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The Performance Consequences of Ambidexterity in Strategic Alliance Formations: Empirical Investigation and Computational Theorizing

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Although alliance studies have generally favored an ambidextrous approach between exploration and exploitation, they tend to overlook a firm's characteristics, its industry constraints, or the dynamic network in which the firm is embedded. This study examines the ambidexterity hypothesis and its boundary conditions with a unique research method. We not only analyze empirical data from five U.S. industries spanning eight years, but also expand theoretical insights to the network level by building a computer simulation model. Both our empirical and simulation results reveal the contingencies of the ambidexterity hypothesis in alliance formation. Our findings show that although an ambidextrous formation of alliances benefits large firms, a focused formation of either exploratory or exploitative alliances benefits small firms. In an uncertain environment an ambidextrous formation enhances firm performance but so does a focused formation in a stable environment. Finally, the simulation model demonstrates that a firm's centrality and structural hole positions in network relations can moderate the relationships between alliance formation choices and firm performance, and that the ambidexterity hypothesis may be limited to the earlier stage of the network. Our study provides critical evidence into the viability of adopting a dynamic network perspective in understanding the ambidexterity hypothesis and advancing strategic alliance research beyond static and dyadic levels.

Key words: alliance formation; ambidexterity hypothesis; social networks; empirical analysis; computer simulation
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Firms are constantly faced with the challenges of two concomitant choices: alignment and adaptation (Gibson and Birkinshaw 2004). Researchers suggest that alignment (exploitation) enables firms to engage in refinement, implementation, efficiency, and production, whereas adaptation (exploration) attaches importance to adaptive mechanisms that call for experimentation, variation, search, and innovation (Baum et al. 2000a, March 1991). Both conceptual generation and empirical testing have suggested an ambidexterity hypothesis where the pursuit of both exploration and exploitation will improve firm performance and survival (He and Wong 2004, Levinthal and March 1993, Tushman and O'Reilly 1996).

Given the prevalence of this ambidexterity hypothesis, however, less attention has been given to the investigation of its theoretic boundary. Will ambidexterity lead to good performance for all firms under various contexts, specifically strategic alliance formations? To date, this question still awaits systematic and rigorous examinations. We believe that there may be several theoretical and methodological challenges that limit our understanding of the ambidexterity hypothesis. The first challenge lies in the fact that firms are limited in their resources (Park et al. 2002). As a result, it remains to be seen whether a resource-constrained firm pursuing an ambidextrous approach will be "stuck in the middle" (Porter 1980). Second, firms are constrained by their organizational characteristics and the external environment. Whether such constraints will affect the performance of an ambidexterity has not been fully addressed in the literature. Third, firms are adaptive systems. It is still unclear whether the performance implications of an ambidextrous approach change over time. Last, because firms are interconnected (Granovetter 1985), the performance implication of one firm's ambidexterity approach may also be constrained by its network relations.

The purpose of this study is to examine the above challenges of the ambidexterity hypothesis and understand the boundary conditions under which such an ambidextrous approach will help to improve a firm's performance. Specifically, we look into firms' alliance formation behavior, which can be classified as a form of exploration and exploitation (Koza and Lewin 1998, Park et al. 2002, Rothaermel and Deeds 2004). On the one hand, alliances can be used to exploit complementary resources between alliance partners, reduce risks, and promote stability (Inkpen 2001); on the other hand, they can be used to access and acquire novel knowledge (Grant and Baden-Fuller 2004), explore new technologies and markets, and adapt to technological discontinuities (Hill and Rothaermel 2003). Therefore, an examination of firms' alliance formation decisions allows us to effectively investigate the ambidexterity hypothesis. The question remains: When will the ambidexterity approach in alliance formation improve parent firm performance?

We believe that strategic alliance formations, as firms' strategic choices, are subject to internal and external constraints (Eisenhardt and Zbaracki 1992) and have performance consequences. Strategic decisions in alliance formation involve a trade-off between exploitation and exploration in that firms need to decide how resources are allocated to the refinement of existing partner relationships, as compared to the development of new network relations to secure novel knowledge and resources. Although it is assumed ideal to be ambidextrous so as to reap the benefits of two opposing activities of exploitation and exploration, an indiscriminant adoption of the ambidexterity may be impractical and even detrimental to firm performance under certain contexts.

To enrich our understanding of the ambidexterity hypothesis and advance alliance research toward a dynamic network level, we rely on a unique methodology: the combination of empirical investigation and computational simulation. We believe such a methodology allows a much more rigorous theoretic exploration of our thesis. It is also necessary as it not only offers empirical validity to the study, but also allows critical theory building at the dynamic network level that goes beyond conventional conjectures.

Theoretical Background and Hypotheses

The Ambidexterity Hypothesis

The literature has long acknowledged the importance of an organization's ability to perform two different activities at the same time (Gibson and Birkinshaw 2004, He and Wong 2004). Since Koza and Lewin (1998) extended March's (1991) concepts into the strategic alliance literature, researchers have started to explore the balance between explorative and exploitative alliances in the form of the ambidexterity hypothesis. Specifically, entering an exploratory alliance entails a firm's desire to discover new opportunities, build new competencies, and adapt to environmental changes (Koza and Lewin 1998). Exploitative alliances, on the other hand, are built on a firm's aim to leverage existing capabilities and join existing competencies across organizational boundaries (Rothaermel and Deeds 2004).

The ambidexterity concept in alliance formation has been conceptualized in several ways. Lavie and Rosenkopf (2006) summarized the research in this area and generalized three dimensions of ambidexterity, namely function-based, structure-based, and attribute-based dimensions. Function-based dimension mainly looks at the content of alliance formation. Structure-based dimension looks at the positions of a firm's partners in a broader network. Network ties, as a potential source of learning, promote efficient skill transfer among firms or generate novel discoveries (Powell et al. 1996). Attribute-based dimension, however, refers to the intertemporal variance in the organizational attributes of a firm's partners.

In this study, we specifically focus on the structure-based ambidexterity in alliance formation for several reasons. First, the idea of expanding a firm's network boundary through new alliance partners versus consolidating its network through existing partners is well grounded in the paradigm of exploration and exploitation (e.g., Beckman et al. 2004). Second, the structure-based ambidexterity is closely related to firms' adaptation. Local search within existing partners ensures current viability, enabling firms to become experts in current domains, whereas organizational boundary spanning ensures future viability, bringing in new resources and knowledge beyond the current network (Rosenkopf and Nerkar 2001). Third, firms are not isolated from the external environment (Granovetter 1985). Structure-based ambidexterity goes beyond an atomistic view of firms and incorporates external social factors, which directly affect firm performance (Baum et al. 2000b, Uzzi 1996).

Organizational boundary spanning through new or existing alliance partners has rich theoretical implications. For example, several theoretical streams such as the resource-dependence theory, organizational-learning theory, evolutionary theory, and social-network perspective have emphasized the importance of forming new interfirm relations to offset resource dependence, introduce new knowledge, expand organizational boundaries, and adapt to the evolutionary process (Burt 2000, Doz 1996, Pfeffer and Salancik 1978). At the same time, it is also vital for firms to encourage close and repeated ties with existing partners to develop social capital, enhance efficiency, and maintain stability (Coleman 1988, Ghemawat and

Costa 1993, Podolny 1994). These two tendencies conflict with each other to the extent that they are competing for firms' limited resources. Firms often have to evaluate their internal constraints and external opportunities before deciding on an ambidextrous or focused approach in network building.

Accordingly, in this study we regard the focused view as either strengthening network ties with existing partners or expanding to new partners in the alliance network. Ambidexterity is referred to as the simultaneous and balanced presence of both existing and new partners in a firm's alliance network. It should be noted that although we control for a firm's cumulative number of alliance partners, we focus on how newly formed (i.e., formed in the year of the study) exploratory and exploitative alliances may directly impact parent firm performance while considering the roles of firm characteristics and the industry environment. Our approach allows us to view alliance formation as a firm's strategic choice and more directly identify the performance impact of a firm's alliance formation decisions.

Conceptual and empirical studies have predominantly suggested that organizations can benefit from ambidexterity in their alliance formation (e.g., He and Wong 2004, Koza and Lewin 1998). A study by Kogut and Zander (1993) demonstrates how firms may benefit from combining the current knowledge within a firm's existing network partners and newly acquired knowledge through boundary-spanning behaviors with new partners. O'Reilly and Tushman (2004) found in their study that more than 90% of the ambidextrous organizations achieved their goals. Ambidextrous organizations can effectively pursue incremental innovations, architectural innovations, and discontinuous innovations. Therefore, they are able to master evolutionary and revolutionary changes (Tushman and O'Reilly 1996). He and Wong (2004) made an empirical test of the ambidexterity approach in the context of technological innovation. Their study shows that the interaction between explorative and exploitative innovation strategies is positively related to the sales growth rate. We summarize such suggestions in the following hypothesis:

Hypothesis 1. *A firm with an ambidextrous formation of exploratory and exploitative alliances will tend to have better performance than one with a focused formation of either exploratory or exploitative alliances.*

Organizational, Environmental, and Network Context

Although the importance of understanding ambidexterity has been emphasized in various areas of the management research (Gibson and Birkinshaw 2004, O'Reilly and Tushman 2004), questions remain regarding how an ambidextrous organization can maintain a sustainable competitive advantage and how organizational and environmental context may moderate the effects of an ambidextrous approach on firm performance. Some studies have started to cast doubts on the performance benefits of ambidextrous organizations (e.g., Van Looy et al. 2005). We believe that the ambidexterity hypothesis faces several specific and serious challenges: limited resources in a firm, environmental impacts, and network constraints. Thus, we endeavor to investigate the roles of organizational and industry characteristics, as well as the network context, as they affect firm's resource flows and subsequent alliance decisions.

Organizational Characteristic. Large variations exist among firms and environments in terms of the resource abundance that constrains a firm's ability to form alliances and adapt to the external environment (Nelson and Winter 1982, Simon 1987). Strategic decisions therefore involve a trade-off between exploitation and exploration in that firms need to decide on the amount of resources allocated to the refinement of existing partner relationships, as compared to the development of new network relations to secure novel knowledge and resources. Firms' resource conditions not only affect their desire to create alliances, but also their opportunity and ability to do so (Park et al. 2002). For example, Lant et al. (1992) argued that firms must allocate more resources toward exploration in unstable environments than in more stable ones.

Firm size. Given that resources play a critical role, how the ambidexterity approach may benefit firm performance also depends on firm size, a commonly adopted proxy for firm resources in the organization literature. Although firm-level physical resources can be conceptualized in many ways such as slack resources (Tan and Peng 2003) and specific resources in certain functional areas (Park et al. 2002), previous literature suggests that firm size provides a parsimonious index to reflect the extent of a firm's overall resource constraints. For example, researchers in the area of population ecology have consistently argued that large organizational size enhances the capacity to withstand environmental shocks, whereas the margins for error are small for small organizations because they cannot easily adapt to temporary setbacks (Hannan et al. 2003, Hannan and Freeman 1977). Other organizational researchers also suggested that the organization size is positively associated with absolute increases in the pool of resources available for organizational use (Beckman et al. 2004, Pfeffer and Salancik 1978). Large organizations thus are able to produce a degree of resource certainty that ensures continued viability and face weaker constraints on the activities that they can legitimately pursue (Hannan et al. 2003).

Benefits from ambidexterity in alliance formation will be amplified for large organizations if they can not only exploit established relations to generate cash flow but also explore new territories to overcome the problem of organizational inertia (Leonard-Barton 1992). Often, exploration and exploitation activities compete for scarce organizational resources (March 1991). Given their relatively loose resource constraints, large firms are able to allocate substantial amount of their resources to both exploration and exploitation without the threat to immediate survival. Conversely, resource constraints in small firms prevent them from seeking an ambidextrous alliance formation (Markino and Inkpen 2003) and also increase the possibility of being stuck in the middle. Small firms are also associated with younger age and lower status, which may further limit their flexibility in alliance formation (Stuart 2000). We thus argue that small firms will achieve better performance by explicitly pursuing one particular strategy in alliance formation, as such a focused approach will maximize the value of their limited resources. Therefore:

Hypothesis 2. *A large firm will tend to benefit more from an ambidextrous formation of exploratory and exploitative alliances, whereas a small firm will tend to benefit more from a focused formation of either exploratory or exploitative alliances.*

Environmental Uncertainty. Several scholars have noticed the importance of environmental uncertainty in firms' selection of exploration and exploitation. For example, Rowley et al. (2000) contended that environmental uncertainty increases the rate of innovation required to survive, and therefore such environments demand relatively high investments in exploration. However, other researchers found that a high level of environmental uncertainty leads to a threat rigidity (Straw et al. 1981), which motivates firms to give more weight to the exploitation of their existing resources and relations (Podolny 1994).

Although firms may have divergent tendencies toward either direction under high environmental uncertainty, the performance implications of such tendencies have seldom been addressed in the literature. We argue that environmental uncertainty moderates the relationship between firms' ambidextrous approach in alliance formation and economic performance. Specifically, we contend that firms will be better served if they take an ambidextrous approach in alliance formation under high environmental uncertainty, whereas a focused approach will be profitable under a stable environment.

As suggested by the two different findings above, a high rate of environmental uncertainty brings about two contrasting requirements on firms: flexibility and efficiency. In a highly uncertain environment, over reliance on existing interfirm relations for the purpose of efficiency and uncertainty reduction may block firms from analyzing emerging trends in the market, and the redundant information flow among existing partners will further suffocate innovation (Powell et al. 1996). The consequence of overexploitation in uncertain environments may result in competence trap (Levinthal and March 1993) and lead to core rigidities (Leonard-Barton 1992). At the same time, overexploration for the purpose of flexibility can result in chaotic organization, which makes it impossible to retain a sense of identity and continuity over time. This is especially important in a volatile environment. Overexpansion in the network boundary by forming new network ties creates unclear responsibilities, inadequate controls, and lack of direction and shared ideology (Volberda and Lewin 2003, p. 2127). An ambidextrous approach will thus strategically balance these two demands and generate better performance in an uncertain environment.

Conversely, a stable environment is characterized by a slower change in the competitive landscape, in which dominant product design and process technologies are usually clear (Hambrick et al. 1982). Adaptation pressures tend to be reduced in a stable environment so that firms can exclusively focus on the in-depth exploitation of existing relations. Increased trust and fine-grained information flow among existing partners will reduce the transaction costs and greatly improve economic efficiency, thus enabling an improved performance. Another effective strategy may be a new positioning in the interfirm network by breaking away from constraints in the existing network and seeking external resources from new partners. The potential side effects arising from this exploration will be minimized because of increased information processing capabilities and predictable prospect in a stable environment. Firms are thus able to gain an edge over rivals by explicitly taking one direction. Formally:

Hypothesis 3. *A firm with an ambidextrous formation of exploratory and exploitative alliances will tend to exhibit better performance in an uncertain environment, whereas a firm with a focus approach will tend to have better performance in a stable environment.*

Network Context. It is well acknowledged in both sociology and management literature that firms are not isolated from their external environment and that prior relations among firms, both direct and indirect, create a network in which firms are embedded (Granovetter 1985). The structure and quality of social ties among firms shape economic actions by creating both unique opportunities and access to those opportunities (Uzzi 1996). We build on this network-embeddedness perspective, positing that a firm's strategic choice of alliances can also be subject to network constraints. We focus on the effects of firm centrality and structural holes, which are the two key constructs in the network research (Ibarra 1993, Burt 1992). Centrality captures a firm's positional advantage and status within the network, whereas structural holes examine the advantages of being a broker for resource flows. We also control for network-level homogeneity to reflect the overall power distribution in network relations (Abrahamson and Rosenkopf 1997). In addition we examine network dynamics, as it will help us further understand the processes leading to firms' strategic choices of alliance formation and how the performance implications of ambidexterity approach changes over time.

Firm Centrality. Firms exhibit various network characteristics, the most important of which may be centrality (Ahuja et al. 2003, Freeman 1979). *Firm Centrality* is defined here as the extent to which a firm occupies a central position with strong ties to other network members (Wasserman and Faust 1994). Firms central in interorganizational networks are exposed to more sources of information than firms that are not. Central firms are argued to improve firm performance by adopting an ambidextrous approach in alliance formation. Firms' high centrality implies a high position in a status hierarchy (Ibarra 1993). Central firms thus have a high level of control over relevant resources and command a great potential for influence by creating asymmetric resource dependencies (Pfeffer and Salancik 1978). In other words, central firms can have a larger pool of relations, which they can exploit or explore to their advantages.

Indeed, some studies have suggested that central firms may benefit from exploiting existing relations in interfirm networks (e.g., Ibarra 1993). Central firms are in a favorable position to see a more complete picture of all the alternatives available in the network than the peripheral firms, and enjoy a broad array of benefits and opportunities unavailable to those in the periphery (Perry-Smith and Shalley 2003). However, central firms also have a tendency for over embeddedness in their existing network, which may incur the risks of learning myopia (Levinthal and March 1993). Extreme centrality through strengthening existing ties by a central firm may be associated with too much domain-relevant knowledge and experience, which hinders the exploration of new ideas (Perry-Smith and Shalley 2003). That may explain why some central firms may loose their advantageous positions after structure-loosing events (Madhavan et al. 1998). If central firms can reverse the tendency toward overembeddedness by engaging in exploration of new relationships along with exploitation of existing ones, they should be able to achieve better performance.

Peripheral firms, on the contrary, are left with limited alternatives to compete in the network. They are devoid of network resources and lack the flexibility to pursue both exploration and exploitation efficiently (Dyer and Singh 1998). To avoid spreading their limited resources too thin, those firms with a low degree of centrality will increase their performance by focusing on one strategy and maximizing the value of either exploration or exploitation. As a result, we expect to see the following hypothesis:

Hypothesis 4. *A firm with a high degree of centrality in the alliance network will tend to have better performance if it adopts an ambidextrous formation of exploratory and exploitative alliances, whereas a focused formation of alliances will tend to bring better performance to firms with a low degree of centrality.*

Structural Holes. Firms can also derive benefits in a network by arbitraging resource and information flows between two otherwise disconnected actors in the network (Burt 1992). Players who span the holes will be in a better position to overcome the local search for distant and unique knowledge (Rosenkopf and Almeida 2003), efficiently transfer knowledge, maneuver among disconnected clusters, and reap the information and control benefits over other actors (Burt 1992). We argue that firms with a high degree of such brokerage positions will improve performance by explicitly focusing on either expansion of the network ties or strengthening of the existing ties, whereas firms with a low degree of brokerage positions tend to perform better with an ambidextrous approach in alliance formation.

The advantages from spanning structural holes, although compelling, are of transitory nature, which motivates broker firms to either quickly exploit them or expand new ties to compensate for the loss. Burt (2002) in his investigation of bankers' social networks in a large organization found that bridge relations decay at an alarming rate. Nine out of ten bridges from a certain year will be gone the next year. Soda et al. (2004, p. 894) also found that the value of social capital as closure persists whereas that of structural holes decays over time. Structural holes only provide concurrent information and arbitrage value. It suggests that it will be in the best interest of broker firms to quickly transform their advantageous positions to economic benefits. For example, assume firm A sits between otherwise unconnected firms such as B and C through one type of alliance relationship. On one hand, A will be more likely to reap greater benefits by forming repeated yet different alliances with B and C separately, taking full advantages of information and control benefits in multiple areas. Otherwise, these benefits will disappear along with the decay of structural holes. On the other hand, if the benefits that firm A can reap from brokering between B and C are limited in a certain area, A is motivated to develop new ties so that it can fill in potential holes in the network. In this sense, a focused approach in either exploitation or exploration of network ties will help broker firms to increase performance.

Conversely, firms with few structural holes may be able to maximize their rents through an ambidextrous approach. First, they have to overcome their structural disadvantage in order to develop long-term competitive advantage. Building relationships with new alliance partners repositions firms in their networks and gradually confers them a competitive advantage (Perry-Smith and Shalley 2003). Second, they have to rely on existing relations to generate constant support and resources for network expansion. Further, it should be noted that firms with few structural holes may not necessarily be insufficient in resources, which are necessary for an ambidexterity approach. For example, a dense network may allow the existence of few structural hole opportunities, yet firms in a dense network can still enjoy affluent resource sharing among closely connected partners (Coleman 1988). Therefore:

Hypothesis 5. *A firm with a high degree of brokerage positions in the interfirm network will tend to have better performance if it adopts a focused formation of either exploratory or exploitative alliances*, *whereas an ambidextrous formation of alliances will tend to bring better performance for firms with few structural holes*.

Network Dynamics. Strategic alliance formation is a process of dynamic evolution (Dyer and Nobeoka 2000), through which interfirm relationships are strengthened or weakened and network characteristics evolve. Scholars have alerted us to the importance of understanding such dynamics. For example, Doz (1996) argued that without dynamic adaptation relationships in strategic alliances would build up too much inertia, leading to their eventual failure. Madhavan et al. (1998) also discussed the importance of reshaping interfirm relationships to maintain the viability of a firm's strategic networks.

We explore the role of network dynamics in the ambidexterity hypothesis. Given that alliance formation is a function of firms' past interactions (Gulati 1995a), we posit that the performance implications will change at different stages of network development (Doz 1996). Specifically, when the network is new and firms have little past experience to rely on, having a focused approach in alliance formation may be highly risky because firms may become locked into unproductive relationships or inefficient expansions (Gulati et al. 2000). In contrast, having an ambidextrous formation of alliances may help firms to avoid the danger of committing too much too early. In addition, newness often correlates with uncertainty. Similar to our arguments on environmental uncertainty, firms will be better off when they adopt an ambidextrous approach in a young network. Thus:

Hypothesis 6. *A firm with an ambidextrous formation of exploratory and exploitative alliances will tend to have better performance in early years of the network*, *whereas a firm with a focused formation of either exploratory or exploitative alliances will tend to have better performance in later years of the network*.

Research Methodology

In this study, we adopt a unique methodology: a combination of empirical investigation and computational theorizing. We start by examining the first three hypotheses using both the simulation model and the empirical data, which also serve as a cross-validation of the simulation model. Then we examine the role of network context and dynamics on strategic alliance formation using the simulation model, which can allow us to extend theoretical insights that cannot be gained based on the empirical data.

Such a combined method provides a unique approach toward the field of strategic alliances. It allows us to conduct cross-method validations as advocated by some scholars (Eisenhardt 1989), thereby enhancing the theoretical rigor of the empirical research and moving beyond the limitations of pure computer simulation. Such a cross-method validation also tests a "theory with degrees of freedom coming from the multiple implications of [the] theory. The process is a kind of pattern-matching" (Campbell 1975, p. 182), which, as further described by Yin (1994, p. 106), can be achieved by "compar[ing] an empirically based pattern with a predicted one (or with several alternative predictions)," therefore strengthening the validity of the theory. Specifically, we analyze such pattern matching based on multiregression results from both the empirical analysis and the computational model. We believe this combined approach, although still exploratory in nature, is not only necessary due to the lack of network information in the real-world data, but also important as it allows us to connect the scattered dots of strategic alliances and examine them in a true and dynamic network environment, moving beyond a static dyadic setting, which has also been called for by various scholars (e.g., Gulati et al. 2000).

Empirical Data

We randomly selected firms from five industries, representing both high-growth and stable environments. Specifically, data were collected from 1988 to 1995, covering 33 firms in the pharmaceutical, 25 firms in the computer, 25 firms in the food, 5 firms in the steel, and 7 firms in the paper industries. These firms were selected from Standard & Poor's Compustat (SPC) because complete financial data are needed to validate the performance index. Moody's FIS Online was used to complement SPC. Only firms that have all the needed financial data for the eight specified years

Table 1 Variables and Measurement

Variables	Empirical measurement	Simulation measurement
Firm Performance	Net sales over current asset in year t	Net resources generated and exchanged over initial resource output in year t
Alliance Ambidexterity	A categorical variable based on the exploration index: If the index is between 0.2 and 0.8, alliance ambidexterity = 1; if not, alliance ambidexterity = 0 Exploration index = (total # of *new* partners for all of a firm's alliances in year t)/(total # of *all* partners for a firm's alliances in year t)	A categorical variable based on the simulation experimental design. If an ambidextrous approach is used, alliance ambidexterity = 1; otherwise, alliance ambidexterity = 0
Total Alliance Partners	Total # of alliance partners (old and new) for a firm in year t	Total number of alliance partners (old and new) each firm has established by the end of year t
Environmental Uncertainty	The volatility of the net sales of all firms in a four-digit SIC industry. It is obtained through the standard error of the regression slope coefficient divided by the mean of sales, with the variable year regressed on the net industry sales variable. The basic equation is $Y_t = b_o + b_1 t + a_t$, where y = industry sales, t = year, and a = residual	Volatility of resource distribution at the network level, with one distributed around the rate of 0.003 and the other distributed around the rate of 0.04
Firm Size	Current asset in year $t - 1$ (in Billion$)	A firm's resource asset at year $t - 1$ (in 1,000 units)
Alliance Event Year	Observation year from 1988 to 1995, recoded as from year $t_o + 1$ to year $t_o + 8$. Unlike the simulation model, the year when alliance activities originated in an industry is unknown	Observation year t: from 1 to 30
Firm Centrality		Weighted degree centrality of the firm based on tie strength in year t
Firm Structural Holes		Number of structural holes filled by the firm in year t
Network Homogeneity		Level of even distribution of individual firm centralities in the network in year t
Network Size		Number of firms in the network in year t

were included in this study. Alliance data over the eight years were retrieved from the SDC Platinum database for each firm and validated through Lexis-Nexis and the Dow Jones News Retrieval Service. The SDC Platinum database provides archival information on alliances and merger and acquisition activities and is regarded as one of the most comprehensive databases of its kind (Anand and Khanna 2000). Our pilot data analysis revealed few cross-industry alliances among the 95 sampled firms, likely resulting from the fact that they are from five different industries. As a result, the empirical sample does not allow a network analysis.

Measures. Table 1 lists variable descriptions of *Firm Performance*, *Alliance Ambidexterity*, *Total Alliance Partners*, *Environmental Uncertainty*, and *Alliance Event Year.* We further describe some of them below.

We view alliance formation as a firm's external channels for resource exchange and accumulation (Gulati 1998). As a result, we use net sales over current assets to measure *Firm Performance* because they capture the amount of resources being produced and exchanged as well as the amount of total resources a firm has. Such measures have been adopted in other ambidexterity research (e.g., He and Wong 2004). It shows how efficiently a firm uses its assets to generate sales, reflects the current profitability, and is widely used in the accounting and finance literature (e.g., Ballesta et al. 1999).

To calculate *Alliance Ambidexterity*, we have focused on the identification of new and old partners, as suggested by March (1991) and similarly conducted by Beckman et al. (2004) and Lavie and Rosenkopf (2006). Specifically, through the SDC Platinum database, we identified the total number of alliances formed by a firm for each year, located all the partners from these alliances, and checked if each partner had prior relation (old partner) or no prior relation (new partner) with the firm. Our study intends to compare the performance implications of an ambidextrous versus a focused approach in alliance partner selection. Thus, we opted to dichotomize the alliance ambidexterity.[1] A value of 1 or 0 on the exploration index (see Table 1) would indicate that firm has only new or old alliance partners respectively in a given year. Therefore, a value between 0 and 1 would indicate a mixed number of new and old partners in a firm's alliance formation. Ideally, a perfect ambidexterity would require an absolute equal number of new partners and old partners, which would result in a value of 0.5 in the exploration index for a firm each year. In this study, we take a broader and more realistic view on the issue of ambidexterity and examine whether firms have mixed numbers of new and old partners. Specifically, firms

[1] We also experimented with a continuous measure of ambidexterity by calculating the reverted absolute value of deviations from 0.5. It produced consistent results as the categorical approach. To be comparable with the simulation model, only the categorical approach of ambidexterity is reported here.

with the exploration/exploitation index ranging from 0.2 to 0.8 were categorized as having an ambidextrous formation of alliances in that year, whereas those with the exploration/exploitation index less than 0.2 or greater than 0.8 were categorized as having a focused formation of alliances in either exploitation or exploration. We also tried the range between 0.3 and 0.7 as well as that between 0.4 and 0.6. All of them yielded similar results. We chose this range for two reasons: First, it allows us to have sufficient number of cases for statistical analyses; and second, it is a more robust measure than the ideal ambidexterity measure. Thus, it should provide a stricter test of the boundary conditions of the ambidexterity hypothesis.

Environmental Uncertainty refers to the volatility or difficult-to-predict discontinuities in a given industry (Dess and Beard 1984). Following Bergh and Lawless (1998), we measured *Environmental Uncertainty* as the volatility of net sales of all firms in a four-digit SIC industry (see Bergh and Lawless 1998, pp. 91–92). Data for four-digit industry sales were collected from U.S. Census Bureau: The Annual Survey of Manufacturers. Larger values of volatility indicate greater environmental uncertainty.

Firm Size has been conceptualized in various ways, with some emphasizing a firm's human resources such as number of employees and others emphasizing a firm's physical resources. Also, a firm's size can affect its market power and thus its ability to dominate partners in an alliance (Hitt et al. 2000). We measured *Firm Size* using a firm's physical resources (current assets lagged by one year) to facilitate the pattern comparison with simulation models. Given the increasingly boundaryless environment of today's business due to interfirm behaviors such as outsourcing, the relationship between a firm's legal number of employees and its output has become much less correlated. In addition, a correlation analysis of our empirical data reveals a value of 0.73 between our firm size measure and the number of firm employees. Current assets give us information about the available resources of each firm in our sample. Since firms in our sample have similar standards for reporting the cost basis of investments on their balance sheet, this measure is comparable across all the firms in our sample (Mitton 2002). This measure is also widely used in the current organizational research (e.g., Hand and Lev 2003).

Simulation Model

We believe computer simulation may be especially valuable to the study of alliance formation for two main reasons. First, strategic alliance formation is about adaptive strategic decision making (March 1991). Using simulations, we can model specific processes of exploration and exploitation. It allows us to examine the impact of alliance formation and specifically the role of ambidexterity in a well-controlled and dynamic setting (Burton et al. 2006). Second, strategic alliances have often been treated as isolated events involving two partners. As a result, the understanding of the network embeddedness is lacking (Gulati 1998). With the help of simulation, we can model firms in a complete network which enables us to examine alliance formation not just at the dyadic level, but also at the network level. Specifically, we focused on how network embeddedness, in the form of firm centrality, structural holes, and network dynamics provides additional theoretical insights beyond the empirical study.

Model Description. We extend the simulation work by March (1991) and model firms as adaptive agents existing in networks of alliance relations through which firms can exchange resources and learn from past interactions (Repenning 2002, Sorenson 2003). March's original simulation model is a simplistic one in which each cell has only three arbitrary values: −1, 0, 1. In contrast, our model extends his by allowing continuous measures of learning. Further, March's model is mainly concerned with the state of equilibrium and the speed to reach such a state as a result of exploration and exploitation with the assumption that such equilibrium is always desirable. On the contrary, our model is concerned with a more managerial issue—the performance consequences of such an equilibrium.

We focus on two major drivers for interfirm alliance formations. The first driver deals with the resource needs of firms, which create initial conditions and economic incentives for alliance formations (Doz 1996). Specifically, we model multiple firms within an industry network to have different resource needs (input resources) in order to generate different outputs (output resources). One firm's output resources can very well be another firm's input resources. The strength of the resource driver between two firms will be determined by how one firm's input resources will depend on the other's output resources through the calculations of their resource match. The second driver deals with adaptive interfirm relationships, which allows behavioral learning and searching in firms' alliance formation choices. We model multiple firms within a network to have learning capability and can adapt their alliance behavior based on prior interfirm experiences. The magnitude of this behavioral driver between two firms will be determined by the frequency of their prior successful alliance experiences or the strength of ties.

Similar to the empirical measure, we have focused on the identification of familiar/strong and new/weak relationships (March 1991, Beckman et al. 2004). Given the advantage of computational modeling, we can design experimental conditions under which there are pure exploratory, exploitative, or ambidextrous approaches for forming interfirm alliances. For pure exploratory alliance relationships, the simulation model lets each firm search for its next potential partner based on new or weak ties. For pure exploitative alliance relationships, the simulation model forces each firm to search alternatively for their next potential partners based on familiar or strong ties. For ambidextrous alliance relationships, the simulation model forces each firm to search for their next potential partner in an alternating fashion, one based on familiar/strong ties and the next based on new/weak ties.

Based on these two drivers in the model, whether a firm will form an alliance relationship with another firm in the network will depend on not only how the potential partner can meet its resources needs but also how their relationships in the past have worked, which also influences the strength of ties—one of the most important characteristics of network relations (Granovetter 1985, Gulati 1998). By focusing on such key aspects of alliance formation, we can examine the impact of the network context and achieve the balance between model realism and theoretical purpose (Burton and Obel 1995). An earlier version of the model was also reported in another study by one of the authors (Lin 2002). The simulation is written in the UNIX C programming language. Further technical details are in Appendix A (provided in the e-companion).[2]

Measures. Table 1 lists variable descriptions of *Firm Performance*, *Alliance Ambidexterity*, *Total Alliance Partners*, *Environmental Uncertainty*, *Firm Size*, *Alliance Event Year*, *Firm Centrality*, *Structural Holes*, *Network Homogeneity*, and *Network Size*. For *Firm Performance* we used a measure comparable to that for empirical data. To reduce conceptual overlap with *Firm Size*, which was measured as the total initial resources (including both input and output resources) by the firm in the previous year, we defined *Firm Performance* as the net resource exchanged and accumulated by the firm, which is the total resource exchanged and accumulated in that new year minus the initial output resources and divided by the initial output resources. We also double-checked the autocorrelation between last year's resources and current year's resources. The value is at 0.5, which is reasonable given that firms are engaging in adaptive behaviors that allow them to learn from past experiences (Axelrod 1997, Hoover and Perry 1989).

We have utilized the advantage of computer simulation to create settings for ambidextrous or focused alliance formations. Partners were located by having the computer check whether there were contacts and resource exchanges between the focal firm and any other firm in the network and under what setting (ambidextrous or focused) such relationships were established. We have also used a weighted degree centrality based on tie strength to capture *Firm Centrality* in the network (Wasserman and Faust 1994). To calculate a *Firm's Structural Holes*, we first identified a firm's alliance partners and then counted how often any two of its alliance partners are not directly connected. This allows us to measure the number of structural holes that have been filled by the firm (Burt 1992).

To calculate Network Homogeneity, we extended the formula for graph centrality recommended by Freeman (1979, p. 228):

$$H_D = 1 - \frac{\sum_{i=1}^{n}[C_D(p^*) - C_D(p_i)]}{\max \sum_{i=1}^{n}[C_D(p^*) - C_D(p_i)]}, \qquad (1)$$

where $C_D(p_i)$ is the individual point centrality of node i, and $C_D(p^*)$ is the maximum individual point centrality in a network. As a result, the network homogeneity H_D measures the relative degree of homogenous distributions of individual point centralities within the network.

With the advantage of computer simulation it also becomes possible to explore the effect of Network Dynamics, which corresponds to *Alliance Event Year*. This exploration is not possible empirically as the alliance data collected were merely snapshots of isolated historical events at the dyadic level.

Simulation Experiments. Using the control advantage of computer simulation, we set the number of nodes (i.e., network size) at 25 or 75 as specified in the algorithm and each firm in the industry network as facing an environmental volatility rate around 0.003 or 0.04 in each of the experiments. We then modeled the alliance formation dynamic following either an exploration, exploitation, or ambidextrous mechanism over a 30-"simulation-year" period. Outcomes from the simulation experiments were stored in an output file that contains each node's alliance behaviors and resource transactions, on which each firm's network characteristics and performance can be further calculated.

Results

Tables 2(a) and 2(b) present the means, standard deviations, and correlations for the variables in both empirical model and the simulation model.

Empirical Analyses

Table 3 depicts the empirical hierarchical regression models. To assess the potential threat of multicollinearity, we estimated the variance inflation factors of the models. The highest VIF factor is 4.1 and the average VIF is around 2. These numbers are well

[2] An electronic companion to this paper is available as part of the online version that can be found at http://mansci.journal.informs.org/.

Table 2(a) Descriptive Statistics and Correlation Matrices: Empirical Data

No.	Variables	Mean	Std. dev.	1	2	3	4	5
1	*Firm Performance*	2.37	1.29					
2	*Alliance Event Year*	5.18	2.07	0.09				
3	*Environment Uncertainty*	0.01	0.01	−0.25**	0.26**			
4	*Alliance Ambidexterity*	0.32	0.47	−0.24**	0.21**	0.22**		
5	*Total Alliance Partners*	7.52	15.07	−0.13*	0.11	0.05	0.47**	
6	*Firm Size*	2.03	2.33	−0.08	0.05	0.03	0.30**	0.47**

Note. $N = 282$. $^{*}p < 0.05$ (one tailed); $^{**}p < 0.01$ (one tailed).

Table 2(b) Descriptive Statistics and Correlation Matrices: Simulation Data

No.	Variables	Mean	Std. dev.	1	2	3	4	5	6	7	8	9
1	*Firm Performance*	1.91	1.11									
2	*Alliance Event Year*	15.50	8.66	0.10**								
3	*Environment Uncertainty*	0.02	0.02	0.19**	0.06**							
4	*Alliance Ambidexterity*	0.33	0.48	−0.37**	0.00	0.00						
5	*Total Alliance Partners*	5.12	1.11	−0.33**	−0.07**	−0.04**	0.03**					
6	*Firm Size*	1.55	1.51	0.50**	0.12**	0.23**	−0.42**	−0.43**				
7	*Firm Centrality*	1.23	0.28	−0.10**	0.23**	−0.03**	0.13**	0.06**	−0.19**			
8	*Structural Holes*	4.97	4.74	0.09**	−0.15**	−0.11**	−0.27**	0.20**	0.10**	−0.04**		
9	*Network Homogeneity*	0.27	0.14	−0.51**	0.11**	−0.13**	0.28**	0.34**	−0.64**	0.47**	−0.03**	
10	*Network Size*	62.50	21.65	−0.01	0.00	0.00	0.00	0.02**	0.00	−0.49**	−0.33**	−0.34**

Note. $N = 18{,}000$. $^{*}p < 0.05$ (one tailed); $^{**}p < 0.01$ (one tailed).

below the recommended ceiling of 10 (Kleinbaum et al. 1988). Because we have multiple observations for a firm over years, it may raise the concern of potential interdependence, which violates the assumption of OLS regression. To address this, we used an OLS model with Huber/White robust standard errors. Robust standard errors, combined with the clustering option, relaxed the assumption of interdependence within the cluster.

To test Hypothesis 1 on the overall effect of having an ambidextrous formation of alliances, we found that *Alliance Ambidexterity* is negatively significant in Model 3.1. This suggests that a simple pursuit of ambidexterity in alliance formation without considering other factors does not help firm performance.

Table 3 Performance Consequences of Alliance Formation: Empirical Results

Variables	Model 3.1	Model 3.2
Step 1. Main and Control Variables		
Alliance Event Year	0.17 (2.49)*	0.16 (2.44)*
Environmental Uncertainty	−0.27 (−3.20)**	−0.38 (−3.58)**
Alliance Ambidexterity	−0.20 (−3.06)**	−0.47 (−3.50)**
Total Alliance Partners	−0.05 (−0.95)	−0.05 (−0.98)
Firm Size	0.01 (0.09)	−0.08 (−0.65)
Step 2. Interactions		
Alliance Ambidexterity × *Environmental Uncertainty*		0.27 (2.70)**
Alliance Ambidexterity × *Firm Size*		0.15 (1.65)†
N	252	252
Adjusted R^2	0.14	0.17

Note. t-statistics are in parentheses. $^{\dagger}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$.

Therefore, Hypothesis 1 is not supported. This is not surprising as it confirms the validity of our initial intention to examine the boundary conditions of the ambidexterity hypothesis.

To test Hypothesis 2 on the role of firm size in the ambidexterity hypothesis, we found a marginally significant effect for the interaction between *Alliance Ambidexterity* and *Firm Size* in Model 3.2. This indicates that having an ambidextrous formation of alliances will help large firms, but having a more exclusive formation of either exploratory or exploitative alliances will help small firms, supporting Hypothesis 2.

Regarding the role of environmental uncertainty in the ambidexterity hypothesis, we found that the interaction between *Alliance Ambidexterity* and *Environmental Uncertainty* is positively significant at $p < 0.01$ level in Model 3.2. This suggests that having an ambidextrous formation of alliances will help firm performance in an uncertain environment but not in a stable environment. Hypothesis 3 is supported.

Computational Extensions

Although the empirical results serve as a partial baseline against which the validity of the simulation model can be compared, the limitations of the empirical data have made it impossible to conduct analyses at the network level in a true dynamic fashion. For the simulation results, our emphasis was not on the significance and magnitude of the coefficients but on the patterns that can be derived as theoretical insights for future empirical testing. To ensure internal validity and reliability of the simulation model, we have

Table 4 Performance Consequences of Alliance Formation: Computational Theorizing

Variables	Model 4.1	Model 4.2	Model 4.3	Model 4.4	Model 4.5 (Alliance Event Year ≤ 9)
Step 1. Main and control variables					
Alliance Event Year	0.04 (5.90)***	0.03 (4.06)***	0.06 (7.63)***	0.06 (6.50)***	0.06 (5.13)***
Environmental Uncertainty	0.07 (8.31)***	−0.01 (−0.48)	0.03 (2.80)*	0.03 (2.79)***	−0.03 (−2.24)***
Alliance Ambidexterity	−0.17 (−49.31)***	−0.45 (−17.05)***	−0.63 (−22.78)***	−0.63 (−22.84)***	−0.65 (−9.54)***
Total Alliance Partners	−0.12 (−19.47)***	−0.11 (−16.32)***	−0.09 (−14.45)***	−0.09 (−14.39)***	−0.08 (−8.82)***
Firm Size	0.47 (44.06)***	0.49 (42.42)***	0.30 (22.51)***	0.30 (22.51)***	0.52 (27.19)***
Step 2. Interactions					
Alliance Ambidexterity × Environmental Uncertainty		0.10 (13.59)***	0.07 (9.12)***	0.08 (9.26)***	0.08 (8.01)***
Alliance Ambidexterity × Firm Size		0.23 (6.83)***	0.15 (5.21)***	0.14 (5.13)***	0.22 (6.16)***
Step 3. Network Variables					
Firm Centrality			0.05 (2.55)*	0.05 (2.56)*	0.04 (1.42)
Structural Holes			0.04 (4.46)***	0.04 (4.30)***	0.04 (3.82)***
Network Homogeneity			−0.30 (−34.46)***	−0.30 (−34.11)***	−0.14 (−10.27)***
Network Size			−0.05 (−5.79)***	−0.05 (−5.81)***	−0.004 (−0.41)
Alliance Ambidexterity × Firm Centrality			0.31 (8.58)***	0.30 (7.96)***	0.34 (4.50)***
Alliance Ambidexterity × Structural Holes			−0.03 (−4.52)***	−0.02 (−4.12)***	−0.01 (−0.96)
Step 4. Network Dynamics					
Alliance Ambidexterity × Alliance Event Year				0.02 (1.97)*	−0.07 (−6.08)***
N	17,999	17,999	17,999	17,999	5,399
Adjusted R^2	0.40	0.41	0.45	0.45	0.50

Note. t-statistics are in parentheses. $^{\dagger}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

grounded the model in literature related to organizational learning, strategic alliances, and social networks (Carley and Prietula 1994, March 1991) and conducted some systematic sensitivity analyses (Hoover and Perry 1989, Taber and Timpone 1996).[3]

Table 4 depicts the hierarchical regression models based on the simulation results. Models 4.1 and 4.2 have revealed a very similar pattern to Models 3.1 and 3.2 in Table 3. As a result, Hypothesis 1 is again not supported, but Hypotheses 2 and 3 are supported. Figure EC.2 and Figure EC.3 in Appendix C also provide some visual plots of the interaction effects.[4] The results have provided a partial validity test for the computer simulation model and laid the foundation for extending theoretical insights at the network level.

To explore Hypothesis 4 regarding the role of firm centrality in the ambidexterity hypothesis, Model 4.3 shows a significantly positive relationship for the interaction between *Alliance Ambidexterity* and *Firm Centrality*. This suggests that firms with a high degree of centrality may be better off with an ambidextrous formation of alliance partners (see also Figure EC.4 in Appendix C). It thus lends support to Hypothesis 4.

To examine the role of structural holes in the ambidexterity hypothesis, the simulation model yields a significantly negative coefficient for the interaction between *Alliance Ambidexterity* and *Structural Holes* (see also Figure EC.5 in Appendix C). This suggests that a firm with more structural holes may be better off with a more focused formation of alliance partners, thus supporting Hypothesis 5.

Exploring the role of network dynamics, Model 4.4 shows a positively significant interaction between *Alliance Ambidexterity* and *Alliance Event Year*. However, after we further probed into the dynamics and reexamined the model for alliance event year less and equal than 9, Model 4.5 presents a different pattern than Model 4.4. It suggests that network dynamics do affect the performance implication of ambidextrous approach in alliance formation. When a network is young, firms will be better served by adopting an ambidextrous approach (see also Figure EC.6 in Appendix C), thus lending support to Hypothesis 6. Of course, we need to keep in mind that this is still a very general finding and that more in-depth examinations will be needed in future research.

Discussion

In this study, we view alliance formations as firms' strategic choices and examine the ambidexterity hypothesis using both empirical data and a simulation model. Our study, as a first and exploratory attempt

[3] We have applied sensitivity analyses on experimental parameters (e.g., *RI*, *RO*, *MI*, *MO*) to examine how their small variations may alter the main, aggregated outcomes. The general patterns of those results have remained unchanged. We did not conduct further sensitivity analyses on other variables as they were being theorized to have effects on the outcomes. The results (Appendix B) are posted in the e-companion.

[4] To help illustrate the interaction effects, we have created Figures EC.2–EC.6 in Appendix C; see the e-companion.

in the field, calls attention to the need for a more systematic understanding of the underlying mechanisms of strategic alliance formations while considering the network dynamics and the external environment. Findings can also be viewed as new theoretical insights that can be further explored in future research.

The simulation model matched the empirical results reasonably well and generally corroborated the findings from the empirical data. The unsupported main hypothesis on ambidexterity suggests that the basic model should be of a contingency nature, which was also intended by this study. Our results demonstrate that there is a limit to prior findings on ambidexterity hypothesis, which tends to be heavy on concepts but light on contingency conditions (He and Wong 2004, Koza and Lewin 1998). The ambidexterity approach in alliance formation does not always guarantee increased economic benefits for firms. Rather, firms need to evaluate it based on their own organizational characteristics and external conditions. Our findings support the argument that large firms are able to reap the benefits of ambidexterity, whereas small firms are advised to maximize the value of their limited resources by adopting a focused approach in alliance formation (Beckman et al. 2004, Stuart 2000). Also, we found that an ambidextrous approach helps firms in uncertain environments, which demand both efficiency and flexibility, whereas a stable environment gives firms more leeway in adopting either exploitation or exploration.

Moving beyond the empirical analysis, the simulation model has shown the importance of understanding the dynamic network context as was also illustrated by Abrahamson and Rosenkopf (1997), although they only focused on limited network measures such as network density. Findings from the simulation model on Hypotheses 4 and 5 have demonstrated the importance of considering network attributes in the ambidexterity hypothesis. As researchers argued that firms are not isolated from external network relations, firms' network attributes do affect the performance implications of their approach in alliance formation (Ahuja et al. 2003, Gulati 1998). Specifically, we found that a central firm with an ambidextrous approach will increase its performance, whereas a peripheral firm with a focused approach will be better off. In addition, firms in structural hole positions can achieve better performance by taking a focused approach, whereas firms with few hole positions can enhance performance by pursuing an ambidextrous approach. These findings have reconfirmed the different nature of centrality and structural holes as acknowledged by previous researchers (Burt 1992, Reagans and Zuckerman 2001). These results have also provided some important and concrete directions for firms to better position themselves within the nexus of partner relations.

The support for Hypothesis 6 suggests that firms indeed rely on past interactions when forming new alliances. It is thus important to take a dynamic perspective toward strategic alliance research. It will be interesting to further explore emerging networks, as our research reveals that new networks may have fundamentally different mechanisms in alliance formations from those of established networks.

This study has made several important contributions to the alliance literature in general and the ambidexterity hypothesis in particular. First, it has been one of the first studies to advance our understanding of the boundary conditions for the ambidexterity perspective. Our findings support assertions that firms are bounded by their limited and unique resources, and an ambidexterity approach may need to vary with different industry environments and firm characteristics (Park et al. 2002, Van Looy et al. 2005). In alliance formation, firms often have to make a conscious choice regarding exploration or exploitation. An absolute ambidextrous criterion, if adopted indiscriminately, may be harmful to firms under certain conditions. Second, our study addresses alliance formation as not solely dictated by dyadic relations but also constrained by network conditions. Firms are embedded in their network, which brings about both opportunities and constraints. Our study suggests that firms' centrality and structural hole positions not only affect their strategic choices in alliance formation (Gulati 1995b), but also have rich performance implications. Third, it examines the dynamic effect of alliance formation on firm performance by exploring the underlying mechanisms in well-controlled simulation experiments. Last, our unique methodological approach in using both empirical data and simulation models further validates our findings on the ambidexterity hypothesis and also provides theoretical insights for future studies.

For this study there are also boundary conditions and other aspects that can be further pursued in future research. First, our study has focused on the context of strategic alliance formations. As a result, we should use caution when trying to extend the findings to other settings where ambidexterity may be based on internal balances (Burton et al. 2006). Second, our alliance ambidexterity measure is based on a sample of relatively uneven distributions of new and old alliance partners (1,591 new partners and 532 old partners). Although our measure has revealed the limitations of an ambidextrous approach in alliance formations, it would be interesting to investigate additional empirical data sets of more evenly distributed new and old partners. This may allow us to have a better understanding of the focused approach with less bias toward new alliance partners. Third, we have treated exploration, exploitation, and ambidexterity as three experimental settings for the simulation model. Although this has provided a better-controlled context, future research can also revise the simulation model to allow more natural choices of exploration, exploitation, and ambidexterity. Still, challenges can exist regarding the assumptions, measurements, and effects of such choices. Fourth, we have taken the view of strategic alliances as a means for firms to accumulate and exchange resources, relying on resource-based performance measures as our dependent variables. Although this approach has enabled us to make our results comparable between the empirical study and the simulation model, future research may need to try different performance measures, thus searching for additional boundary conditions of the ambidexterity hypothesis. Fifth, future efforts may need to further investigate the dynamics of networks and how they affect firms' performance over time. Our study makes an exploratory effort in this direction, and it suggests that young networks may exhibit different patterns from old ones. Future studies can explore other proxies for network dynamics in addition to the age of networks. Overall, our findings from the simulation model such as the dynamic-network effect could serve as valuable directions for future theoretical and empirical research.

Electronic Companion

An electronic companion to this paper is available as part of the online version that can be found at http://mansci.journal.informs.org/.

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Online Supplement

Appendix A. General Algorithm of the Simulation Model

Parameter Descriptions

—YR: Year of the network in the experiment. It can take a value from 1 to 30 in this study.

—EU: Environmental uncertainty measured as the volatility rate of the network. It is used to adjust yearly resources available to firms in the network. It can take a value around 0.003 or 0.04, in order to match the empirical data. For example, if the network faces a volatility rate of 0.04 in a particular year, then each firm within the network will have a resource adjustment by a factor of $(1+0.04)$, as further described below.

—N: Number of nodes (firms or actors) in a network. It can take a value of either 25 or 70.

—RI: Number of types of input resources for each node. It can take the value of 10.

—RO: Number of type of output resource for each node. It can take a value of 10.

—MI: Maximum amount of resources for each type in RI. It can take the value of 70. For each type of input resources, a randomly generated amount of resources in the range from 0 to MI can be generated. When the amount is 0, that type of input resources becomes non-existent and so the node will have one less type of input resources.

—MO: Maximum amount of resource for each type in RO. It can take the value of 35. For each type of output resources, a randomly generated amount of resources in the range from 0 to MO can be generated. When the amount is 0, that type of output resources becomes non-existent and so the node will have one less type of output resources.

—RI_{ik}: Amount of input units for node i's type k resources. It is initialized using the following equation:

$$RI_{ik} = (\text{random generator MOD } (MI+1)) \times (1.0 + EU),$$

where random generator MOD $(MI+1)$ generates a random number between 0 to MI.

—RO_{jl}: Amount of output units for node j's type l resources. It is initialized using the following equation:

$$RO_{jl} = (\text{random generator MOD } (MO+1)) \times (1.0 + EU),$$

where random generator MOD (MO + 1) generates a random number between 0 to MO.

—$\{MT_{ij}\}$: Resource match matrix representing the initial resource relationship among all the nodes in the network. The value for each cell MT_{ij} in the matrix is determined by the extent to which node i's output resources match node j's input resources across all possible types. For example, if node I has the following types of output resources that have non-zero amount: Type_2 (amount = 3), Type_3 (amount = 8), and Type_RO (amount = 23); and node j has the following types input resources that have non-zero amount: Type_1 (amount = 10), Type_2 (amount = 23), Type_3 (amount = 69), then there are two matches between node i and node j. Or, $MT_{ij} = 2$.

—$\{CT_{ij}\}$: Contact matrix representing the alliance relationships among all the nodes in the network. The value of each cell CT_{ij} is initially set to zero and can be incremented by 1 each time there is an actual resource exchange between node i and node j.

—$\{ST_{ij}\}$: Tie strength matrix representing the strength of relationships based on both the resource match and their actual contacts in the following dynamic relations among all the nodes in the network.

The value of each cell ST_{ij} is determined by the addition of MT_{ij} and CT_{ij}, in which CT_{ij} can be adjusted after each exchange among any two nodes.

—T: Total time units allowed for each node in each year, which is set at 50 units. Each node's search activity, resource exchange activity will take certain amount of time units. By assigning this number, the simulation allows the nodes to have sufficient time to conduct their alliance relations while not let the model go into infinite loops. The simulation results also show that 99.5% of the nodes can meet their resource needs within the time units allowed. In another study of ours, we have explored the effect of time pressure on organizations' efficiency of resource accumulations (Lin 2002).

Experiment Intializations

1. Set the maximum number of years YR (30) for the simulation; set the volatility rate of the network V, which is a randomly generated number around 0.003 or 0.04.
2. Generate N (25 or 75) nodes, each of which needs up to RI (10) types of input resources to produce up to RO (10) types of output resources. For each type of input resource, the amount is randomly generated with the range between 0 to MI (70), which is further adjusted by the volatility rate of the network V. For each type of output resource, the amount is randomly generated with the range between 0 to MO (35), which is also further adjusted by the volatility rate of the network V.
3. Calculate the resource match matrix $\{MT_{ij}\}$, which measures for each pair of nodes i and j, the extent to which node i's output resources match node j's input resources across all possible types.
4. Set up an initial contact matrix $\{CT_{ij}\}$ for all nodes that contains only zeros before interactions exist between each pair of nodes.
5. Calculate the initial tie strength matrix $\{ST_{ij}\}$ for all pairs of nodes, based on both the resource match matrix and the contact matrix.

Processes

6. Start year Y_m.
7. If the exploitation/exploration mechanism is used, each node i in the network searches for another node j that has the next strongest/weakest tie with node i. Exchange resources between node j and node i. If node i's input resource needs are met or time has expired, go to 9. Otherwise, go to 7.
8. If the ambidextrous mechanism is used, each node j in the network alternatively searches for another node j that has the next strongest tie with node i and another node k that has the next weakest tie with node i. Exchange resources between node j and node i, and node k and node i. If node i's input resource needs are met or time has expired, go to 9. Otherwise, go to 8.

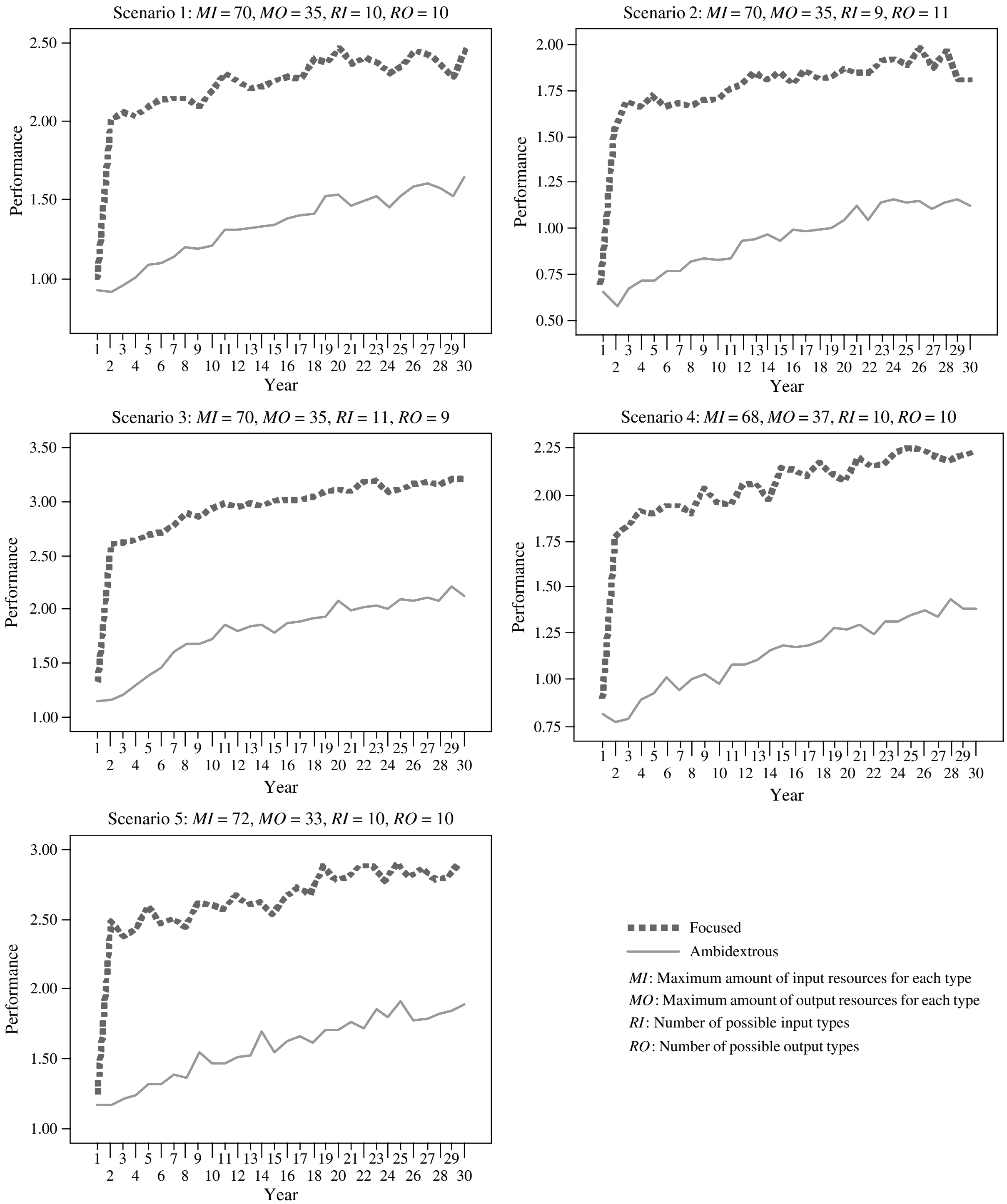
Adaptations

9. At the end of year, record resources generated and exchanged and number of alliance partners for each node.
10. Adjust resource input demand for all nodes and update the resource match matrix $\{MT_{ij}\}$ based on a new industry volatility rate V.
11. Update the contact matrix $\{CT_{ij}\}$ for each pair of nodes.
12. Update the tie strength matrix $\{ST_{ij}\}$ for each pair of nodes based on $\{MT_{ij}\}$ and $\{CT_{ij}\}$.
13. If year m is less than YR, go to 6. Otherwise, stop and print out outcomes.

Appendix B. Sensitivity Analysis Results

We have conducted systematic sensitivity analyses on experimental parameters (RI, RO, MI, MO) to examine how their small variations (with systematic changes of one and two units in either direction for each parameter) may alter the main, aggregated outcomes across the years. The general patterns of those results have remained consistent statistically ($p < 0.001$), in particular with regard to the significant differences between the performance outcomes based on either focused or ambidextrous approaches across all event years. We did not conduct further sensitivity analyses on other variables as they were being theorized to have effects on the outcomes. Figure EC.1 has shown some of the main sensitivity analysis results as a result of one unit changes for parameters RI, RO, MI, and MO.

Figure EC.1 Main Sensitivity Analysis Results



Appendix C. Interaction Plots

Figure EC.2 Interaction Between Ambidexterity and Firm Size

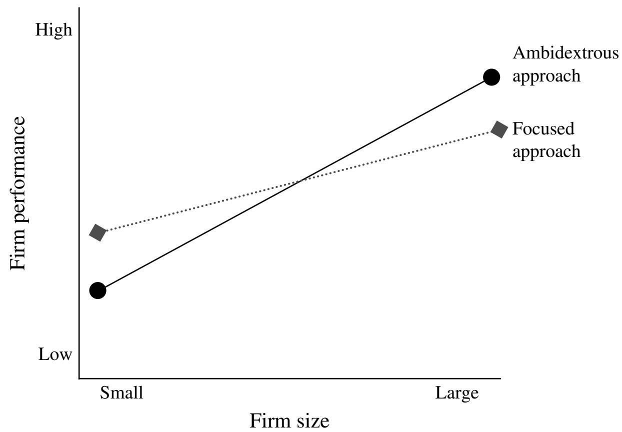


Figure EC.3 Interaction Between Ambidexterity and Environmental Uncertainty

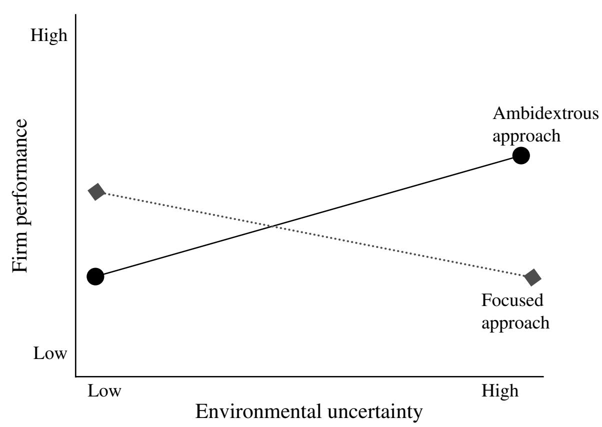


Figure EC.4 Interaction Between Ambidexterity and Firm Centrality

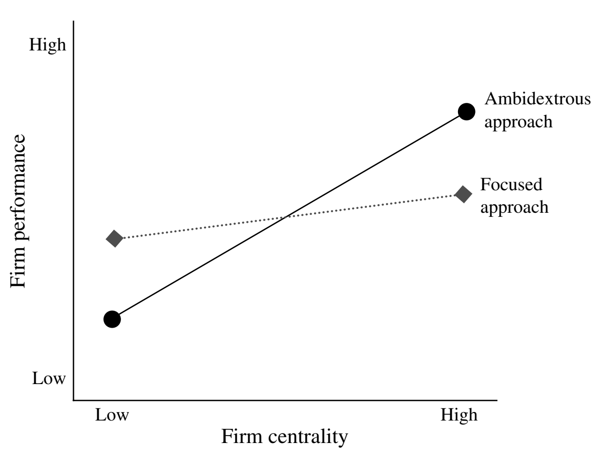


Figure EC.5 Interaction Between Ambidexterity and Structural Holes

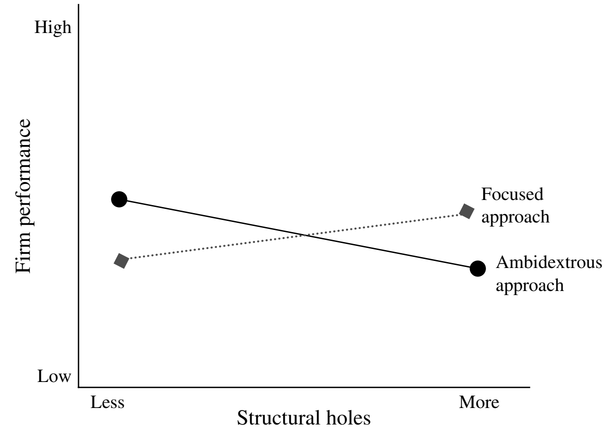


Figure EC.6 Interaction Between Ambidexterity and Alliance Event Year (Year ≤ 9)