Interlocks and Firm Performance: The Role of Uncertainty in the Directorate Interlock-Performance Relationship

Geoffrey P Martin, Dr, Melbourne Business School
Remzi Gozubuyuk, Dr
Manuel Becerra, Dr

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ABSTRACT

We examine how uncertainty influences the performance effects of directorate interlocks. Our study offers a new perspective of directorate interlocks as mechanisms that enable firms to improve performance when confronted with greater uncertainty, suggesting that uncertainty positively moderates the interlock-performance relationship. This contrasts with the view based on resource dependence theory suggesting networks reduce uncertainty and enhance firm performance, implying that uncertainty mediates the interlock effect upon performance. Using a sample of 3,745 firms across manufacturing industries in U.S. during the period 2001 to 2009, we find support for the moderation argument and less convincing support for mediation, suggesting that firms may not form interlocks necessarily to reduce uncertainty. Instead, firms may create interlocks to enable adaptation and enhance performance when confronted by uncertainty.

Keywords: directorate interlock, performance, uncertainty, networks, resource dependence
INTRODUCTION

Drawing upon resource dependence theory (Pfeffer and Salancik, 1978), empirical research in strategy and organization theory shows that firms respond to uncertainty by developing or reinforcing networks, such as directorate interlocks (i.e., the network of firms a director is appointed by), in order to avoid uncertainty’s potential negative performance effects (Beckman, Haunschild, and Phillips, 2004; Boyd, 1990; Pfeffer, 1972; Podolny, 1994). This research literature is generally based on the idea that interlocks enhance performance through reducing uncertainty. However, a review of the cumulative results of empirical research examining the relationship between interlocks and firm performance reveals inconclusive findings (Peng, 2004). Mizruchi’s (1996) lament – more than 15 years ago – regarding the dearth of empirical testing and the need for novel theoretical explanations of interlocks’ influence upon firm performance remains valid today (Mizruchi, 1996; Peng, 2004). Thus, our understanding of the mechanisms through which directorate interlocks influence firm performance – and especially the role of uncertainty in that relationship – remains under-developed.

Uncertainty is generally defined as the difficulty in predicting future outcomes (Beckman et al., 2004) or, more precisely for organizational studies, the inability to predict firm performance (Milliken, 1987). Beckman et al. (2004) note that uncertainty may be: (1) firm-specific and therefore unique to the firm; or (2) market related, affecting a group of firms. In addition, uncertainty could originate from the firm’s interface with its environment or market and still be unique to the firm, which could be described as a combination of firm and market uncertainty. We seek to understand how the level of uncertainty – originating from any of these three sources – affects the presumed link between directorate interlocks and firm performance. More specifically, we investigate interlocks as mechanisms for dealing with uncertainty in two different ways: (1) as a mechanism for reducing uncertainty, which is consistent with resource
dependence theory; and (2) as a mechanism for enabling firm adaptation to enhance performance when confronted with uncertainty. The first perspective is actually a mediation argument, suggesting that interlocks reduce uncertainty, which in turn enhances firm performance. This view is consistent with much of the existing literature maintaining that centrality and structural holes in the focal firm’s network reduces uncertainty through providing information and control that enhances the firm’s ability to predict future events (Beckman et al., 2004; Podolny, 1994, 2001). In contrast to this traditional perspective, we submit that uncertainty may also positively moderate the relationship between directorate interlocks and firm performance. This subtle but important change in explaining causality suggests that firms’ interlocking networks are more beneficial when uncertainty is present, even if interlocks do not actually reduce such uncertainty. That is, the benefits associated with the structural holes and centrality in interlock networks, such as information, enhanced capabilities, and learning (Gulati, 1999; Podolny, 2001; Zaheer and Bell, 2005), will be more useful when firms are confronted with greater uncertainty, but they are not necessarily intended to reduce it. This is the key idea that we develop and test in our study and which we maintain will apply to any source of uncertainty; that is, any source making firm performance more volatile and difficult to predict.

We empirically analyze both theoretical arguments regarding the role of uncertainty in the presumed link between directorate interlocks and firm performance – mediation and moderation – using a sample of 3,745 firms across manufacturing industries in the US during the period 2001 to 2009. We find strong support for our prediction that the relationship between network position (i.e., structural holes and degree centrality of directorate interlocks) and performance is positively moderated by uncertainty. Interlocks have a more positive performance effect in the presence of higher uncertainty. In contrast, we find only very weak support for the
hypothesis that director networks reduce uncertainty, which we operationalize as variability in actual or expected firm performance. These results challenge previous research arguing interlock benefits arise from uncertainty reduction (Haunschild and Beckman, 1998; Mizruchi, 1996).

Our empirical findings make three important contributions to the networks literature. First, we suggest a new causal relationship among directorate interlocks, uncertainty, and performance. Our findings that: (1) uncertainty positively interacts with networks to influence performance; and (2) directorate interlocks’ uncertainty reduction effect is very weak or non-existent, suggest that firms may form linkages through strategically adding directors not so much to reduce uncertainty, but to improve their capacity to deal with uncertainty through leveraging network (interlock) resources. For example, when one firm acquires another firm (Haunschild, 1994) or enters new markets (Greve, 1996), a director’s networks may enhance the performance of those strategies not because it reduces the uncertainty associated with those actions, but because the firm is better positioned to benefit when confronted by such uncertainties. Thus, networks facilitate adaptation that enhances performance when confronted with uncertainty, which may result from the firm’s own strategic actions or broader market factors, such as pending changes in technology or regulation.

Second, our results suggest an explanation for the previous equivocal findings regarding the effect of director networks upon performance. Previous mixed findings regarding the relationship between directorate interlocks and performance may be due to the failure to consider the critical moderating role of uncertainty (Burt, 1983; Fligstein and Brantley, 1992; Pennings, 1980). Our results show that the effect of interlocks on performance depends crucially upon the degree of uncertainty confronting the firm. In fact, we find no effect of networks on performance for low levels of uncertainty. Thus, to understand the performance implications of interlocks, it is
necessary to consider the degree to which a firm can actually leverage the potential benefits of interlocks, which is contingent on the degree of uncertainty that a firm faces. This underlines the fact that one can have access to, but not necessarily utilize, valuable resources.

Finally, we contribute to the directorate interlock literature by providing new empirical evidence that confirms the relationship between interlocks and firm performance with more rigorous methodology. Earlier cross-sectional studies of this relationship are open to the criticisms of reverse causality (i.e., better performing firms may have more opportunities for creating interlocks) and omitted variable bias (Mizruchi, 1996; Nicholson and Kiel, 2007). To account for these possible threats to the validity of the interlock-performance relationship, we utilize a longitudinal research design and instrumental variables to control for endogeneity of the network position. In sum, we are able to offer a theoretical explanation for and empirically show that interlocks have clear performance consequences, moderated by uncertainty.

**THEORY AND HYPOTHESES**

The conceptualization of uncertainty used by management scholars can be traced to Knight’s (1921) seminal definition of uncertainty as a situation where probabilities regarding possible future outcomes are unknown. Later definitions of uncertainty in business settings have converged around the limited predictability of future outcomes (Beckman *et al.*, 2004; Daft, Sormunen, and Parks, 1988; Duncan, 1972; Hoffman, 2007; Milliken, 1987). The literature has also sought to distinguish between different types of uncertainty in management. For example, one can distinguish between: (1) the uncertainty experienced by the focal firm (or ego) in resource allocation and market decisions (egocentric uncertainty), and (2) the uncertainty of a firm’s alters – or the focal firm’s consumers and alliance partners – regarding the future actions and output of the focal firm (alter-centric uncertainty) (Podolny, 2001). More recently, Beckman
and colleagues (2004) have categorized uncertainty as either: (1) firm-specific uncertainty – that which is unique to the firm; or (2) market uncertainty – affecting a broad set of firms (Beckman et al., 2004). The first type is internal to the firm (or firm-specific). For example, a firm may experience turnover in the top management team, creating uncertainty with regard to their ability to successfully replace the outgoing executive. The second type described by Beckman and colleagues (2004) derives from the environment more broadly and includes uncertainty created by macro-economic or political factors that affects all firms; for example, all firms will experience some degree of uncertainty regarding future shocks to the economy, given the difficulty in predicting how those shocks may affect future demand for their products or services. Combining the two sources of uncertainty referred to by Beckman and colleagues (2004), it is possible to also conceive of a third type of uncertainty that emerges from the firm’s interface with its environment. This uncertainty is a result of exchange and competitive relationships with other organizations, as stressed by resource-dependence theorists (Pfeffer and Salancik, 1978) and combines elements of Beckman and colleagues’ (2004) firm-specific and market uncertainty. As an example, this third type could include a supply disruption, creating uncertainty as to how the firm will source its production inputs in the future.

We make our theoretical arguments, exploring the role of uncertainty in the relationship between networks (established by directorate interlocks) and performance, regardless of whether the source of uncertainty is the firm itself, its interface with the market, or the broader market factors. Events associated with any of these three sources of uncertainty will have an effect on the predictability of firm outcomes (i.e., variability in firm performance) and are therefore relevant to our hypotheses regarding the role of uncertainty in understanding the performance

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1 We thank an anonymous reviewer for elucidating this third type of uncertainty that builds upon the two types of uncertainty – firm-specific and market – previously described by Beckman et al. (2004).
benefit of directorate interlocks.

**Interlocks as Mechanisms for Reducing Uncertainty**

First, we examine how uncertainty may mediate the relationship between directorate interlocks and firm performance. Thus, we explore the influence of: (1) directorate interlocks upon uncertainty; and (2) uncertainty upon performance.

*Directorate interlocks and uncertainty.* Uncertainty has been a central construct in the study of interorganizational relationships. Thompson (1967) maintained that an organization’s technical core needs to be protected from environmental uncertainty to function effectively. According to this view, uncertainty is a product of conflict and interdependence, implying that uncertainty is reduced through managing and mitigating interdependence, as described below:

When situations of exchange and competition are uncertain and problematic, organizations attempt to establish linkage with elements in their environment and use these linkages to access resources, to stabilize outcomes, and to avert environmental control. (Pfeffer and Salancik, 1978: 144, emphasis added)

One example of interorganizational linkages that may reduce uncertainty is interlocking directorates. Interlock linkages provide four benefits to organizations from this perspective. First, they provide information about the activities of the other organization that may be crucial for the focal organization, e.g., strategic plans and cost and price structure (Baum and Ingram, 2003; Boyd, 1990; Galbraith, 1973; Haunschild, 1994; Podolny, 2001). Second, they provide an opportunity to communicate information from the focal firm to the partner firm; for instance, a banker sitting in the board of a company will be very easily informed about the financial needs of the company (Boyd, 1990; Selznick, 1957). Third, interlock linkages facilitate coopting the other organization (Thompson, 1967). The board member from another company will be exposed to the problems and viewpoints of the focal organization and will be more likely to identify with the organization, becoming a natural ally and committing to the organization’s perspective and
problems (Thompson, 1967). Finally, interorganizational linkages create legitimacy for the focal organization by integrating the organization with its environment (Podolny, 1994). Through these four factors, linkages stabilize outcomes by reducing uncertainty that stems from the behavior of other organizations that the focal organization depends on, as emphasized within resource-dependence theory.

The uncertainty reduction effect of network linkages is also likely to be effective regardless of the type of uncertainty in question. For example, linkages are likely to reduce uncertainty generated from within the firm, such as through providing information that may assist the firm in launching new products. Similarly, linkages can reduce uncertainty associated with broader market factors, such as future changes in industry regulations, by providing some degree of control over the regulation setting process. That is, drawing upon resource dependence theory, linkages such as interlocks are likely to be effective in reducing uncertainty confronted by the firm stemming from a wide range of sources, regardless of whether they are created by the firm, the environment, or the firm/environment interaction.

More recently, Hoffmann (2007) has suggested that firms may follow three alternative strategies in dealing with uncertainty: (1) shaping the environmental changes to align with firm strategy (shaping strategy); (2) stabilizing the environment in order to avoid organizational change (stabilizing strategy); and (3) adapting to the changes in the environment (adapting strategy). In contrast to the adapting strategies that we analyze later, organizations often follow shaping or stabilizing strategies in order to “actively reduce environmental uncertainty and influence how the environment evolves by developing and deploying their resource base in a focused manner” (Hoffman, 2007: 831-2, emphasis added). This claim is consistent with the view that organizations attempt to coopt and control other organizations, often through their
interlocks, to neutralize changes in their environment and thus align them with their own strategy.

Previous research has explored the development of networks and interlocks (the latter as a subset of the former) in response to uncertainty from this resource dependence perspective (Beckman et al., 2004). In this sense, there is some evidence of the uncertainty reduction effect of networks from case studies (Asanuma, 1985; Dore, 1983; Gerlach, 1992; Smitka, 1991; Uzzi, 1997). For example, Uzzi (1997) explained how downstream firms in embedded relationships are likely to inform their suppliers of an expected decline in future demand, which enhances forecasting accuracy and improves the predictability of business cycles. Yet, to our knowledge, the effect of networks upon overall uncertainty facing a firm has not been examined in detail and corroborated statistically, though the existing literature usually implies this connection.

Based upon this perspective, let us explore how two critical aspects of a firm’s network of directorate interlocks (i.e., centrality and structural holes) are likely to reduce uncertainty:

**Centrality.** Network centrality refers to a central position within network relationships (Freeman, 1979; Wasserman and Faust, 1994). A central position in the directorate network should enable reduced dependence upon the firm’s surrounding environment and mitigate the negative consequences of the changes that may adversely affect its technical core (Thompson, 1967). More specifically, higher levels of centrality allow the firm to access more information (Ahuja, 2000). The information gained from a central position in the interlock network should make it easier for the firm to anticipate future events related to the general market or at the firm’s interface with its environment more accurately and shape them, thus reducing the volatility of its future performance. Similarly, a central position in the interlocking network also allows the firm to convey information to its partners, improving the coordination of its activities with other
organizations – such as, suppliers, customers, and competitors – in order to reduce possible fluctuations in resource requirements, demand, and prices, which are major sources of uncertainty for the firm (Ahuja, 2000).

In sum, the information, communication, and coordination benefits of network centrality enhance a firm’s ability to shape or stabilize the environment. Thus, this reasoning, based on resource dependence, suggests that centrality in the interlocking directorates network will reduce the level of uncertainty that firms face, making their performance less volatile and relatively more predictable.

_Hypothesis 1: Centrality in interlocking directorate networks is negatively related to uncertainty._

*Structural holes.* Structural holes refer to the lack of ties between different parts of a network, reflecting the degree of redundancy in social networks (Burt, 1992). If all nodes of a network are directly connected, information exchange can become circular and information to which an actor has access will lack diversity. An ego-network rich in structural holes provides two benefits: information and control (Podolny, 2001).

Information benefits suggest access to diverse and timely information as well as access to referrals (Burt, 1992). This information reduces firm uncertainty regarding how best to combine resources and realize market opportunities (Podolny, 2001). Control stems from the central actor being _tertius gaudens_ or “the third who benefits” (Simmel, 1923). There are two _tertius_ strategies: “being the third between two or more players after the same relationship, and being the third between players in two or more relations with conflicting demands” (Burt, 1992: 31). Firms may achieve power through their structural position following either of these two _tertius_ strategies that allow them to exert control over other organizations (Burt, 2004). For example, a firm whose managers sit on the board of two different banks may play one against the other in
order to guarantee a steady flow of financial capital for a certain duration and with better conditions, especially if the bankers are not in communication and therefore cannot coordinate with each other. In this situation, the focal firm is coopting two organizations, which cannot coopt each other due to a lack of direct relationship. This structural position of tertius gaudens helps the firm to achieve a steady stream of inputs into the firm that should reduce uncertainty that stems from the firm’s dependence on these inputs.

In sum, structural holes and the associated information, power, and control over future outcomes reduces uncertainty through narrowing the range of possible firm outcomes by shaping and stabilizing the environment. Thus:

_Hypothesis 2: structural holes in interlocking directorate networks are negatively related to uncertainty._

_Uncertainty and performance._ The negative relationship between uncertainty and firm performance is well established in strategy and organization theory, both theoretically and empirically. In order to function efficiently, every organization needs to be able to predict resources and demand, and plan accordingly. Unpredictable changes in input and output make this task very difficult. For example, unpredictable supply for manufacturers reduces their ability to forward plan production and guarantee satisfaction of future demand, leading to additional costs and/or foregone revenue.

In a related stream of research, empirical findings support a negative relationship between risk and return in strategic management (Andersen, Denrell, and Bettis, 2007; Bowman, 1980; Bromiley, 1991; Henkel, 2009). Though Knight (1921) had originally differentiated between risk and uncertainty on the basis that risk is associated with a known probability distribution while uncertainty is not, risk and uncertainty have come to be used interchangeably by risk scholars (Bettis, 1982; Bromiley, Miller, and Rau, 2001; Ruefli, Collins, and Lacugna,
1999). Some concerns have been raised about the observed negative risk-return relationship in extant research, particularly regarding an identification problem (Ruefli et al., 1999), but the negative risk-return correlation seems robust, even after controlling for methodological concerns (Henkel, 2009). Thus, regarding the second leg of our mediation argument:

_Hypothesis 3: Uncertainty is negatively related to firm performance._

**Interlocks as Mechanisms for Adapting When Confronted by Uncertainty**

We now turn to the moderating effect of uncertainty upon the interlock-performance relationship, which constitutes the main focus of our paper. First, we develop hypotheses for the main effects of directorate interlocks (that is, director network centrality and structural holes) on firm performance. Later, we analyze how uncertainty moderates these relationships.

*Directorate interlocks and performance.* Different types of network studies have shown a positive relationship between a favorable position in interorganizational networks and firm performance (Baum and Oliver, 1992; Collins and Clark, 2003; Dyer, 1996; Podolny, 1993; Powell, et al., 1999; McEvily and Marcus, 2005; Zaheer and Bell, 2005). This relationship has been corroborated in alliance networks (Ahuja, 2000), interpersonal managerial networks (Uzzi, 1997), and venture capital syndicates (Hochberg, Ljungqvist, and Lu, 2005).

Though the theoretical arguments and empirical findings regarding the performance effects of networks should also apply to directorate interlocks, studies examining the performance effect of directorate interlocks have been few and yielded equivocal results. For example, some studies of the performance effect of interlocks have shown the relationship to be small yet positive (Burt, 1983; Carrington, 1981; Pennings, 1980), with only Carrington (1981) showing a strong and unequivocal positive relationship. To the contrary, other studies have shown a negative association between interlocks and performance (Fligstein and Brantley, 1992) and
there is also evidence that unprofitable firms are more likely to form interlocks (Boeker and Goodstein, 1991; Dooley, 1969; Mizruchi and Stearns, 1988; Richardson, 1987).

A positive relationship between interorganizational networks and firm performance has been explained using theories of network enabled capabilities and networks as external resources (Gnyawali and Madhavan, 2001; Gulati, Nohria, and Zaheer, 2005; McEvily and Marcus, 2005; Zaheer and Bell, 2005), though it has not received strong support in the context of directorate interlocks (Mizruchi, 1996; Peng, 2004). We now briefly explain how network centrality and structural holes with respect to a firm’s director networks may positively affect firm performance. We do not develop these hypotheses in greater depth as they have been widely examined in the networks literature.

**Centrality and performance.** Firms that are central in interlocking directorate networks will have access to more information (Useem, 1984). The information provided by network centrality is posited to facilitate transfer of best practices (Davis, 1991; Shipilov, Greve, and Rowley, 2010) and learning (Beckman and Haunschild, 2002); both best practices and learning enhance the firm’s performance prospects directly. The information provided by a central position has also been referred to as external resources that are likely to enhance firm performance or enable capabilities that in turn enhance firm performance (Gulati, 1999; Zaheer and Bell, 2005). Thus:

*Hypothesis 4: Firm centrality in interlocking directorates is positively related to firm performance.*

**Structural holes and performance.** While centrality increases the volume of information, it does not guarantee that this information will be diverse. If all the contacts of a focal organization are connected to each other, the different contacts will be redundant as information sources (Burt, 1992). In contrast, a network with more structural holes will give the firm access
to diverse information (Podolny, 2001). The firm will have the opportunity to consider multiple perspectives when making a decision and will more likely be informed regarding pitfalls of the options. Thus:

_Hypothesis 5: Structural holes of a firm in interlocking directorates are positively related to firm performance._

_Interlock benefits contingent upon uncertainty._ The two hypotheses above claim that board interlocks have positive implications for firm performance without having considered yet the role of uncertainty confronting the firm. Let us now focus on the moderating effect of uncertainty on the positive performance effect of directorate interlocks and why greater uncertainty may enhance the positive performance effects.

Clearly, directorate interlocks and networks provide access to external resources (Boyd, 1990; Gulati, 1999; Zaheer and Bell, 2005). We submit that the performance benefits of these network resources will be enhanced when the firm is confronted with greater uncertainty. The director networks provide resources through access to information, such as impending environmental change (enabling environmental scanning capabilities) and details regarding how that information can be interpreted (Boyd, 1990; Useem, 1984). This view is consistent with Hoffman’s (2007: 832) description of benefits of alliance networks through an “adaptive strategy,” where the firm will “strategically adapt to unpredictable environmental developments by using their alliance portfolios to quickly and flexibly access different kinds of resources.” Thus, the information based resources provided by networks can enable adaptation that provides performance benefits to the firm.

According to the moderation argument, the goal of forming interlocks may not only be to coopt or control other organizations, as described by resource dependence theorists. A further goal may be to gather information regarding best practices, geographic or industry-specific
knowledge, and market trends to enable adaptation when confronted by impending changes associated with the source of uncertainty (Boyd, 1990; Hoffman, 2007; Zaheer and Bell, 2005). Thus, the director networks are in effect communication channels that provide access to information-based resources (Gulati, 1999) or enable capabilities (Zaheer and Bell, 2005), allowing firms to enhance performance when confronted with uncertainty. In other words, interlocks may not be used necessarily as a mechanism that assists in coopting, controlling, and ultimately reducing uncertainty (by stabilizing and shaping the environment), as emphasized in our earlier set of hypotheses, but as a resource enabling the firm to benefit (by adapting to the changes in the environment) when confronted by uncertainty. It also follows that the benefit of the networks resources associated with interlocks will be greater and more easily discernible when uncertainty is higher. We expect this performance benefit of networks to occur regardless of the source of uncertainty.

To illustrate our theory development with regard to the benefits of interlocks in the presence of firm-specific uncertainty, consider a hypothetical Firm A that is experiencing greater uncertainty than Firm B as a by-product of strategic actions such as entering new product markets, where Firm B has no presence (Greve, 1996). Assume further that both firms have the same director networks that potentially offer resources and capability enhancement for new market entry. Firm A as a result of choosing to enter the new market, will now be able to utilize these resources – provided by their directors’ networks – to deal with uncertainty associated with the new markets, such as uncertainty with regard to consumer trends in those markets. Benefits derived from director networks may include advice and assistance regarding how consumer preferences are likely to change and what product lines are necessary to benefit from that change. These are the resources within Firm A’s director networks that this firm is able to utilize. By
contrast, Firm B has not gone beyond their original market, preferring stability to strategies that may increase uncertainty. Thus, Firm A derives stronger performance benefits from their network due to utilizing the network resources available to it and therefore benefiting when confronted by the uncertainty created as a result of new market entry.

In sum, the potential for performance enhancement created by interlock networks is more likely to be realized at higher levels of uncertainty. We have also described how this uncertainty can be of any type, resulting from firm-specific factors, broader market uncertainty, or a combination of both. In any case, uncertainty is likely to lead to greater utilization of, and therefore enhanced performance benefit from network resources, even if networks do not influence the amount of uncertainty per se. Thus, the purpose of the interlock networks may not be solely to fight against uncertainty and reduce performance fluctuations, but to access resources and create flexibility that can provide performance benefits as uncertainty escalates. This reasoning implies that uncertainty should positively moderate the relationship between interlocks and firm performance.

*Hypothesis 6: Uncertainty will positively moderate the relationship between centrality in interlocking directorate networks and firm performance.*

*Hypothesis 7: Uncertainty will positively moderate the relationship between structural holes in interlocking directorate networks and firm performance.*

**METHODS**

**Data**

This study required financial and board representation data. Our sources were Compustat and I/B/E/S for financial and share analyst data of U.S. firms, and the Corporate Library for directorate interlocks over the period 2001 to 2009. This period was dictated by the limits of the Corporate Library database. We examine a total of 16,907 firm year observations across 3,745
firms during that period. Compustat contains 10-K report data for all publicly traded corporations and is used for all income statement and balance sheet data. We also draw analyst forecast data from the detailed files of the I/B/E/S database, which includes analyst forecasts of Earnings per Share one year in advance. We used data from the Corporate Library for the calculations of network centrality and structural holes measures. The Corporate Library is a large governance ratings agency with analysts who are frequently cited in the press and public prominence, and it is commonly used in management research (Cowen and Marcel, 2011; He and Huang, 2011). Thus, our sample includes firms that were represented in Corporate Library, I/B/E/S, and Compustat data sets across our 9-year panel.

**Variables**

*Performance.* We use return on assets (ROA) as our dependent variable in line with the existing literature (Geletkanycz, Boyd, and Finkelstein, 2001; Rowley, Behrens, and Krackhardt, 2000), calculated as income before extraordinary items divided by total assets.

*Uncertainty.* Consistent with the existing literature, we define uncertainty based on the difficulty in predicting the focal firm’s outcomes (Beckman, *et al.*, 2004; Milliken, 1987). More precisely, we focus on variability of firm performance, because greater variability reflects lower predictability and therefore higher uncertainty (Baird and Thomas, 1985; Bettis, 1982; Bromiley, *et al.*, 2001; Collins and Ruefli, 1992; Milliken, 1987; Ruefli *et al.*, 1999). Performance variability captures any source of variability, including the three sources of uncertainty discussed in our theoretical development above, such as uncertainty that is: (1) specific to the firm, such as that resulting from variability of income due to product or market-entry strategies (firm-specific uncertainty); (2) originating from the firm’s interface with its market or environment, such as that associated with exchange, competition, or cooperation relationships (firm/market
uncertainty); (3) created by macro issues across the entire industry or economy, such as macro-economic events (market uncertainty). With regard to the latter, despite that this source of uncertainty confronts every firm in the industry or economy, the change in performance due to market events will vary across firms; that is, the level of performance variability that firm/market or market events create will depend upon each firm’s unique exposure to the event in question.

We use three measures of past performance variability to capture the degree of uncertainty for each firm in our sample. First, we use past income stream variability, measured as the standard deviation of firm ROA (ROA SD) during the five-year period up to the year in question (Andersen et al., 2007; Henkel, 2009). It should be noted that we also used the coefficient of variation, yet the results were essentially the same as when we used ROA SD. We report the results for ROA SD to remain consistent with the accumulated empirical literature.

Second, we use a measure of firm stock price variability (i.e., market performance) based on the capital asset pricing model (CAPM) (Miller and Bromiley, 1990). We estimated firm beta using a four factor model (market premium, small minus big, high minus low, and momentum), following the standard method in finance research that accounts for the limitations of one-factor models (Carhart, 1997; Fama and French, 1992). A high beta suggests that the firm’s stock price, i.e., its market performance, is susceptible to greater variability relative to the overall market.

Our third measure of uncertainty directly estimates predictability of future firm performance, using variability of financial analysts’ expectations of earnings per share (EPS) one year in advance (Bromiley, 1991). A wide range of estimates (i.e., higher standard deviation in analysts’ expectations) indicates greater uncertainty regarding future firm performance. We use only firms with more than three analyst forecasts to estimate the extent to which there is greater difficulty in predicting future accounting performance for each firm in the sample. Similar to past perform-
ance variability, the analysts’ variations in predictions of future performance variability will be a function of firm and broader market related factors.

*Network position.* To test our hypotheses about the effect of network position on firm performance, we used two measures widely used in network research. First is the degree centrality; the second is structural holes. These two measures correspond to different types of social capital benefits from networks: degree centrality is related to ‘information volume’ whereas structural holes are related to ‘information diversity’ (Koka and Prescott, 2002).

We calculate “degree centrality” as the number of interlock ties a firm has with the other firms (Freeman, 1979). Degree centrality is one of the most widely used measures of network position and effectively measures the connectedness of an actor in a network (Koka and Prescott, 2002; Wasserman and Faust, 1994). We preferred degree centrality over other measures of centrality for three reasons. First, high degree centrality in interorganizational networks has been both a common measure in the study of networks as external resources, (Ahuja, 2000; Haunschild and Beckman, 1998; Owen-Smith and Powell, 2004; Powell *et al.*, 1999) and also has been the most commonly used centrality measure in resource dependence theory (e.g., Beckman *et al.*, 2004). Alternative measures of centrality are not so extensively used in either ‘networks as an external resource’ or ‘resource dependence’ literatures. Second, degree centrality has been associated with our theoretical mechanisms of information gathering (Ahuja, 2000), knowledge transfer and coordination (Davis, 1991), and learning (Beckman and Haunschild, 2002) while alternative measures such as Bonacich centrality (Bonacich, 1987) has been mostly associated with status (Bothner, Smith, and White, 2011; Podolny, 2001), which is not within the scope of our study. Finally, degree centrality is complementary to our second network measure (structural holes) since degree centrality is related to the volume of information while structural
holes are related to the diversity of information and they jointly capture the informational features of interlocks that we analyzed earlier in the theory section (Koka and Prescott, 2002). Other measures, such as betweenness centrality and closeness centrality, are conceptually and empirically similar to the idea of structural holes, in the sense that both concepts explain to what extent the focal actor is between all the other actors in a network (Everett and Borgatti, 2005).

We calculate structural holes at the firm level in two steps. First, we calculate lack of access to structural holes using Burt’s (1992: 54) network constraint measure:

$$ (p_{ij} + \sum p_{ik}p_{kj})^2, k \neq i,j $$

In this equation, $p_{ij}$ represents the strength of tie between firms i and j, while $\sum p_{ik}p_{kj}$ represents sum of indirect tie strength in the linkage of i and j, all through firm k. In the second step, we follow Zaheer and Bell (2005) to calculate Hole Access as one minus the constraint score of the firm (where the constraint score was non-zero) and zero for each of the other cases, transforming our calculation from a measure of lack of access, to one of access. A high aggregate constraint score is indicative of a situation where one has developed a redundant network in which one’s contacts are connected to each other (Burt, 1992). Thus, our measure of Hole Access (one minus the constraint measure), will be indicative of low network redundancy: a high Hole Access score will represent less redundancy; conversely, a low Hole Access score is indicative of higher redundancy in a firm’s networks.

**Statistical Analysis**

In our empirical analysis we first run ordinary least squares (OLS) regression models using firm performance and uncertainty as dependent variables. We also use two-stage least squares (2SLS) regressions to account for possible endogeneity in our measures of network position when predicting our two dependent variables: uncertainty and performance. In all
regressions we use firm fixed effects and year dummies to control for unobservable differences among firms and changes in the business cycle respectively. Using fixed effects allows us to fully exploit our panel data (Certo and Semadeni, 2006; Halaby, 2004; Wooldridge, 2002). Hausman (1978) specification tests suggested that fixed effects models were appropriate for all regressions \( x^2 = 98.85; \ p < .01 \). As a result, all analyses were estimated with the \textit{xtreg} command in STATA to account for the panel structure of our data, using the firm as the grouping variable. As an additional precaution, all non-binary variables were standardized to reduce the likelihood of multi-collinearity created by the inclusion of the interaction terms in the models.

We control for variables previously found to influence predictability of firm outcomes that could change throughout the 9-year period for the firms in the sample, including: (1) leverage, measured by total debt divided by total assets, because financial leverage increases firm fixed costs and thus exposure to economic downturn (Amit and Livnat, 1988); (2) capital intensity, which also commits firms to higher fixed costs and increases earnings volatility (Lev, 1974); (3) R&D intensity, to control for uncertainty regarding the outcome of R&D (Kamien and Schwartz, 1971; Loury, 1979; Scherer, 1967); and (4) firm size, which is associated with greater resilience to change (Devers, \textit{et al.}, 2008; Larraza-Kintana, \textit{et al.}, 2007).

To capture the effect of network position on uncertainty, we take advantage of our longitudinal dataset. Thus, for the analysis of ROA SD as dependent variable, we regress network measures in the present year against income variation in the next five years. This way we capture the effect of network position today on the variability of future performance, which is a reflection of the predictability, or uncertainty of firm outcomes (Bromiley, \textit{et al.}, 2001). For example, when modeling the effect of network measures in 2001 upon uncertainty, we use the standard deviation of ROA over the period 2001 to 2005 (inclusive) as the dependent variable.
As noted above, we also controlled for endogeneity in 2SLS regression models using network position to predict uncertainty and performance. These robustness tests were applied because: (1) networks may be increased or reinforced in anticipation of future uncertainty (Beckman et al., 2004; Boyd, 1990); and (2) it is possible that networks may be influenced by firm performance (e.g., Uzzi and Gillespie, 2002). Thus, we are concerned with the endogeneity of networks when predicting uncertainty and performance. To control for endogeneity problems, we needed to find instruments valid for these variables. Two instrumental variables were used for both centrality and structural holes: (1) the size of the board; and (2) geographical concentration, calculated as number of firms in a state divided by the area of the state to estimate the physical proximity of the firm to other firms.

With regard to interlock network centrality, board size is an exogenous predictor because firms with larger boards are likely to have more interlocks (our centrality measure); on the other hand, higher geographical concentration is likely to increase the ease with which directors can form further linkages, thus leading to more interlocks. Regarding structural holes, board size is likely to exogenously influence this variable because more board members increases the probability that redundancy in the network will be reduced and structural holes filled. Geographical proximity is also likely to influence structural holes to the extent that proximity makes it easier for directors to fill gaps in their network because they are more likely to know a larger number of actors, providing greater network diversity and fewer structural holes.

As prescribed by Angrist & Pischke (2008), in order to conduct 2SLS analysis for our interaction models with first stage models appropriately identified (in models predicting performance using moderation arguments), we created additional instruments by multiplying the two instrumental variables (board size and geographic concentration) with the uncertainty
variables (that were interacted with endogenous network variables). The suitability of the instruments was tested (1) by reference to the F statistic and significance of instrumental variables in first stage regressions predicting the endogenous (network) variables, and (2) using the Sargan-Hansen statistic to validate their exogeneity (test of over-identification) (David, et al., 2010). First stage analysis of 2SLS models showed strong significance of the vast majority of our instrumental variables, including the interactions between the instruments and the uncertainty variables. The Sargan-Hansen statistic met the threshold in each case with the only exception of the interactions with CAPM beta in Table 5. The null hypothesis for the Sargan test is that the instruments as a group are exogenous, i.e., uncorrelated with the error term; thus, if the Sargan statistic is insignificant, we fail to reject that null hypothesis, which is the case in all of our 2SLS models (except in one case). Overall, based on results from the first stage regressions and Sargan-Hansen tests, we are confident that our instrumental variables are valid such that they allow us to control for endogeneity.

RESULTS

Table 1 presents the descriptive statistics and correlations among the main variables in our study. Our uncertainty measures are negatively correlated with performance, yet the correlations between our network measures and uncertainty are mixed. The descriptive statistics show pre-standardized means and standard deviations to facilitate their interpretation, though all variables were standardized for the subsequent analyses. Average board size approximates those of other governance studies (e.g., Coles, Daniel, and Naveen, 2006; He and Huang, 2011), as does the average number of boards per director (Stuart and Yim, 2010).

*** Insert Tables 1, 2 & 3 about here ***
Hypotheses 1 and 2 predict that director network centrality and structural holes (respectively) in interlocking directorate networks are negatively related to our measure of uncertainty. Table 2 shows the OLS analysis using network centrality and structural holes as independent variables to predict uncertainty. While structural holes have no effect upon any of our three measures of uncertainty, network centrality negatively influences one of the uncertainty measures (CAPM beta) in the OLS models. Yet none of the coefficients are significant in the 2SLS analysis that controls for endogeneity (Table 3). Thus, the results do not provide support for the uncertainty reduction effect of networks, which was suggested by Hypotheses 1 and 2. In order to test the second leg of the mediation hypothesis, we next examine the results for Hypothesis 3, predicting that uncertainty is negatively related to firm performance. The results in Table 4 (Models 1, 2, and 3) using OLS regression models provide clear support for two of the three measures of uncertainty, analyst forecast SD and ROA SD, but not for the CAPM beta. We reach the same conclusion from the 2SLS analysis (Table 5). Thus, while there is support for the negative effect of uncertainty on performance as Hypothesis 3 predicted, there is no evidence that interlocks reduce uncertainty, after controlling for endogeneity.

To test the mediation effect more rigorously, we applied three mediation tests: (1) the traditional Sobel (1982) test, (2) mediation tests with bootstrapped standard errors to account for possible departures from the normality assumptions (Preacher and Hayes, 2004), and (3) tests of multiple mediation, which are based on structural equation modeling to explore the mediated effect of networks on performance through the three uncertainty variables in a single structural equation model (MacKinnon, 2008). We applied the first two of these mediation tests using both network measures (structural holes and centrality) with each of the three uncertainty measures. For the third test we use two models (one for each network measure) with multiple uncertainty
paths between the network measure and firm performance in each. In the first two tests, with only one exception, we failed to find a significant mediation effect of uncertainty in the relationship between director network position and firm performance. The exception was that 0.06% of the total effect of structural holes upon performance was mediated by CAPM beta. In the third test (multiple mediation) we used two models, one for each network measure, with both models having each of the three uncertainty measures included. No significant mediated path was found in these two tests of multiple mediation. On the basis of these results from our mediation testing, we conclude there is very weak empirical support for the argument that network position improves firm performance through its effect upon uncertainty. The lack of support is not surprising given that we had found no effect of network position upon uncertainty in the OLS and 2SLS regression analysis, which tests the first leg of the mediation.

In contrast to the results above, there is clear evidence that uncertainty moderates the relationship between network position and firm performance. Hypotheses 6 and 7 predict that uncertainty will positively moderate the relationship between director network position (centrality and structural holes) and firm performance. Tables 4 and 5 provide support for these hypotheses. Network centrality positively and significantly (p<0.001) interacts with two of the three uncertainty measures to influence firm performance. The results are similar for structural holes as the interaction with uncertainty is also significant for the same two coefficients (at p<0.001 and p<0.05). A similar pattern of relationships appears when we apply 2SLS with the exception that the analyst uncertainty interaction with structural holes loses significance in Model 7, Table 5. Thus, the majority of our tests support the moderation hypotheses, especially for ROA SD and Analyst Forecast SD measures of uncertainty.

*** Insert Tables 4 & 5, Figures 1 & 2 about here ***
Figures 1a, 1b, 2a and 2b further depict how the relationship between network position and firm performance becomes positive when there is higher uncertainty. In these figures we use the 10th and 90th percentiles as low and high values respectively in the graphs. When uncertainty is high, network centrality and structural holes have a positive relationship with performance; by contrast when uncertainty is low, the performance effect of networks is close to zero or even negative. For example, when uncertainty is high, a one standard deviation increase in the number of interlocks (9.7) results in approximately 2% improvement in firm performance (i.e., ROA). Given that mean ROA is 0.01, this is actually the difference between making profits or losses. The difference between the 10th and 90th percentile in the distribution is approximately three standard deviations, meaning that the high centrality firms are likely to earn a 6% performance premium over the low centrality firms when confronted by high uncertainty, whereas high centrality for firms facing lower uncertainty will lead to 3% lower ROA relative to low centrality firms. These numbers are approximately the same in the case of structural holes. Note that the negative performance effect of uncertainty means that firm performance at high uncertainty is always lower than firm performance under low uncertainty.

In sum, there is clear evidence that uncertainty positively moderates the relationship between directorate interlocks and performance. Interlocking directorates improve performance when there is high uncertainty, as shown by the significant interactions between network and uncertainty variables. However, the main effect of network position on performance provided unexpected results that deserve to be discussed. Hypotheses 4 and 5 predict that director network centrality and structural holes should be positively related to firm performance. Table 4 using OLS shows that the network measures are significantly related to performance, positively for structural holes, but negatively for centrality. The significance vanishes in Table 5 using 2SLS.
regressions. Thus, Hypotheses 4 and 5 provided mixed results that disappear once we account for endogeneity. This is consistent with the equivocal results obtained by extant research that investigates the interlock-performance relationship. Our findings suggest that the relationship between director networks and performance is contingent upon the level of uncertainty confronting the firm, such that only when there is high uncertainty the effect of network position on firm performance is clearly observable and positive. However, in case of low uncertainty, it is usually insignificant and it may turn to negative, as Figures 1 and 2 depict.

**DISCUSSION**

This study advances our understanding of how networks and uncertainty relate to firm performance. We explain and empirically test the two possible roles of uncertainty as mediator and moderator of the relationship between directorate interlocks and firm performance. We find that while there is weak support for the uncertainty reduction effect of director networks, these networks appear to enhance firm performance when uncertainty is high. The findings in favor of the moderating effect of uncertainty in the director network-performance relationship make several contributions to the governance and networks literatures, which we discuss below.

First, our findings clearly show that interlocks have a strong positive effect on performance, yet only in the presence of high uncertainty. Coupled with the weak support for the uncertainty reduction effect of director networks, this result substantially changes our conceptualization of the role of interlocks and networks in dealing with uncertainty and presumably enhancing firm performance. Instead of being a reactive mechanism for reducing uncertainty, our study suggests that interlocks and networks can be exploited as a resource for enhancing firm performance, precisely when uncertainty is greater. For example, expansion into
new countries is an inherently risky strategy that is likely to increase uncertainty about the firm’s future financial returns (Greve, 1996). Yet the director’s network resources can make the firm more likely to succeed in its strategy, such as through having supplier and customer relationships that may facilitate successful expansion of operations abroad. In this example the firm proactively makes strategic choices that both: (1) increases uncertainty as a by-product of its choice; and (2) exploits their network resources in order to successfully adapt and enhance firm performance. As our results show, earlier research may have somehow exaggerated the role of director networks in reducing uncertainty, though it seems clear that networks increase the likelihood of success in the midst of uncertainty.

Second, this paper contributes to the directorate interlocks literature by explaining the inconsistent findings in the literature regarding the relationship between interlocks and firm performance (Mizruchi, 1996; Peng, 2004). We do so by showing that this relationship is contingent on the level of uncertainty. Failure to consider the role of uncertainty may result in a positive, insignificant, and even negative interlocks-performance relationship. Our results show mixed direct effects of either network centrality or structural holes on performance (Tables 4 and 5), but there is a clear positive interaction effect of both network measures with our uncertainty variables. As shown in Figures 2a and 2b, there is a positive relationship only at higher levels of uncertainty, but there is a negative relationship between network measures and performance for low levels of uncertainty. Therefore, we show that in order to understand the performance benefits of directorate interlocks it is necessary to consider the firm’s ability to leverage the potential benefits provided by interlocks, which occurs when uncertainty is greater.

Third, we also contribute to the network literature by investigating in a longitudinal setting the causality within the relationship between interlocking directorate networks and
performance. Previous studies were mostly cross-sectional in nature and did not clearly specify whether: (1) interlocks influence performance; (2) it is performance that drives interlocking behavior; or (3) both are jointly determined. Earlier research suggests that poor performing firms look for outside members, hence increasing their centrality in the network (Boeker and Goodstein, 1991; Mizruchi and Stearns, 1988). Along similar lines, individuals will be more inclined to accept positions in better performing firms (Fombrun and Shanley, 1990), thus causing high performing firms to be more central. In our longitudinal study, controlling for endogeneity that may stem from reverse causality or omitted variables, we showed that there are performance benefits from interlocks, though this effect is dependent upon the level of uncertainty.

In our judgment, our results may be used to avoid an overly simplistic application of resource dependence theory to director networks. Networks research claims that firms build or reinforce networks in response to uncertainty (Beckman, et al., 2004; Boyd, 1990), which may be the case, but possibly not only as mechanisms utilized to reduce uncertainty. Because the negative effect of uncertainty upon firm outcomes has been outlined clearly by resource dependence theorists since the seminal work of Pfeffer and Salancik (1978), some researchers may have admitted, perhaps too quickly, the need to reduce or defend against uncertainty in order to enhance performance, without considering how some firms may benefit from higher levels of uncertainty. Networks (or interlocks) may be useful when uncertainty is particularly high, not because they help firms reduce it, but because they help them to extract performance benefits when confronted by it. This is also consistent with Hoffman’s (2007) examination of different adapting strategies for using alliance networks to deal with uncertainty, such as increasing flexibility.
Future Research and Limitations

Aside from the strong support for the moderating role of uncertainty on the network-performance relationship, our finding that interlocks have a very limited uncertainty reduction effect may be puzzling for some network scholars. The empirical results raise the questions: why did we find weak results when examining the effect of director networks upon uncertainty? We initially expected that uncertainty could have both mediation and moderation effects on the network-performance relationship, but we found strong support only for the latter. While the significant findings are interesting on their own and highlight the potentially performance enhancing effect of director networks when dealing with high uncertainty, future research should investigate if there are specific cases in which networks may indeed stabilize firm performance.

We should also note that we have considered only one type of network: directorate interlocks. Future research could explore the inter-relationship among networks, uncertainty, and performance for other types of networks and may find different results for the role of uncertainty. For example, researchers could explore how uncertainty affects the relationship between the position of a firm in alliance networks and its performance. Finally, we have not explored the different sources of uncertainty separately as mediators or moderators of the relationship between directorate interlocks and firm performance. Future research could attempt to understand if the role of uncertainty in the networks-performance relationship differs across the types of uncertainty. Similarly, we have not delved into the precise value that different types of directors may bring to each firm. It is possible that different types of directors may have different effects upon uncertainty and performance. Future research could benefit from exploring the different effects of inside or outside directors, as well as other director characteristics.
REFERENCES


