FRIENDS OR STRANGERS? IT ALL DEPENDS ON CONTEXT: A REPLICATION AND EXTENSION OF BECKMAN, HAUNSCHILD, AND PHILLIPS (2004)

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Research summary: *The formation of interorganizational ties is a consequential phenomenon examined in strategic management research. Beckman, Haunschild, and Phillips (2004) is one of the first studies to comprehensively consider interorganizational network change by exploring factors that affect both alliance and board interlock formation. They find that firm-specific uncertainty relates to broadening actions, whereas market-level uncertainty causes firms to reinforce current structures. Our replication considers whether these relationships operate similarly in a differing temporal context. Building from the framework of the original study, we suggest our findings offer intriguing new empirical evidence highlighting the importance of time as a boundary condition in understanding embedded firm actions.*

Managerial summary: *The development of interorganizational relationships, such as alliances and ties between boards of directors, has an important impact on innovation, strategic actions, and firm performance. This study examines whether the dynamics of interorganizational relationship formation remain consistent over time. We replicate earlier work by Beckman and colleagues (2004), but with an expanded data set covering more than 20 years. Over this broader time horizon, we find a shift in behavior, with companies facing firm-specific uncertainty seeking to reinforce their current relationships and companies facing industry-wide uncertainty seeking to diversify their risk by expanding their network. Our results demonstrate the importance of replication studies in research and contribute to a more nuanced understanding of the complexity surrounding interorganizational relationships.* Copyright © 2016 John Wiley & Sons, Ltd.

INTRODUCTION

Interorganizational relationships are a critical topic in strategy research, given their impact on innovation (Sampson, 2007), strategic decisions such as acquisitions and international expansion (Beckman and Haunschild, 2002; Connelly *et al.*, 2011), and firm performance (Krishnan, Martin, and Noorderhaven, 2006). Broadly defined, interorganizational relationships are cooperative partnerships among two or more firms joining together to share resources and knowledge in order to create mutual gains in competitive position and performance (Auster, 1994; Oliver, 1990). Central to our understanding of interorganizational

relationships is the examination of how and why these relationships form and develop. Research recognizes uncertainty reduction as a key motivation for forming interorganizational relationships (Powell, Koput, and Smith-Doerr, 1996). Strategic alliances and board interlocks are two of the most dominant and common forms of interorganizational relationships; however, research often examines them as separate phenomena (Drees and Heugens, 2013; Pfeffer, 1987).

Beckman *et al.* (2004) provide one of the few exceptions by examining the role of uncertainty in predicting the formation of both strategic alliance and board interlock networks. The authors theorize that two forms of uncertainty—firm-specific and market—determine alliance and interlock formation. Firm-specific uncertainty reflects "uncertainty that is unique and often internal to the firm" (Beckman *et al.*, 2004: 260). Conversely, market uncertainty "is external and shared across a set of firms" (Beckman *et al.*, 2004: 262). Depending on whether a firm faces more firm-specific or market uncertainty, it may attempt to broaden its network by forming relationships with new partners, reinforce its preexisting ties by forming additional relationships with current partners, or create multiplex ties in which both alliances and interlocks are pursued with a given external partner. Reflecting the overall impact of their work, their study is well cited, with more than 700 *Google Scholar* citations.

We suggest that a reexamination of the relationships and results of their study may offer important new insights to strategy research with respect to the temporal context of interorganizational tie formation. The sample context for their study was between 1988 and 1993. While their study offered key insights into the formation of interorganizational relationships, we consider whether the time context may be an important boundary condition driving their results. As Whetten (1989: 492) states, "theorists should be encouraged to think about whether their theoretical effects vary over time, either because other time-dependent variables are theoretically important or because the theoretical effect is unstable for some reason." Following this insight, we consider whether the dynamics of interorganizational relationship formation remain consistent over time. To do so, we replicate the original Beckman *et al.* (2004) study, taking the analysis a step further to track the original sample firms through 2010. This allows us to replicate their study directly and examine the model across

a much longer time period. In this regard, we are able to loosen the boundary conditions of time and to consider whether the original findings are consistent across a broader time horizon.

Our replication offers a number of important contributions to the literature on interorganizational relationship formation. First, by conducting a direct replication and extension of the original work, we can contribute additional empirical evidence that may help elucidate the mechanisms underlying interorganizational tie formation. By repeating the analyses presented in Beckman *et al.* (2004) and using their same sampling criteria and approach, we test the reproducibility of their findings, building additional information that may corroborate or contradict their results. Furthermore, we build on their study by considering how these relationships may change in a different empirical context. In doing so, our study offers insights into the generalizability of the original research and adds to the establishment of repeatable cumulative knowledge on interorganizational tie formation (Bettis *et al.*, 2016).

Second, by increasing the sample period from five years to more than 20 years, we extend the work of Beckman *et al.* (2004) by providing further temporal contextualization of their findings. Following prior replication studies (e.g., Finkelstein, 1997; Mayer and Whittington, 2003), we show the role that time may play as an important boundary condition in determining strategic actions and behavior. Our study suggests that the drivers of interorganizational relationship formation may have changed between 1989 and 2010. Time is recognized as an important mechanism that can influence and shape theoretical relationships (Ancona *et al.*, 2001; Mosakowski and Earley, 2000), and is important in understanding theoretical boundary conditions (Dubin, 1978; Shadish, Cook, and Campbell, 2002). Our work adds to the recognition of the role that time may play in strategy research (Mosakowski and Earley, 2000).

Our replication study, using a longer time context, provides a contrast to their earlier findings, suggesting that the relationship between uncertainty and interorganizational tie formation may change when the boundary condition of time is relaxed. Beckman and colleagues' original study offers critical insights into the complexity surrounding the formation of such relationships, and we see our study complementing and extending their earlier work. The findings from our replication offer the opportunity for a more complete understanding of

the dynamics and interdependencies of interorganizational relationships.

ALLIANCES, INTERLOCKS, AND UNCERTAINTY

Interorganizational relationships represent a key mechanism for reducing uncertainty (Pfeffer and Salancik, 1978). Two of the most frequently used forms of interorganizational relationships are strategic alliances and board interlocks (Drees and Heugens, 2013; Oliver, 1990; Pfeffer, 1987). Strategic alliances may take the form of joint ventures, research and development (R&D) agreements, research consortia, joint-marketing agreements, buyer-supplier relationships, and a variety of other alliance modes (Das and Teng, 2000). A board interlock is created when two firms share a common director (Burt, 1980; Mizruchi, 1996).

Strategic alliances provide a means of reducing uncertainty in, and dependence on, the external environment (Pfeffer and Nowak, 1976; Steensma *et al.*, 2000). Partners may collaborate to share risk and band together to more readily acquire costly, scarce resources. Firms with greater dependence, less power, and in turn, higher uncertainty will more readily attempt to form strategic alliances (Pfeffer and Nowak, 1976; Xia, 2011). This perspective indicates that firms will enter into alliances when they lack the control or power over critical resources in the environment, and they perceive alliances as a means of reducing their uncertainty.

Similarly, interlocks are recognized as a means to manage environmental uncertainty and dependencies, and gain access to critical resources (Boyd, 1990; Pfeffer and Salancik, 1978). A board interlock represents an attempt by a focal firm to co-opt the environment by appointing an individual representing another firm or entity in the environment (Pfeffer, 1972). Research generally supports the perspective that firms tend to form more interlocks in more uncertain markets (Boyd, 1990; Hillman, Zardkoohi, and Bierman, 1999; Lang and Lockhart, 1990).

While uncertainty is broadly considered to be a driver for the formation of interorganizational relationships, Beckman *et al.* (2004) posit that the nature of the underlying uncertainty faced by the firm influences tie formation. Building from prior work in behavioral decision theory and organization literature, Beckman *et al.* (2004: 260) define *uncertainty* as "the difficulty firms have in predicting the future, which comes from incomplete knowledge," and suggest that it can exist at two levels, firm and market.

Beckman *et al.* (2004) build on the idea of unsystematic risk in the capital asset pricing model (CAPM) to develop their notion of firm-specific uncertainty. In CAPM, firm-specific risk is referred to as unsystematic risk and is defined as the variance in a firm's returns that are not explained by movements in the market portfolio (Bettis, 1983; Brealey, Myers, and Allen, 2008; Chatterjee *et al.*, 1999). This type of risk can be controlled through portfolio diversification. Beckman *et al.* (2004) extend this concept by suggesting that firm-specific uncertainty captures all uncertainty that is unique to the firm and it can drive firms to diversify, or broaden, their network structure by forming ties with new partner firms in order to reduce such unique uncertainty.

Once again building on a concept from the CAPM model, market uncertainty is roughly analogous to systematic risk. Systematic risk captures economy-wide risks that cannot be avoided or controlled through diversification (Bettis, 1983; Brealey *et al.*, 2008; Chatterjee *et al.*, 1999). Beckman *et al.* (2004) posit a slightly narrower view of systematic risk by focusing on the uncertainty of a given industry rather than economy-wide uncertainty, though they do suggest that market uncertainty is driven by exogenous factors and is outside of the firm's control. Because market uncertainty is shared by a group of firms, these firms may react by seeking stability and trust through forming reinforcing relationships with current partners (Gulati, 1995). Beckman *et al.* (2004) theorize that interorganizational ties can be reinforced either through the addition of new relationships of the same type with existing partners (e.g., forming a second alliance with the same partner), or through the addition of relationships of a different type with an existing partner, also known as tie multiplexity (i.e., forming an alliance with an already interlocking firm, or vice versa). While alliances and board interlocks represent different types of interorganizational relationships, Beckman *et al.* (2004) propose that it is the type of uncertainty that drives tie formation, regardless of the type of tie being considered. The hypotheses tested in the original study are summarized in Table 1.

Table 1. BHP (2004) hypotheses summary

BHP (2004) Hypotheses
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
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

Beckman *et al.* results summary

Beckman *et al.* (2004) found general support for their hypotheses, suggesting that firms change their networks in response to uncertainty. In Table 2, we provide the full results of the models from the original study, reflecting the effects of uncertainty on broadening, reinforcing, and multiplex ties in alliances and board interlocks. To facilitate direct comparison of our results, Table 2 also reports the models for our direct replication, the replication in a later time period, and the full-period analysis spanning the time frame of the original study through 2010 (each of these analyses are described in greater detail below).

In the original analysis, market uncertainty was found to be positively related to reinforcing alliances and board interlocks as well as the creation of multiplex ties. In their sample, the coefficients and probabilities that values for these tests would be as large as the observed effects under the null hypothesis are $\beta = 6.460$, $p = 0.005$; $\beta = 15.111$, $p = 0.001$; and $\beta = 11.473$, $p = 0.09$, respectively.[1] This provides evidence in support of their Hypotheses 3, 4, and 5. However, firm-specific uncertainty had differing results. Specifically, Hypothesis 1, which suggests that firm-specific uncertainty would

be positively related to broadening alliances, was not supported in their sample. In fact, the authors originally found a negative effect ($\beta = -1.504$, $p = 0.03$), opposite of their prediction. However, given their theory was focused on firms experiencing exceptional levels of uncertainty within an industry, the authors restricted their sample to the most extreme cases, in which firm-specific uncertainty was in the top half of observed firms and market-specific uncertainty was in the lowest quartile. Under these conditions with a sample of 101 observations, firm-specific uncertainty did become positively related ($\beta = 9.602$, $p = 0.01$) to alliance broadening. However, Hypothesis 2, suggesting firm-specific uncertainty is positively related to broadening interlock ties, received no support ($\beta = -0.429$, $p = 0.57$).

Overall, these results suggest that when an industry is facing uncertainty, firms engage in reinforcing ties with existing partners, across two types of interorganizational relationships, alliances and interlocks. When faced with firm-specific uncertainty, firms attempt to broaden their alliance networks only in extreme cases such as when they are the only firm in the industry facing uncertainty. It would seem from the Beckman *et al.* (2004) results that firms facing uncertainty individually either struggle with partner availability, or follow more of a threat-rigidity response, as opposed to seeking diversification in ties.

REEXAMINING THE ROLE OF UNCERTAINTY IN TIE FORMATION ACROSS TIME

Given that the Beckman *et al.* (2004) sample context may reflect temporal boundary conditions that may directly impact the likelihood and type of interorganizational relationship formation (Mayer and Whittington, 2003; Yu, Gilbert, and Oviatt, 2011), it is useful to replicate their study using an extended sampling time frame. Organization actions and behaviors, such as forming external ties, must be understood by considering the context in which the firm is embedded (Gavetti, Levinthal, and Ocasio, 2007). From this embeddedness perspective, the temporal setting may be an important factor influencing how uncertainty shapes interorganizational tie formation. While Beckman *et al.* (2004) identified the importance of context and uncertainty at the firm and market levels, our replication extends

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[1] We calculated the *p*-values from the original study based on the reported coefficients and standard errors.

Table 2. Regression results

	Alliance broadening				Alliance reinforcing			
	BHP Table 3, Model 2				BHP Table 3, Model 5			
Sample	Original study	Direct replication	Later period	Full period	Original study	Direct replication	Later period	Full period
Time period	1988–1993	1988–1993	1994–2010	1988–2010	1988–1993	1988–1993	1994–2010	1988–2010
Variable								
Firm-specific uncertainty	−1.504	−0.880	−0.015	−0.178	0.858	0.132	0.982	0.642
	(0.708)	(0.408)	(0.152)	(0.149)	(1.180)	(0.979)	(0.385)	(0.309)
Market uncertainty	0.016	0.715	0.186	0.275	6.460	4.141	0.699	0.500
	(1.665)	(0.843)	(0.152)	(0.148)	(2.304)	(1.886)	(0.550)	(0.418)
Controls								
(Log) assets	0.265	0.908	0.302	0.338	0.604	1.799	0.296	0.289
	(0.045)	(0.288)	(0.079)	(0.057)	(0.088)	(0.647)	(0.154)	(0.102)
Adjusted ROA	0.002	−0.062	−0.037	−0.042	−0.020	0.168	0.029	0.023
	(0.008)	(0.055)	(0.040)	(0.032)	(0.011)	(0.124)	(0.094)	(0.073)
Prior alliances (0)	−1.433	−0.010	−1.089	−0.935	−3.212	−2.150	−2.179	−1.958
	(0.310)	(0.154)	(0.147)	(0.120)	(0.312)	(0.490)	(0.350)	(0.283)
Prior alliances (1−2)	−0.767	0.061	−0.553	−0.457	−2.114	−0.948	−1.374	−0.894
	(0.222)	(0.119)	(0.098)	(0.081)	(0.266)	(0.276)	(0.275)	(0.186)
Prior alliances (3−15)	−0.207	−0.054	−0.339	−0.258	−0.775	−0.601	−0.883	−0.577
	(0.140)	(0.097)	(0.074)	(0.061)	(0.168)	(0.227)	(0.163)	(0.127)
Centrality	n/a	n/a	n/a		n/a	n/a	n/a	n/a
Number of prior acquisitions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Industry controls								
Service	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Chemicals	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Utilities	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Computers	1.131	n/a	n/a	n/a	1.106	n/a	n/a	n/a
	(0.235)				(0.361)			
Bank	−0.914	n/a	n/a	n/a	−2.987	n/a	n/a	n/a
	(0.273)				(1.048)			
Electronics	0.702	n/a	n/a	n/a	1.390	n/a	n/a	n/a
	(0.186)				(0.292)			
Pharmaceuticals	0.366	n/a	n/a	n/a	1.038	n/a	n/a	n/a
	(0.230)				(0.380)			
Year controls								
Year 1988	−1.392	−3.946	n/a	−3.784	n/a	−17.630	n/a	−17.337
	(0.178)	(0.317)		(0.293)		(0.425)		(0.326)
Year 1989	−0.022	−4.184	n/a	−3.764	n/a	−1.887	n/a	−1.538
	(0.123)	(0.249)		(0.247)		(0.548)		(0.591)
Year 1991	−0.506	0.255	n/a	0.175	n/a	0.272	n/a	1.012
	(0.107)	(0.095)		(0.072)		(0.211)		(0.214)
Year 1992	−0.576	0.117	n/a	−0.057	n/a	0.291	n/a	0.890
	(0.108)	(0.058)		(0.064)		(0.112)		(0.272)
Additional year dummies	n/a	n/a	*Included*	*Included*	n/a	n/a	*Included*	*Included*
Constant	−1.279	n/a	n/a	n/a	−6.388	n/a	n/a	n/a
	(0.529)				(0.955)			
Log likelihood	−2032.78	−1245.91	−4132.82	−6131.83	−634.00	−419.69	−1057.60	−1705.00
(Wald) Chi-squared	345.3	802.3	1101	2232	319.8	10,004	971.5	20,100
Number of obs.	1,470	1,447	3,012	4,459	1,470	1,447	3,012	4,459

Table 2.   Continued

Interlock broadening				Interlock reinforcing				Multiplex ties			
BHP Table 4, Model 2				BHP Table 4, Model 4				BHP Table 5, Model 2			
Original study 1990–1993	Direct replication 1990–1993	Later period 1994–2010	Full period 1990–2010	Original study 1990–1993	Direct replication 1990–1993	Later period 1994–2010	Full period 1990–2010	Original study 1988–1993	Direct replication 1988–1993	Later period 1994–2010	Full period 1988–2010
−0.429	0.268	−0.291	−0.072	−1.890	0.908	0.178	0.163	1.803	0.430	0.799	0.495
(0.733)	(0.285)	(0.212)	(0.224)	(2.532)	(1.162)	(0.526)	(0.483)	(3.399)	(1.290)	(0.956)	(0.614)
2.523	0.519	−0.354	−0.200	15.111	2.954	0.038	0.204	11.473	7.180	−0.324	0.275
(1.622)	(0.482)	(0.368)	(0.274)	(4.408)	(1.703)	(0.541)	(0.443)	(6.743)	(3.672)	(0.738)	(0.534)
0.109	0.276	0.206	0.247	−0.010	−0.071	0.215	0.110	0.288	−0.554	0.283	−0.354
(0.046)	(0.213)	(0.092)	(0.078)	(0.128)	(0.669)	(0.136)	(0.113)	(0.159)	(1.056)	(0.278)	(0.175)
−0.005	0.115	−0.021	−0.006	−0.017	0.158	−0.021	−0.004	0.055	−0.311	0.160	0.167
(0.009)	(0.058)	(0.037)	(0.032)	(0.029)	(0.165)	(0.082)	(0.068)	(0.040)	(0.293)	(0.140)	(0.145)
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−2.989	−0.354	−1.155	−1.310
								(0.677)	(0.674)	(0.140)	(0.523)
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−1.933	−1.014	−1.067	−1.052
								(0.624)	(0.665)	(0.564)	(0.425)
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−0.647	−4.64E-04	−0.708	−0.374
								(0.468)	(0.396)	(0.431)	(0.335)
−0.002	−0.108	−0.043	−0.036	0.043	−0.120	−0.018	−0.019	n/a	n/a	n/a	n/a
(0.006)	(0.012)	(0.005)	(0.005)	(0.015)	(0.034)	(0.008)	(0.007)				
0.017	−0.006	−0.039	−0.051	−0.017	−0.232	0.058	0.044	n/a	n/a	n/a	n/a
(0.054)	(0.089)	(0.047)	(0.036)	(0.149)	(0.270)	(0.090)	(0.073)				
−0.093	n/a	n/a	n/a	0.992	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(0.215)				(0.506)							
0.031	n/a	n/a	n/a	0.532	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(0.175)				(0.417)							
0.377	n/a	n/a	n/a	1.444	n/a	n/a	n/a	n/a	n/a	n/a	n/a
(0.175)				(0.421)							
−0.781	n/a	n/a	n/a	−24.947	n/a	n/a	n/a	−1.057	n/a	n/a	n/a
(0.295)				(99,240)				(0.936)			
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−0.235	n/a	n/a	n/a
								(0.837)			
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.596	n/a	n/a	n/a
								(0.511)			
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−0.825	n/a	n/a	n/a
								(1.088)			
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−18.654	n/a	−16.556
									(0.671)		(0.340)
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−17.974	n/a	−16.283
									(0.479)		(0.362)
−0.341	−0.048	n/a	3.546	n/a	−0.182	n/a	0.390	n/a	−0.254	n/a	0.242
(0.090)	(0.065)		(0.261)		(0.200)		(0.287)		(0.279)		(0.377)
−0.480	−0.018	n/a	3.488	n/a	0.171	n/a	0.543	n/a	0.057	n/a	0.034
(0.076)	(0.051)		(0.257)		(0.191)		(0.320)		(0.412)		(0.511)
n/a	n/a	*Included*	*Included*	n/a	n/a	*Included*	*Included*	n/a	n/a	*Included*	*Included*
0.559	n/a	n/a	n/a	−2.941	n/a	n/a	n/a	−4.907	n/a	n/a	n/a
(0.424)				(1.167)				(1.900)			
−1499	−720	−4069	−5526	−302	−178	−1469	−1902	−144	−64.8	−170.4	−300.62
68.14	112.7	29,803	34,796	32.91	16.85	27,810	25,682	50.06	8437.99	8381.21	11738.66
720	719	3,012	3,731	720	719	3,012	3,731	1470	1,447	3,012	4,459

Robust standard errors in parentheses for replication results, standard errors for original study results.

their work, considering these relationships across a broader temporal context.

METHODS

Data sources and sample

We sought to follow the original work as closely as possible with respect to all assumptions and aspects of data structure. We collected data starting from the original study period, tracking the largest 300 firms listed by *Fortune* in the year 1990, the same sample criteria used in Beckman *et al.* (2004); however, we track this set of firms for a longer period of time, through 2010. This allows us to begin with a direct replication of their analyses in the original time frame of 1988–1993 for alliance formation and 1990–1993 for interlock formation, repeat the same analyses in a later time period of 1994–2010, and finally, conduct the same hypothesis tests regarding firm-level and market uncertainty across the entire period spanning the beginning of their observation window through the end of our data collection, 1988–2010 for alliances and 1990–2010 for interlocks. Using the same approach as the original article, we eliminated privately held and non-U.S.-based organizations, yielding a sample of 249 firms. We then observed board interlocks and alliance relationships among this sample from 1988 through 2010. Accounting for some cases of missing data, our full sample covers 4,459 firm-year observations for alliance and multiplex tie formation, and 3,731 observations for interlock formation. After omitting observations with missing data, the direct replication sample covers a total of 1,447 firm-year observations in the period of 1988–1993 for alliance and multiplex tie formation, and 719 observations for the direct replication tests of interlock formation.[2] The replication in the later time period of 1994–2010 covers 3,012 firm-year observations for all tests of interorganizational tie formation.

Variables

The dependent variables for the replication are constructed in the same manner as the original study.

Alliance broadening and *Alliance reinforcing* are count variables reflecting the number of times during an observation year that a focal firm in our sample engaged in a strategic alliance with a new partner firm (broadening), or a new alliance involving a partner with which the focal firm has collaborated in a previous alliance (reinforcing). As with the original study, we draw from the Securities Data Corp. (SDC) database to identify alliance relationships. The board interlock tie formation dependent variables, *Interlock broadening* and *Interlock reinforcing,* are count variables constructed in a similar fashion. As with the original study, we collected board data directly from firm proxy statements and calculated board interlock tie formation based on our within-sample network of firms (Cannella, Jones, and Withers, 2015). Finally, the dependent variable, *Multiplex tie formation* is measured as the count of new alliance ties formed between firms that shared one or more previous board interlockties.

We directly follow the approach of Beckman *et al.* (2004) in the construction of the independent variables for the replication study. *Firm-specific uncertainty* is the standardized monthly volatility of the focal firm's stock. This is measured as the standard deviation of the focal firm's monthly closing prices on the stock market over the course of the year, divided by the average of the firm's monthly closing price over the same period. This measure is then lagged by one year relative to the year of observation. *Market uncertainty* is measured as the average monthly volatility across all companies in the focal firm's industry. As in the original article, we follow the *Fortune* industry classifications in constructing this measure.

We match the same set of control variables from the original study. Financial measures *(Log) assets* and *Adjusted ROA* are included to control for firm size and performance. These data are collected from the COMPUSTAT database. We control for *Centrality* in the interlock analysis, measured as the degree centrality, or total number of interlock ties held by the focal firm, lagged from the year prior to observation. We do not follow Beckman *et al.* (2004) in using industry control dummy variables; as described in further detail below, we implement fixed effects regression techniques in our replication analysis, which eliminate the need for time-invariant industry controls. Finally, we do control for *Prior alliances* in the alliance analysis and *Prior acquisitions* in the

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[2] Consistent with the original Beckman *et al.* study, the relatively smaller sample size for the interlock tests is due to the use of 1990 as a reference year to predict subsequent interlock tie formation, while 1988 serves as the baseline reference year for alliance formation.

interlock analysis in the same manner as the original study.

Analysis

Beckman *et al.* (2004) employ a negative binomial regression in their analysis. As they note, this is the appropriate model specification for dealing with discrete count-based outcome variables exhibiting an overdispersion to zero (Greene, 2003). However, the original study used a random effects model, which may be influenced by unobserved factors reflected in the between-firm variance, leading to potentially biased results. Fixed effects models overcome this issue by including indicator variables for all firms, and in turn, only focusing on within-firm variance (Allison, 2005, 2009). Negative binomial fixed effects models available within most statistical software programs, however, are not viable solutions—these models use conditional maximum likelihood estimations and are not true "fixed effects models" (Guimarães, 2008). As such, more recent work suggests that Poisson Quasi-Maximum Likelihood estimation is suitable for fixed effects analysis of panel data with discrete, over-dispersed dependent variables (Allison and Waterman, 2002; Carnahan and Somaya, 2013). We implemented this regression specification using the "xtpqml" command in Stata. Finally, we compared the random and fixed effects estimators using a Hausman test (Hausman, 1978), which suggested the random effects model was not appropriate for our sample.

RESULTS

Direct replication of Beckman *et al.* study

Descriptive statistics and bivariate correlations for all study variables are shown in Table 3, revealing key similarities and differences between our replication study and the original work by Beckman *et al.* (2004).

First, the overall level of alliance activity in our 1988–2010 sample seems higher than in the original study. The mean values for both broadening and reinforcing alliance ties are somewhat higher (2.65 versus 1.82 for broadening alliances; 0.52 versus 0.45 for reinforcing). Alliances may have grown in popularity as a means for external collaboration and engagement over the longer period of our

replication study (Dunning, 1995; Rivera-Santos and Inkpen, 2009). The comparison of interlock ties between our replication and the original study reveals lower mean values for broadening ties (1.92 versus 2.87), though an increase for reinforcing interlocks (0.25 versus 0.16). Institutional changes such as the adoption of Sarbanes-Oxley legislation in 2002 may account for the changes in interlock ties as the market for directors became more constricted (Linck, Netter, and Yang, 2009). Finally, we note that the mean levels of firm-specific uncertainty and market uncertainty are slightly higher in the replication sample (0.14 versus 0.10 for the former; 0.14 versus 0.10 for the latter). This may be due to time-period differences in uncertainty at the firm and market levels.

We report the results of our direct replication of the Beckman *et al.* study period in Table 2, alongside the findings of the original study. For each of the hypothesis test models from the Beckman *et al.* study, we conduct replication tests using Poisson Quasi-Maximum Likelihood models using fixed effects.[3] In general, the direct replication results shown in Table 2 provide a close match to the findings of the original study. Firm-specific uncertainty is shown to have a negative effect on broadening alliance formation ($\beta = -0.880$). In our replication sample, the probability of obtaining values as large as the observed coefficient under the null hypothesis is $p = 0.03$. In the case of broadening interlocks, the statistical evidence is not as compelling ($\beta = 0.268$, $p = 0.35$). Beckman *et al.* (2004) discuss that this may relate to a threat-rigidity response in cases of high firm-specific uncertainty.[4] Our results for market uncertainty also closely match their work, showing its positive role in the formation of reinforcing alliances ($\beta = 4.141$, $p = 0.03$) and interlocks ($\beta = 2.954$, $p = 0.08$) as well as in the formation of multiplex ties ($\beta = 7.180$, $p = 0.05$). Overall, the similar results of this direct replication reaffirm the original findings within the 1988–1993 time frame and provide evidence that we are indeed

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[3] As mentioned previously, Hausman tests indicated that random effects negative binomial models were not appropriate.

[4] In their study, they demonstrate that a subset analysis of firms facing high firm-level uncertainty and low market-level uncertainty reveals positive effects of firm-specific uncertainty on broadening alliance formation, consistent with their underlying theory. We attempted a similar analysis, and did note the change in sign for the coefficient, but failed to achieve compelling levels of significance.

Table 3. Descriptive statistics and bivariate correlations

	Variable	Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7	8	9
1	Broadening alliances	2.65	8.20	0	160									
2	Reinforcing alliances	0.52	3.03	0	76	0.84								
3	Broadening interlocks	1.92	3.02	0	30	0.18	0.12							
4	Reinforcing interlocks	0.25	0.67	0	10	0.09	0.07	0.46						
5	Multiplex reinforcing	0.03	0.21	0	4	0.43	0.35	0.16	0.10					
6	(Log) assets	8.67	1.31	−2.87	13.59	0.32	0.22	0.12	0.15	0.17				
7	Adjusted ROA	0.02	0.96	0	46.45	0.02	0.03	0.02	0.01	0.02	−0.02			
8	Centrality	7.48	8.31	0	45	0.30	0.19	0.48	0.21	0.14	0.22	0.03		
9	Number of prior acquisitions	0.83	0.86	0	4	0.22	0.13	0.15	0.12	0.09	0.32	0.06	0.20	
10	Prior alliances (0)	0.61	0.49	0	1	−0.36	−0.21	−0.25	−0.13	−0.16	−0.26	−0.01	−0.34	−0.27
11	Prior alliances (1–2)	0.18	0.38	0	1	−0.05	−0.06	0.06	0.03	−0.04	−0.04	0.00	0.07	0.08
12	Prior alliances (3–15)	0.16	0.37	0	1	0.14	0.01	0.16	0.08	0.07	0.18	−0.01	0.24	0.15
13	Industry: computers	0.03	0.17	0	1	0.20	0.18	−0.05	−0.02	0.11	0.01	−0.02	−0.06	0.02
14	Industry: bank	0.00	0.06	0	1	−0.02	−0.01	−0.03	−0.02	−0.01	0.00	0.00	−0.05	−0.05
15	Industry: electronics	0.01	0.11	0	1	−0.02	−0.02	0.05	0.00	−0.01	0.03	0.01	0.06	0.07
16	Industry: service	0.02	0.13	0	1	0.25	0.22	0.01	0.01	0.06	0.10	0.00	0.07	0.07
17	Industry: utilities	0.00	0.06	0	1	−0.02	−0.01	−0.04	−0.02	−0.01	0.03	0.00	−0.04	0.03
18	Industry: chemicals	0.10	0.30	0	1	−0.04	−0.04	0.02	0.01	−0.02	−0.06	0.00	0.02	−0.01
19	Industry: pharmaceuticals	0.05	0.21	0	1	0.07	−0.01	0.08	0.07	−0.01	0.18	0.00	0.10	0.03
21	Market uncertainty	0.14	0.10	0.01	1.55	0.04	0.02	−0.09	−0.02	0.05	0.05	−0.02	−0.11	0.00
22	Firm-specific uncertainty	0.14	0.11	0	1.61	0.02	0.03	−0.05	−0.01	0.03	0.03	−0.07	−0.10	0.00

	Variable	10	11	12	13	14	15	16	17	18	19	20
11	Prior alliances (1–2)	−0.58										
12	Prior alliances (3–15)	−0.55	−0.20									
13	Industry: computers	−0.07	−0.06	0.03								
14	Industry: bank	0.01	0.01	−0.01	−0.01							
15	Industry: electronics	0.00	0.02	−0.01	−0.02	−0.01						
16	Industry: service	−0.07	−0.03	0.05	−0.02	−0.01	−0.01					
17	Industry: utilities	0.05	−0.03	−0.03	−0.01	0.00	−0.01	−0.01				
18	Industry: chemicals	0.01	0.01	0.01	−0.06	−0.02	−0.04	−0.04	−0.02			
19	Industry: pharmaceuticals	−0.13	−0.03	0.19	−0.04	−0.01	−0.02	−0.03	−0.01	−0.08		
21	Market uncertainty	0.02	−0.02	−0.03	0.11	0.02	0.01	0.07	−0.01	−0.02	−0.05	
22	Firm-specific uncertainty	−0.03	0.01	0.01	0.08	0.02	0.01	0.07	−0.01	−0.02	−0.03	0.30

following a similar empirical approach to Beckman *et al.* (2004).

Relaxing the time-based boundary conditions of the Beckman *et al.* study

Next, we test the effects of firm-specific and market uncertainty in the later time period of 1994–2010, and across the entire time span of our data sample, 1988–2010. The results of these analyses are included in the third and fourth columns of each section of Table 2. When compared to the time frame of the original study, firm-specific uncertainty is not shown to have as significant an effect on broadening alliance formation in 1994–2010 ($\beta = -0.015$, $p = 0.92$) or in 1988–2010 ($\beta = -0.178$, $p = 0.23$). However, we note an interesting effect; market uncertainty shows increasing significance in predicting broadening alliances across 1994–2010 ($\beta = 0.186$, $p = 0.22$) and 1988–2010 ($\beta = 0.275$, $p = 0.06$). In contrast to the original study, our replication in a different and broader time horizon suggests that uncertainty at the market level, rather than the firm level, may become important in driving broadening alliances within a different temporal context.

The tests for the effects of firm-level uncertainty on broadening interlock formation show somewhat higher significance in 1994–2010 ($\beta = -0.291$, $p = 0.17$ versus $\beta = -0.429$, $p = 0.57$ in the original), though limited significance in 1990–2010 ($\beta = -0.072$, $p = 0.75$). Unlike the interesting effects in broadening alliances, we do not observe a greatly significant role of market uncertainty in predicting broadening interlocks over either time span ($\beta = -0.354$, $p = 0.34$ in 1994–2010; $\beta = -0.200$, $p = 0.46$ in 1990–2010).

We next turn to the later period tests of the effects of the two forms of uncertainty on reinforcing interorganizational ties. We see a similar interesting reversal between firm and market uncertainty in predicting reinforcing alliance formation. While market uncertainty becomes somewhat less significant than in the original time frame ($\beta = 0.699$, $p = 0.20$ in 1994–2010; $\beta = 0.500$, $p = 0.23$ in 1990–2010), firm-specific uncertainty is highly significant in those periods ($\beta = 0.982$, $p = 0.01$ in 1994–2010; $\beta = 0.642$, $p = 0.04$ in 1990–2010). Once again, temporal effects appear to change how different forms of uncertainty increase the likelihood of alliance tie formation. With respect to reinforcing interlock ties, the later time period and full-time period results show very low significance for coefficients associated with both market uncertainty ($\beta = 0.038$, $p = 0.94$ in 1994–2010; $\beta = 0.204$, $p = 0.64$ in 1990–2010) and firm-specific uncertainty ($\beta = 0.178$, $p = 0.74$ in 1994–2010; $\beta = 0.163$, $p = 0.74$ in 1990–2010).

Finally, the last two columns of Table 2 report our later period tests for multiplex tie formation. While market uncertainty was significant in predicting multiplex tie formation in the original study and in our direct replication, this is no longer the case in the later period and full period. ($\beta = -0.324$, $p = 0.66$ in 1994–2010; $\beta = 0.275$, $p = 0.61$ in 1990–2010). This provides evidence that some aspects of the differing time periods reduce the effects of uncertainty in multiplex tie formation.

DISCUSSION

Using a similarly constructed sample of the largest 300 firms listed by *Fortune*, but across a longer time period, we replicated Beckman *et al.*'s (2004) study of market and firm-specific uncertainty on broadening, reinforcing, and multiplex network tie formation. Our baseline replication of their analyses in the time frame of the original study matched closely with their results, providing evidence to corroborate their initial findings within that sample time period. Interestingly, our analyses across a longer sampling period yielded strikingly different results. Overall, Beckman *et al.* (2004) propose that firm-specific uncertainty would relate to firm network broadening actions, while market-specific uncertainty causes firms to reinforce current network ties. Our replication finds a more nuanced relationship across a longer time period: Market-specific uncertainty caused firms to broaden their network partners through alliances but not interlock ties; while, firm-specific uncertainty was related to reinforcing existing ties in alliance networks. While the original work finds that market-specific uncertainty drives multiplex tie formation, our later period and broader period analyses show much lower significance for this effect.

Recent research suggests that there may be a general trend toward broadening network ties. For example, Hambrick *et al.* (2004: 323) examine data from 1980 to 2000 and posit that "Instead of a narrowing of resource providers, the strategic evolution of many industries was toward a broader set of resource relationships." In other words, to deal

with uncertainty, the dominant approach has been to broaden interorganizational ties. Despite this trend, however, firms with higher levels of firm-specific uncertainty may be disadvantageously positioned within the network structure. These firms, in particular, may lack the ability to find new partners willing to form either strategic alliances or board interlocks to help diversify firm-specific risk when considering the formation of these relationships over longer time horizons.

Comparing our results with those of the original study suggests that time may represent an important contextual influence on the formation of interorganizational relationships. Strategic management scholars recognize the inherent complexity that derives from these contextual considerations, which, in turn, may influence how organizations compete and gain competitive advantage (D'Aveni, Dagnino, and Smith, 2010; Finkelstein, 1997; Hitt *et al.*, 2001). Reflecting this complexity, we find that by relaxing the temporal boundary conditions, the relationships between firm-level and market uncertainties, and reinforcing and broadening ties may change relative to the original findings in Beckman *et al.* (2004). For example, in our analysis of the broader time span, our results suggest that firms experiencing greater firm-level uncertainty may seek reinforcing alliances rather than engaging in the broadening alliance ties observed in the original study. Similarly, we see changes in the effects of market uncertainty, which enhances the likelihood of reinforcing alliance and interlock ties in the time period of the original study, but increases the chances of broadening alliances across the full sample period. Finally, we find diminished evidence that multiplex ties are affected by market uncertainty in the different time period. As such, our study highlights the nuance that may emerge from reexaminations of the studies over time and the importance of considering time in strategic management (Mosakowski and Earley, 2000). We suggest that our results, when combined with those of Beckman *et al.* (2004), demonstrate the broader influences of time considerations on firm tie formation in both alliance and interlock networks.

Contribution

Our replication of Beckman *et al.* (2004) offers a number of contributions in advancing research on interorganizational relationships. This has proven to be an important topic for management scholars and one of the central themes addressed in the *Strategic Management Journal* in recent years. Our results provide new statistical evidence into the mechanisms that might direct these relationships. As such, we would suggest that the original and current studies work in tandem to provide a more nuanced perspective of uncertainty in interorganizational tie formation by capturing the role of context—in this case, time—in the decision of firms to form alliances and board interlocks.

Our work combined with Beckman *et al.*'s (2004) original study provides compelling evidence that temporal considerations may be important boundary conditions to understanding alliance and interlock formation. The aggregate results of the two studies suggest that firms respond to greater market uncertainty by reinforcing their existing external ties during the original studies sampling context, while when examining the formation of these relationships across a longer time period, firms are more likely to seek out new, broadening relationships. At the same time, firm-specific uncertainty causes them to pursue new relationships during growth periods, but reinforce existing ties in periods of economic decline. From a theoretical standpoint, this suggests that temporal conditions play an important role in determining how firms address uncertainty.

Future research

Through our reexamination and extension of Beckman *et al.*'s (2004) original study, our replication offers a number of promising avenues for future research. Future work on interorganizational relationships may look for ways to further contextualize theory and empirical tests to offer new insights into the complexity around these relationships. For example, the recent economic recession of 2008 may have far reaching implications for how firms form and utilize interorganizational relationships. Delving into this type of question may require examining data that span the pre- and post-event contexts (for recent examples, see Chakrabarti, 2015; Ndofor, Vanevenhoven, and Barker, 2013) or examining phenomena for longer periods of time than is traditionally done in strategy research (e.g., Certo and Semadeni, 2006).

Research may also further consider the role of multiplexity in interorganizational relationships. A major contribution of Beckman and colleagues' original work was the dual consideration of strategic alliances and board interlocks. Yet, subsequent

research has largely failed to address simultaneous, multiple forms of interorganizational relationships. This omission is unfortunate given the interrelatedness of these different organizational strategies (Gulati and Westphal, 1999). As such, a number of important questions around multiplexity remain unanswered. For example, are certain organizations more likely to develop multiplex relationships? How do firms manage and govern these multiplex relationships? Are there long-term benefits to multiplex ties? Or, do firms benefit more from relationship diversity?

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