Friends or Strangers?

Firm-Specific Uncertainty, Market Uncertainty, and Network Partner Selection

Christine M. Beckman•
University of California - Irvine
Graduate School of Management
Irvine, CA 92697-3125
(949) 824-3983
(949) 725-2869
Cbeckman@uci.edu

Pamela R. Haunschild
University of Texas, Austin
McCombs School of Business
Austin, TX (512) 471-5081
Pamela.Haunschild@mccombs.utexas.edu

Damon J. Phillips
University of Chicago
Graduate School of Business
Chicago, IL 60637
(773) 834-2863
damon.phillips@gsb.uchicago.edu

Forthcoming, *Organization Science*

• The order of authorship is alphabetical, reflecting their equal contributions.

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ABSTRACT

In this study, we address the topic of interorganizational network change by exploring factors that affect the choice of alliance and interlock partners. While many studies have been devoted to investigating various factors driving network partner choice, there is also an interesting and unexplored tension in this body of work. On the one hand, much work emphasizes change in social structure – showing that firms expand networks by forming new relationships with new partners. At the same time, other scholars emphasize stability of social structure – showing that firms tend to choose past exchange partners. We seek to reconcile this tension by proposing that firms form new relationships with new partners as a form of exploration, and form additional relationships with existing partnerships as a form of exploitation (March, 1991). Further, whether exploration or exploitation is chosen depends on the type of uncertainty that firms are facing: whether it is firm-specific or market-level uncertainty. We test our hypotheses using data on both interlock and alliance networks for the 300 largest U.S. firms during the 1988-1993 period. Our results provide some evidence that whether networks are stable or changing depends on the type of uncertainty experienced by firms.

During the past twenty-five years, scholars have conducted substantial research on factors that affect partner selection in interorganizational networks. Partner selection is critical to network theory, as it is a fundamental driver of network stability and change. Pfeffer and Salancik (1978) were among the first scholars to draw attention to network change by showing that firms expand their networks by incorporating new players in an effort to alleviate the uncertainty and constraint that comes with being dependent on others (see also Burt, 1983; Gargiulo, 1993). Firms also expand their networks to learn about new practices and technologies (Kogut, 1988; Powell, Koput and Smith-Doerr, 1996).

While this research focuses on network change through the alteration of network structure with new ties, a second stream of research emphasizes the stability of social structure (Wellman and Berkowitz, 1988). These studies suggest that firms will, under certain conditions, reinforce their existing network ties, forming additional relationships with pre-existing partners. For example, Podolny (1994) showed that in markets with a high degree of market uncertainty investment bankers tend to interact with those they have interacted with in the past, and Gulati (1995) showed that firms tend to repeat alliances with previous alliance partners. From this perspective, firms tend to reinvest in present network structures, rather than expanding them.

The purpose of the current study is to reconcile these two perspectives and understand what determines how firms alter their network relationships. We seek to predict when firms will add new relationships and when they will expand the relationships already in place. The idea of expanding to new network partners versus reinforcing with existing partners is similar to the concepts of exploration and exploitation in organizational learning (March, 1991). Exploration involves experimenting with new alternatives. Thus, forming new relationships with new partners is a form of exploration, where firms

expand their knowledge and access to resources through new network partners. Exploitation involves refining and extending existing knowledge. Forming additional relationships with existing partners is a form of exploitation, where firms extend their existing knowledge base with existing partners. But when will firms broaden their relationships (explore) and when will they reinforce (exploit)?

We argue the nature of the uncertainty facing the firm will drive network partner selection. The link between uncertainty reduction and formal interorganizational networks has a noteworthy foundation. Firms establish linkages with other firms in an attempt to control uncertainty (e.g., Thompson, 1967; Pfeffer and Salancik, 1978; Burt, 1983). Several scholars have noted the importance of uncertainty as a driver of partner selection (e.g., Podolny, 1994; Haunschild, 1994), but they have not examined the nature of the uncertainty involved. We introduce a framework whereby uncertainty is classified according to whether a focal firm alone faces uncertainty, or whether a set of firms in a market face a common set of uncertainties. While studies such as Pfeffer and Salancik (1978) consider the consequences of uncertainty experienced by single firms, scholars like Podolny (1994) explore the effect of uncertainty experienced by entire industries or markets. This distinction lies at the core of our argument.

Our central thesis is that a firm facing unique uncertainty (what we call firm-specific uncertainty) selects its network partners differently from a firm that is a member of a larger group facing collective uncertainty. In the first scenario, search behavior leads to the forging of new ties, while the latter scenario leads firms to strengthen existing affiliations. The greater the uncertainty that a firm faces alone, the more likely that firm will broaden its set of ties by establishing ties with organizations that it has not had ties with in the past. Likewise, the greater the uncertainty that a firm's market or industry faces, the more likely that firm will strengthen the ties it presently has.

We test the relationship between uncertainty and network partner selection using two common, but very different, types of interorganizational network ties: interlocking directorates and strategic alliances. This is a crucial element of our study. Few scholars examine both types of ties within a single study, although a great deal of research exists about each (see Gulati and Westphal, 1999 for an exception). Examining two types of ties simultaneously allows us to talk more confidently about the impact of uncertainty on network change and stability. By using two very different types of ties, we reduce the possibility that the idiosyncrasies of any one type of tie drive our results. Ultimately, we seek an understanding of the relationship between uncertainty and network transformation that contributes to the general knowledge about how, when, and why social structure is altered.

Uncertainty

Different types of uncertainty have been discussed and investigated in both the behavioral decision theory and organization literatures (e.g., Thompson, 1967; Galbraith, 1973; March & Olsen, 1976; Weick, 1979). Many studies define uncertainty, develop typologies of uncertainty, and trace various forms of uncertainty to firm responses (e.g., Mosakowski, 1997; Milliken, 1987). We begin with a definition of uncertainty that underpins most others' definitions: uncertainty is the difficulty firms have in predicting the future, which comes from incomplete knowledge. What is common across studies of uncertainty is the premise that individuals and organizations strive to reduce uncertainty because "certainty renders existence meaningful and confers confidence in how to behave and what to expect from the physical and social environment" (Hogg and Terry, 2000: 133). The uncertainty-reduction hypothesis suggests reducing uncertainty is a primary individual motivator or "fundamental need" guiding behavior (Hogg and Mullin, 1999: 253; see also Dewey, 1929; Bourgeois, 1984). While this argument is at the individual level, there are corresponding arguments that apply to organizations. For example,

managing uncertainty through various structural arrangements has been noted as a key issue for organizational design (e.g., Thompson, 1967; Williamson, 1981). Although many scholars propose that organizations respond to uncertainty, what is meant by uncertainty seems to differ from study to study. We propose that one key dimension underlying many uncertainty studies is the level of the uncertainty, i.e., whether it is firm-specific or market based. Further, these two types of uncertainty require different adaptation strategies.

Firm-Specific Uncertainty

Firm-specific uncertainty can stem from a variety of sources but the key underlying dimension is that these sources produce uncertainty that is unique and often internal to the firm. So, for example, firms might experience uncertainty that arises from internal changes like entering a new market (Greve, 1996), acquiring another firm (Haunschild, 1994), or experiencing a turnover in top management (Carroll, 1984). Firms might also experience technical uncertainty, which is uncertainty about the likelihood of technical success and the costs associated with success (McGrath, 1997). Technical uncertainty is firm-specific to the extent that other firms have different capabilities and probabilities of success. Firm-specific uncertainty need not arise solely from internal issues, as there may be external firm-specific sources of uncertainty such as that arising from a firm's relationships with its exchange partners (Williamson, 1981; Gulati and Westphal, 1999), but firm-specific uncertainty is unique to that firm.

In the finance literature, the concept of nonsystematic or unique risk is loosely analogous to firm-specific uncertainty.[1] The key to nonsystematic risk is that it can be controlled through diversification (Brealey and Myers, 2003). A key feature of firm-specific uncertainty, therefore, is that it is often more controllable than market uncertainty. Firms experiencing unique uncertainty will broaden (i.e., diversify)

their network of partners in the same way that investors diversify their portfolios in order to minimize nonsystematic risk. This is not to say that firm-specific uncertainty is never exogenous (as we noted above), or that firms can always control this type of uncertainty, but it is more likely to be controllable than market uncertainty. Through diversity in firm networks, firms gather unique information that aid in making better firm-level decisions (Beckman and Haunschild, 2002) and reduce reliance on any single partner.

Firms search or seek additional information in an attempt to reduce or manage firm-specific uncertainty (Galbraith, 1973; Shafir, 1994; Haunschild, 1994). New partners in a firm's network offer one important source of new information. New partners broaden the scope of the firm, increasing the likelihood of obtaining new information and of adding to the diversity of information to which a firm is exposed. Considering a firm's network as a knowledge base to be tapped, firms expand that knowledge base by forming new relationships with new partners. This is an exploration response, focused on gathering new information on new alternatives through new relationships (Baum and Ingram, 2003). It is likely, therefore, that firm-specific uncertainty will lead to broadening (forming new relationships with new partners).

The literature on organizational networks also suggests that new partners are likely to represent relatively weak ties for a firm. Granovetter (1973) classifies ties according to the amount of time, emotional intensity, intimacy, and reciprocal services involved. New relationships, on average, are typically weaker on these dimensions than existing relationships. Weak ties are beneficial because they are conduits to new, unique information (Granovetter, 1973; Hansen, 1999). Thus, firms are likely to seek out such ties when experiencing uncertainty because this unique, novel information may be useful in addressing issues that the firm has been unable to address effectively with their existing sources of

information (cf. Baum and Ingram 2003). Firm-specific uncertainty creates the need for the unique information that comes from new, relatively weak ties with new partners.

Finally, independent of the benefits of information diversification and exploration, firm-specific uncertainty may cause firms to broaden their network as an attempt to maintain or regain legitimacy. Establishing new relationships can signal to external constituents (in our setting, the business community) that firm-specific issues are being recognized and dealt with. If the business community perceives a problem within an organization, it can lead to investor speculation, which may magnify existing firm-specific uncertainties. To symbolically demonstrate firm competence and restore investor confidence, firms have an incentive to take action (Rao and Sivakumar, 1999). Establishing new partnerships signals an action on the part of the firm, as well as confidence on the part of partners, which may alleviate investor concern.

To summarize: in the case of firm-specific uncertainty, firms attempt to reduce uncertainty by forming relationships with new network partners, which is a form of exploration. They do this because of the desire for diversification in information sources and legitimacy concerns. New relationships are more likely to provide new and different information than existing relationships. Although this strategy may increase firm-specific uncertainty to the extent that less is known about the new partners than existing partners, this increase in relationship uncertainty is likely to be offset by the benefits of diversification, which should reduce other forms of uncertainty, such as technical uncertainty and uncertainty due to major internal changes.

Empirical studies support the idea that firms will broaden networks in response to firm-specific uncertainty. Mizruchi and Stearns (1988) found that firms create new financial interlocks when faced with declining solvency and profit rates-- a likely source of firm-specific uncertainty. Also, Podolny

(2001) argues that a diverse network is associated with egocentric (firm-specific) uncertainty. A relationship between broadening and firm-specific uncertainty is also supported by economic and sociological approaches to understanding firm collaboration. For example, Teece (1989) and Powell, Koput and Smith-Doerr (1996) argue that firms uncertain of how to develop new knowledge and to innovate (e.g., in periods of technological ferment) are motivated to establish new relationships with others: organizations, universities, suppliers, etc.

In addition to academic work, we draw attention to examples in the popular press of broadening relationships in response to firm-specific uncertainty. For example, Apple Computer adopted a broadening strategy in 1997 when it revamped its board of directors. Facing a tumultuous time after firing the CEO Gilbert Amelio, Steve Jobs spearheaded an effort to bring in four new board members in an attempt to give credibility to Apple and to search for new solutions for the company (Tran, 1997). Apple faced an incredible amount of uncertainty as a result of unstable management; uncertainty unique to Apple at that time. Broadening the expertise on the board was an attempt to reduce that uncertainty and show the world that Apple was on the right track. In the language of our paper, Apple Computer faced firm-specific uncertainty and responded by broadening its network. More recently, in the wake of recent corporate scandals, many companies broadened their board of directors by bringing in new directors with varied experiences. CEOs often seek board members with diverse viewpoints and experiences in an attempt to gather new information (Beckman and Haunschild, 2002).

The firm experiencing uncertainty, however, is only half of the partnership, and partners need a rationale for establishing relationships with firms facing firm-specific uncertainty. We offer two key explanations for why partners would establish a relationship with a firm facing uncertainty. First, while

partners may generally seek internal certainty, they may not seek it in their external interactions. As the Apple example illustrates, executives from Oracle and Intuit were willing to serve on Apple's board despite the uncertainty surrounding the company. In fact, firms benefit from partnering with those that have different experiences, and even negative experiences, because the diversity represented by such experiences helps them make better decisions (Beckman and Haunschild, 2002). The research on alliances as real options suggests a second rationale for alliance partnering with firms facing firm-specific uncertainty. Joint ventures are opportunities to share risk in an uncertain environment and give firms the opportunity for future value at a current bargain price (Kogut, 1991)[2]. Partners, by allying with a firm experiencing uncertainty, are likely to have the option of further expansion if the market or firm prospects improve, or if uncertainty is reduced. Therefore, a potential partner may be motivated to take advantage of the current uncertainty facing a firm and establish an option for future value by seeking terms that are favorable in the current environment.

If our thesis is correct, broadening is not a function of a particular type of tie but rather, the type of uncertainty faced by the firm. That is, we expect firms to broaden their networks through both interlocking directorates and strategic alliances in response to firm-specific uncertainty. The strength of our evidence will reside, in part, with the degree to which firm behavior generalizes across different types of interorganizational relationships. We thus hypothesize that firm-specific uncertainty will increase broadening for both alliances and interlocks.

H1: The higher the level of firm-specific uncertainty, the more likely a firm is to broaden its alliance network, forming alliance relationships with new partners.

H2: The higher the level of firm-specific uncertainty, the more likely a firm is to broaden its interlock network, forming interlocks with new partners.

Market Uncertainty

If firm-specific uncertainty is largely internal, controllable and unique, market uncertainty is external and shared across a set of firms. In the finance literature, this is analogous to systematic or market risk, which consists of factors that are common to the entire economy (Brealey and Myers, 2003). Market risk, because it is systematic, cannot be controlled and is independent of what happens at the firm level.[3] Markets vary in their level of uncertainty and unpredictability, and firm fortunes may vary considerably within those markets. Firm-specific uncertainty and market uncertainty are independent theoretical constructs, as it is possible for firms experiencing high uncertainty to be in markets experiencing low uncertainty, and vice versa.

Many organizational studies examine market uncertainty, emphasizing sources of uncertainty that cannot be managed or reduced by the actions of a single firm. For example, Burgers, Hill and Kim (1993) examined competitive and demand uncertainty as two forms of uncertainty beyond the control of a particular firm. Competitive uncertainty is created when the competitive actions of a rival influence a firm. This type of market uncertainty has been found to increase with the concentration ratio of the industry (Wiersema and Bantel, 1993). Demand uncertainty comes from the general level of demand for an industry's products (e.g., semiconductors). Although firms can respond to demand uncertainty, it is a consistent source of uncertainty that firms cannot eliminate to the extent that customer preferences are unstable and changing (March, 1978). A third example is input cost uncertainty (McGrath, 1997): firms have difficulty managing or reducing input cost uncertainty because often firms have only weak influence over their supplier's prices. These examples do not exhaust the many ways scholars have measured or described market-level uncertainty, but they serve to show that there are many sources of such uncertainty that are out of an individual organization's control.

Under these conditions organizations are likely to respond very differently than they would to firm-specific uncertainty. With firm-specific uncertainty, firms respond through broadening and search. But with market uncertainty, firms respond by reinforcing existing relationships. Podolny (1994) argues that interacting with past partners is the best strategy since market uncertainty makes partner quality difficult to assess. Similarly, when firms in a market are all uncertain, because of consumer demand, industry level technology trajectories and standards, input costs and the general competitive climate, quality assessments are difficult. Sjostrand (1992) argues when the source of uncertainty is unknown (or distant), actors will tend to form relationships with others who share similar ideals and values. This banding-together of similar and familiar others is likely to extend to the organizational level when "organizations facing uncertainty would strive for homogeneity" (Hogg and Terry, 2000: 133). Thus, when uncertainty is outside of the firm's control and shared across firms, uncertainty is reduced through interactions with similar others. Adding additional relationships with existing partners is likely to result in fairly strong ties characterized by deep levels of trust (Larson, 1992). We thus expect that market uncertainty will cause firms to reinforce their existing relationships, adding ties to existing relationships.

Reinforcing existing relationships is a form of an exploitation response (Baum and Ingram, 2003). Exploitation in this case suggests that firms maintain their present partners but with greater commitment. When faced with market uncertainty, organizations seek stability and trust in inter-partner relationships, which is more likely to occur in existing partner relationships than with new (uncertain) relationships (c.f., Hansen, 1999). This is a form of threat-rigidity response (Staw, Sandelands and Dutton, 1981), where firms respond to threat (general market uncertainty) by continuing to do what they are doing. This response is more likely to occur with market uncertainty than with firm-specific uncertainty because, as noted earlier, the options for dealing with general market uncertainty are fewer.

Empirical support for the idea that firms will respond to market uncertainty by reinforcing relationships can be found in studies by Galaskiewicz and Shatin (1981) and Gulati (1995), who find that market uncertainty causes firms to select partners they know well. Galaskiewicz and Shatin (1981) argue that in turbulent environments, organizational leaders will rely on past affiliations in order to reduce uncertainty. Forming additional relationships with existing partners is a way of selecting partners that firms know well. Economists have also investigated the relationship between market uncertainty and reinforcing. Geertz (1978) highlights this relationship in his observation of a Moroccan bazaar economy, where traders respond to uncertainty about product quality by focusing on relations with past and present partners. Using the term clientelization, Geertz (1978) argues that traders trade with partners they know well to counteract and profit under market uncertainty. Clientelization improves the richness and reliability of information a trader is given. In this case, as with the firms examined by Podolny (1994) and Gulati (1995), uncertainty can be classified as market-based because all participants in the market had difficulty determining the quality of a potential item or relationship.

In addition to the academic work, the business press also offers evidence that firms reinforce relationships under conditions of market uncertainty. For example, the computer industry faced great uncertainty in the early 1990s. In responding to this uncertainty, computer firms engaged in joint ventures and alliances and "an unprecedented round of co-operation swept through the industry" (Manchester, 1992). While these alliances are not necessarily with existing partners, we do see that Apple Computer added 10 alliances to firms they already had alliances with during this period (using data from the Securities Data Corporation). Other firms did the same. More recently, we see companies in the airline industry strengthening existing relationships in response to demand uncertainty created by the events of September 11, 2001. Long- standing alliances, such as the Star Alliance,

SkyTeam alliance and Oneworld alliance, have added new partnerships to existing cooperative agreements (Sarsfield, 2002). In fact, the European Commission began an investigation because "SkyTeam members are 'deepening' their bilateral pacts" (Sarsfield, 2002). In this case, the existing alliance added codesharing flights to its partnership, which amounts to an additional alliance with the same partners. This suggests the airline industry is attempting to reduce market uncertainty (which includes demand uncertainty) by reinforcing existing relationships.

Partner motivation is straightforward in the case of market uncertainty, as the airline example demonstrates. Firms in the same industry, facing the same market uncertainty, have similar motivations for reinforcing existing relationships with one another. For partners inside the industry, they reinforce the relationship according to the same reasoning as the focal firm – to increase the reliability and trust in their exchange relationships. For partners outside the focal firm's industry, not only is there a similar motivation (firms can learn from the uncertainty facing others), but this learning can be enhanced given the focal firm's industry experience with managing uncertainty.

Of course, organizations can sometimes act together in an attempt to manage exogenous uncertainty, e.g., lobbying activities, but in general the choices are fewer and thus, reinforcing is more likely to be chosen. Reinforcing an existing network allows firms to strengthen, deepen and exploit ties that already exist. From this perspective, uncertainty is a catalyst for reinvestment in the present network structure rather than a motivation to alter the present structure with new ties. This reinvestment in the network can be accomplished two ways. First, firms may reinforce by adding relationships of the same type with existing partners. For example, if a firm has an alliance with another firm, adding a second alliance with that same firm is a form of network reinforcing. Second, firms may add relationships of a different type with an existing partner, e.g., adding an alliance when an officer of that

firm is already on the board. This latter form of reinforcing is analogous to the concept of relationship multiplexity in the network literature (Wasserman and Faust, 1994), where multiplexity is defined as two or more different types of relationships occurring together. For example, in May of 2002, Disney and Microsoft formed a first time alliance, but they shared a board tie that began in 2000. This increased the multiplexity of the Disney-Microsoft alliance, which may have been a response to the uncertainty firms in technology and entertainment markets faced in 2002.

H3: The higher the level of market uncertainty, the more likely a firm is to reinforce its networks, forming additional alliances with existing alliance partners.

H4: The higher the level of market uncertainty, the more likely a firm is to reinforce its networks, forming additional interlocks with existing interlock partners.

H5: The higher the level of market uncertainty, the more likely a firm is to increase the multiplexity of its existing networks, forming interlocks with existing alliance partners and vice versa.

METHOD

We investigate network partner broadening and reinforcing using a sample of the 300 largest service and industrial firms listed by Fortune and Forbes in 1990. For each of these 300 firms, we collected information on two types of network relationships: interlocking directorates and strategic alliances. We eliminated 6 firms that were not publicly held US based companies because information about them was not consistently available.

For the analyses of interlocking directorates, we collected network changes from firm proxy statements. We further eliminated firms that did not file a proxy statement every year between 1990 and 1993, leaving us with a sample of 240 firms. We started with interlocks existing in 1990, and then coded every director change during 1991, 1992, and 1993. From the biographical data in the proxy statements, we collected information on all inside and outside directors of the focal firms. Inside

directors are executives and board members of the focal company and create *sent ties* when they sit on the board of another company. Outside directors create *received ties* from the firm with which they are principally affiliated. Outside directors also create *neutral ties* to the focal firm from those firms on whose boards they sit (but with whom they are not principally affiliated). We use the terminology of sent, received and neutral ties to describe board affiliations according to the norms in interlock research (Palmer, Barber, Zhou and Soysal, 1995). We hypothesize that focal firms alter their network ties in an effort to reduce or manage uncertainty. As such, our theory requires that the firm experiencing the uncertainty have some control over the broadening or reinforcing of these ties. Using the terms defined above, this means that *sent* and *received ties* are likely to be influenced by uncertainty, but *neutral ties* are not. Changing received ties is certainly under the control of the focal firm because the firm decides whom to ask to sit on its board, and received ties are created when a firm asks someone from another company to sit on their board. For the focal firm to affect sent ties requires that the officer (and board member) of a focal firm be named to the board of another company. Although it may be more difficult to control getting on another board (sent tie) relative to asking someone on your board (received tie), it is still possible to do. We did not include neutral ties in our analyses because the formation and change of these ties are largely the decision of organizations and individuals outside the focal firm, and thus outside our theory.

For the analyses of strategic alliances, we collected alliance partner information from the Securities Data Corp (SDC) database, now part of Thomson Financial. We collected data on all strategic alliances of the sampled firms between 1988 and 1992, including joint ventures, financial alliances, licensing agreements and other forms of joint activity. The analyses reported in the paper include joint ventures, joint marketing alliances, joint manufacturing alliances and joint natural resource

exploration alliances, as these types of alliances seem to be more likely to be the result of efforts to manage uncertainty than licensing, equity purchase, funding, royalty, and other miscellaneous alliances. These alliances are not directional (i.e., we code a joint manufacturing alliance for the focal firm regardless of where the manufacturing takes place). We also conducted analyses including the full sample of all types of alliances, with very few differences in results. This is probably due to the fact that these other types of alliances represent less than half of all alliances.

Variables

Broadening and Reinforcing. The dependent variables (broadening and reinforcing) were constructed by counting the number of annual broadening or reinforcing events for each sampled firm. Using 1990 as our base year, we examined interlock changes from 1990 to 1991, 1991 to 1992 and 1992 to 1993. Using 1988 as our base year, we examined alliance changes during 1989, 1990, 1991, 1992, and 1993. There were 2,182 interlock changes and 3,333 alliance changes during the periods studied. Interlock broadening occurs when a focal firm establishes a sent or received interlock with another firm where no interlock existed during the year prior to the observed year. Interlock reinforcing occurs when the focal firm establishes a sent or received interlock with a firm with whom they had an existing interlock during the prior year. For example, if two additional interlocks are created with an existing interlock partner, we count two reinforcing events.

Alliance broadening occurs when a focal firm establishes an alliance with another firm where no alliance existed from 1988 to the year prior to the observed year. Alliance reinforcing occurs when the focal firm establishes another alliance with a firm with whom they had an alliance during any year from 1988 to the year prior to the observed year.

To measure multiplexity (a special case of reinforcing), we counted firms adding an interlock to

a firm with whom they had an alliance with in the past, or adding an alliance to a firm with whom they had an interlock for the years 1988-1992, giving us 5 years of firm observations. To count alliances added to a firm with whom they had an interlock, we compared interlock ties in 1985 with alliances in 1988-1990. We looked at the interlock data in the prior year for alliances in 1991-93. To count the interlocks added to a firm with which they had an alliance, we compared alliance data in 1989-1992 with interlock data from 1990-1993. Because we did not have interlock data in 1989, we could not calculate interlocks added to an existing alliance in 1989.

The following example will clarify these different measures. Conagra had no interlock ties to DuPont in 1990 or 1991 and no alliance ties to DuPont until an alliance was established in 1991. In 1993, an additional alliance was established and an interlock tie was also created. So Conagra has a 1991 alliance broadening count of one as no alliance existed from 1988 to 1990. Conagra also has a 1993 alliance reinforcing count of one for adding an additional alliance to the pre-existing alliance relationship with DuPont. Finally, Conagra has a 1993 multiplexity (reinforcing) count of one for adding an interlock to their pre-existing alliance relationship.

One possible concern with our broadening measure is that it is left-censored in the sense that a firm doing an alliance in 1989, for example, may have had an alliance with that same partner in 1985, which would not show up in the 1988-1993 sample. Alliances and interlocks often last multiple years, so an alliance created in 1985 may still be in existence in 1988. Thus, we may be miscoding some reinforcing events as broadening because the firms engaged in an alliance prior to the sample period. To check this, we conducted a subanalysis on our original sample where we checked to see if the results for later (e.g., 1990-1993) are different from earlier (e.g., 1988-89) alliances. Later alliances are less likely to be subject to left-censoring on the broadening variable than are the earlier alliances. The

significance of the hypothesized results are no different in these analyses, which provides evidence that left-censoring is not a problem for the alliance broadening analysis. For the interlock analysis, we collected data for 1985 and conducted broadening analyses with 1985 as a base year (examining whether the focal firm established an interlock with another firm where no interlock had existed in 1985). The significance of our hypothesized results are the same using this measure of broadening, again suggesting left censoring is not a problem.

Firm-specific uncertainty. We use the volatility of a firm's stock price as a proxy for the uncertainty facing that firm. Lang and Lockhardt (1990:110) state that "volatility is positively related to firm managers' perceptions of uncertainty and therefore reflects phenomena that affect decision making" (see also Bourgeois, 1985). Although Lang and Lockhardt focus on annual earnings before interest and taxes, they argue that financial volatility and uncertainty are related. Leblebici and Salancik (1982) and Baker (1984) used the volatility of the future options market and volatility of stock price, respectively, to proxy for market uncertainty. Volatility is an applicable measure of uncertainty for these studies, which are in the context of trading floors, because price volatility makes future values difficult to predict. Stock price volatility is a useful measure of uncertainty for other contexts, including ours, because a high degree of price volatility is likely to correspond to managerial perceptions of uncertainty, which, in turn, are likely to impact a firm's decision making (Lang and Lockhart, 1990; Bourgeois, 1985). Price volatility has been used largely to measure market uncertainty, but the logic should apply to firm-specific uncertainty as well. Price volatility also operationalizes uncertainty as a somewhat negative thing for a firm to experience, which matches the theoretical expectation that firms will engage in actions designed to avoid or reduce uncertainty. Firms are generally motivated to reduce uncertainty because stakeholders tend to favor organizations with high levels of reliability (Hannan and Freeman, 1984). As

our focus is on different levels of uncertainty (firm-specific and market), we measure stock price volatility both for firms and industries. Firm-specific and market uncertainty are theoretically independent, and, although firm and industry price volatility are correlated, they are empirically distinct as well.

Firm-specific uncertainty is operationalized as the standardized monthly volatility of the focal firm's stock in the year prior to the network change. The monthly volatility is calculated as the coefficient of variation for firm *j*'s annual monthly stock closing price; or:

$$\frac{\text{Standard Deviation (Firm's Monthly Closing Price, Year } i\text{, Firm } j)}{\text{Average (Firm's Monthly Closing Price, Year } i\text{, Firm } j)}$$

where *i*=1987-1992. The index *j* represents each of the firms in the sample. Dividing the standard deviation by the mean allows the measurement of uncertainty to be interpretable across firms with different price ranges. If a firm's stock price experiences high variance relative to its average price, the focal firm is experiencing high firm-specific uncertainty. The higher the volatility, the more uncertainty. Monthly stock price data were obtained from Compustat and from CRSP when Compustat data were unavailable.

Market uncertainty. Market uncertainty is operationalized as the mean monthly stock price volatility of all sampled firms in the focal firm's industry grouping in the year prior to the network change. For example, if Fortune classifies the focal firm as a member of the food and beverage industry, market uncertainty is measured as the mean monthly price coefficient of variation for all Fortune firms in the food and beverage industry for the representative year (not including the focal firm). If a firm's industry stock price experiences high variance relative to its average, the focal firm (and other firms in the same industry) is experiencing high market uncertainty. We measure uncertainty in year *i* and examine

network partner changes in year *i+1*. [4]

Control Variables. While we are interested in the role of uncertainty on interlock and alliance partner selection, there may be other important resource considerations that could affect interlock and alliance changes in general. We control for many variables that have been found to affect interlock and alliance partner changes, and we control for variables that could be related to our independent variable, uncertainty. We are searching for a general understanding of what makes firms alter their networks, not only alliances or only interlocks, so it is important to control for variables that may impact both types of relationships. If we find results for uncertainty across both types of relationships, this strengthens the generality of our findings and suggests that it is uncertainty that causes network changes, not some other unmeasured variable. The control variables we used include focal firm size, performance, centrality, year, focal industry, and prior acquisition activity by the focal firm. Since the firm-specific and market uncertainty measures are correlated, we also control for the other uncertainty variable (for each hypothesis) in order to ensure that the firm-specific uncertainty effects are net of market uncertainty and vice versa.

Firm Size. Larger firms may have more resources and a greater ability to make network changes and are also likely to make more desirable partners, so we control for firm size in our models. Size was measured as total assets of the focal firm, measured the year prior to the change in networks (i.e., 1990 assets were used in models predicting broadening in 1990-1991). We also ran models with total sales of the focal firm and the results were substantively the same. The size data were highly skewed, so we logged the asset variable. The transformed asset measure improved the model fit, so we used logged assets in all analyses. Size data were obtained from Compustat.

Performance. Many studies have examined the relationship between performance and

interlocks, with inconsistent results (Mizruchi, 1996). It may be that poor performers attract interlocks, as dependent others seek control over their fates. Or good performers may attract interlocks (and alliances) as they are desirable partners and have the resources to devote to partnership formation. So to control for any relationship between performance and interlocking or performance and alliances, we used ROA (return on assets), normalized by industry, as a control variable in all analyses. We also examined ROE (return on equity) and found the same results. Since our models fit better with ROA, we used ROA in all analyses. Performance data were obtained from Compustat.

Centrality. We needed to control for the fact that firms with many ties to other firms, or firms with large board sizes, may be more (or less) likely to change their board interlocks and alliances. It seems plausible that firms that already have many interlocks (i.e., are central in the interlock network) or already have many alliances (i.e., are central in the alliance network) may be approaching a limit on their capacity to add relationships. On the other hand, firms with many relationships with other firms may be more likely to increase their board size, or engage in alliances, simply because they have a large number of potential partners available in their current networks. They may also increase board size or alliances because their cumulative experience with interlocks and alliances increases their absorptive capacity (Cohen and Levinthal, 1990), increasing their ability to manage new relationships. We measured both interlock and alliance degree centrality for the year prior to the change in networks. In separate interlock analyses, we controlled for board size instead of degree centrality and the results did not change. Due to the high correlation between firm centrality and board size, we control only for firm centrality in the final interlock analyses presented here. In the alliance data, the total number of alliances completed by the focal firm was highly skewed. For over half of the observations, the focal firm had no alliances in the prior year. The centrality score for the observation at the 75th quartile was only two.

Therefore, rather than a count variable, we used a series of dummy variables (no prior alliances, one to two prior alliances, three to 15 prior alliances, and over 15 prior alliances) as our centrality measure. Results with a continuous variable are similar, but the model fit is better with the inclusion of the dummy variables.

Focal Firm Industry. Some industry factors may affect a firm's propensity to broaden or reinforce networks. In analyses using dummy variables to control for industries, we found that certain industries have an effect on interlock networks and others have an effect on alliance networks. We included all industries that had a significant effect in either the broadening or reinforcing analyses for each type of tie. For the alliance analyses, we report models controlling for the computer, banking, pharmaceutical and electronics industries. Those industries are more likely to affect alliance networks than other industries (such as financial services, service, utilities and chemical industries). For the interlock analyses, we report models controlling for the service, chemical, utilities and computer industries. For the multiplex reinforcing analyses, we include the industries from the alliance analyses.

Year and Prior Focal Firm Acquisitions. We also included a series of dummy variables for the various years in the sample to capture any macroeconomic effects or other effects that vary from year to year. For both the interlock and alliance broadening analyses, including years significantly improved the fit of the models, so we included year dummy variables for all broadening analyses. For the reinforcing analyses, we found year dummy variables added no significant explanatory power and in fact significantly decreased the fit of the models. As a result, we included year dummy variables for the broadening but not the reinforcing analyses. Finally, for the interlock analyses, we included the number of acquisitions the focal firm had engaged in during the prior three years as a control variable. This is to control for the increased likelihood of board changes after an acquisition. As the acquisition variable

was highly skewed, we logged it prior to entering it into the analyses. We did not include these control variables for the alliance analyses because we could not construct a theoretical reason why acquisitions would influence alliance formation and change.

Analysis Technique

Given that our dependent variables are count variables (the number of broadening and reinforcing events), we use negative binomial models. Negative binomial models correct for overdispersion and have been used in other studies of overdispersed counts (Barnett, 1997; Haunschild and Beckman, 1998). For all analyses, we modeled partner selection using a maximum-likelihood random-effects negative binomial model. We chose not to use a fixed-effects model because fixed-effects models can produce biased estimates when the sample period is short (Hsiao, 1986). We also examined zero-inflated negative binomial models, which account for the prevalence of zero outcomes in the data. For the reinforcing analyses in particular, we have a large number of observations with a zero outcome. Zero-inflated models first determine whether the outcome is zero, then model the nonzero outcomes (Greene, 1993). We chose to report the random-effects negative binomial models rather than the zero-inflated models for two reasons. First, these models are simpler and more familiar in existing research. Second, our theory does not differentiate between whether a firm changes its network and how much a firm changes its network, so the choice of what variables to include in the logistic analysis of zero outcomes is not driven by our theory. However, we ran both zero-inflated negative binomial models and fixed-effects models as a check and found similar results to those reported below.

RESULTS

Table 1 presents the means and correlations for all key alliance variables. Note that firm and

market uncertainty have a fairly high correlation (.48), but the correlation is still low enough that the two types of uncertainty seem to be capturing a good deal of unique information. Table 2 presents the means and correlations for all key interlock variables. The correlation between reinforcing and broadening is much lower here (.21) than in the alliance data (.72). Firms that create alliances are much more likely to change their networks, but this may be due to the longer time span included in the alliance data relative to the interlock data. We see that the computer industry experienced a high level of market uncertainty (and to a lesser extent firm-specific uncertainty), relative to other industries, during the period of our study. Firms experienced high levels of market and firm-specific uncertainty in 1990 and low levels in 1992.

Insert Tables 1 and 2 about here

Broadening Results

Table 3 presents the results of our alliance analyses. In Table 3, we examine H1, which predicts that firm-specific uncertainty will result in firms broadening their alliance relationships, forming new alliances with new partners. Model 1 presents the control variables alone. Several of these variables are significant. Large firms are more likely to broaden their alliance network. Firms in the computer and electronic industries are more likely to broaden than firms in omitted industries. Firms in the banking industry and firms with two or fewer prior alliances are less likely to broaden their alliance network than firms in omitted industries or firms that engaged in more than 15 prior alliances. Firms were less likely to broaden their alliance network in 1988, 1991 and 1992 relative to 1990. We include the market uncertainty variable in order to control for any market uncertainty in the firm-specific

uncertainty measure, and we find no effect for market uncertainty.[5]

In Model 2 we add the firm-specific uncertainty variable. Model 2 shows no support for Hypothesis 1 – firm-specific uncertainty is not significantly related to broadening alliances. Surprisingly, we find strong evidence of a threat-rigidity response in the face of high levels of firm-specific uncertainty (Staw, Sandelands, and Dutton, 1981). That is, firms are less likely to broaden their alliance networks when faced with firm-specific uncertainty. Given that our theory suggests that broadening is most likely when the focal firm is experiencing a high degree of uncertainty alone, we next restricted our analysis to those situations where firms were experiencing high firm-level uncertainty and low market-level uncertainty. We did this by analyzing firms with firm-specific uncertainty above the median but market industry in the lowest quartile for all industries. These are the firms that are most alone in their uncertainty: despite the high firm-specific uncertainty, very few others in their industry were experiencing uncertainty. The results of this analysis are in Model 3. As can be seen in Model 3, the coefficient on the firm-specific uncertainty is positive and significant. This suggests that at the highest levels of firm-specific uncertainty and lowest levels of market uncertainty, firms are reaching out and broadening their alliance networks. But in the vast majority of cases they broaden their network less when faced with firm-specific uncertainty. All-in-all, Hypothesis H1 only applies to extreme circumstances, leading us to reject general support for this hypothesis.

Insert Table 3 about here

Table 4 presents the results of our interlock analyses. We had predicted in H2 that firms broaden their interlock networks in response to firm-specific uncertainty. Model 1 presents the results

for the control variables alone, including a control for market uncertainty. Similar to the alliance results, we find large firms have a higher likelihood of broadening. We also find that firms in the computer industry are less likely to broaden their interlocks than other industries, and firms are less likely to broaden in 1991 and 1992 relative to 1993. We add the firm-specific uncertainty variable in Model 2 but find no significant effect. Similar to Model 2 in Table 3, the coefficient is negative but it is not significant. When we subdivide the sample further into those with firm-specific uncertainty above the median and in industries with the lowest quartile of market uncertainty, there is still no effect for firm-specific uncertainty. Thus, we find no evidence for Hypothesis 2. Firm-specific uncertainty does not appear to lead to broadening in the case of interlock networks.

Insert Table 4 about here

Reinforcing Results

We return to Table 3 to examine the results of our analyses for alliance reinforcing, adding additional alliances with existing alliance partners. Model 4 presents the control variables alone. We find many controls variables to be significant, similar to the broadening analyses. The similar results for broadening and reinforcing suggests that large, central firms in certain industries are more likely to alter their networks by both broadening and reinforcing their network. As in the above analyses, we add the uncertainty variable not hypothesized as a control variable (in this case firm-specific uncertainty) to ensure that our market uncertainty variable has an independent effect. When we include market uncertainty in Table 3, Model 5, we find a strong positive effect. Model 5 shows, in support of Hypothesis 3, that firms experiencing high market uncertainty are likely to reinforce their alliance

network. Thus, independent of firm-specific uncertainty, firms are reinforcing alliances under conditions of high market uncertainty.

In the above analysis, we combined alliances that occur within the industry and alliances that occur outside the industry. According to our theory, we would expect the reinforcing inside the industry to be stronger when there is market uncertainty than reinforcing outside the industry (because firms facing similar market uncertainty are more likely to stick together than firms facing dissimilar levels of market uncertainty). When we break alliances into inside and outside the industry, and analyze the effects of uncertainty on only inside-industry alliances, we find that the effect of uncertainty is stronger within industry (6.92 coefficient; standard error 3.27) than outside industry (5.35 coefficient; standard error 2.69).

Table 4 presents the results for our analyses of interlock reinforcing. Model 3 presents the control variables alone. We find that firms central in the interlock network are more likely to reinforce, perhaps because they have more firms with existing relationships with whom they can reinforce. In addition, utilities companies are more likely to reinforce than firms in other industries, such as banks and aerospace companies. In H4 we had predicted that firms would reinforce their interlock networks in response to market uncertainty. To test this we add market uncertainty in Model 4, and find a strong positive effect. Model 4 shows, in support of Hypothesis 4, that market uncertainty increases the likelihood of interlock reinforcing.

Table 5 presents the results of our analyses for multiplexity (an additional form of reinforcing), where firms add interlocks to existing alliance partners, or alliances to existing interlock partners. Model 1 presents the control variables alone. In H5 we had predicted that firms would increase the multiplexity of their networks in response to market uncertainty. To test this, we add market uncertainty

in Model 2 and find a significant positive effect. Model 2 shows, in support of Hypothesis 5, that firms reinforce their networks under conditions of market uncertainty, forming interlocks with existing alliance partners and vice versa. Taken together, the findings in Tables 3-5 offer strong support for the idea that firms respond to market uncertainty by reinforcing their existing networks, adding interlocks to interlocks, alliances to alliances, and increasing the multiplexity of their networks.

Insert Table 5 about here

In order to address issues of unobserved heterogeneity not captured by our controls, we ran all the earlier-reported models with a lagged dependent variable (broadening or reinforcing). Inclusion of such a variable should also address firm-specific tendencies to broaden or reinforce. Inclusion of the lagged dependent variable did not substantively change the results found here (results available from the authors).

Overall, we find strong evidence across both interlocks and strategic alliances that market uncertainty leads to network reinforcing. When firms are part of an industry facing uncertainty, they respond by creating more relationships with existing partners. We find firms do seem to broaden their alliance networks in response to firm-specific uncertainty in extreme cases, but in all other cases they are less likely to broaden their networks in response to firm-specific uncertainty.

Extension: Does Broadening and Reinforcing Reduce Uncertainty?

Our hypotheses suggest that firms choose to alter their network structure in an attempt to reduce or cope with uncertainty. When firms experience firm-specific uncertainty, they should broaden their network. The theory supporting these hypotheses implies that tie formation is likely to have the

functional value of reducing the local uncertainty the focal firm faces (e.g., Powell, Koput, and Smith-Doerr, 1998; Pfeffer and Salancik, 1978). This occurs as a result of new knowledge and information added through the new relationship. Rarely has this assumption been tested, however, and empirical evidence is scant. The lone exception in organizational research is a study by Das, Sen, and Sengupta (1998). Comparing a symmetric window of 50 days before and after a strategic alliance announcement, they find that firm-specific uncertainty (stock volatility) decreases. However, they do not distinguish between alliances with new partners (broadening), or additional alliances with past partners (reinforcing).

We believe that broadening, an act providing access to new knowledge, is a more effective means for attenuating high firm-specific uncertainty than is reinforcing. In addition, while we did not hypothesize market uncertainty to affect broadening, it is possible that broadening also reduces market uncertainty. New relationships with firms in the same industry reduce market uncertainty to the extent that it creates new opportunities for collective action. Reinforcing relationships, on the other hand, should not reduce either firm-specific or market uncertainty because no new knowledge is obtained and no new possibilities for collective action are created.

We tested the impact of network changes on the firm-specific and market uncertainty in a supplementary analysis. We examined whether broadening or reinforcing reduces firm-specific or market uncertainty. We find significant results in the alliance data but not the interlock data. Forming new alliances tends to result in reductions in firm-specific uncertainty, particularly when firms broaden outside their industry. As we would expect, broadening inside the industry also reduces market uncertainty. Possibilities for collective action are enhanced with these new relationships. In neither instance does reinforcing reduce market uncertainty. Instead, for alliances, reinforcing existing

partnerships actually increases market uncertainty. This is true regardless of whether reinforcing occurs inside or outside the industry. This suggests a cycle whereby firms, when faced with market uncertainty, engage in alliances with those they have prior alliances, which increases market uncertainty.

We report these results as a footnote because firms may act to alter their networks in an attempt to manage or cope with uncertainty, but that does not necessarily mean that the attempt will be successful. In fact, consistent with our findings for reinforcing, there is a fair amount of research suggesting that knowledge is difficult to acquire through network relationships like alliances (Kogut and Zander, 1992; Liebeskind et al., 1996). All that is important for our hypotheses is that firms *believe* reinforcing or broadening their networks will be useful and alter their networks accordingly. In order to fully address the dynamic nature of how this process works – if firms broaden their network in an attempt to reduce uncertainty, and a firm's uncertainty is then reduced as a result of broadening – more detailed analyses are required. We offer our tentative supplementary findings as encouragement for future research.

DISCUSSION

The results of this study provide support for the idea that firms change their networks in response to uncertainty, in ways that are very similar across two very different types of interorganizational relationships. Firms tend to exploit and reinforce their networks when they experience market uncertainty, adding additional interlock and alliance relationships with existing partners. They also tend to explore and broaden their alliance networks when they are experiencing very high degrees of firm-specific uncertainty and low levels of market uncertainty, but they explore less in all other cases. These findings have several implications for change in interorganizational network structures at the macro level. While earlier research on interorganizational networks suggests that firms

are strongly interconnected (e.g., Mintz and Schwartz, 1981), our study casts interorganizational networks in a more dynamic light. To the extent that firms experience market uncertainty, they are more likely to solidify and even balkanize the present network structure. This idea is consistent with Podolny and Phillips (1996), who suggest that market uncertainty causes status hierarchies to become more stratified over time; with high status firms increasing their status more quickly than low status firms.

Our study is the first, to our knowledge, to study two very different types of networks and to hypothesize similar processes occurring in both networks. Doing this helps move us toward a general theory of network transformation which is independent of the specific type of network being studied. Indeed, our results for reinforcing are quite consistent across both interlocks and alliances. Our results for broadening, however, are not. There is no effect of firm-specific uncertainty on interlock broadening, but there is a negative effect on alliance broadening (except in the case of firms facing high firm-specific and low market uncertainty where we find the hypothesized positive effect).

The different effects for interlock and alliance broadening could be due to several factors. First, we have many more alliance events than interlock events, thus potentially making the non-effect in the interlock sample due to insufficient power to detect an effect. The firm-specific uncertainty coefficient is negative for both alliances and interlocks (although it doesn't reach significance for the interlock analysis) suggesting this explanation has merit. Or it could be that interlocks are slower to change than alliances, and our study does not cover a long enough period to detect these changes. We find that reinforcing interlocks occurs at a rate sufficient to detect in our sample, but forming new interlocks may take longer than reinforcing interlocks. Alternately, perhaps our measure market uncertainty, because it is based on a larger number of firms, is a more robust measure of uncertainty than our firm-specific measure. Finally, it could be that the partner motivation for creating a relationship with a firm facing

firm-specific uncertainty is weaker for interlocks than alliances and firms have more difficulty broadening through interlocks; research on alliances as real options suggest clearer benefits for firms to engage in alliances (Kogut, 1991). This highlights the need for more comparative research across different types of network ties, as they may differ in response rates as well as other important characteristics.

Future Research

We need further thought and research to understand why, in the case of alliances, firms broaden less in the face of firm-specific uncertainty except in the extreme cases where they broaden more in response to high firm-specific and very low market uncertainty. These findings might be due to the fact that network change is a two way process. Firms are attempting to establish new relationships with other firms, and those partner firms can accept or reject these overtures. When firms experience high degrees of firm-specific uncertainty, potential partners may reject them. This effect may be caused by a perceived unattractiveness of firms with high levels of firm-specific uncertainty, resulting in difficulty broadening by these firms. The negative main effect for broadening supports this idea: controlling for market uncertainty, firms experiencing firm-specific uncertainty are less likely to broaden. Firms may not be able to find willing partners with whom to broaden. However, firms do broaden when there is high firm-specific and very low market uncertainty, those very situations that partners should be most difficult to find. This argues for a firm-level choice rather than a choice driven by partners. Firms may respond to firm-specific uncertainty with threat-rigidity and not engage in relationship building unless they are in an isolated situation and uncertain position. Perhaps firms chose inaction in the face of firm-specific uncertainty (Staw, Sandelands and Dutton, 1981) unless they are forced into action by the relative instability of their position. This is consistent with the ideas behind problemistic search (Cyert and March, 1963; Greve, 1998).

In addition, future research might profitably consider differential responses to uncertainty by firms of different sizes, or firms having different characteristics. We may have some sample selection bias because of our exclusive focus on large firms, but we believe this bias works against finding results. Das, Sen, and Sengupta's (1998) study of the relationship between a firm's stock volatility (an indicator of firm-specific uncertainty) and strategic alliances formed from 1987 to 1991 shows that that alliances had a strong effect on the stock volatility of smaller firms while having a much weaker effect on their larger alliance partners. This finding is consistent with Barnett (1997) who argues and shows that larger firms have less need to respond to external stimuli. Thus, the influence of uncertainty on network change should be lower for this sample of larger firms, suggesting that we should find less support for our hypotheses.

Implications and Conclusion

The results of this study suggest important extensions to existing work in three areas: (1) organizational learning; (2) network theories, and (3) work on threat-rigidity effects.

First, we used the concepts of broadening and reinforcing, which are similar to those the concepts of exploration and exploitation in organizational learning theories (March, 1991). Our results suggest that firms use their networks primarily as a means to exploit under conditions of market uncertainty. If we consider a firm's network as a knowledge base to be tapped, then firms exploit that knowledge base by forming additional relationships with existing partners. This provides them with a way to utilize existing knowledge more effectively. Firms explore new knowledge by forming new relationships with new partners, essentially expanding the knowledge represented in their network. We find limited evidence firms do this when faced with high firm-specific uncertainty and low market uncertainty. This supports the now well-established idea that networks affect information and

knowledge.

Our study also contributes to network research by investigating factors that cause networks to change. What we add is the idea that partnering choices are contingent on the type of uncertainty that firms face. Furthermore, we find that by distinguishing between the uncertainty that a firm and an industry face, we can better understand whether network change serves as a means of alleviating uncertainty. Firms attempt to manage the uncertainty in their networks by modifying their ego-centric network. While some past research implies that creating new network partnerships should reduce a firm's uncertainty, there have been few attempts to empirically test the assumption. Our study addresses whether network change is an effective strategic response to uncertainty. Our findings suggest that broadening attenuates the level of uncertainty a firm faces. Firms that create new alliances in response to firm-specific uncertainty experience less firm-specific uncertainty as a result.

In addition, our study is one of the few to attempt to test a theory of interorganizational network dynamics using two types of relationships. The robustness of our findings across alliances and interlocks gives us a validation for our market uncertainty hypotheses that is rare in the empirical study of interorganizational networks. It is our hope that this study encourages other scholars to consider and test theoretical understanding that are independent of the type of relationship, or at least properly understand the scope of evidence using a single type of interorganizational tie.

We also contribute to network research through our exploration of the effects of uncertainty on relationship multiplexity. While there has been much discussion of relationship multiplexity as a concept (Wasserman and Faust, 1994), there has been little work on what causes multiplexity to occur. We show that it occurs under conditions of market uncertainty. This demonstrates the power of uncertainty to affect multiple forms of interfirm relationships.

Our work fits with existing work on threat-rigidity and the stability of social structure. We find that market uncertainty leads firms to reinforce their existing networks, and firm-specific uncertainty (with the noted extreme exception) leads firms to reduce their broadening. Reinforcing ties, however, does not affect the level of market uncertainty that a firm faces. Firms that create additional ties with existing partners will not experience any reduction in the uncertainty they face. Ironically, this is the strategy most firms seem to adopt. When faced with market uncertainty, firms are more likely to reinforce their networks and restrain from broadening. Although establishing new ties appears to be an effective strategy for reducing firm-specific uncertainty, firms only do so in extreme circumstances (when faced with high firm-specific uncertainty and very low market uncertainty).

Finally, our study contributes to the increasingly large body of work on network change and network dynamics. We show that the direction of change can be affected by firm level and environmental level uncertainty, and thus help reconcile large bodies of work showing that networks sometimes change, and sometimes are stable. This presents new opportunities for theory development and demonstrates the importance of uncertainty on network structure.

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[1] Although nonsystematic risk includes risk associated with a particular industry, we focus our concept more narrowly on the firm.

[2] Kogut focuses on market uncertainty alone. However, we use this logic to explain why firms would partner with others facing both firm-specific and market uncertainty.

[3] Systematic risk in the finance literature focuses on the entire economy, whereas we focus on the uncertainty of a given industry.

[4] Other measures of uncertainty may in some ways be more sophisticated than the price volatility measures that we have chosen to examine. Beta, for example, measures a firm's sensitivity to the market and volatility relative to other firms in the market. Theoretically, however, beta confuses the very two concepts that we were trying to untangle because beta includes both firm and market uncertainty as components. When we included beta in the analyses, the results we report below did not change, so we decided to use a simpler measure of uncertainty that captured more accurately the concepts we were trying to measure.

[5] For all analyses, the significance of the hypothesized effects is the same, regardless of whether one or both uncertainty variables are in the model.

Table 1 Descriptive Statistics and Correlations for Alliance Variables (N=1470)

Variable	Mean	S.D.	Min.	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Broadening	1.82	4.65	0	61	1.00																	
2. Reinforcing	0.45	2.41	0	50	0.72 *	1.00																
3. Multiplex Reinforcing	0.03	0.19	0	3	0.17 *	0.21 *	1.00															
4. (Log) Assets	8.94	1.22	1.79	12.35	0.21 *	0.18 *	0.09 *	1.00														
5. Adjusted ROA	0	5.35	-74.13	56.22	-0.02	-0.06 *	0.00	-0.07 *	1.00													
6. Prior Alliances (0)	0.55	0.50	0	1	-0.31 *	-0.19 *	-0.12 *	-0.18 *	0.04	1.00												
7. Prior Alliances (1-2)	0.23	0.42	0	1	-0.04	-0.08 *	-0.02	0.01	0.01	-0.59 *	1.00											
8. Prior Alliances (3-15)	0.18	0.38	0	1	0.21 *	0.06 *	0.09 *	0.13 *	-0.03	-0.51 *	-0.25 *	1.00										
9. Prior Alliances (16 or more)	0.05	0.21	0	1	0.43 *	0.50 *	0.17 *	0.17 *	-0.05 *	-0.25 *	-0.12 *	-0.11 *	1.00									
10. Industry: Computers	0.04	0.19	0	1	0.37 *	0.34 *	0.03	-0.05 *	-0.06 *	-0.09 *	-0.06 *	0.08 *	0.21 *	1.00								
11. Industry: Bank	0.05	0.22	0	1	-0.06 *	-0.04	0.00	0.37 *	-0.02	0.06 *	0.01	-0.06 *	-0.04	-0.05	1.00							
12. Industry: Aerospace	0.04	0.20	0	1	0.03	-0.02	0.05	-0.02	0.01	-0.07 *	-0.03	0.10 *	0.03	-0.04	-0.05	1.00						
13. Industry: Electronics	0.06	0.23	0	1	0.10 *	0.10 *	0.06 *	-0.03	0.07 *	-0.11 *	0.03	0.03	0.15 *	-0.05	-0.06 *	-0.05	1.00					
14. Industry: Photo	0.01	0.12	0	1	0.04	0.00	0.14 *	0.07 *	0.00	-0.12 *	0.06 *	0.05 *	0.06 *	-0.02	-0.03	-0.03	-0.03	1.00				
15. Industry: Chemicals	0.08	0.27	0	1	0.02	-0.04	0.01	-0.09 *	-0.03	-0.10 *	0.03	0.11 *	-0.02	-0.06 *	-0.07 *	-0.06 *	-0.07 *	-0.04	1.00			
16. Industry: Pharmaceuticals	0.04	0.19	0	1	0.01	-0.01	-0.01	-0.03	0.25 *	-0.17 *	0.07 *	0.15 *	-0.01	-0.04	-0.05	-0.04	-0.05	-0.02	-0.06 *	1.00		
17. Market Uncertainty	0.10	0.03	0.03	0.22	0.20 *	0.21 *	0.05	0.00	-0.11 *	-0.04	0.01	-0.01	0.08 *	0.43 *	0.16 *	-0.06	-0.10 *	-0.32 *	0.05 *	0.05 *	-0.16	1
18. Firm-specific Uncertainty	0.10	0.06	0.02	0.80	0.01	0.04	0.01	-0.07 *	-0.24 *	0.02	-0.02	-0.02	0.02	0.21 *	0.08 *	-0.01	-0.04	-0.06 *	-0.02	-0.05	0.48 *	1.00

* p<.05

Table 2 Descriptive Statistics and Correlations for Interlock Variables (N=720)

Variable	Mean	S.D.	Min.	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Reinforcing	0.16	0.55	0	5	1.00														
2. Broadening	2.87	3.25	0	38	0.21 *	1.00													
3. (Log) Assets	9.03	1.15	6.51	12.29	0.06	0.17 *	1.00												
4. Adjusted ROA	0	4.61	-25.36	21.91	-0.03	-0.07 *	-0.17 *	1.00											
5. Centrality	14.54	8.22	0	50	0.12 *	0.13 *	0.37 *	-0.02	1.00										
6. # of Prior acquisitions	1.56	0.86	0	3.99	0.03	-0.04	0.31 *	-0.01	0.24 *	1.00									
7. Industry: Service	0.05	0.22	0	1	0.02	-0.05	-0.13 *	0.08 *	-0.11 *	0.06	1.00								
8. Industry: Chemicals	0.08	0.27	0	1	0.10 *	-0.03	-0.16 *	-0.17 *	0.04	0.05	-0.07	1.00							
9. Industry: Utilities	0.07	0.26	0	1	0.11 *	0.10 *	0.21 *	-0.01	0.08 *	-0.02	-0.06	-0.08 *	1.00						
10. Industry: Computers	0.04	0.19	0	1	-0.06	-0.10 *	-0.04	-0.04	-0.10 *	0.05	-0.05	-0.06	-0.05	1.00					
11. Year 1991	0.33	0.47	0	1	0.03	-0.03	-0.02	0.11 *	0.08 *	0.04	0.00	0.00	0.00	0.00	1.00				
12. Year 1992	0.33	0.47	0	1	0.02	-0.10 *	0.00	-0.08 *	-0.05	0.09 *	0.00	0.00	0.00	0.00	-0.50 *	1.00			
13. Year 1993	0.33	0.47	0	1	-0.05	0.13 *	0.02	-0.02	-0.02	-0.13 *	0.00	0.00	0.00	0.00	-0.50 *	-0.50 *	1.00		
14. Market Uncertainty	0.10	0.03	0.03	0.23	0.04	-0.05	0.02	0.02	-0.03	0.01	-0.08 *	0.08	-0.28 *	0.45 *	0.41 *	-0.05	-0.37 *	1.00	
15. Firm-specific Uncertainty	0.10	0.05	0.02	0.51	-0.03	-0.06	-0.05	-0.14 *	-0.05	-0.06	-0.05	0.04	-0.16 *	0.25 *	0.23* *	-0.03	-0.21 *	0.52 *	1.00

* p<.05

Table 3 Random-Effects Negative Binomial Regression Models for the Effects of Firm-Specific and Market Uncertainty on Alliance Broadening and Reinforcing·

	Alliance Broadening			Alliance Reinforcing	
Variable	Model 1	Model 2	Model 3 ··	Model 4	Model 5
Firm-specific Uncertainty		**-1.504** **	**9.602** **	1.425	0.858
		(0.708)	**(3.887)**	(1.128)	(1.180)
Market Uncertainty	-0.446	0.016	32.842		**6.460** **
	(1.678)	(1.665)	(23.231)		**(2.304)**
Controls:					
(Log) Assets	0.274 **	0.265 **	-0.096	0.593 **	0.604 **
	(0.045)	(0.045)	(0.156)	(0.087)	(0.088)
Adjusted ROA	0.006	0.002	-0.063	-0.022 **	-0.020
	(0.007)	(0.008)	(0.049)	(0.011)	(0.011)
Prior Alliances (0)	-1.450 **	-1.433 **	-2.038 **	-3.266 **	-3.212 **
	(0.292)	(0.310)	(0.497)	(0.308)	(0.312)
Prior Alliances (1-2)	-0.783 **	-0.767 **	-0.272	-2.165 **	-2.114 **
	(0.212)	(0.222)	(0.563)	(0.261)	(0.266)
Prior Alliances (3-15)	-0.211	-0.207	-0.292	-0.875 **	-0.775 **
	(0.137)	(0.140)	(0.473)	(0.161)	(0.168)
Industry Controls:					
Computers	1.024 **	1.131 **		1.442 **	1.106 **
	(0.230)	(0.235)		0.324	(0.361)
Bank	-0.961 **	-0.914 **		-2.765 **	-2.987 **
	(0.272)	(0.273)		(1.042)	(1.048)
Electronics	0.691 **	0.702 **	1.182	1.375 **	1.390 **
	(0.184)	(0.186)	(0.799)	(0.289)	(0.292)
Pharmaceuticals	0.361	0.366	2.537 **	1.012 **	1.038 **
	(0.230)	(0.230)	(0.671)	(0.377)	(0.380)
Year Controls:					
Year 1988	-1.335 **	-1.392 **	-1.945 **		
	(0.174)	(0.178)	(0.495)		
Year 1989	0.009	-0.022	-0.415		
	(0.121)	(0.123)	(0.455)		
Year 1991	-0.475 **	-0.506 **	-1.586 **		
	(0.106)	(0.107)	(0.459)		
Year 1992	-0.539 **	-0.576 **	-2.373 **		
	(0.107)	(0.108)	(0.459)		
Constant	-1.473 **	-1.279 *	7.296	-5.741 **	-6.388 **
	(0.520)	(0.529)	(37.304)	(0.916)	(0.955)
Log Likelihood	-2035.18	-2032.78	-80.27	-637.70	-634.00
Chi-Square	340.23	345.30	135.66	304.59	319.77
df	13	14	12	9	10
# of Obs.	1470	1470	101	1470	1470

*p< .05, **p< .01; one-tailed test for hypothesized effects.

· Unstandardized coefficients are reported. Standard errors in parentheses.

Table 4 Random-Effects Negative Binomial Regression Models for the Effects of Firm-Specific and Market Uncertainty on Interlock Broadening and Reinforcing·

	Interlock Broadening				Interlock Reinforcing			
Variable	Model 1		Model 2		Model 3		Model 4	
Firm-specific Uncertainty			**-0.429**		1.081		-1.890	
			(0.733)		(2.285)		(2.532)	
Market Uncertainty	2.315		2.523				**15.111**	**
	(1.585)		(1.622)				**(4.408)**	
Controls:								
(Log) Assets	0.110	**	0.109	*	0.070		-0.010	
	(0.046)		(0.046)		(0.127)		(0.128)	
Adjusted ROA	-0.004		-0.005		-0.007		-0.017	
	(0.009)		(0.009)		(0.029)		(0.029)	
Centrality	-0.002		-0.002		0.041	**	0.043	**
	(0.006)		(0.006)		(0.015)		(0.015)	
# of prior acquisitions	0.019		0.017		-0.043		-0.017	
	(0.054)		(0.054)		(0.150)		(0.149)	
Industry Controls:								
Service	-0.091		-0.093		0.825		0.992	*
	(0.215)		(0.215)		(0.500)		(0.506)	
Chemicals	0.034		0.031		0.711		0.532	
	(0.175)		(0.175)		(0.410)		(0.417)	
Utilities	0.382		0.377	*	0.933	*	1.444	**
	(0.175)		(0.175)		(0.380)		(0.421)	
Computers	-0.789	*	-0.781	**	-24.189		-24.947	
	(0.294)		(0.295)		(112511)		(99240)	
Year 1991	-0.350	**	-0.341	**				
	(0.089)		(0.090)					
Year 1992	-0.483	**	-0.480	**				
	(0.076)		(0.076)					
Constant	0.529		0.559		-2.378	*	-2.941	**
	(0.421)		(0.424)		(1.175)		(1.167)	
Log Likelihood	-1499.23		-1499.05		-307.92		-302.39	
Chi-Square	67.83		68.14		21.69		32.91	
df	10		11		10		11	
# of Obs.	720		720		720		720	

*p< .05, **p< .01; one-tailed test for hypothesized effects.

· Unstandardized coefficients are reported. Standard errors in parentheses.

Table 5 Random-Effects Negative Binomial Regression Models for the Effects of Market Uncertainty on Alliance-Interlock Multiplexity·

Variable	Model 1		Model 2	
Firm-specific Uncertainty	3.376		1.803	
	(2.984)		(3.399)	
Market Uncertainty			**11.473**	*
			(6.743)	
Controls:				
(Log) Assets	0.312	*	0.288	
	(0.161)		(0.159)	
Adjusted ROA	0.055		0.055	
	(0.038)		(0.040)	
Prior Alliances (0)	-2.972	**	-2.989	**
	(0.665)		(0.677)	
Prior Alliances (1-2)	-1.877	**	-1.933	**
	(0.609)		(0.624)	
Prior Alliances (3-15)	-0.651		-0.647	
	(0.457)		(0.468)	
Industry Controls:				
Computers	-0.239		-1.057	
	(0.786)		(0.936)	
Bank	0.059		-0.235	
	(0.818)		(0.837)	
Electronics	0.573		0.596	
	(0.505)		(0.511)	
Pharmaceuticals	-0.879		-0.825	
	(1.080)		(1.088)	
Constant	-4.221	*	-4.907	**
	(1.864)		(1.900)	
Log Likelihood	-144.95		-143.57	
Chi-Square	46.14		50.06	
df	9		10	
# of Obs.	1470		1470	

*p< .05, **p< .01; one-tailed test for hypothesized effects.

· Unstandardized coefficients are reported. Standard errors in parentheses.