performance benefits from its alliance portfolio.

Third, this study's empirical analysis focuses on alliances within the semiconductor industry. Semiconductor firms often build alliances with partners in other industries, such as software and telecommunication. Although assessing resource complementarity and compatibility between industries may be more difficult than doing so within an industry, a valuable area of inquiry would be the impact of resource conditions between a firm and its partners when partners in different sectors are considered in a focal firm's alliance portfolio.

A final limitation concerns the level of analysis in measuring performance. While the performance analysis relied on firm-level analysis, the performance implications for alliance portfolios should also be understood by multilevel analysis. In fact, in line with the results showing low explanatory power for performance variation, comprehension of the relationship between the alliance portfolio and performance may be greater with finer-grained methods measuring intrafirm-level, portfolio-level, and industry factors. Future research may provide further contributions by addressing these issues. Another potential direction would be to investigate additional performance outcomes. Is market performance or technology innovation also likely to be influenced by the resource conditions between a focal firm and its partners? This question would be an interesting focus for future research. Finally, future studies might carefully identify and measure the moderating effects of environmental aspects, such as institutional, technological, and competitive factors, in various industry contexts.

In summary, this study breaks new ground in the alliance portfolio literature by highlighting a focal firm's resource conditions relative to its partners' resource endowment. It suggests that compatibility of network resources and complementarity of technology are key drivers for the improvement of firm performance by leveraging the effectiveness of an alliance portfolio. The empirical results here highlight the importance of resource conditions of both the focal firm and its partners. This study contributes to the understanding of the impact of resources in an alliance portfolio by addressing how the resource conditions of the focal firm and its partners determine the firm's economic performance.

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