ALMA MATER STUDIORUM - Università di Bologna

DOTTORATO DI RICERCA
IN DIREZIONE AZIENDALE
XXIV CICLO

Settore Concorsuale di afferenza: 13/B2
Settore Scientifico Disciplinare: SECS-P/08

Titolo Tesi:

COLLABORATIVE CHANGE: ENVIRONMENTAL JOLT, NETWORK (RE)DESIGN, AND FIRM PERFORMANCE

Presentata da: Leonardo Corbo

Coordinatore dottorato:
Prof. Salvatore Torrisi

Relatori:
Prof.ssa Cristina Boari

Prof.ssa Paolo Boccardelli

Prof. Raffaele Corrado

Prof. Simone Ferriani

Esame finale anno 2012

TABLE OF CONTENTS

INTRODUCTION 2

ADAPTING TO ENVIRONMENTAL JOLTS: A NETWORK CHANGE PERSPECTIVE 12

- INTRODUCTION 13
- THEORETICAL BACKGROUND 16
- PROPOSITIONS 24
- DISCUSSION AND CONCLUSIONS 30
- REFERENCES 33
- APPENDIX 38

THE ROLE OF ENVIRONMENTAL JOLTS ON INTERORGANIZATIONAL NETWORK CHANGE: EMPIRICAL EVIDENCE FROM THE GLOBAL AIRLINE INDUSTRY, 1998-2006 39

- INTRODUCTION 40
- THEORY AND HYPOTHESES DEVELOPMENT 43
- METHODS 56
- RESULTS 60
- DISCUSSION AND CONCLUSIONS 61
- LIMITATIONS AND FUTURE DIRECTIONS 65
- REFERENCES 67
- APPENDIX 71

ENVIRONMENTAL JOLTS, FIRM SIZE, AND THE RELATIONSHIP BETWEEN BROKERAGE AND FIRM PERFORMANCE 75

- INTRODUCTION 76
- THEORY AND HYPOTHESES DEVELOPMENT 79
- INDUSTRY SETTING 89
- METHODS 91
- RESULTS 98
- DISCUSSION AND CONCLUSIONS 101
- LIMITATIONS AND FUTURE DIRECTIONS 106
- REFERENCES 108
- APPENDIX 114

ACKNOWLEDGEMENTS 117

CONCLUSIONS 119

INTRODUCTION

Over the past decades, academic researchers have become increasingly fascinated with the growing number of cooperative ties that firms create with each other. While much of the previous studies has focused on competitive dynamics, scholars are progressively redirecting their attention to the dynamics of cooperation. Decision makers belonging to manufacturing and services industries recognize the importance of cooperation switching from pure competition to coopetition (Brandenburger & Nalebuff, 1996). Big corporations like Motorola, Siemens, American Airlines and Toyota have all recognized the importance of collaborating to compete.

There are many options through which a firm can partner with another. One of fastest growing sets of interorganizational ties is represented by strategic alliances that firms enter to achieve a common goal. Among the various definitions of strategic alliances I choose the one provided by Das and Teng (2000: 33) who define them as “voluntary cooperative inter-firm agreements aimed at achieving competitive advantage for partners”. Given the broad definitions of strategic alliances provided by previous studies, including the one I have chosen, it may be complex to define which agreement can be classified as strategic and which not. To give a more precise definition of the scope of inter-firm relationships I follow the classification provided by Yoshino and Rangan (1995). Figure 1 provides an overview of the range of interorganizational relationships that can be categorized as strategic alliances.

Insert Figure 1 about here

One of the reasons why strategic alliances have become so popular is their flexible nature. Strategic alliances lie at the heart of the make or buy continuum. In other words they could be seen as a compromise between the excessive costs and time required for an organic growth and the complexity and high capital requirements for mergers and acquisitions. For this reason strategic alliances have been frequently considered as an engagement between two companies whereas a merger is typically considered as a marriage. Just as an engagement between two individuals, strategic alliances can be the premise of a deeper future cooperation which may turn into a merger, or marriage to use the previous metaphor. However, during the alliance phase, the two companies will have time to explore if they are fit to each other and if the outcome of the cooperation does not meet the initial target, the relationship may terminate with smaller damages than in the case of a merger or acquisition. It has been recently estimated that many of the world’s largest companies had over 20% of their assets tied up in alliances (Ernst, 2004). According to a study made by Partner Alliances, over 80% of Fortune 1000 CEOs believed that alliances would account for almost 26% of the companies’ revenues in 2007-08 (Kale, Singh, & Bell, 2009). Despite those numbers, alliance failure rates range between 60 and 70% (Hughes & Weiss, 2007). To solve this paradox, practitioners and scholars have elaborated a series of tools and “recipes” such as creating a solid business plan backed up by a detailed contract or defining metrics for assessing the value the alliance delivers.

Besides these relevant aspects, I believe there is one important problem characterizing most, if not all, companies engaging in multiple alliances: the focus on single dyads. It is not rare to observe within a company the absence of a specific function dedicated to alliance management with alliances being managed at the corporate level with the support of mid-level managers in finance or marketing departments. This may increase even more the complexity of managing a broad set of alliances leading to a myopia that hinders the firm’s ability to fully exploit the interdependencies between each dyadic tie. In my view, the adoption of a holistic approach toward alliance management could maximize the benefits the firm can accrue from its portfolio of alliances. The portfolio metaphor refers to a firm's collection of direct alliances with partners. It is akin to the notion of the egocentric network, which encompasses the focal firm (ego), its set of partners (alters), and their connecting ties (Wasserman and Faust, 1994). The fact that a firm may have a great number of ties suggests that it has to simultaneously manage this portfolio and address potentially conflicting demands from multiple partners (Gulati, 2007). Accordingly, it may be reasonable to argue that competition has progressively moved from one-to-one competition to competition between ego networks and to competition between groups of ego networks. Recent examples of this pattern can be found in airlines, automobiles, telecommunications, and computers. In the airline industry for instance, in order to overcome regulatory barriers and share costs while increasing market coverage, airlines have teamed up by building alliance groups that compete with each other. Gomes-Casseres has been one the first scholars to argue that the competitive game is often transformed from firm versus firm to group versus group. He coined the term constellation to describe a set of firms linked together through alliances and that competes in a particular competitive domain (Gomes-Casseres, 1996).

Although the focus may have switched from more micro to more macro levels, research on inter-firm relationships has curiously been for its most part cross-sectional. Furthermore, there has been a more or less implicit assumption of stability in the majority of these studies. A recent special issue appearing on Organization Science edited by Ahuja, Soda, and Zaheer (2011) has specifically tackled some of the above issues. These scholars raise some important questions concerning the validity of previous research highlighting the positional and relational benefits of networks. For example, we know that actors that span structural holes can use their position to benefit themselves as they trade information, favors, and the like. But this raises the natural question of why structural holes remain unfilled. What happens as other players in a network observe the returns to network entrepreneurship of the sort envisaged most famously in Burt's work (Ahuja *et al.*, 2011: 1024)? These considerations suggest that in order to have a better understanding of the emergence and evolution of interorganizational networks, we need to formulate and test hypotheses using longitudinal datasets. In an effort to do so, my thesis provides an important contribution to the alliances and networks literature by explicitly surpassing the static view on alliance networks.

The adoption of an evolutionary approach implies that networks change over time through the creation and/or dissolution of ties. In this regard, it is necessary to understand the determinants of these changes (antecedents) and the impact they may have on a company's performance (consequences). Although in recent years some progress has been made in understanding the dynamics of networks, for the most part scholars have focused on the endogenous influence of network structure to explain the evolution of networks. In its most prominent exposition, an evolutionary view of networks has emphasized network structure as its own context for evolution (Gulati & Gargiulo, 1999). Minor contributions are therefore taking into account exogenous factors. The combination of focusing almost exclusively on the endogenous influence of network structure on network change and the assumption of equilibrium have led scholars to underestimate the importance of studying the impact of factors exogenous to the network (e.g. environmental changes) and situations far from equilibrium. My study is one of the very first attempts to do so and thus provides a valuable contribution to the small but growing research on network change.

To study how disruptions stemming from the external environment influence network behavior and its performance consequences, I introduce the concept of environmental jolt. The first scholar to explicitly address situations far from equilibrium by using the term environmental jolt is Meyer (1982) in his seminal study of organizational response of a group of hospitals in the San Francisco area during a doctors' strike. Discontinuities or shocks can profoundly transform the structure of networks eventually resulting in the reorganization of an entire sector. At the same time, companies can use their networks to mitigate the uncertainty caused by such shocks. Since a jolt may interest the network at more than one level (e.g, the ego network, the dyads, the triads or the whole network), it is necessary to conduct multilevel research to get a complete picture of network dynamics. This thesis focuses specifically on egocentric networks, dyads, triads, and ultimately on the whole level since macro changes at the industry network level are driven by the aggregation of numerous micro changes (changes at the firm ego network level), much as the behavior of an overall market rests on the individual behaviors of numerous market participants (Koka, Madhavan, & Prescott, 2006: 726). In particular, I explore the effects of an environmental jolt on the formation and dissolution of dyadic and triadic ties using a longitudinal dataset of nine years in the global airline industry. In so doing, I follow the more traditional definition of network change which defines network change as the formation, dissolution or replacement of (dyadic) ties. Given that an environmental jolt could also impact on network structure, it is also worth exploring the structural changes that the jolt produces and their impact on firm performance. Accordingly, I also explore how changes in the structure (e.g., creation of structural holes or network closure) impact on firm performance contingent on environmental changes. Below I summarize some noteworthy outcomes of my research:

- In response to an exogenous shock, firms have a tendency to adopt a more conservative posture by limiting entrepreneurial networking actions;
- At the dyadic level, this attitude is explained through the formation of relationships on the basis of similarity (homophily) during the jolt period;
- At the triadic level, this attitude is explained through the formation of transitive triads (transitive closure) during the jolt period;

- Building a sparse network has a positive effect on operating performance of companies under conditions of stability;
- After an exogenous shock, this strategy loses its efficacy;
- Firm size is an important variable to take into account in studying network dynamics;
- Large firms that build a sparse network during the jolt, report negative operating performance.

The empirical setting in which this research has been carried out is the global airline industry which is usually regarded as a troubled industry. This industry has repeatedly reported severe losses due to both inherent problems characterizing the industry (e.g, fierce competition following deregulation which saw the entrance of new competitors and the emergence of the low cost business models) and the fact that the financial performance of the industry is strongly correlated with the larger business cycle (Figure 2).

Insert Figure 2 about here

Exogenous shocks such as the explosion of the dot-com bubble in 2000, the security implications of September 11th 2001, the Severe Acute Respiratory Syndrome outbreak in 2003 and the United States housing price bubble of 2007 have substantially impacted airlines capability to recover which has resulted in the collapse of many, sometimes well-established, airlines such as AOM French Airlines, Trans World Airlines (TWA), Pan American World Airways (Pan Am), Sabena, and Swissair just to name a few. Faced with these challenges, airlines have increasingly understood the importance of cooperation first through dyadic ties and then through the creation of multi-partner alliances or constellations that compete with each other and with other single big carriers, such as Virgin and Emirates, that do not belong to any of these constellations. The airline industry is being to a large extent considered a mature one, with established technology and transportation being considered as a commodity. Given that outright cross-border acquisitions are often disallowed, airlines have entered into alliances to build seamless networks with limited additional costs, to bypass restrictive regulations, to increase market presence and visibility, to create a unified marketing image, and to provide a foundation for the coordination of services to eventually reduce costs and competition (Iatrou & Oretti, 2007). For the above reasons the airline industry appeared to be an excellent context in which to test my hypotheses. As an exogenous and negative jolt, he 9/11 terrorist attacks in the United States provided me with a natural experiment to conduct my research. To my knowledge, this has been the very first study to theorize and test on the impact of environmental jolts on interfirm networks and this, I believe, is the greatest contribution of this work which develops as follows.

This thesis is a collection of three essays. The first essay, *"Adapting to Environmental Jolts: A Network Change Perspective"*, is a theoretical paper. Its main purpose is to understand the underlying forces that trigger network evolution by developing a conceptual framework at the firm and the environment levels of analysis. Non-routine situations, as opposed to routine ones, are seen as a central force in shaping patterns of network evolution. Firm level attributes size, centrality, and geographic scope are taken into account in the relationship between environmental change and network change. By paying attention to the impact of non-routine changes in the external environment, this paper facilitates bridging the theoretical foundations of network evolution from an evolutionary to a revolutionary view of network change. The other two essays are empirical and use second-order data although employing different statistical methods. The first empirical paper, *"The Role of Environmental Jolts on Interorganizational Network Change: Empirical Evidence from the Global Airline*

Industry, 1998-2006 ", focuses on the antecedents of network change. The purpose of this study is to investigate the impact of non-routine change in the environment on well established network mechanisms at the dyadic and triadic levels of analysis. The originality of this study lies in the fact that it is one of the very first network studies proposing, and empirically testing, a multilevel model of network change. Moreover, no previous studies have examined the longitudinal impact of disruptive forces on the network attributes at multiple levels of analysis. The second empirical paper, *"Environmental Jolts, Firm Size, and the Relationship Between Brokerage and Firm Performance"*, focuses on the consequences of network change. The purpose of this study is to investigate the characteristics at the environment and firm level that influence the relationship between a firm's brokerage propensity and its performance. The link between a firm's position in an alliance network and its performance is still poorly understood. This study contributes to the structural holes theory by proposing a contingency model that encapsulates both firm and environment attributes. Moreover, it departs from previous research that has analyzed the structural holes-performance relationship in static environments by looking at the differences in this relationship in periods of equilibrium and disequilibrium.

REFERENCES

Brandenburger, A., & Nalebuff, B. 1996. ***Co-opetition: A revolution mindset that combines competition and cooperation***. Currency Doubleday: New York.

Das, T. K., & Teng, B. 2000. A resource-based theory of strategic alliances. ***Journal of Management***, 26(1): 31-61.

Ernst, D. 2004. Envisioning collaboration. In J. Bamford, B. Gomes-Casseres, & M. Robinson (Eds.), ***Mastering alliance strategies***. San Francisco: Jossey-Bass.

Gomes-Casseres, B. 1996. ***The alliance revolution: the new shape of business rivalry***. Harvard University Press: Cambridge, MA.

Gulati, R. 2007. ***Managing Network resources: Alliances, affiliations, and other relational assets***. Oxford University Press: New York.

Gulati, R., & Gargiulo, M. 1999. Where do interorganizational networks come from? ***American Journal of Sociology***, 104(5): 1439–1493.

Hughes, J., & Weiss, J. 2007. Simple rules for making alliances work. ***Harvard Business Review***, 85: 122-131.

Iatrou, K., & Oretti, M. 2007. Airline choices for the future: From alliances to mergers. Ashgate: Aldershot, UK.

Kale, P., Singh, H., & Bell, J. 2009. Relating well: Building capabilities for sustaining alliance networks. In P. Kleindorfer & Y. Wind (Eds.), ***The network challenge: Strategies for managing the new interlinked enterprise***. London: Pearson Press.

Koka, B. R., Madhavan, R., Prescott, J. E. 2006. The evolution of interfirm networks: Environmental effects on patterns of network change. ***Academy of Management Review***, 31(3): 721-737.

Meyer, A. D. 1982. Adapting to environmental jolts. ***Administrative Science Quarterly***, 27(4): 515-537.

Wasserman, S., & Faust, K. 1994. ***Social Network Analysis: Methods and Applications***. Cambridge University Press: Cambridge, U.K.

Yoshino, M., & Rangan., S. 1995. ***Strategic alliances: An entrepreneurial approach to globalization***. Boston: Harvard Business School Press.

APPENDIX

Figure 1. Scope of inter-firm relationships

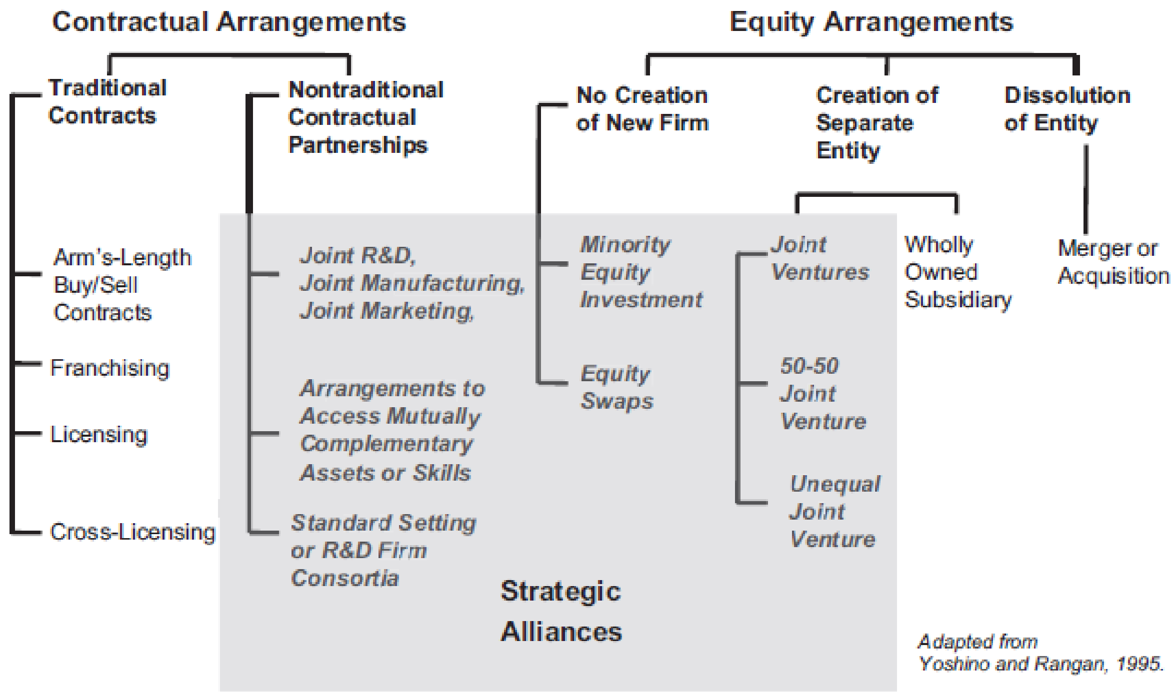
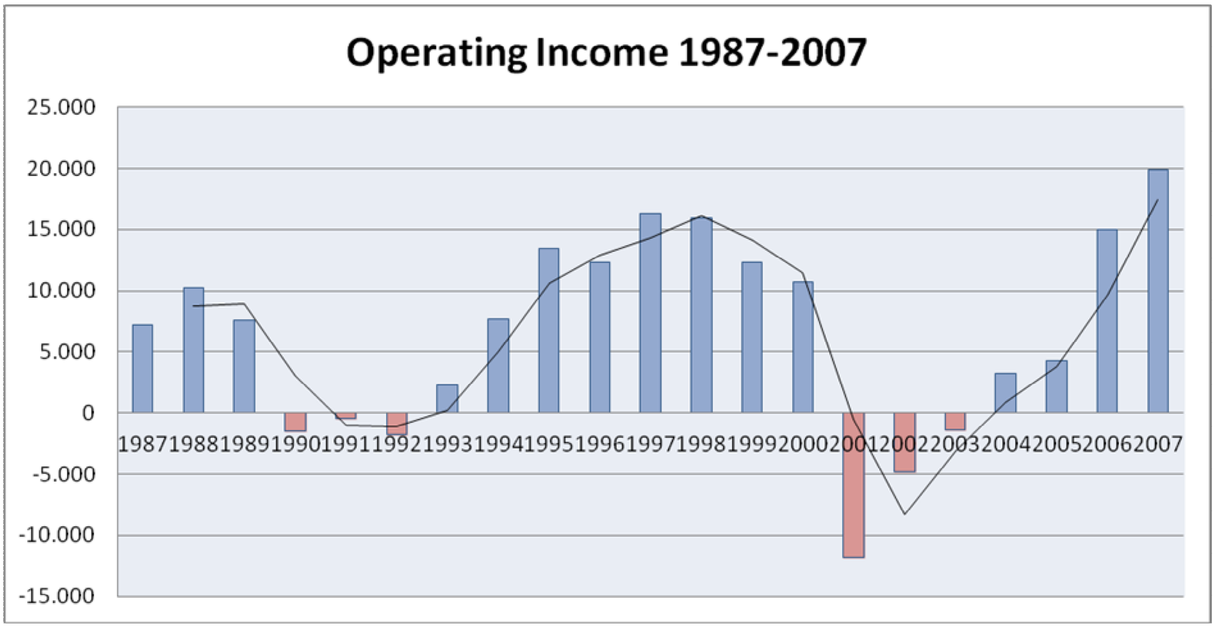


Figure 2. Overview of the global airline industry profitability, 1987-2007 (Source: ICAO)



ADAPTING TO ENVIRONMENTAL JOLTS: A NETWORK CHANGE PERSPECTIVE

Presented at:

- *Academy of Management Annual Meetings* (AoM), San Antonio, TX, USA, 2011
- *27th EGOS Colloquium*, Gothenburg, Sweden, 2011

Abstract. *Motivated by the need to understand which are the underlying forces that trigger network evolution, we develop a multilevel theoretical model to examine the relationship between changes in the environment and network change. We refer to network change as the dissolution or replacement of an interorganizational tie, adding also the case of the formation of new ties with new or preexisting partners. Previous research has paid scant attention to the organizational consequences of quantum change enveloping entire industries in favor of an emphasis on continuous change. To highlight radical change we introduce the concept of environmental jolt. Since network change can be explained at multiple levels, we incorporate the firm-level variables centrality, firm size, and geographic scope as moderators. Propositions linking environmental and firm attributes with network change are offered to enrich the discourse on network evolution.*

Adapting To Environmental Jolts: A Network Change Perspective

ABSTRACT

Motivated by the need to understand which are the underlying forces that trigger network evolution, we develop a multilevel theoretical model to examine the relationship between changes in the environment and network change. We refer to network change as the dissolution or replacement of an interorganizational tie, adding also the case of the formation of new ties with new or preexisting partners. Previous research has paid scant attention to the organizational consequences of quantum change enveloping entire industries in favor of an emphasis on continuous change. To highlight radical change we introduce the concept of environmental jolt. Since network change can be explained at multiple levels, we incorporate the firm-level variables centrality, firm size, and geographic scope as moderators. Propositions linking environmental and firm attributes with network change are offered to enrich the discourse on network evolution.

Keywords: multi-level; network change; environmental jolt

INTRODUCTION

From time to time, organizational environments undergo cataclysmic upheavals – changes so sudden and extensive that they alter the trajectories of entire industries, overwhelm the adaptive capacities of resilient organizations, and surpass the comprehension of seasoned managers (Meyer, Brooks, & Goes, 1990: 93). Transient perturbations whose occurrences are difficult to foresee and whose impacts on organizations are disruptive and potentially inimical are also known in literature as environmental jolts (Meyer, 1982). Scholars dealing with business studies have assumed for a long time that organizations operate in equilibria. This assumption of equilibrium and linearity has distracted organizational and strategic management researchers from studying the impact of profound changes in organizational theory and research. Although they recognize the existence of field-wide flux, emergence, convergence and collapse, sidestep direct investigations of the causes and dynamic processes are often times left to political scientists and institutional economists (Meyer, Gaba, & Colwell, 2005). As a result, no theories and *little empirical work* have been developed explaining the organizational consequences of quantum changes enveloping entire industries (Meyer *et al.*, 1990) (words in *italics* added). Accordingly, we contribute to the literature by developing a network perspective of quantum change and by specifying an empirically testable multilevel theoretical model of environmental, network, and firm effects on network dynamics, following the occurrence of disruptive events.

A vast literature has documented that the fate of organizations is the outcome of organization/environment interaction (e.g. Lawrence & Lorsch, 1967; Pfeffer & Salancik, 1978). Strange enough, there is little research on how this interaction affects alliance networks. This paper focuses on environmental jolts as a central force in shaping patterns of network evolution. To investigate the process of change, we will employ a contingency model whereby environmental jolts provide the occasion for structuring. In particular, our dependent construct, brokerage propensity, indicates how entrepreneurial and flexible a firm is in structuring its network of ties. Moreover, in order to capture also the moderating role of the firm level contingencies we include in our analysis firm characteristics namely firm size, which indicates a firm's potential to establish new ties based on its resources, geographic scope, which indicates how geographically interspersed a firm's ties are, and network centrality which is a measure of structural embeddedness.

Previous research has shown that organizations need to align to their environments if they are to survive, and network change is one way of aligning organizations with such environments (Kim, Hongseok, & Swaminathan, 2006). Following Kim *et al*. (2006), we define network change as the dissolution or replacement of an interorganizational network tie, adding also the case of the formation of new ties with preexisting partners or with new ones, that lead to a more dense or sparse network over time.

Given this background, the particular theme we want to analyze is the impact of uncertainty on network change in the face of disruptive events. Our first assumption is that quantum change provoked by an external shock generates extreme uncertainty (Meyer, 1982). Previous literature has recognized the importance of interorganizational linkages as uncertainty absorbers (Pfeffer & Salancik, 1978). Firms are embedded in networks, which, in turn, are embedded in external environments. Dynamic changes in environments can be expected to have a strong influence on network evolution, yet such linkages have been rarely studied. The tradition in network analysis has been to view networks as given contexts for action, rather than as being subject to deliberate design (Nohria, 1992) assuming that network structure endures over time (Schott, 1991). In contrast, we follow more recent trends that address the need for an evolutionary perspective on interfirm networks (e.g., Madhavan, Koka, & Prescott, 1998).

Overall we have three main goals in this paper. First, we review previous contributions on environmental jolts and punctuated equilibrium theory in an attempt to reconcile the evolutionary and revolutionary views of organizational change. Second, by incorporating environmental jolts as an integral part in our study, we contribute to the alliance and network literature by recasting emphasis on the relationship between external environmental context and firm level network restructuring. Third, by adopting a dynamic approach toward the study of how networks evolve and change over time, the study has also important implications for managers seeking to build effective networks. Following previous contributions, we argue that alliance networks are intentionally shaped by alliance managers surpassing the idea that they are given contexts for action. Thus, in order to understand how managers do this, research needs to move beyond asking how networks constrain and shape action, to examining what factors constrain and shape networks (Madhavan *et al.*,1998:440).

We proceed as follows. The following section reviews the existing literature on change, moving progressively from organizational to network change, and triggers of change, the environmental jolts in our case. We then proceed with a review of the main contributions regarding brokerage and closure network strategies as adaptation strategies in the face of situations of turbulence. In the ensuing section, we develop propositions on how situations of extreme uncertainty generated by environmental jolts affect network strategies also contingent on firm variables. Discussion and conclusions follow.

THEORETICAL BACKGROUND

Theories of Change: Incremental versus Quantum Change

Literature dealing with organizational change has studied the process of change in various ways. Change has been portrayed both as a continuous organizational process (March, 1981) and as brief episodes interspersed between long periods of stability and inertia (Miller & Friesen, 1984). Some writers have focused on changes as volitional managerial actions (Andrews, 1971) while others conceive of changes as results of unforeseen exogenous events (Meyer, 1982). Change happens in two fundamentally different modes as proposed by Meyer *et al*. (1990). Continuous, or first-order change, occurs within a stable system that itself remains unchanged. Discontinuous, or second-order change, transforms fundamental properties or states of the system. First-order change is incremental or *evolutionary* while second-order change is said to be of a *quantum* nature because many elements change in a major or a minor way within a brief interval. Quantum changes are defined as *revolutionary* when they radically transform many elements of the structure. The distinction between first and second order change has been likened to that between simple motion and acceleration (Watzlawick, Weakland, & Fisch, 1974). The concepts of first and second order change have been applied in virtually every unit of analysis examined by organizational scientists: single- versus double-loop learning by individuals (Argyris & Schön, 1979), variations versus reorientations in products (Normann, 1971), adaptation versus metamorphosis by organizations (Miller & Friesen, 1984), competence-enhancing versus competence-destroying changes in technology (Tushman & Anderson, 1986), and evolution versus revolution in industries (Schumpeter, 1950). Adding the level at which change is assumed to occur provides a second dimension for classifying organizational change. Thus, theories about how firms maintain alignments with their environments can be classified along the aforementioned dimensions, mode (first versus second order) and level (firms versus industry) of change (Meyer *et al.*, 1990).

Insert Table 1 about here

One paradigm that has heavily influenced our thinking about change processes is Darwin's model of evolution as a slow stream of small mutations, gradually shaped by environmental selection into novel forms (Gersick, 1991). Within the field of evolutionary biology, however, Darwinian gradualism has been challenged by the punctuated equilibrium model of evolution proposed by Eldredge and Gould (1972). These authors claim that lineages exist in essentially static form (equilibrium) over most of their histories, and new species arise abruptly, through sudden, revolutionary "punctuations" of rapid change (Gersick, 1991). Advocates of the incremental view of change in organizational literature are adaptation theorists such as Miles and Snow (1978) and Pfeffer and Salancik (1978) at the firm level. At the industry level, population ecologists (e.g., Hannan & Freeman, 1989) argue that differential rates in the entry and exit of firms cause populations to evolve gradually to fit the technical and economic constraints of environmental niches while institutional theorists (e.g. Scott, 1987) argue that organizations experience pressure to conform to the normative expectations of their institutional environments. On the other hand, organizational theorists who have adopted the punctuated-equilibrium perspective propose that organizational evolution has two distinct and recurring phases: 1) long periods of quasi-equilibrium, during which organizations make only incremental changes in structure and activities, and 2) brief periods of disequilibrium, during which many new organizations appear and many existing ones are transmogrified (Tushman & Romanelli, 1985; Tushman & Anderson, 1986; Miner, Amburgey, & Sterns, 1990; Haveman, Russo, & Meyer, 2001). The exogenous shocks that punctuate equilibria make it possible for novel organizational mutations, intentional or random, to take hold (Haveman *et al.*, 2001). Subsequent periods of flux endure until a dominant design emerges. A period of incremental change, characterized by relative stability, then follows which is, in turn, broken by a new discontinuity. At its heart, punctuated equilibrium is a theoretical explanation for how organizations will typically accomplish fundamental transformation. Meyer's (1982) seminal work directly explored the influence on revolutionary change of environmental jolts concluding that they provoke crises in the organizations that facilitate revolutionary transformation.

The Influence Of Environmental Change On Organizational Change

The distinction drawn between incremental and quantum change can be associated to the concepts of uncertainty and jolt. Uncertainty reflects the unpredictability and volatility of an industry while a jolt is a high-impact and low-duration event. Changes in these two dimensions may influence changes in interorganizational ties with the former producing more gradual change over time while the latter generates significant change.

Jolts. Although minor, incremental changes may occur gradually over long periods of time, the likelihood of a major restructuring may only occur when the organization encounters an "exogenous shock" (Barley, 1986: 80) such as a technological breakthrough, a large-scale shift in government regulation, and a strong political reform. Such a shock may be conceptualized as a sudden, dramatic increase in uncertainty (Tushman & Anderson, 1986). Environmental jolts, may create uninhabited or unexploited habitats where new forms of organization can thrive (e.g. Russo, 2001) and in some occasions may redesign the boundaries of a whole industry.

The result of destabilizing environmental jolts is often a re-examination of institutionalized logics and practices and a reorientation of organizational strategies and processes with environmental demands (Oliver, 1992; Sine & David, 2003). Jolts act as catalysts of change just as novel scientific theories emerge only amid a mounting state of crisis caused by failure of existing paradigms to adequately explain observed reality (Kuhn, 1970; Sine & David, 2003). Environmental jolts rarely threaten the survival of soundly designed organizations with well-maintained environmental alignments. However, seismic tremors often disclose hidden flaws in the architecture and construction of buildings, and environmental jolts trigger responses that reveal how organizations adapt to their environments (Meyer, 1982).

After an environmental jolt, new opportunities are concomitantly created as the environment redefines attractive market positions (Meyer *et al*., 1990). Although jolts affect all firms, individual firms may deal with these jolts in different ways. Indeed, the exploitation of new opportunities or the growth and survival after a period of turmoil vary among firms. However, instead of viewing an environmental jolt as a crisis that is dangerous or destructive, some scholars suggest that firms can perceive it largely as changes in the opportunity set in the external environment (Meyer, 1982; Haveman, 1992; Wan & Yiu, 2009).

Uncertainty. Research has shown that environments can affect firms' strategies as well as their performance (Porter, 1980). Therefore, it is plausible to argue that changes in the environment will influence a firm's decision makers. Adapting to environmental contingencies and exploiting the opportunities created by those contingencies can be a source of competitive advantage. Environmental dynamism concerns the amount of uncertainty emanating from the external environment (Baum & Wally, 2003). Dynamism is reflected by the regularity in and amount of change occurring in the environment. Recent theory and empirical research suggests that discontinuities lead to eras of great ferment, experimentation and uncertainty and environmental jolts are one of the elements producing such uncertainty.

The notion of uncertainty has been defined in a variety of ways in the literature. For example, information theorists define uncertainty of an event "as the logarithm of the number of possible outcomes the event can have…" (Garner, 1962: 19) while organizational theorists Lawrence and Lorsch (1967: 27) state that uncertainty consists of three components: 1) the lack of clarity of information, 2) the long time span of definitive feedback, and 3) the general uncertainty of causal relationships. Cyert and March (1963) and March and Simon (1958) have argued that the reduction and management of uncertainty is a major organizational enterprise. Furthermore, Thompson (1967: 159) asserted that dealing with uncertainty is the *essence* of the administrative process (emphasis added in *italics*).

We begin with a definition of uncertainty that underpins most others' definitions: uncertainty is the incapacity to predict future states of the world (Pfeffer and Salancik, 1978; Anderson & Tushman, 2001; Beckman, Haunschild, & Philips, 2004). As Dess and Beard (1984) emphasize, it is not simply a proxy for variation or fast rates of change. Indeed, rapid but entirely predictable change creates no uncertainty at all.

Scholars that have dealt with uncertainty have classified the concept in a variety of ways. Wernefelt and Karnani (1987) have distinguished between demand, supply, competitive uncertainty and uncertainty stemming from external factors, Beckman *et al.* (2004) between market and firm-specific uncertainty, Podolny (2001) between actor egocentric and altercentric uncertainty while Anderson and Tushman (2001) between market and technological uncertainty.

The label "environmental" is attached to the term uncertainty when the source of the uncertainty is the organization's external environment. Thus, the "something" which is unpredictable is specified as being the organizational environment (Milliken, 1987). More specifically, some scholars (e.g., Duncan, 1972; Miles & Snow, 1978) argue that uncertainty should be related to specific components of the environments such as suppliers, competitors or customers. Environmental uncertainty has been viewed and measured using both objective and perceptual approaches (Duncan, 1972; Yasai-Ardekani, 1986; Milliken, 1987). The former implies that it is possible to characterize environments in terms of how objectively uncertain they are (e.g., Child, 1972); the latter implies that environmental uncertainty is inherently "in the eye of the beholder" and thus ought to be studied as a perceptual phenomenon (e.g., Huber, O'Connell, & Cummings, 1975).

Adapting to Environmental Change: the Role of Interorganizazional Strategic Alliances

The message that organizations must adjust their structure to changes in their environment has been a dominant one in the organizational literature (Miller, 1981). The main assumption underlying this stream of research is that the environment is not a constant variable and that the firm may have to change its structure in response to environmental contingencies. More recently scholars have begun to think of the firm as an interconnected entity, rather than an independent actor that adjusts its structure and strategy to environmental changes without taking into account its surrounding relationships. According to the resource-based view (RBV), a firm's resources drive value creation via the development of competitive advantage. Specifically, it is suggested that possessing valuable and rare resources provides the basis for value creation. This value may be sustainable when those resources are also inimitable and lack substitutes (Barney, 1991). In their role of uncertainty absorbers, network ties prove to be themselves a key strategic resource. However, a firm's ability to maximize the value of the network as a resource is partly contingent on its ability to respond to environmental stimuli. Accordingly, the importance of the environment for managing resources suggests that contingency theory logic should be integrated into our understanding of the RBV.

The structure of networks of interorganizational ties plays an important role in the evolution of an industry. Consequently, managers engage in strategic maneuvering to secure key positions in their industry's network, such as entering into strategic alliances in order to ensure access to key technologies or other resources. Hence, periods of strategic change in the history of an industry are often marked by observable flurries of interfirm activity (Madhavan *et al.*, 1998: 440). Alliances are one of the key ways that firms respond to uncertainty and rapid environmental change (Pfeffer & Salancik, 1978; Gulati, 1998) because they are perceived as faster, lower cost, and more reversible than internal development or acquisition. According to Gulati and Gargiulo (1999), strategic alliances are a vivid example of voluntary cooperation in which organizations combine resources to cope with the uncertainty created by environmental forces beyond their direct control. Indeed, the number of interorganizational alliances has grown and this is partly due to the increasing uncertainty surrounding the international business arena (Gulati & Gargiulo, 1999). Thus, rapid and unpredictable changes in the environment may lead to changes in an organization's needs and its orientation toward ongoing partnerships (MacIntyre, 1981). These changes in needs and orientation can derive from continuous processes or can be triggered by unforeseen events. Whatever the source of change, alliances follow evolutionary paths that produce an impact on firms' performance (Harrigan, 1985). Following Gulati (1998: 305), we argue that the evolution of some alliances may be akin to a punctuated equilibrium model in which there may be discrete stages that occur due to discontinuous changes in the environment (Gray & Yan, 1997).

In its most notable explication, the evolutionary view of networks emphasizes network structure as its own context for evolution (Gulati & Gargiulo, 1999). On the other hand, most of the alliance research suggests that firms form interorganizational networks in response to environmental stimuli exogenous to the network (Koka *et al*., 2006) – for example resource dependence theorists argue that interorganizational linkages are a means to cope with environmental changes (Pfeffer & Salancik, 1978). External, as well as internal, factors act as occasions for firms to take advantage of the ensuing changes to structure their ego networks in order to strengthen their position in the network. Key events such as technological shakeouts have the power to disrupt previous configurations and their impact on structure may be either structure-reinforcing or structure-loosening (Madhavan *et al.*, 1998). However, most of the existing literature focusing on the effects of disruptive events on structure has analyzed the impact of endogenous jolts. According to this literature, the impetus for structure-loosening events, initiated by players who are already in key positions in the network (e.g., a new pricing strategy) is more likely to come from small peripheral firms while the opposite happens for structure-reinforcing events that are initiated by more peripheral players who desire to improve their positions. The consequences on network structure of exogenous shocks need yet to be explored.

Received literature highlights two basic network strategies firms can adopt as a response to environmental change: expanding or enhancing the interconnectedness of their relational neighborhoods. These choices also affect the position that the firm will occupy in the network over time. In periods of relative tranquility characterized by incremental change, the positional modifications are less relevant in magnitude when compared to adjustments made following a period of upheaval.

Brokerage and Closure. Research has emphasized two distinct yet interrelated approaches on how firms can structure their networks. In essence, these two approaches reflect alternative network strategies employed by firms in the pursuit of competitive advantage (Koka & Prescott, 2008). The first approach emphasizes the benefits arising to firms because of their embeddedness in the network. Networks that show high degrees of closure – also called dense networks to underline that all the partners are linked to each other directly – are the source of positive outcomes. The more closed the network, the stronger the benefits, because in closed networks information about behavior flows faster, trust and norms develop more quickly and effective sanctions that ensure trustworthiness can be applied more rapidly on firms that violate their partner's expectations (Coleman, 1988). In sociology, Granovetter (1985) argues that the threat of sanctions makes trust more likely between people who have mutual friends (mutual friends being a condition of "structural embeddedness"). From this perspective, firms tend to reinvest in present network structures, rather than expanding them. Such behavior will lead to a progressive network closure over time. The second approach draws on Burt's (1992) structural holes construct to highlight entrepreneurial benefits arising to firms. Emphasizing the importance of open networks – networks where partners have no direct linkages among themselves – Burt argues that the network position associated with the highest economic return lie between, and not within, dense regions of relationships. From this perspective, firms tend to broaden their present network structures. Such a behavior will lead to a progressive network expansion over time. An elegant way to reconcile the debate around closure and brokerage is to adopt a contingency approach. Focusing on environmental change is one of the contingencies that has been recently proposed.

PROPOSITIONS

Building on the above we develop a multilevel theoretical model with independent and dependent constructs at multiple levels (Klein, Danserau, & Hall, 1994) to specify how environmental and firm attributes affect network design. Several reasons brought us to build a multilevel model. Prior research has examined network dynamics at firm (Beckman *et al*., 2004), network (Madhavan et al., 1998), and environmental level (Pfeffer & Salancik, 1978). Moreover, multilevel models are particularly suited for scholars who adopt a relational approach since it is easy to move from one level to another. Indeed, expanding the analysis to include both firm, and environmental contingencies enriches our discussion on how networks evolve and change over time.

To choose our independent constructs we applied the following “tests”. First, the constructs should be the most appropriate for modeling multilevel network change phenomena. Previous contributions on network change have already called for the adoption of a multilevel perspective in explaining network dynamics (e.g., Kim *et al*., 2006). In addition, the constructs should have sufficient theoretical and empirical support in the literature (Gnyawali & Madhavan, 2001). The constructs that met our tests are: (1) environmental jolts (environmental-level attribute), (3) centrality, (4) firm size, and (5) geographic scope (firm-level attributes).

We believe that our considerations on network change face specific challenges: limited amount of resources and breath of operations of a firm, environmental impacts, and network constraints. Thus, we seek to investigate the roles of organizational and environmental characteristics as well as the network context, as we contend that firms collaborative choices are highly contingent on these elements.

The line of reasoning is as follows. Firms basically live in relative tranquility that is abruptly interrupted by periods of flux. When the environment is stable, they should pursue the advantages stemming from closure in order to build alliances with trusted partners. On the other hand, in periods of instability they should be flexible enough to adapt to the new scenarios and adopt a more entrepreneurial orientation while maintaining their previous alliances that were built with key partners for strategic resources. This line of reasoning fits with the idea that the benefits stemming from brokerage are short-termed and subject to decay while closure benefits tend to endure over time (Burt, 2002).

Effects of Environmental Attributes

Given the importance of network closure and brokerage as key dimensions of network design and the fact that they lie behind the structure of a firm's relationships as explained in the previous section, we focus our study on how changes in uncertainty impact on network structure when the environment is unstable.

Previous literature documents well that variability across organizational environments affects the nature of organizational strategies and strategy formulation (Dess, 1987). Therefore, changes in the environmental scenarios are likely to cause network changes. More specifically environmental conditions affect the opportunities available to firms, in terms of the potential array of interfirm options, and the resources available for network actions (Koka & Prescott, 2008). Our assumption is that environmental jolts have a significant power to change the levels of environmental predictability which, in turn, affect network design. After a jolt takes place, an increase in uncertainty is accompanied by a decrease in resource availability. Under such conditions, literature has suggested that building sparse networks, in our case the adoption of a brokerage posture, is the preferred strategy (Burt, 2000; Rowley, Behrens, & Krakhardt, 2000). In a similar vein, Koka and Prescott (2008) argue that following an environment-changing event, it is more beneficial to search entrepreneurial rather than prominent positions in the interfirm network whereas stable environments emphasize the importance of dense networks and prominence. Previous research in this field has mainly focused on endogenous events which take place inside the industry boundaries. Endogenous jolts have the peculiarity that, although they act as occasions for industry restructuring, they are typically initiated by incumbents. Examples of such events are regulatory reforms or radical technological changes affecting an industry. This changes will produce an observable impact on the network of relations within the industry pushing firms to reinforce their current relationships or to initiate a new set of relationships with a different set of partners (Madhavan *et al*., 1998). However, in the face of exogenous events such as wars and natural disasters, to which neither core nor peripheral players have power on, the outcomes may be not so easy to predict in terms of structural change.

Proposition 1: Under conditions of high uncertainty following an environmental jolt, there will be an increase in firms' brokerage propensity.

Effects of Firm Attributes

The notion of centrality reflects the significance of a firm in its network. Being a well-connected and significant player in a network can be a source of competitive advantage (Madhavan *et al*., 1998). At the simplest level of conceptualization, a highly central firm is likely to be connected to many more partners than the less central firm. Centrality comes from being the object of relations from other contacts. Firms central in interorganizational networks are exposed to more sources of information than more peripheral firms. Moreover, the central firm is in a favorable position to see a more complete picture of all the available options in the network (Lin, Yang, & Demirkan, 2007). However, aside of the benefits described, centrality has some downturns too. The most notable is the tendency of central firms to be overembedded in their existing networks which could lead to inertia and threat rigidity (Staw Sandelands, & Dutton, 1981) or learning myopia (Levinthal & March, 1993). When the environment is stable, we expect central firms to strengthen their position by consolidating previous partnerships while forging few new alliances in order to broaden their opportunity set. On the contrary, following a jolt, an increase in the level of uncertainty could stress the importance of trusted partners with whom the firm has already transacted in the past (Podolny, 1994; Gulati, 1995) or of partners of trusted partners. Support for this argument derives from Granovetter's (1982) assertion that strong ties are more likely to be useful to an actor who is in an insecure position. Focusing resources on a few philos ties could be the preferred action when the ego is facing uncertainty and change (Krackhardt, 1992) and occupies a central position. This behavior could be also justified by central firms desire to maintain their position of privilege in the network in that the more central a firm is, the more it is visible. High network visibility, generated by centrality, is an asset in that it renders the firm a desirable partner since partnering with a central firm could give access to a larger pool of relations. Hence, when the environment is unstable, central firms may be more risk adverse (and thus less prone to forge alliances with new partners) which hinders their brokerage propensity. On the other hand, more peripheral firms will try to loosen the previous network structure in order to gain more centrality. According to this reasoning, more peripheral firms may adopt a more entrepreneurial orientation when the environment is experiencing an environmental jolt.

Proposition 2: The increase in brokerage propensity following an environmental jolt is likely to be stronger for less central firms than for more central ones.

The differences between firms and environments in terms of resource abundance constrain a firm's ability to form alliances and adapt to external environment (Nelson & Winter, 1982; Lin *et al.*, 2007). Thus, managers need to decide how to allocate their resources while structuring their alliance networks which implies a trade-off between favoring a more or less entrepreneurial posture.

Given that resources play a critical role, the impact of an environmental jolt on network design also depends on firm size, a commonly adopted proxy for firm resources in the organization literature. Accordingly, firm size is of great importance in the face of extreme uncertainty. Despite a widespread (but often implicit) recognition of its importance, little contemporary research attention focuses on size (Dobrev & Caroll, 2003). Such reductionism has led the majority of empirical studies – in either strategic management or organization theory – to include size as a control variable (Dobrev & Caroll, 2003).

Larger firms have generally more resources compared to the smaller ones to allocate to the diversification of their network. Conversely, smaller firms should be more constrained in terms of partners choice and volume of new alliances they can create. Moreover, following population ecology literature, we argue that large organizational size enhances the capacity to withstand environmental shocks, whereas the margins for error are small for small organizations because they cannot easily adapt to temporary setbacks (Hannan & Freeman, 1977). Although the dimension advantage poses large firms at lower risk of failure, it acts at the same time as a constraint toward change. Such rigidity of size may be even stronger when the environment is hostile. On the other hand, smaller firms will have higher incentives to be entrepreneurial, exploit the window of opportunity created by the shock, and maximize their limited network opportunities.

Proposition 3: The increase in brokerage propensity following an environmental jolt is likely to be weaker for large firms than for small ones.

Geographic scope, defined as the international extent of a firm's operations (Delios & Beamish, 1999) will also influence a firm's ability to structure its network. We assume that the more geographically expanded the operations of a firm are, the more networking opportunities will accrue to that firm. On the other hand, firms that forge alliances in the same geographical areas will probably create a more stable and reliable network but will incur in greater redundancy. Thus, the more internationally expanded are a firm's operations, the more it will be able to exploit opportunities for arbitrage and to set terms of trade that favor it over its partners. Accordingly, geographic scope could be of particular usefulness during a crisis. However, a broad international presence could push a company to feel at more ease in the face of a disruption. Firms that already have international presence, may have less incentives to expand their networks internationally. For a company with a broad geographic scope of operations, expanding its network internationally would generate a reinforcing effect. On the other hand, a more localized company will have higher incentives to diversify its network internationally in the face of an environmental jolt. Expanding operations internationally through alliances would be a less costly and faster option to diversify risk than establishing activities in safer regions through direct investments.

Proposition 4: The increase in brokerage propensity following an environmental jolt is likely to be weaker for firms with a broader geographic scope.

DISCUSSION AND CONCLUSIONS

Motivated by the need to understand which are the underlying forces that trigger network evolution, we have looked at the impact of environmental, and firm variables on network change. We defined network change as the change in a firm's portfolio of ties. The mechanism behind such process can be explained at multiple levels: how the external environment (environmental jolts), structural embeddedness (network centrality), and firm characteristics (firm size and geographic scope) enable, or constrain, network change.

Thus, formulating the enablers of network change provides fresh insights into a vibrant stream of research on interorganizational relations: network evolution. Combining an ecological perspective using the relational approach is not novel (e.g., Burt, 1992; Hannan & Freeman, 1989). However, efforts to integrate these two perspectives revolve around basic concepts such as niche or structural equivalence to find statistical effects of covariates in statistical models (Kim *et al.*, 2006). Moreover, it has long been assumed that the source of change in interorganizational networks is the network itself neglecting the role of the external environment. Likewise, this endogenous view of network evolution has assumed that change is a gradual process disregarding radical change. Our network change perspective may facilitate bridging the theoretical foundations of network evolution from an evolutionary to a revolutionary view of network change.

By focusing on the enablers of network change we have disregarded the impediments and constraints that may obstacle the transition of networks from one state to another. To overcome this limitation, future studies may address the following question: What is the role of network change disablers in limiting a firm's ability to modify its tie portfolio? Organizational age, status, organizational history and culture, dimension of the alliance portfolio, regulatory barriers are just few of the constraints that could increase network inertia.

Beyond empirical testing to see if the proposed association between network change and the other variables holds, we believe that our work can be used as a starting point to address questions such as: How does network change relate to firm performance? What is the role of the external context on the relationship between network change and firm performance? Future research may use longitudinal research designs to explore such matters.

Networks as organizational forms have become well institutionalized (Powell, 1990) and much of the literature has focused on dyadic change, such as partner selection, while being silent on the implications of such activities for the evolution of whole networks (Koka *et al.*, 2006). Switching the attention from only one level of analysis toward a multilevel perspective appears as a promising avenue for future research also stimulated by recent development of multilevel network modeling tools such a *p** (Koka *et al.,* 2006).

For alliance managers, incorporating the external environment when building their alliance networks is of extreme importance since it would lead to a broader and less biased picture of the whole array of opportunities available. Another critical aspect is learning from rare events such as environmental jolts. Are companies and their managers able to learn from environmental jolts? If they do learn, are managers able to develop crisis management capabilities over time? Companies usually safeguard from such events via contingency plans. However, do they take advantage of previous errors in order to recover rapidly in the face of future shocks?

In conclusion, changing network ties can contribute to a firm's competitive advantage over its competitors. Nevertheless, it is important to recognize that such change is not always the result of deliberate action but it is rather a necessity in order to cope with the uncertainties generated by the external environment as well as with the challenges posed by the network in which a firm is embedded, and the strategic moves of its actors, along with the firm's peculiarities. The multilevel model of network change we have proposed allows a better understanding of such dynamics.

REFERENCES

Anderson, P., & Tushman, M.L. 2001. Organizational environments and industry exit: the effects of uncertainty, munificence and complexity. ***Industrial and Corporate Change,*** 10 (3): 675- 711.

Andrews, K. R. 1971. ***The concept of corporate strategy***. Homewood, IL: Dow Jones-Irwin.

Argyris, C., & Schon, D. 1978. ***Organizational learning: a theory of action perspective.*** Reading, MA: Wesley.

Barley, S. R. 1986. Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. ***Administrative Science Quarterly***, 31 : 78-108.

Barney, J. B. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17: 99-120.

Baum, J. R., & Wally, S. 2003. Strategic decision speed and firm performance. ***Strategic Managementm Journal***, 24: 1107–29.

Beckman, C. M, Haunschild, P. R, & Philips, D. J. 2004. Friends or strangers? Firm-specific uncertainty, market uncertainty, and network partner selection. ***Organization Science,*** 15 (3): 259–275.

Burt, R. S. 1992. ***Structural holes: The social structure of competition***. Cambridge, MA: Harvard University Press.

Burt, R. S. 2002. Bridge Decay. ***Social Networks***, 24 (4): 333-363.

Child, J. 1972. Organizational structure, environment, and performance: The role of strategic choice. ***Sociology,*** 6: 1-22.

Coleman, J.S. 1988. Social capital in the creation of human capital. ***American Journal of Sociology,*** (Supplement) 94: 95–120.

Cyert, R. M., & March, J. G. 1963. ***A behavioral theory of the firm***. Englewood Cliffs, NJ: Prentice-Hall.

Delios, A., & Beamish, P. W. 1999. Geographic scope, product diversification, and the corporate performance of Japanese firms. ***Strategic Management Journal***, 20: 711–727.

Dess, G. G., Beard, D. W. 1984. Dimensions of organizational task environments. ***Administrative Science Quarterly,*** 29, pp. 52–73.

Dess, G. G. 1987. Consensus on strategy formulation and organizational performance: Competitors in a fragmented industry, ***Strategic Management Journal***, 8(3): 259–277.

Dobrev, S. D., & Carroll, G. R. 2003. Size (and competition) among organizations: Modeling scale-based selection among automobile producers in four major countries, 1885-1981. ***Strategic Management Journal,*** 24: 541-558.

Doz, Y. 1996. The evolution of cooperation in strategic alliances: initialconditions or learning processes? ***Strategic Management Journal,*** Summer Special Issue, 17: 55–83.

Duncan, R.B. 1972. Characteristics of organizational environments and perceived environmental uncertainty. ***Administrative Science Quarterly***, 17: 313-327.

Eldredge, N., & Gould S. J. 1972. Punctuated equilibria: An alternative to phyletic gradualism. In T. Schopf (ed.). ***Models in Paleobiology***: 82-115. San Francisco: Freeman, Cooper.

Garner, W. 1962. ***Uncertainty and structure as psychological concepts***. New York: John Wiley.

Gersick, C. J. G. 1991. Revolutionary change theories: A multi-level exploration of the punctuated equilibrium paradigm. ***Academy of Management Review***, 16: 10–36.

Gnyawali, D. R., & Madhavan, R. 2001. Cooperative networks and competitive dynamics: a structural embeddedness perspective. ***Academy of Management Journal,*** 26: 431-445.

Granovetter M. 1973. The strength of weak ties. ***American Journal of Sociology***, 78, 1360–1380.

Granovetter, M. 1985. Economic action, social structure and embeddedness. ***American Journal of Sociology***, 91: 481–510.

Gray B, Yan A. 1997. Formation and evolution of international joint ventures: Examples from U.S.– Chinese partnerships. In P. Beamish, J. P. Killing (eds.), ***Cooperative Strategies: Asian Pacific Perspectives***: 57–88. San Francisco, CA: New Lexington Press.

Gulati, R. 1995. Social structure and alliance formation patterns: A longitudinal analysis. ***Administrative Science Quarterly***, 40: 619–652.

Gulati, R. 1998. Alliances and networks. ***Strategic Management Journal***, Special Issue 19(4): 293–317.

Gulati, R., & Gargiulo, M. 1999. Where do interorganizational networks come from? ***American Journal of Sociology***, 104(5): 1439–1493.

Hannan, M. T., & Freeman, J. 1989. ***Organizational ecology***. Cambridge, MA: Harvard University Press.

Harrigan, K. R. 1985. ***Strategies for Joint Ventures.*** Lexington, MA: Lexington Books.

Haveman, H. A. 1992. Between a rock and a hard place: Organizational change and performance under conditions of fundamental environmental transformation. ***Administrative Science Quarterly***, 37(1): 48–75.

Haveman, H.A., Russo, M.V., & Meyer, A.D. 2001. Organizational environments in flux: The impact of regulatory punctuations on Organizational Domains, CEO Succession, and Performance. ***Organization Science***, 12 (3): 253-273.

Huber, G. P., O'Connell, M. J, & Cummings, L. L. 1975. Perceived environmental uncertainty: Effects of information and structure. ***Academy of Management Journal,*** 18 (4):725-740.

Kim, T., Oh, H., & Swaminathan, A. 2006. Framing interorganizational network change: A network inertia perspective. ***Academy of Management Review,*** 31(3): 704-720.

Klein, K. J., Dansereau, F., & Hall, R. J. 1994. Levels issues in theory development, data collection, and analysis. ***Academy of Management Review***, 19: 195-229.

Koka, B. R, Madhavan, R., & Prescott, J. E. 2006. The evolution of interfirm networks: Environmental effects on patterns of network change. ***Academy of Management Review,*** 31(3): 721-737.

Koka, B. R, & Prescott, J. E. 2008. Designing alliance networks: The influence of network position, environmental change, and strategy on firm performance. ***Strategic Management Journal,*** 29:639-661.

Krackhardt, D. 1992. The strength of strong ties: The importance of philos in organizations. In N. Nohria and R. Eccles (eds.), ***Networks and Organizations: Structure, Form and Action***: 216-239**.** Boston, MA: Harvard Business School Press.

Kuhn, T.S. 1970. ***The structure of scientific revolutions*** (originally published 1962). Chicago: University of Chicago Press.

Lawrence, P.R., Lorsch, J.R. 1967. ***Organizations and Environments***. Boston, MA: Harvard Business School Press.

Levinthal, D., & March, J. 1993. The myopia of learning. ***Strategic Management Journal***, 14 (Winter Special Issue): 94–112.

MacIntyre, A. 1981. After Virtue. Notre Dame, IN: University of Notre Dame Press.

Madhavan, R., Koka, B.R., & Prescott, J.E. 1998. Networks in transition: How industry events (re)shape interfirm relationships. ***Strategic Management Journal,*** 19:439-459.

March, J. G., Simon, H. A. 1958. ***Organizations***. New York: John Wiley and Sons.

March, J. G. 1981. Footnotes to organizational change. ***Administrative Science Quarterly***, 26: 563–577.

Meyer, A.D. 1982. Adapting to environmental jolts. ***Administrative Science Quarterly*** 27 (4):515-537.

Meyer A. D., Brooks G. R., Goes J. B. 1990. Environmental jolts and industry revolutions: Organizations responses to discontinuous change. ***Strategic Management Journal,*** 11: 93-110.

Meyer A. D., Gaba V., Colwell K. A. 2005. Organizing far from equilibrium: Nonlinear change in organizational fields. ***Organization Science***, 16(5): 456-473.

Miller, D. 1981. Toward a new contingency approach: The search for organization gestalts. ***Journal of Management Studies***, 18: 1–26.

Miller D., & Friesen P.H. 1984. ***Organizations: A Quantum View***. Englewood Cliffs, NJ: Prentice-Hall.

Miles, R.E., & Snow, C.C. 1978. ***Organizational strategy, structure and process.*** McGraw-Hill: New York.

Milliken, F. J. 1987. Three types of perceived uncertainty about the environment: State, effect, and response. ***Academy of Management Review***, 12: 133–143.

Miner, A.S., Amburgey, T.L., & Stearns, T.M. 1990. Interorganizational linkages and population dynamics: buffering and transformational shields. ***Administrative Science Quarterly***, 35: 689-713.

Nelson, R. R., & Winter, S. 1982. ***An evolutionary theory of economic change.*** Cambridge, MA: Harvard University Press.

Nohria, N. 1992. Introduction: Is the network perspective a useful way of studying organizations?. In N. Nohria and R. Eccles (eds.), ***Networks and Organizations: Structure, Form and Action***: 1-22. Boston, MA: Harvard Business School Press.

Normann, R. 1971. Organizational innovativeness: product variation and reorientation. ***Administrative Science Quarterly***, 16: 203-215.

Oliver, C. 1992. The antecedents of deinstitutionalization. ***Organizational Studies,*** 13 (4), 563–588.

Pfeffer J., & Salancik G. 1978. ***The external control of organizations: A resource dependence perspective***. New York: Harper & Row.

Podolny, J. M. 1994. Market uncertainty and the social character of economic exchange. ***Administrative Science Quarterly***, 39: 458–483.

Podolny, J. 2001. Networks as pipes and prisms of the market. ***American Journal of Sociology,*** 107: 33–60.

Porter, M.E. 1980. ***Competitive strategy: Techniques for analyzing industries and competitors.*** New York: Free Press.

Rowley, T., Behrens, D., & Krackhardt, D. 2000. Redundant governance structures: An analysis of structural and relational embeddedness in the steel and semiconductor industries. ***Strategic Management Journal***, March Special Issue 21: 369–386.

Russo, M.V. 2001. Institutions, exchange relations, and the emergence of new fields: Regulatory policies and independent power producing in America, 1978–1992. ***Administrative Science Quarterly***, 46(1): 57–86.

Schott, T. 1991. Network models. In R. S. Burt (ed.), ***Structure: A General Purpose Network Analysis Program, Version 4.2***.: 107–206. New York: Columbia University.

Scott, W.R. 1987. ***Organizations: Rational, natural and open systems***. Englewood Cliffs, NJ: Prentice-Hall.

Schumpeter, J.A. 1950. ***Capitalism, socialism and democracy***. New York: Harper and Row.

Sine, W.D, & David, R.J. 2003. Environmental jolts, institutional change, and the creation of entrepreneurial opportunity in the US electric power industry. ***Research Policy,*** 32: 185–207.

Staw, B. M., Sandelands L. E., & Dutton J. E. 1981. Threat-rigidity effects in organizational behavior: A multilevel analysis. ***Administrative Science Quarterly,*** 26: 501–524.

Thompson, J. D. 1967. ***Organizations in action***. New York: McGraw-Hill.

Tushman, M.L., & Romanelli, E. 1985. Organizational evolution: A metamorphosis model of convergence and reorientation. In Cummings L., Staw B. M. (Eds.). ***Research in organizational behavior,*** vol. 7: 171-222. Greenwich, CT: JAI Press.

Tushman, M.L., & Anderson, A. 1986. Technological discontinuities and organizational environments. ***Administrative Science Quarterly***, 31: 439-465.

Wan, W.P., & Yiu, DW. 2009. From crisis to opportunity: Environmental jolt, corporate acquisitions, and firm performance. ***Strategic Management Journal,*** 30: 791–801.

Watzlawick, P.J., Weakland, H., & Fisch R. 1974. ***Change: Principles of problem formation and problem resolution***. New York: Norton.

Wernerfelt, B., & Karnani, A. 1987. Competitive Strategy under Uncertainty. ***Strategic Management Journal.*** 8, 187-194.

Yasai-Ardekani, M. 1989. Effects of environmental scarcity and munificence on the relationship of context to organizational structure. ***Academy of Management Journal,*** 32 (1):131-156.

Zhiang, L., Haibin, Y., & Demirkan, I. 2007. The performance consequences of ambidexterity in strategic alliance formations: Empirical investigation and computational theorizing. ***Management Science***, 53 (10): 1645–1658

APPENDIX

Table 1. Models of change within organizations and industries (Meyer *et al*., 1990)

		Fisrt-Order Change	*Second-Order Change*
Firm Level		**Adaptation**	**Metamorphosis**
	Focus	Incremental change within organizations	Frame-breaking change within organizations
	Mechanisms	Incrementalism Resource dependence	Life cycle stages Configuration transitions
	Authors	Lindblom (1959) Miles & Snow (1978) Pfeffer & Salancik (1978)	Ginsberg (1988) Greiner (1972) Miller & Friesen (1984) Tushman & Romanelli (1985)
Industry Level		**Evolution**	**Revolution**
	Focus	Incremental change within established industries	Emergence, transformation, and decline of industries
	Mechanisms	Natural selection Institutional isomorphism	Punctuated equilibrium Quantum specification
	Authors	Hannan & Freeman (1977) McKelvey & Aldrich (1983) DiMaggio & Powell (1983) Scott (1987) Zucker (1987)	Astley (1985) Barney (1986) Gould & Eldredge (1977) Schumpeter (1950)

THE ROLE OF ENVIRONMENTAL JOLTS ON INTERORGANIZATIONAL NETWORK CHANGE: EMPIRICAL EVIDENCE FROM THE GLOBAL AIRLINE INDUSTRY, 1998-2006

Submitted to[1]:

- *Strategic Management Society Conference,* Prague, Czech Republic, 2012.

Abstract. *This study uses the panel data social network analysis program SIENA to estimate the effects of well established network mechanisms at multiple levels of analysis on alliance formation. The concept of environmental jolt is introduced to see if and how a network evolves in a linear or in a punctuated way. The study reveals that firms react to environmental jolts by forming homophilous ties and transitive triads as opposed to the non jolt periods. The empirical setting is the global airline industry, which can be regarded as a constantly changing network of alliances. Our findings suggest that jolts are an important predictor of network change and should be thus incorporated in studies of network dynamics.*

[1] A shorter version of this paper is currently under review at the SMS 2012 Conference.

The Role of Environmental Jolts on Interorganizational Network Change: Empirical Evidence from the Global Airline Industry, 1998-2006

ABSTRACT

This study uses the panel data social network analysis program SIENA to estimate the effects of well established network mechanisms at multiple levels of analysis on alliance formation. The concept of environmental jolt is introduced to see if and how a network evolves in a linear or in a punctuated way. The study reveals that firms react to environmental jolts by forming homophilous ties and transitive triads as opposed to the non jolt periods. The empirical setting is the global airline industry, which can be regarded as a constantly changing network of alliances. Our findings suggest that jolts are an important predictor of network change and should be thus incorporated in studies of network dynamics.

Keywords: environmental jolt; homophily; transitivity; airline industry; Siena

INTRODUCTION

During the last decades organization and management theory scholars have progressively moved the focus of their research from individual firms to the interactions between them giving birth to the social networks stream of literature. One of the most prominent ideas of this approach is that organizations are embedded in thick webs of relationships that can facilitate or constrain economic action. This would suggest that economic relationships between actors might be more likely when they have a prior social relationship. Indeed, previous network ties have been shown to determine future network ties given that firms tend to partner with companies with whom they have partnered in the past (Gulati, 1995).

Given this background, the selection of actors with whom the firm will transact becomes of critical importance in pursuing a sustainable competitive advantage over time. Scholars have conducted substantial research on factors that affect partner selection in interorganizational networks. Partner selection is critical to network theory, as it is a fundamental driver of network stability and change (Beckman, Haunschild, & Phillips, 2004). Previous literature on interorganizational relationships provides a number of alternative explanations for why organizations seek partnerships with other organizations. Among these are efficiency, legitimacy, power and the acquisition of scarce resources (Galaskiewicz, 1985; Oliver, 1990). Partners are especially sought out when environments are turbulent in order to mitigate uncertainty and buffer core technologies (Thompson, 1967).

Despite the advances in our understanding of partner selection at the dyadic level and of the effects of networks, still most of our theorizing suggests a static approach on the part of these actors with respect to the network itself. Indeed, one of the previous standard criticisms of the social network research program was its neglect of network change (Emirbayer & Goodwin, 1994: 1413). More recently, research concerning network change at the interorganizational level has appeared (e.g., Gulati, 2007; Zaheer & Soda, 2009). The use of new analytical developments that deal with some of the tricky issues concerning statistical dependence seem to be particularly promising for research on network change (Kilduff & Brass, 2010). However, empirical studies using such tools have been mostly limited to interpersonal networks (Snijders, van de Bunt, & Steglich, 2010). We fill this void by testing a model of network dynamics at the macro level.

In prior research related to network change at the interorganizational level, scholars have largely focused on the network structure as a predictor of network evolution (Koka, Madhavan, & Prescott, 2006). In this paper we challenge this argument. Although we acknowledge the importance of network structure as a predictor of network evolution, we suggest that environmental factors exogenous to the network can be a major driver of network partner selection. However, small changes in the external environment will not create the urge for change given that organizations tend to be structurally inert. The likelihood of a major restructuring may only occur when the organization encounters an “exogenous shock”

(Barley, 1986: 80). Transient perturbations whose occurrences are difficult to foresee and whose impacts on organizations are disruptive and potentially inimical are also known in literature as environmental jolts (Meyer, 1982). Supporting evidence would suggest that environmental jolts affect network change and thus are influential in the emergence of new networks as organizations adjust to the external changes.

As an exogenous shock, the September 11 2001 terrorist attacks (also known as "9/11") in the United States provide us with a natural experiment to observe how differentials in unpredictability following a major shakeout affect firms network design in the airline industry before, during, and after an environmental jolt. The 9/11 has been one of the worse and unexpected tragedies of the last decades which severely impacted the US economy and consequently the global economy producing a "domino effect". As a result, firms wealth was severely hit by the sudden shock and some of them were forced to disappear from the business arena.

By addressing patterns of network structure, social network analysis permits the study of the whole and the parts of social networks simultaneously (Wellman, 1988). The parts of the networks include dyads, triads, cliques and larger structures such as components (Kilduff & Brass, 2010). Despite the intrinsic advantage of the network approach in which a researcher can simultaneously address actor, group and network characteristics, previous contributions have mostly focused either on ego (Ahuja, 2000), the dyad (Gulati, 1995), the triad (Madhavan, Gnyawali, & He, 2004) or the whole network (Provan & Milward, 1995). To complete such puzzle, this paper seeks to advance our understanding of network dynamics by focusing on how non-routine events stemming from the external environment can transform network structure at multiple levels of analysis.

Many previous studies on the issues surrounding interorganizational networks have been cross-sectional in nature which have prevented researchers from empirically separating a firm's network ties and network positions from their antecedents. To do so, researchers need to depart from the traditional static view of networks and rely on dynamic models that capture changes in network structures over extended periods (Shipilov, 2006). The airline industry provides an opportunity to empirically test our hypotheses over the period 1998-2006 and to contribute to the small but growing research on network dynamics (Gulati & Gargiulo, 1999; Shipilov, 2006; Zaheer & Soda, 2009). Airlines utilize bilateral and multilateral alliances in order to meet the ever increasing demand for *seamless* travel and to share costs and revenues. These networks consist of horizontal alliances, which allows us to mitigate some of the effects power-related factors can play in networks containing a dominant player among several overly-dependent suppliers or distributors (Rowley, Behrens, & Krachardt, 2000).

We proceed as follows. The following section reviews the existing literature on environmental jolts and network change. We then proceed with a discussion of how sudden changes in the external environment affect well established network properties at the dyadic and the triadic levels. In the ensuing section, we provide a description of our research context. Lastly we describe our data, statistical methods and measures. We conclude with the implications of our results.

THEORY AND HYPOTHESES DEVELOPMENT

Environmental jolts and interorganizational network change

The partner selection literature documents why firms ally, the circumstances under which alliances can improve performance, and the conditions under which firms face increasing costs due to their alliances. Firms typically form alliances to lean about new practices and technologies (Kogut, 1988), pool complementary resources (Eisenhardt & Schoonhoven, 1996), and enter new markets (Rothaermel & Boeker, 2008). The outcome of building relationships with different partners is a web of ties, also known as a firm's alliance portfolio. The alliance portfolio is akin to the notion of the egocentric network (Lavie, 2007). Social network theories have been recently applied in studies of performance implications of strategic networks (Gulati, Nohria, & Zaheer, 2000). Several studies have examined how the number of alliances, and network properties such as density and structural holes, affect firms' innovation output, new product development, revenue growth, market share, market value, or profitability (Ahuja, 2000; Rothaermel, 2001; Rowley *et al.*, 2000; Stuart, Hoang, & Hybels, 1999; Zaheer & Bell, 2005). Nevertheless, although there is an increasing interest in understanding network outcomes, less attention has been paid on the antecedents and the causes of network structure. The understanding of network outcomes is incomplete without an appreciation of the genesis and evolution of the underlying network structure (Ahuja, Soda, & Zaheer, 2011). The issue of time becomes fundamental in explaining network dynamics and surpassing the static view of networks. The passage of time is required for relationships to be cemented, be strengthened, and become imbued with trust and affect (Krackhardt, 1992). On the other hand, as time passes the purpose for which a relationship was built may decay or external events could make the relationship become dysfunctional for the parties involved leading to its dissolution.

Ahuja *et al.* (2011) have identified four microfoundations to explain the genesis and evolution of networks, namely agency, opportunity, inertia, and exogenous factors. By microfoundations these authors mean the basic factors that drive or shape the formation, persistence, dissolution, and content of ties in the network. Although our focus is mainly on how exogenous factors affect structural change at the dyadic- and triadic- levels, our theoretical framework comprehends also the other three mechanisms as we believe they are all interrelated. We choose to focus mainly on exogenous factors and random processes for the following reason. Quite surprisingly, among the four microfoundations, exogenous factors is still the less explored one although business environments are constantly and increasingly hit by shocks and discontinuities. More broadly, the tendency to neglect the study of situations far from equilibrium has distracted organizational and management researchers from studying the impact of profound change in organizational theory and research. Some noteworthy exceptions to this phenomenon are Schumpeter (1942), Meyer (1982), Tushman & Romanelli (1985), and Romanelli & Tushman (1994). However, none of these previous studies has explicitly addressed the issue of how organizational networks reconfigure following exogenous and unexpected events[2]. We explain below how the four microfoundations relate to each other to explain how networks change.

*Exogenous factor*s generated by random processes can be described as non-routine events also known as environmental jolts (Meyer, 1982). Jolts act as seismic tremors that may unveil hidden flaws in organizational network architectures. However, just as minor earthquakes rarely topple well-designed buildings resting on solid foundations, environmental jolts, rarely threaten the survival of soundly designed organizations with well-maintained environmental alignments (Meyer, 1982: 515). Jolts generate extreme and unusual uncertainty but at the same time they create opportunities for change. To respond to such uncertainty, organizations may modify their alliance portfolio in order to select ties that are effective and cut ineffective ties. Alliances are instrumental to responding to rapid and environmental change (Pfeffer & Salancik, 1978; Powell, White, Koput, & Owen-Smith, 2005) because they are perceived as faster, lower cost, and more reversible than internal development or acquisition. Understanding the evolution of alliances can provide critical insights into how such ties can be better managed (Gulati, 1998). Thus, not only alliances are an effective means of coping with uncertainty due to their flexible nature, but the design of the alliance

[2] The limited amount of studies dealing with how events impact organizational networks has dealt with events that take place within the industry boundaries (e.g., Madhavan *et al.*, 1998). Such events can be defined as endogenous as opposed to the exogenous ones which take place outside the industry boundaries and on which none of the incumbent firms can exercise any influence.

network itself is a powerful tool for managers in times of instability. In sum, environmental changes create the “fit” necessity so that companies are faced with two basic options, break with the past and restructure their networks (proactive approach) or keep investing in their previous relationships (reactive approach). We associate the first scenario with *agency* (Sewell, 1992) while the second one is more close to *inertia* (Kim, Oh, & Swaminathan, 2006).

Contingency theorists have long recognized that organizations must adjust their structure to changes in their environment (Lawrence & Lorsch, 1967; Miller, 1982). The main assumption underlying this stream of research is that the environment is not a constant variable and that the firm may have to change its structure in response to environmental contingencies. This means that companies managers take deliberate actions to modify structure which in network terms equals to modifying their network structure. Managers are thus active change agents that promote the creation and the evolution of networks. At the same time, the urge to change is only created in the face of extreme events which act as ‘occasions’ for restructuring (Madhavan, Koka, & Prescott, 1998) while generally companies are relatively inert and tend to pursue stability rather than instability. In other words, firms ties will tend to become more stable over time as partners develop routines and norms and habits. However, although such stability can be beneficial to a partnership at the dyad level, if we consider the whole firm alliance network, it could lead to threat rigidity and path dependence. Networks will tend to move toward equilibrium as firms exhaust their potential for tie activity within the existing environmental state. Significant changes in the environment disrupt such equilibrium as firms respond to the altered environmental state by making changes to their alliance portfolio (Koka *et al*., 2006: 726). Finally, in shaping their networks, actors maybe driven by *opportunity* which means that much networking behavior is driven by convenience. This suggests that firms tend to prefer linking within groups rather than across them (Li & Rowley, 2002) or that they tend to form alliances with firms they have prior alliances with or with their partners' partners (Gulati, 1995).

Using as a point of departure the Ahuja *et al.* (2011) framework and the Contractor, Wasserman, and Faust (2006) identification of families of theoretical mechanisms that have been used to explain the creation, maintenance, dissolution, and reconstitution of organizational networks, we build on literatures of exchange theory and balance theory to identify two constructs: homophily, and transitivity which inform how networks change and evolve over time due to changes in the external environment (see Table 1). We explore these relationships in greater detail as we unpack the underlying mechanisms enabling firms to change their network structure in the face of environmental jolts.

Insert Table 1 about here

An 'occasion' for change

Previous work in organizational research has underlined the usefulness of a theory of how organizational phenomena are structured (Barley, 1986). A promising line of reasoning suggested by this work is to investigate specific events as 'occasions for structuring' (Barley, 1986). More recent work on interorganizational networks has embraced such approach (Madhavan, Koka, & Prescott, 1998). These authors focused on how key industry events acted as occasions for network restructuring. Our focus differs in one, but important, aspect. Quite differently from these authors, our focus is on key events that happen outside the industry boundaries on which incumbents can have no influence. This has important implications for the evolution of the network since in the first case it is possible to trace some predictable trajectories given the more predictable nature of industry events as compared to exogenous ones while in our case incumbents are exposed to the event in an undifferentiated way.

An event focus tracks the evolution of an industry network over time by examining structure through various ‘windows of time’ (Doreian, 1986). The window’s length depends on specific events. A key advantage of this approach is that both managers and researchers are likely to agree that industry events provide more relevant ‘check points’ for network evolution than arbitrary time periods (Madhavan *et al*., 1998). We now turn our attention to a major event that radically reshaped the airline industry, which is the setting of our study: the September 11, 2001 terrorist attacks (also known as the “9/11”).

The evolution of the airline industry has been characterized by long-term business cycles. Since the deregulation of the airline market in the U.S. in1970, the industry has faced a series of events that had a profound impact on its development. Examples of those events include the 1991 Gulf War and the oil crisis the late seventies. However, the 9/11 is considered to be the more severe one. Not industry has suffered greater economic damage from the terrorist attacks of September 11, 2001 than the airline industry (Ito & Lee, 2005). To further highlight the dramatic impact that this jolt had on the industry we report the following paragraph from the report produced for the U.S. Congress:

> *“The airline industry was in financial trouble before the attacks. Most Wall Street analysts were projecting an overall financial loss for the industry in the range of $1- 2 billion for 2001. Industry losses for the full year were instead over $7 billion […]. It now appears, that the events of September 11 changed the airline industry in some fundamental ways that are not yet fully understood.”*

The impact of the 9/11 has been so severe that demand was still below pre-attack levels in the following two years. The event not only hit severely the US carriers but also affected the whole industry. In the aftermath of the jolt, North Atlantic traffic fell by 26%, there was a decrease in Europe of more than 10% and more than 17% in the Far East. Moreover, European and North American carriers reduced their capacity by 20% with similar adjustments occurring in other international routes. Irrespective of the direct consequences for commercial aviation, the 9/11 hit the world economy and made the recession inescapable. For the first time since 1974, all major economic regions faced a simultaneous economic downturn.

Jolts and Homophily

Do dyadic relationships evolve over time? If yes, how do they change in the face of a major environmental jolt? The answer to this question informs our first hypothesis. In creating, maintaining, and dissolving social ties, the most immediate effect of organizations network activity is reflected on dyadic relationship. In our context, dyads are represented by contractual agreements among firms such as strategic alliances and joint ventures. A key factor promoting the creation and the evolution of networks is the notion that actors purposively enact their social structures, generally referred to as agency behavior (e.g., White, 1992). They do so by choosing or not choosing to establish new connections, by dissolving existing ones, or by strengthening or weakening relationships (Ahuja *et al.*, 2011). For instance, theories of social exchange (Blau, 1964) suggest that actors forge ties using a calculus of exchange of material or information resources. In other words, agency behaviors shape network evolution through an instrumental perspective and can be more directly interpreted as emanating from a self-interested, utility reasoning (Ahuja *et al.*, 2011).

One of the most important perspectives on partner selection is provided by assortative mechanisms which speculate that network change relies on the compatibility or complementarity of actors attributes. A basic characteristic of dyads is that a contact between similar others will occur at a higher rate than among dissimilar others. Lazarsfeld and Merton (1954: 23) coined the term homophily to refer to "a tendency for friendships to form between those who are alike in some designated respect". Literature on interpersonal networks offers a wide range of examples in which actors select each other based on attributes such as age, race, gender, religion or ethnicity. For example, in a study on age homophily, Fischer (1982) found that age homophilous ties tend to be more close, longer lived, to involve a larger number of exchanges, and to be more personal while in a study on religious homophily Fischer (1977) found that Jewish men in Detroit have 80% of their friendships with other Jews. Based on the evidence that people are more likely to connect with self-similar others, previous research has also demonstrated that homophilous ties are less subject to decay (Lazarsfeld & Merton, 1954). Do the same logics apply to interorganizational ties? To answer this question we use evidence from alliance research. Quite differently from how individuals form their ties, firms often form ties with alters that possess complementary assets. For example, it has been found that diversity is actively pursued by firms forming ties in the investment banking industry (Podolny, 1994). Compared with interpersonal ties, interorganizational relationships may be more prone to heterophily because the trust orientation of homophily between individuals may be functionally substituted by contracts between organizations, and the desire for expressive benefits found in interpersonal networks may be absent in interfirm ones (Granovetter, 1985). More recently, such net distinction has been questioned giving more space to hypotheses predicting a balance between heterophilous and homophilous ties. For example, Casciaro and Lobo (2008) demonstrate that people collaborate with others that have complementary specializations but similar demographic traits that facilitate communication and trust. Scholars are thus encouraged to abandon the search for a universalistic solution in favor of research that evaluates the choices and balance of homophily and heterophily in order to understand the conditions under which one process or the other dominates and the balance that is struck in different social settings (Rivera, Soderstrom, & Uzzi, 2010).

Firms select their partners based on some attributes such as experience, size, industry niche, and geographic location. If they look for similar others, they will form homophilous ties otherwise if they search for complementary partners they will form heterophilous ties. In exploring how firms choose their partners over time, one possible criterion for partner selection may be related to the cost of keeping a tie active contingent on the changes in the external environment. For example, it may be possible that firms change their partnering behavior in times of danger compared to times of relative tranquility. Thus, heterophilous and homophilous relationships can be put into a continuum in which they alternate according to the requirements stemming from the external environment. Drawing on previous studies (Gulati & Gargliulo, 1999; Shipilov, Rowley, & Aharonson, 2006) we select one of the most basic and important sources of homophily/heterophily: organizational size. Size is a particularly salient factor because it is easily observed. There are many benefits achievable through larger size. Greater scale implies greater efficiency in the production of goods or in the delivery of services, greater employee specialization based on the intricate division of labor, and extraction of rents from experiential learning among others (Dobrev & Carroll, 2003). However, those firms face also specific problems related to their size, the most notable being inertia. Given a choice of potential alliance partners and the fact that organizations utilize partnerships to access resources they do not produce internally, larger firms should be attracted to smaller firms in order to access smaller firm's entrepreneurial talent and capitalize on their flexibility (Shipilov *et al.*, 2006).Moreover, within an industry, companies are usually direct competitors with companies of the same size which also increases their likelihood of allying with companies of a different size.

However, partnerships between dissimilar others also hide uncertainties given by the different firms background. For example, a large firm could forge an alliance with a smaller one as a first step toward a subsequent acquisition of the latter. Although such event is not always to be seen as a negative one, it could be viewed negatively by the small firms owners which could result in a lack of trust and commitment, and give birth to learning races (Hamel, 1991). On the other hand, a small firm could use horizontal alliances as a means to acquire valuable information and knowledge from larger companies. Relying on the fact that two big companies A and B would be more likely to compete rather than cooperate, the small firm could gain positional advantages by placing itself between them (i.e. becoming a broker).

Even though in times of relative tranquility, both large and small firms may be willing to face the “cost of dissimilarity” in order to achieve the benefits given by complementary alliances, in times of danger such risk-taking approach may be counterproductive. Previous research at the individual level has demonstrated that homophily becomes more important to tie activation during times of crisis or trouble (Hurlbert, Haines, & Beggs, 2000). Under turbulent task environments and conditions of uncertainty, actors will assume a more defensive posture and will be more likely to direct their networking efforts to others with a common background (Galaskiewicz & Shatin, 1981). Accordingly, we expect that higher levels of heterophily may be replaced by a tendency to form homophilous ties when there is high environmental uncertainty generated by a jolt. Taken together these arguments lead us to the following:

H1: *In the aftermath of an environmental jolt, firms will show a higher level of homophily compared to the period before and after the environmental jolt.*

Jolts and Triads

Do network triads evolve over time? If yes, is their evolution affected by environmental jolts? Triads, subsets of three actors and the possible ties among them, play a key role in relating micro-structural tendencies with macro-structural patterns being at the intersection between dyadic relationships and overall network or parts of it (e.g., small worlds). Although triads have received great attention in studies on interpersonal networks, their role and underlying dynamics appear to be underexplored in the interorganizational context (Baker & Faulkner, 2002; Shipilov & Li, 2010). The triad is a core structure of high-order networks, and since dyads are embedded in triads, they represent a valuable layer of meaning for the network analyst (Madhavan, Gnyawali, & He, 2004). Work based on balance theory (Heider, 1958) is an important strain in triadic analysis. This theory suggests that in the relation of three actors or triad, balance state will occur if the algebraic multiplication of signs in the triad relation has the value of positive. Triads are believed to be influential for the formation of relationships due to the transitivity principle (Granovetter, 1973). Transitivity is the tendency of forming mutual ties by two actors A and B that are connected to a third common party C. At the dyad level this implies that prior indirect ties – at geodesic distance of two – turn into direct ties. The main reason why triads tend to be transitive is because actors strive to reduce inconsistencies and uncertainties in their social and cognitive worlds, and attempt to establish balances in their relationships (Heider, 1958). While this is mostly true in the case of interpersonal networks, in interfirm networks transitive triads are justified by the desire of the parties involved to achieve joint value creation, such as economies of scale (Madhavan *et al*., 2004). The more triads become transitive, the higher the level of the interconnectedness will be. A tendency toward closure produces dense cliques of strongly interconnected actors in the network. Groups of strongly interconnected actors generally show a high level of trust and commitment (Walker, Kogut, & Shan, 1997). The underlying assumption is that the selection of relationships, the maintenance of existing ones, and the dissolution of old ones is conditioned by trust, information, and opportunities for interaction that are structured by the network (Rivera, Soderstrom, & Uzzi, 2010).

The above arguments have received support in previous studies. For instance, Newman (2001) documented that those scientists who have had common co-authors were more likely to collaborate and form relationships over time than those who did not share authorship. In another study, Burt (1999) concluded that triads were more likely to be cohesive and balanced when there is trust between three actors. At the interfirm level, transitive triads have been found within the same geographical regions and within the same technological classes in the global steel industry (Madhavan et al., 2004). Consequently, it seems reasonable to suggest that triadic transitivity should reinforce path dependent pressures within dyads, that is the higher is the frequency of prior collaborations between two actors who have a common third party, the more likely should be that the two actors continue cooperating with each other while collaborating with the third party at the same time.

Given the above arguments, it seems reasonable to expect that, as time passes and an industry becomes more mature, transitive triads will increase. However, this endogenous assumption of linearity maybe questioned when we take into account the role that environmental influences may have on triads formation or dissolution. Despite the external environment plays an important role in shaping network structure, in previous research on triads the "within-the-network" perspective, which views the shape and the structure of the network in a prior time period, has prevailed as the focal predictor of network change (Stuart & Sorenson, 2007). We complement and expand literature on network change at the triadic level by exploring the impact of environmental jolts on triads over time. Environmental pressures create the need of alignment for organizational networks. The higher those pressures, the more difficult it would be for firms to maintain structures that were suitable in the previous context. Thus, in this paper, we argue that triads may evolve in a punctuated way. Because dyadic relationships that share a common party will tend to become triads over time due to inertia and path dependence, the overall transitivity will tend to increase. In other words, firms are constrained in their future tie activity by their existing networks and there will be relatively few degrees of freedom for network activity as networks become more clustered. Changes in the environment disrupt such equilibrium as firms respond to the altered environmental state by modifying their network structure (Koha, Madhavan, & Prescott, 2006). In that context, shocks in the external environment may render previous networking behavior incompatible with the new scenario and push toward more radical reconfiguration of firms' alliance networks. For instance, in a study of creative artists who collaborated in the creation of Broadway musicals between 1877 and 1995, Uzzi & Spiro (2005) found that clustering decreased significantly after a shock perturbed the network. The authors suggest that shocks may weaken common ties to the same third party or make interaction with a common third party less predictable. In a similar fashion, Shipilov (2005) argues that embedded ties can become liabilities when external shocks to an industry render previous social relationships obsolete. In contrast to those arguments, we suggest that for interfirm linkages, a shock may push firms to search for greater stability and acquaintances provided by less distant partners in the network. By closing their open triads in times of high environmental turbulence, firms engage in competition and uncertainty reduction actions. On the one hand, transitivity could mitigate the uncertainties hidden in open triads (i.e., less opportunistic behavior, more control on partner's activity). On the other hand, in a highly unstable and less munificent environment, it would be reasonable to co-opt more rivals in order to reduce competitive pressures. Accordingly, we argue for a conservative posture during a major upheaval as a mechanism to insulate and buffer firms from the external uncertainties. Hence:

H2: *In the aftermath of an environmental jolt, triads will show a higher tendency toward transitivity compared to the period before and after the environmental jolt.*

METHODS

Data

We tested our hypotheses using longitudinal data on alliances formed in the global airline industry between 1998 and 2006. We identified an alliance as any durable collaborative activity that involved exchange of resources between firms (Ahuja, 2000). All airlines that had formed at least one alliance during the period of our study were included in the database. Data on airline alliances and their evolution are collected through several issues of the Airline Business magazine. These issues contain data on all major forms of cooperative relationships (e.g., blocked seat, code-sharing, marketing) but exclude cooperation on frequent flyer programs as well as alliances among charter and cargo carriers which are not the focus of this study. We used these data to build a series of sociomatrices. A particular matrix entry X_{ij} corresponds to an active tie between an airline in row i and an airline in row j. Thus, inactive alliances in the study period were excluded. Forming year-wise matrixes is necessary in order to create a panel dataset for the purpose of year-wise testing of hypotheses. Such approach is also particularly indicated for testing environmental change hypotheses (Koka & Prescott, 2008). The database includes information on individual airlines observed over time. The final sample consists of an unbalanced panel of 264 airlines, including companies that have disappeared from the business arena and those that were founded during the analysis period. To this day, these carriers represent almost 80 percent of the total world passenger traffic, covering more than 80 countries in the world.

Estimation Procedure

In order to test how homophily and transitivity drive the dynamics of the network, we apply a stochastic network simulation procedure across the nine observations between the period 1998-2006. We do so by using the program SIENA (Simulation Investigation for Empirical Network Analysis), as developed by Snijders (2001). This program has been specifically designed for the statistical analysis of dynamic networks. Moreover, SIENA fills a gap by allowing researchers to apply a dynamic or evolutionary approach to social network analysis while also focusing on individual actors in organization research (Felin & Foss, 2005).

SIENA treats the evolution of the network as driven by the changes the actors make in their outgoing ties, that is the ties they send to other actors, one at a time. One such change may consist either of establishing a new tie or withdrawing an existing one. The actors are assumed to add or withdraw their outgoing ties guided by their preferences for alternative local configurations of the network, formalized in a hypothesized random utility function. Choosing a model of the evolution of the network is equivalent to selecting the components of the utility function that underlies the actors' choices.

The parameters associated to the components of the utility function correspond to the hypothesized dynamical tendencies of the network; they are estimated by means of an iterative procedure, that implies many simulations of the evolution of the network between consecutive observations, until convergence on a set of parameter estimates is obtained. Based on these parameter estimates, a last series of simulations is performed which produces an estimate of the standard errors.

The internal logic of SIENA models implies at least the estimation of a number of *rate* parameters, and the *degree* parameter. A *rate* parameter is estimated for each period between consecutive observations of the network; it measures how frequently actors change their outgoing ties. In other words, rate parameters measure the speed of the change of the network in each period. Modeling the evolution of a network across *m* discrete observations implies then the estimation of *m-1* rate parameters. Our models include three rate parameters for the periods 1998-1999, 1999-2000, 2000-2001, two for the periods 2001-2002 and 2002-2003, and three for the periods 2003-2004, 2004-2005, and 2005-2006.

The inclusion of the *degree* parameter is needed to condition on the observed density of the network (the number of ties) while assessing higher order structural features. This is important because, for instance, the observation of a certain number of transitive triplets could be trivial in a network with a very high density, while in a sparse network (low density) it could well indicate an important structural mechanism of the network's evolution.

Other parameters are almost always included in SIENA models not because they are intrinsic to the model's logic, but because they reflect the most classical and widely observed structural tendencies of networks. Among them we focus on transitive triads. *Transitive* closure involves triples of actors at the micro-level, and induces important macro-structural implications (Granovetter, 1973). In longitudinal modeling transitive closure can be shown to be the outcome of a number of different (though not exclusive) micro-mechanisms, that correspond to distinct SIENA parameters. In this study we test for the *transitivity* parameter.
Finally, one of the important features provided by SIENA is that it allows the membership of the network to change across the observations. The membership of our network changed during the observation period through the entry and the exit of some players. In the analyses these changes were dealt with by setting to structural zeros the embedded ties that involved a firm not yet in the network, as described in Snijders, Steglich, Schweinberger, & Huisman (2008).

Variables

Rate of change. This variable indicates the average number of tie changes per actor between two consecutive waves. In particular, we identified three waves in the period before (1998-2001) and three waves in the period after the environmental jolt (2003-2006) while the jolt period consisted of two waves (2001-2003).

Homophily. A tie between two actors that share a common attribute may be more likely to take place. We selected *firm size* as our measure to test homophily selection effects.

Firm size. Firm size was operationalized as the natural logarithm of the fleet size, which is a frequently used indicator for size in the airline industry. Other measures could have been used in place of fleet size such as the number of employees, total assets or number of clients served. Concern about what measure of size should be used is especially important in cross-industry studies (Kimberly, 1976), but for studies confined to a single industry, the effects of size can be more easily disentangled (Blau & Schoenherr, 1971).

Transitive triads. The variable transitive triads is operationalized as transitivity or the tendency of friends of friends to become friends. In our context, this means the tendency of forming alliances with partners' partners.

Environmental jolt. The dummy variable *environmental jolt* took the value of 1 for the years 2001, 2002, and 2003 and 0 otherwise. Extending the effects of the jolt for a period of three years is a judgment based on previous studies (Madhavan *et al.*, 1998; Koka & Prescott, 2008; Wan & Yiu, 2009) and industry evidence. The global economic downturn that began at the end of 2000 with the bursting of the dot.com bubble, continued through 2003. The events of

September 11, 2001 exacerbated pessimism about the future and spread from the United States to other countries as described in business and trade journals (Polzehl, Spokoiny, & Starica, 2004). After 9/11 attacks, global demand for air travel collapsed immediately. The downturn of 2001 was perceived as the worst airline crisis ever, resulting in a "perfect storm" (Franke & John, 2011). Although people commenced flying shortly after, it was not until 2004 when pre-jolt demand level was reached. Recovery was also delayed due also to the 2003 pandemic threat of SARS which further increased our confidence in our 3-year window choice.

RESULTS

Table 1 shows correlations. Table 2 shows the results of the model for the whole period of analysis. The parameter *transitive triads* is positive and significant (0.4457, $p < 0.05$) which means that actors have a tendency towards network closure or transitivity. Our parameter for homophily, *fleet size similarity*, is negative and significant (-0.5061, $p<0.05$) which suggests that overall the firms in our sample have a tendency toward the creation of heterophilous ties. The dummy variable *during* which represents the jolt period is positive and significant (0.1531, $p<0.05$). This result indicates that there is a tendency to form more ties during the jolt period compared to the periods of more tranquility. Finally the interaction between *fleet size* and the dummy *during* is positive and significant (0.9468, $p<0.05$). This result is quite relevant since it demonstrates that airlines are more prone to form homophilous ties in the jolt period.

Table 3 shows the results of the models for the three periods: before, during and after the environmental jolt. In the control models (models 1, 3, and 5), we see the rate scores for each period, indicating the average number of tie changes per actor between consecutive waves. The scores are all significant and relatively constant for the whole period with two exceptions: the periods 2002-2003 and 2005-2006. For our study the result in the period 2002-2003 (2.7957, $p<0.05$) is particularly interesting. This decrease in the rate score may be due to the fact that following the jolt on average there will be less tie changes due to lower munificence and higher uncertainty. In other words, companies will be less akin to experiment with their ties. The parameter transitive triads is always significant and positive which confirms the result reported for the whole model in table 2. However, transitivity does not evolve in a linear fashion but in a punctuated way. Following the jolt, transitivity increases (0.4555, $p<0.05$) compared to the before period (0.3858, $p<0.05$) but then decreases again in the subsequent period (0.4085, $p<0.05$). These results confirm hypothesis 2. In models 2, 4, and 6 we introduce fleet size and fleet size similarity (homophily). The size parameter is not significant in each of the three periods although in the first period is negative and then positive in the following two periods which indicates that before the jolt, bigger airlines are less likely to take part in new alliances while the opposite happens after a jolt takes place. The estimation of *homophily* based on firm size clearly indicates that in the jolt period firms of the same size are more likely to form alliances (1.1748, $p<0.05$) while the coefficient is negative and significant before the jolt (-1.2714, $p<0.05$) which suggests that firms are more likely to establish new ties on the basis of heterophily. Thus, hypothesis 1 is confirmed.

DISCUSSION AND CONCLUSIONS

Empirical research on network dynamics has been quite sparse due to practical difficulties (e.g. collection of extensive and broad longitudinal network data) and a lack of attention both on the theoretical and the econometric handling of endogeneity problems (Ahuja *et al.*, 2011). On the other hand, given a network structure or network position, scholars have produced a conspicuous amount of theoretical and empirical contributions on the effects of organizational networks. However, without a comprehension of the logic that drives network creation, *and evolution*, scholarly understanding of its outcomes remains incomplete (Salancik, 1995, words in *italics* added). Accordingly, in this paper, we instrumentally used the concept of environmental jolts to identify what are the forces operating behind network evolution. This approach requires overcoming the static approach that has typically characterized network studies while embracing a temporal perspective. To that respect, taking into account the contingency of time becomes particularly relevant for separating periods of turbulence from periods of relative tranquility.

Moreover, following recent theoretical contributions (Kilduff, Tsai, & Hanke, 2006), we argue for a dynamic stability approach by supporting the argument that organizational networks change constantly in some respects and yet remain stable in other respects. For example, a change at the dyadic level does not automatically produce a change at the triadic level. Yet it may be that a small change at the local level – one firm adding an alliance to its portfolio, for example – can have global implications for change for the whole network – by bringing disconnected clusters of firms much closer together, for instance. Given that shocks tend to perturb the system at different times, companies and industries are faced with periods of tranquility punctuated by disruptions. If we are to understand the evolutionary trajectories of network evolution, then a dynamic stability approach that considers social networks as sets of interlinked actors continuously forming and reforming may be helpful. Networks can be a source of opportunity (Burt, 1992) but also a trap (Benassi & Gargiulo, 2000) and to a certain extent actors can "play" with their ties to maximize the returns they can gain from them. A major shock can modify radically the competitive landscape and the way firms perceive their ties. Evidence shows that shocks are increasingly becoming a less rare phenomenon. Despite that, most of our theorizing is often based on an implicit assumption of stability. Whereas actors respond to the constraints and opportunities of the network in many ways, empirical network research rarely considers the most direct line of attack on a constraining network – to change the network itself (Emirbayer & Goodwin, 1994). Our study aims at contributing to this small but growing line of research.

Our results provide evidence that environmental jolts can be an important predictor of network change at more than one level of analysis. At the dyad level, we found that actors of same size are less likely to form ties when the environment is stable. This result confirms that the motives guiding alliance formation differ from those guiding the formation of interpersonal ties. Individuals are more likely to connect with other individuals that share common attributes such age, gender, and religion. On the other hand, alliance formation is mainly driven by the desire to obtain complementary assets. However, our data suggest that this situation changes in the face of an environmental jolt. Sharing a common attribute, organizational size in our case, may be viewed positively during a jolt. In the case of size, companies of same size, which would usually be competitors, may find it more convenient to form an alliance in an effort to reduce uncertainty and competition. In other words, eliminating some of the competitive pressures within the industry would compensate for the increased pressures coming from an unstable external environment. This finding provides an important contribution to interfirm partner selection literature by suggesting that firms use coopetitive logics in designing their alliance strategy. In times of danger firms will become more cooperative as opposed to periods of higher tranquility in which competitive logics prevail. At the triad level, we find evidence that there is a tendency toward transitivity over time. Firms tend to modify their alliance portfolio by adding or removing ties. Our results suggest that there will be a higher tendency toward addition rather than deletion of ties over time, may be due to inertia and cost of searching new partners to replace old ones. However, in line with previous research (Uzzi & Spiro, 2005), our study suggests that triads evolve in a punctuated way. In particular, we find that an environmental jolt will lead firms to close their triads. In times of crisis firms' alliance activity will be more directed toward firms that are closer to them (i.e. less geodesically distant). Thus, referrals and acquaintances seem to be particularly important during an environmental jolt. Although there is a plethora of studies on interpersonal networks analyzing the triadic microstructure, research on interfirm networks focusing on triads is still limited and mostly cross-sectional in nature. More studies examining structural tendencies over time are needed and our study is one of the first contributions in that direction.

This paper also provides important methodological contributions. First, we address the issue of endogeneity and direction of causality. Failures to account for endogeneity, direction of causality, and unobserved heterogeneity have all been raised as possible sources of methodological error in network research (Ahuja, 2007; Aral & Van Alstyne, 2011). Although the idea that structural advantages are available to occupants of certain network positions is widely accepted, this idea is based on cross-sectional studies (Baum & Rowley, 2008). In reality, it is possible that some advantages precede, rather than follow, network positions (Ahuja *et al.*, 2011). Adopting a longitudinal research design has been recently suggested as a way to separate cause and effect. Moreover, scholars have been encouraged to use exogenous shocks to identify effects. To that respect, our study is one of the very first in network research to explicitly account for endogeneity by using a natural experiment in a longitudinal context.

Second, to obtain accurate estimates of the network's effects on behavior, it becomes important to control for the econometric implications of network change by also using appropriate statistical procedures. To that respect, the development of computer simulation models of network evolution, such as SIENA, is a promising area of research which also facilitates the testing of models that relate multilevel explanatory variables to tie-level outcomes.

Finally, this study also provides a key managerial insight. The fact that the morphology of an alliance network changes contingent on environmental changes suggests that alliance managers should continuously scan the environment trying to foresee its changes and adapt to them. Horizontal alliances are one of the ways in which a firm can diversify risk. Thus, in times of danger, alliances help diversify risk by sharing it with partners. Although shocks are unexpected events, companies should learn from previous jolts in order to make better strategies and easier recovery from future ones. In network terms this means that managers should structure their alliance portfolio in a flexible way - not being trapped in their own nets - so that they can for instance easily switch from heterophilous to homophilous ties in the face of an environmental jolt. In practice, the use of simulation and forecasting tools could be of great help in modeling future scenarios that include the occurrence of unusual events.

LIMITATIONS AND FUTURE RESEARCH

This study is not without limitations. The idiosyncrasy of the event we chose to conduct our natural experiment may put some limits to the generalizability of our results. Other forms of environmental jolts such as natural disasters or wars may be more or less likely to produce the same results. Moreover, this study focuses only on a single, and negative, exogenous event while being silent on the impact of multiple, positive or negative, exogenous or endogenous, events on network restructuring. Future studies could include different types of jolts over a longer time span.

Another caveat is given by the empirical setting we chose. Each industry has its own peculiarities which may hinder our ability to extend our findings to other settings in a normative way. In other words, the patterns found in our study may not replicate in a different setting. Less bureaucratic or younger industries as well as manufacturing industries could be used in future research to test whether our results hold in other empirical settings.

Although our study represents one of the few contributions conceptualizing and empirically testing a multilevel framework of network change, future studies could include more levels (e.g, small world and whole networks) as well as different variables from the ones we have chosen at the pair- and the triad-level. For example, studies focusing on dyads could examine the impact of structural equivalence on alliance formation and deletion over time.

Furthermore, interesting results could emerge from the interactions between different levels of analysis. Using the variables we identified in this paper, future research could explore: 1) whether transitive triads between firms sharing a common attribute are more likely to happen during an environmental jolt, 2) whether homophilous ties are more likely when two firms share a common partner during an environmental jolt.

In focusing on the antecedents of network change, we have kept silent on the performance consequences. A focus on both the antecedents and the consequences may provide a broader and more complete picture of interfirm network evolution. From a practical standpoint, two-stage models could be employed to test such a comprehensive model of network dynamics.

In summary, bridging different levels of analysis and theoretical approaches, we provided an empirically testable framework that deals with how the environment shapes network evolution. We hope our study encourages scholars to undertake more research in situations far from equilibrium and explore their effects on the evolution of networks.

REFERENCES

Ahuja, G. 2000. Collaboration networks, structural holes and innovation: A longitudinal study, ***Administrative Science Quarterly***, 45, 425–455.

Ahuja, G., Soda, S., & Zaheer, A. 2011. The genesis and dynamics of organizational networks. ***Organization Science***, *Articles in advance*, 1-15.

Barley, S. 1986. Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. ***Administrative Science Quarterly,*** 21: 78- 108.

Beckman, C. M., Haunschild, P.R., & Philips, DJ. 2004. Friends or strangers? firm-specific uncertainty, market uncertainty, and network partner selection. ***Organization Science***, 15 (3): 259–275.

Blau, P. M. 1964. ***Exchange and Power in Social Life***. John Wiley & Sons, New York.

Burt, R. S. 1999. The social capital of opinion leaders. ***Annals of the American Academy of Political and Social Science,*** 566: 37–54.

Casciaro T., & Lobo, M. S. 2008. When competence is irrelevant: the role of interpersonal affect in task-related ties. ***Administrative Science Quarterly***, 53:655–84.

Contractor, N., Wasserman, S., & Faust, K. 2006. Testing multi-theoretical multilevel hypotheses about organizational networks: An analytic framework and empirical example. ***Academy of Management Review***, 31: 681-703.

Dobrev S.D., & Carroll G.R. 2003. Size (and competition) among organizations: Modeling scale-based selection among automobile producers in four major countries, 1885-1981. ***Strategic Management Journal***, 24: 541-558.

Eisenhardt, K. M., & Schoonhoven, C.B. 1996. Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms, ***Organization Science,*** 7(2):136-150

Emirbayer, M., & Goodwin J.. 1994. Network analysis, culture, and the problem of agency. ***American Journal of Sociology***, 99(6) 1411–1454.

Fischer, C. S. 1977. ***Networks and Places. Social Relations in the Urban Setting***. New York: Free Press.

Fischer, C. S. 1982. ***To Dwell Among Friends***. Chicago: University Chicago Press.

Galaskiewicz, J., & Shatin, D. 1981. Leadership and networking among neighborhood human service organizations. ***Administrative Science Quarterly***, 26:434-448.

Galaskiewicz, J. 1985. Interorganizational relations. In R. Turner & J. Short (Eds.), ***Annual review of sociology***, vol. 11: 281-304. Palo Alto, CA: Annual Reviews.

Granovetter, M. 1973. The strength of weak ties. ***American Journal of Sociology***, 78: 1360-1380.

Granovetter, M. 1985. Economic action and social structure: The problem of embeddedness. ***American Journal of Sociology***, 91: 481-510.

Gulati, R. 1995. Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. ***Academy of Management Journal***, 38: 85–112.

Gulati, R. 1998. Alliances and networks. ***Strategic Management Journal***, Special Issue 19(4): 293–317.

Gulati, R. 2007. ***Managing network resources: Alliances, affiliations, and other relational assets.*** Oxford University Press, Oxford.

Gulati R, & Gargiulo, M. 1999. Where do interorganizational networks come from? ***American Journal of Sociology***, 104(5): 1439–1493.

Gulati, R., Nohria, N., & Zaheer, A. 2000. Strategic net works. ***Strategic Management Journal***, 21: 203-215.

Hamel, G. 1991. Competition for competence and inter-partner learning within international strategic alliances. ***Strategic Management Journal***, Summer Special Issue, 12, pp. 83–103.

Heider, F. 1958. ***The Psychology of Interpersonal Relations***. New York: Wiley.

Kilduff, M., Brass, D. J.. 2010. Organizational social network research: Core ideas and key debates. ***Academy of Management Annals***, 4 317–357.

Kim, T., Oh, H., & Swaminathan, A. 2006. Framing interorganizational network change: A network inertia perspective, ***Academy of Management Review***, 31(3): 704-720.

Koka, B.R., Madhavan R., & Prescott, J.E. 2006. The evolution of interfirm networks: Environmental effects on patterns of network change. ***Academy of Management Review***, 31(3): 721-737.

Kogut, B. 1988. Joint ventures: Theoretical and empirical perspectives. ***Strategic Management Journal,*** 9: 319–332.

Krackhardt, D. 1992. The strength of strong ties: The importance of philos in organizations. Nohria N., Eccles R. G., eds. ***Networks and Organizations: Structure, Form, and Action***. Harvard Business School Press, Cambridge, MA, 216–239.

Lavie, D. 2007. Alliance portfolios and firm performance: A study of value creation and appropriation in the U.S. software industry. ***Strategic Management Journal***, 28(12): 1187-1212

Lazarsfeld P, & Merton R. K. 1954. Friendship as social process: a substantive and methodological analysis. In ***Freedom and Control in Modern Society***, ed. MA Berger, T Abel, C Page, pp. 18–66. New York: Van Nostrand.

Madhavan R, Koka BR, Prescott JE. 1998. Networks in transition: how industry events (re)shape interfirm relationships. ***Strategic Management Journal***, 19:439-459.

Madhavan, R., Gnyawali, D. R., & He, J. 2004. Two's company, three's a crowd? Triads in cooperative competitive networks. ***Academy of Management Journal***, 47: 918-927.

Lawrence, P.R., & Lorsch J. R. 1967. ***Organizations and Environments***. Harvard Business School Press, Boston, MA.

Li, S. X., T. J. Rowley. 2002. Inertia and evaluation mechanisms in interorganizational partner selection: Syndicate formation among U.S. investment banks. ***Academy of Management Journal***, 45(6): 1104–1120.

Meyer, A.D. 1982. Adapting to environmental jolts. ***Administrative Science Quarterly***, 27(4): 515-537.

Oliver, C. 1990. Determinants of interorganizational relations: Integration and future directions. ***Academy of Management Review***, 15: 241-265.

Pfeffer, J, & Salancik G. 1978. ***The external control of organizations: a resource dependence perspective***. New York, Harper & Row.

Podolny, J. 1994. Market uncertainty and the social character of economic exchange. ***Administrative Science Quarterly***, 39(3): 458–470.

Powell, W. W.,. Koput K. W, White D. R., & Owen-Smith J. 2005. Network dynamics and field evolution: The growth of interorganizational collaboration in the life sciences. ***American Journal of Sociology***, 110(4) 1132–205.

Provan, K.G., & Milward, H.B. 1995. A preliminary theory of network effectiveness: A comparative study of four community mental health systems. ***Administrative Science Quarterly***, 40: 1-33.

Rivera, M. T., Soderstrom S. B., & Uzzi B. 2010. Dynamics of dyads in social networks: Assortative, relational, and proximity mechanisms. ***Annual Review of Sociology***, 36 91–115.

Romanelli, E., & Tushman, M. 1994. Organization transformation as punctuated equilibrium: An empirical test. *Academy of Management Journal*, 34: 1141-1166.

Rothaermel, F. T. 2001. Incumbent’s advantage through exploiting complementary assets via interfirm cooperation. ***Strategic Management Journal***, 22 (6-7): 687-699.

Rothaermel, F.T., & Boeker, W. 2008. Old technology meets new technology: Complementarities, similarities, and alliance formation. ***Strategic Management Journal***, 29 (1): 47-77.

Rowley, T., Behrens, D., & Krackhardt, D. 2000. Redundant governance structures: An analysis of structural and relational embeddedness in the steel and semiconductor industries. ***Strategic Management Journal***, March Special Issue 21: 369–386.
Schumpeter, J.A. 1942. ***Capitalism, Socialism and Democracy***. New York: Harper.

Sewell, W. H., Jr. 1992. A theory of structure: Duality, agency, and transformation. ***American Journal of Sociology***, 98(1) 1–29.

Shipilov, A.V. 2006. Network strategies and performance of Canadian investment banks. ***Academy of Management Journal***, 49(3): 590–604.

Shipilov, A. V., Rowley T. J., & Aharonson, B. S. 2006. When do networks matter? A study of tie formation and decay. ***Advances in Strategic Management***, 23:481–519.

Shipilov, A. V., & Li, S. X. 2010. The missing link: The effect of customers on the formation of relationships among producers in the multiplex triads. ***Organization Science***.

Snijders, T.A.B., Steglich, C.E.G., Schweinberger, M., & Huisman, M. 2008. ***Manual for SIENA version 3.2***. Groningen: University of Groningen, ICS. Oxford: University of Oxford, Department of Statistics.

Snijders, T.A.B., van de Bunt, G.G., & Steglich, C.E.G. 2010. Introduction to actor-based models for network dynamics. ***Social Networks***, 32: 44-60.

Stuart, T.E., Hoang H., & Hybels R. 1999. Interorganizational endorsements and performance of entrepreneurial ventures. ***Administrative Science Quarterly***, 44: 315-349

Stuart, T. E., & Sorenson O. 2007. Strategic Networks and Entrepreneurial Ventures. ***Strategic Entrepreneurship Journal*** 1 (3): 211-227.

Thompson, J. D. 1967. ***Organizations in action***. New York: McGraw-Hill.

Tushman, M., & Romanelli E. 1985. Organizational Evolution: A Metamorphosis Model of Convergence and Reorientation. ***Research in Organizational Behavior*** 7.

Walker, G., Kogut, B., & Shan, J.W., 1997. Social capital, structural holes, and the formation of an industry network. ***Organization Science***, 8, 109–125.

White, H. 1992. Agency as control in formal networks. Nohria, N., & Eccles, R. G., eds. ***Networks and Organizations: Structure, Form, and Action***. Harvard Business School Press, Cambridge, MA, 92–117.

Zaheer, A, & Bell, G. 2005. Benefiting from network position: firm capabilities, structural holes, and performance. ***Strategic Management Journal***, 26(9): 809–825.

Zaheer, A., G. Soda. 2009. Network evolution: The origins of structural holes. ***Administrative Science Quarterly,*** 54(1) 1–31.

APPENDIX

Table 1. Summary of the Theoretical Model

Hypothesis	Variable	Theory	Micro foundations	Illustrative prediction	Measure
1	Dyadic level	Exchange theory	Agency	Mutual ties between actors with similar attributes have a higher probability of occurring	Homophily
2	Triadic level	Balance theory	Opportunity	Friends of friends are more likely to form ties with each other leading to triad closure	Transitivity
-	Environment	-	Exogenous factors	-	Environmental Jolts

Table 2. Correlations

	1.	2.	3.	4.	5.	6.	7.	8.
1. Degree								
2. Transitive triads	-0,464							
3. Fleet size	0,029	-0,278						
4. Fleet size similarità	0,072	-0,157	0,692					
5. Dummy During (2001-2003)	0,111	0,021	-0,064	-0,110				
6. Dummy After (2003-2006)	0,102	-0,028	0,097	0,055	0,434			
7. Interaction Fleet size similarity × Dummy During (2001-2003)	0,063	-0,192	0,178	0,247	-0,026	0,025		
8. Interaction Fleet size similarity × Dummy After (2003-2006)	0,031	-0,016	-0,055	0,098	-0,013	-0,008	0,206	

Table 3. Estimates for the three periods (standard errors in parentheses)

	1998-2006			
	Model 1		Model 2	
Rate 1998-1999	4,6269*	(0,2953)	4,6724*	(0,3011)
Rate 1999-2000	4,0012*	(0,2737)	4,0236*	(0,2763)
Rate 2000-2001	3,6487*	(0,2582)	3,6484*	(0,2440)
Rate 2001-2002	3,8421*	(0,2619)	3,6974*	(0,2535)
Rate 2002-2003	2,6691*	(0,2029)	2,6056*	(0,1993)
Rate 2003-2004	4,3274*	(0,2805)	4,3240*	(0,2979)
Rate 2004-2005	2,2471*	(0,2102)	2,2448*	(0,2075)
Rate 2005-2006	5,3899*	(0,3737)	5,3696*	(0,3819)
Degree	-1,6120*	(0,0243)	-1,6037*	(0,0229)
Transitive triads	0,4462*	(0,0110)	0,4457*	(0,0115)
Fleet size	0,0002	(0,0010)	0,0002	(0,0010)
Fleet size similarità	-0,5013*	(0,1714)	-0,5061*	(0,1842)
Dummy During (2001-2003)			0,1531*	(0,0502)
Dummy After (2003-2006)			0,0629	(0,0407)
interaction Fleet size similarity × Dummy During (2001-2003)			0,9468*	(0,3239)
interaction Fleet size similarity × Dummy After (2003-2006)			0,0540	(0,2259)

Table 4. Estimates for the three periods (standard errors in parentheses)

	1. BEFORE (1998-2001)				2. DURING (2001-2003)				3. AFTER (2003-2006)			
Rate 1	4,7224*	(0,2982)	4,7783*	(0,2978)	4,1176*	(0,2767)	4,1290*	(0,2737)	4,6041*	(0,2989)	4,6038*	(0,2888)
Rate 2	4,0636*	(0,2825)	4,1157*	(0,2822)	2,7957*	(0,2203)	2,8386*	(0,2245)	2,3276*	(0,2176)	2,3617*	(0,2169)
Rate 3	3,7225*	(0,2532)	3,7555*	(0,2585)	-	-	-	-	5,5341*	(0,3690)	5,5593*	(0,3865)
Degree	-1,5361*	(0,0311)	-1,5104*	(0,0304)	-1,3731*	(0,0460)	-1,3793*	(0,0481)	-1,4541*	(0,0334)	-1,4563*	(0,0355)
Transitive triads	0,3858*	(0,0166)	0,3749*	(0,0173)	0,4544*	(0,0247)	0,4395*	(0,0303)	0,4085*	(0,0154)	0,4001*	(0,0155)
Fleet size			-0,0011	(0,0016)			0,0023	(0,0042)			0,0005	(0,0018)
Fleet size similarity			-1,2714*	(0,2324)			1,1748*	(0,5263)			-0,3757	(0,2281)

ENVIRONMENTAL JOLTS, FIRM SIZE, AND THE RELATIONSHIP BETWEEN BROKERAGE AND FIRM PERFORMANCE[3]

Presented at:

- *Strategic Management Society Conference,* Miami, FL, USA, 2011

Abstract. *We treat September 11 terrorist attacks as a natural experiment to investigate how dramatic changes in the external environment can affect the relationship between firms' position in alliance networks and their performance in the global airline industry. We contend that, all else being equal, firms that adopt a brokerage posture will have positive returns. However, we find that in the face of an environmental jolt brokerage relates negatively to firm performance. Furthermore, we argue that the negative relationship between brokerage and performance during an environmental jolt is more significant for larger firms. Our findings indicate the importance of both environmental and firm level attributes for the design of alliance networks and how these affect operational returns.*

[3] An earlier version of this paper has classified as finalist for the "Best Conference PhD Paper Prize" and been nominated for the "Best Conference Paper Prize" and the "Best Conference Paper Prize for Practice Implications" at the 2011 SMS Conference.

Environmental Jolts, Firm Size, and the Relationship Between Brokerage and Firm Performance

ABSTRACT

We treat September 11 terrorist attacks as a natural experiment to investigate how dramatic changes in the external environment can affect the relationship between firms' position in alliance networks and their performance in the global airline industry. We contend that, all else being equal, firms that adopt a brokerage posture will have positive returns. However, we find that in the face of an environmental jolt brokerage relates negatively to firm performance. Furthermore, we argue that the negative relationship between brokerage and performance during an environmental jolt is more significant for larger firms. Our findings indicate the importance of both environmental and firm level attributes for the design of alliance networks and how these affect operational returns.

Keywords: environmental jolt; interfirm networks; brokerage; airline industry

INTRODUCTION

The importance of alliances and networks has greatly increased during the last decade (Harbison & Pekar,1998; Hagedoorn & Osborn, 1997). Strategic alliance research has become something of an industry, challenging the traditional centrality of the firm as a focus for research (Koza & Lewin, 1998). Faced with growing uncertainty and lack of resources, a rising number of companies has recognized the importance of cooperation. As a result, many firms today are embedded in a dense network of interorganizational relationships with customers, suppliers, competitors and complementors (Brandenburger & Nalebuff, 1996; Gomes-Casseres, 1996). Using the network perspective, researchers have focused either on the antecedents or on the consequences of interorganizational networks. Among those who have focused on the consequences of interorganizational networks, attention has been paid to the effects of networks on the mimetic adoption of practices (Haunschild & Beckman, 1998), innovation (Ahuja, 2000; Baum, Calabrese, & Silverman, 2000), survival (Miner, Amburgey, & Sterns, 1990) and performance (Rowley, Behrens, & Krachardt, 2000). Performance has been measured, among others, as innovation output, patenting success, revenue growth, and R&D expenditure (Ahuja, 2000; Baum *et al.*, 2000; Stuart, 2000).

Despite the large number of studies exploring the consequences of interorganizational networks, only a relatively small number of them has used a longitudinal approach, leaving the question of how changes in network ties affect organizational performance open to further inquiry (Kim, Oh, & Swaminathan, 2006). Moreover, network evolution (i.e., change) has been assumed to happen endogenously assuming that the network structure in which the firm is embedded affects the opportunities available to the firm to strategically position itself within the network (Koka, Madhavan, & Prescott, 2006). In its most notable explication, the evolutionary view of networks emphasizes network structure as its own context for evolution (Gulati & Gargiulo, 1999). As a result, we still know very little about how firms respond to environmental stimuli exogenous to the network and with which consequences for their performance. To fill this void, we introduce the concept of environmental jolts, defined as transient perturbations whose occurrences are difficult to foresee and whose impacts on organizations are disruptive and potentially inimical (Meyer, 1982). Researchers looking at the impact of environmental contingencies on network position – performance relationship have typically focused on endogenous jolts, which take place inside the industry boundaries. The impact of an exogenous shock on such relationship needs yet to be explored. Moreover, since we believe that the possibility that a network position augments firm performance may be also a function of firm attributes, we introduce the concept of firm size.

Given the above arguments, we posit that external, as well as internal, factors act as occasions for firms to take advantage of the ensuing changes to structure their ego networks in order to strengthen their position in the network. Our approach to studying network change as a result of both external and internal pressures is similar to the concept of dynamic strategic fit (Zajac, Kraatz, & Bresser, 2000). Drawing on contingency and resource-based arguments, we seek to identify multilevel contingencies that should predict changes in a firm's network strategy and the performance implications of such changes. To that respect, research has emphasized two distinct yet interrelated approaches on how firms can structure their networks, namely brokerage and closure. Instead of asking if the two aforementioned network options affect firm performance we focus on a different question: *what is the impact of external and internal stimuli on the relationship between network structure and firm performance?* We address this question by focusing on two contingencies at the environment (environmental jolt), and the firm (firm size) levels which we argue interact with network structure decisions that affect firm performance. The relationships between characteristics of open networks, moderating variables, and underlying factors are presented in Table 1.

Insert Table 1 about here

The objective of this paper is threefold. First, we seek to contribute to a theory of organizational adaptation that takes into account the presence of exceptional events. Second, we aim to offer new insights and enrich the discourse on the performance consequences of network dynamics by suggesting which are the most effective ways to structure an alliance portfolio and under which conditions. To do so, we introduce firm-, and environment-level factors following recent trends (Burt, 2000; Koka & Prescott, 2008) and recent calls (Shipilov, 2006) in the study of the consequences of interorganizational networks. Finally, we seek to expand the scope of strategic management research by utilizing a natural experiment. Although this is not the first study using a natural experiment approach (e.g, Park & Mezias, 2005), our study is one of the few combining it with a network approach.

The airline industry provides an opportunity to empirically test our hypotheses over the period 1998-2006. Airlines utilize bilateral and multilateral alliances in order to meet the ever increasing demand for *seamless* travel and to share costs and revenues. These networks consist of horizontal alliances, which allows us to mitigate some of the effects power-related factors can play in networks containing a dominant player among several overly-dependent suppliers or distributors (Rowley *et al*., 2000).

The paper is organized as follows. In the next section we briefly review literature on strategic change and structural holes and present the hypotheses. After we describe the empirical setting, the data, and the variables, we present the model and the method and the results of the analyses. We finish by discussing the main implications of the findings, the conclusions that follow from them and the limitations and possible extensions of the present study.

THEORY AND HYPOTHESES DEVELOPMENT

Research in both organization theory and business policy has outlined the importance of context as a factor to consider in order to understand relationships between a firm's strategies and its performance (Pfeffer & Salancik, 1978). Accordingly, the appropriateness of a firm's strategy can be defined in term of its fit, match, or congruence with the environmental or organizational contingencies facing the firm (Andrews, 1971; Hofer & Schendel, 1978). The pursuit of such fit has been traditionally viewed as having desirable performance implications (Miles & Snow, 1994). Typically the notion of fit has been associated with contingency based studies (Lawrence & Lorsch, 1967). In a similar vein, industrial organization scholars have focused on understanding the impact of a firm's environment on performance (Porter, 1980). In sum, these studies have put the emphasis on the OT (opportunities and threats) part of the SWOT framework leaving almost unexplored the SW (strengths and weaknesses) part. In an attempt to shed more light on the sources of competitive advantage, the resource-based model has focused on internal analyses of organizational strengths and weaknesses. The main assumption of RBV studies is that firms within an industry possess heterogeneous resources and that superior rents come from such heterogeneity (Barney, 1991). Although there is little doubt that both approaches have been very fruitful in clarifying our understanding of sources of sustained competitive advantage, both the industry and resource-based perspectives have historically emphasized static equilibria (Zajac *et al.*, 2000). We believe that when the assumption of equilibrium is broken, both the internal and the external perspectives become more interesting and powerful predictors of strategic change.

Change can happen at many levels, including the organization, the organization's alliance portfolio, the whole network or an industry. In this study, our interest is in viewing how interfirm networks change. Moreover, the nature of change can also differ. Change has been portrayed both as a continuous organizational process (March, 1981) and as brief episodes interspersed between long periods of stability and inertia (Miller & Friesen, 1984). Change happens in two fundamentally different modes (Meyer, Brooks, & Goes, 1990). Continuous, or first-order change, occurs within a stable system that itself remains unchanged. Discontinuous, or second-order change, transforms fundamental properties or states of the system. First-order change is incremental or *evolutionary* while second-order change is said to be of a *quantum* nature because many elements change in a major or a minor way within a brief interval. Quantum changes are defined as *revolutionary* when they radically transform many elements of the structure.

Network change has usually been regarded as an evolutionary process with main attention being paid to change through gradual and incremental steps as network actors interact and adapt to each other (Halinen, Salmi, & Havila, 1999). Quite opposite to that view, industry evidence seems to suggest that industries are subject to periods of incremental change that are interrupted by merger waves, multiple bankruptcies or peaks in the formation of alliances among industry players. Examples of such industries include healthcare, semiconductors, airlines and banking.

Received literature offers the possibility to capture both evolutionary and revolutionary change in the analysis of network change through the punctuated equilibrium model. According to this model, systems evolve alternating periods of equilibrium, in which persistent underlying structures permit only incremental change, and periods of revolution, in which these underlying structures are fundamentally altered (Gersick, 1991). Organizational theorists who have adopted the punctuated-equilibrium perspective propose that organizational evolution has two distinct and recurring phases: 1) long periods of quasi-equilibrium, during which organizations make only incremental changes in structure and activities, and 2) brief periods of disequilibrium, during which many new organizations appear and many existing ones undergo deep change (Tushman & Anderson, 1986; Miner, Amburgey, & Sterns, 1990; Haveman, Russo, & Meyer, 2001). In line with previous research that argues that the evolution of some alliances may be akin to a punctuated equilibrium model in which there may be discrete stages that occur due to discontinuous changes in the environment (Gray & Yan, 1997; Gulati 1998), we think that this model may be also fruitful for the study of interfirm networks.

Since our interest is to explain why some companies do perform better than others, and under which circumstances, we relate the above arguments to the contingency approach that has focused on explaining firm performance as a function of fit between organizational structure and environmental characteristics (Lawrence & Lorsch, 1967). Accordingly, firms need to strategically design their networks if they are to acquire the appropriate skills and capabilities in the changed environment. Any mismatch between the needs of the environment and the firm's alliance position could have serious performance implications (Koka & Prescott, 2008: 643). However, considering only the impact of the external environment to explain profitability differences among competitors would be equal to take into account only the OT part of the SWOT framework. Consequently, we need to take into account also a firm's key resources. One of these resources is the network itself. Previous research has typically considered networks as conduits of resources. We believe that networks are more than pipes. Notable exceptions in the networks literature that support our position are Madhavan, Koka and Prescott (1998) and Gulati (1999). We consider interfirm networks as a strategic resource that managers can use to improve a firm's positional advantage, and bargaining power, with respect to its competitors. Moreover, an important firm attribute that can dictate the depth of a firm's strategic maneuvering is the size a firm has. Since designing networks is a strategy on its own, the amount of resources a firm can invest on structuring its network will also have an impact on its ability to obtain superior rents.

We discuss these relationships in greater detail as we unpack the underlying mechanisms that influence a firm's ability to gain advantage from network positions rich in structural holes.

Environmental Jolts

The first contingency we examine is at the environment level. In particular we study the performance implications of changes in network positioning following exogenous disruptions which we define as environmental jolts. Before moving into our discussion, it is important to clarify more in deep what we intend for exogenous environmental jolts. Previous literature has posed significant attention to distinguishing between what is exogenous and endogenous (e.g. Di Maggio & Powell, 1983; Hannan & Freeman, 1989). The main reasoning behind those studies is that exogenous or endogenous forces have the power to modify organizational and in some occasions industry boundaries. Although shocks have been also discussed in those theoretical frameworks, we found less evidence and more confusion on the definitions of exogenous and endogenous shocks. To provide a more nuanced distinction we propose a categorization of jolts along two dimensions namely 1) the influence incumbents can exercise on a disruptive event and 2) the locus in which the jolt takes place (see table 2).

Insert Table 2 about here

Endogenous jolts happen by definition inside the industry boundaries and are influenced by the incumbent firms. Examples of events on which incumbents can exert a significant impact are technological changes and the entry of new competitors or the exit of significant players from the market. On the other hand, there are events on which incumbents can play a less significant role but can still exercise some influence. ‘Occasions’ such as a regulatory initiative that removes strategic barriers are coordinated and orchestrated through a lobbying process, usually conducted dominant firms (Madhavan *et al.*, 1998). Environmental jolts that incumbents experience in an unanticipated manner and on which they have not any influence are exogenous by nature. Examples of exogenous jolts, which represent the focus of this study, include but are not limited to: wars, oil shocks, terrorist attacks, natural disasters, and pandemics.

Many contributors have suggested that alliances are an effective means to cope with environmental uncertainties (Gulati & Gargiulo, 1999; Pfeffer & Salancik, 1978). Accordingly, the way a firm structures its sets of alliances, i.e. the ego network, plays an important role in insulating the effects of an environmental jolt. Previous literature has identified two main network strategies, brokerage and closure, and studied their impact on firms performance. One of the most widely used theoretical lenses to examine the options for configuring the structure of a firm's relationships with its partners is the "open network" perspective (Burt, 1992). Advocates of this view sustain that a firm whose network ties are rich in structural holes is well positioned to cultivate a performance advantage thanks to its timely access to information and better control over its partners (Burt, 1992). Several empirical studies have shown that firms improve their performance as a result of low density in their network (e.g. Hargadon & Sutton, 1997; Burt, 2000). Structural holes in the network have been associated with higher innovativeness (Zaheer & Bell, 2005) and competitive capability development (McEvily & Zaheer, 1999) at the organization level, and with getting a promotion (Burt, 1992) and finding a job (Granovetter, 1973) at the individual level of analysis. Opposite to the "open network" perspective, the closure argument suggests that densely embedded networks with many connections linking ego's alters are facilitative for ego (Coleman, 1988). Several empirical studies have shown a positive relationship between interconnectedness and firm performance. Ahuja (2000) found that closure in the technical collaboration networks of U.S. chemical companies increased the number of patents granted to them while Ingram and Roberts (2000), in a study of Sydney Hotels, showed that the more cohesive the managerial friendship network around a hotel, the higher its economic performance.

Although both network strategies are conceptually attractive, it appears likely that their value in a given circumstance will be contingent on several factors (Ahuja, 2000). Accordingly, scholars have started to examine the contingencies, at different levels of analysis, under which network options are effective in enhancing firm performance (Rowley *et al.*, 2000; Koka & Prescott, 2008). For instance, studying the Canadian investment banking industry, Shipilov (2006) provided evidence that, contingent upon firm's levels of specialization, structural holes are beneficial to firm performance. Conversely, other studies have focused on the environmental contingencies suggesting, for example, that the relationship between structural holes and firm performance is contingent on the industry context (e.g. Pollok, Porak, & Wade, 2004). We complement and extend those studies by focusing simultaneously on environmental and firm contingencies to solve this puzzle.

We begin our discussion by proposing that the impact of adopting a brokerage strategy on a firm's performance is contingent upon the environmental context, specifically the environmental jolt. Turbulent environments, as opposed to more stable ones, pose different challenges on managers decision-making processes with the former suggesting a more prudent behavior while the latter favoring a more opportunity-seeking posture. When it comes to network structuring decisions, environmental jolts may put a premium on those firms that reconfigure their network in the most effective way in order to absorb the uncertainties generated by the shock and adapt to the new environmental scenario. In times of relative tranquility, brokerage may be the preferred strategy in order to obtain information and control advantages by building relationships with disconnected alters. Moreover, the exploration of new ideas, which intrinsically hides some uncertainties, may be facilitated by a less hostile and more munificent environment. We posit that, everything else being equal, firms occupying positions rich in structural holes will be able to increase their performance when the environment is stable. However, such benefits may not apply when the external conditions change dramatically such as in the case of a negative environmental jolt. Jolts have the power to break the status quo, redefine the 'rules of the game' and render previous strategies incompatible with the new scenario. Thus, in conditions of extreme uncertainty stemming from the external environment, adopting a brokerage posture could expose a firm to further uncertainty. Indeed, brokerage is a more hazardous strategy and requires a greater risk-taking propensity as compared to network closure given also the fact that bridging ties are more subject to decay (Burt, 2002).

Support for our argument can be found in previous theoretical and empirical contributions. For example, Granovetter (1982) has argued that strong ties are more likely to be useful to an actor who is in an insecure position. In a similar fashion, Krackhardt (1992) asserted that focusing resources on a few philos ties could be the preferred action when the ego is facing uncertainty and change. In addition, it has been demonstrated that an increase in the level of uncertainty could stress the importance of trusted partners with whom the firm has already transacted in the past (Podolny, 1994; Gulati, 1995) or of partners of trusted partners. Preferring a trusted partner or looking at the partner's immediate partners to form an alliance would lead to a reinforcement of the existing network structure with the ultimate effect of leading to a closer network. Following this logic, we expect that, following an environmental jolt, firms that will opt for the safety of network closure will be more able to withstand the negative effects of the shock. Network closure will thus act as a 'shield' and have a positive impact on firm performance. Therefore:

H1a: Ceteris paribus, brokerage propensity is positively related to performance.

H1b: Brokerage propensity relates negatively to performance during an environmental jolt.

Firm size

Does firm size help to keep up with rapid changes in the external environment? Organizational size is one of the dominant variables in the sociological literature on organizational structure (see Kimberly, 1976 for a review). Hence, examining its influence on the relationship between structure and performance is a reasonable undertaking. Received literature has suggested that achieving large size is beneficial in many ways. A large firm can reduce its dependence from direct competitors, suppliers, customers and complementors as well as create barriers to entry (Porter, 1999). Large size provides the means for global expansion (Henisz & Delios, 2001) and new market entry (Haveman & Nonnemaker, 2000). Large firms are also more likely to innovate (Sorensen & Stuart, 2000).

Organizational size is also strongly related to organizational change and to its outcomes, which is the focus of this study. Previous literature has produced mixed theoretical and empirical arguments on the relationship between organizational size and organizational change. In particular, the two prevailing views have argued for a *fluidity* of size on the one hand and for a *rigidity* of size on the other (Haveman, 1993). Advocates of the first view, have found a positive relationship between correlates of size such as structural complexity, differentiation, and decentralization with the adoption of innovations (e.g., Moch & Morse, 1977). Moreover, given that large firms possess more slack resources, they are less likely to fail if they undertake change (Hannan & Freeman, 1989). Thus, large organizations are more likely than small organizations to complete change successfully once it has begun. The *rigidity* of size argument is related to structural inertia theory which states that inertia increases with organizational size. Accordingly, we expect that larger organizations will tend to be more resistant to change (Hannan & Freeman, 1984). One of the reasons for such rigidity is derived from the increased bureaucratization that large firms face. Bureaucratic organizations are characterized by greater formalization of behavior, a more decentralized managerial decision-making authority and greater task specialization. A second source of rigidity comes from the limited dependence that large firms have on their exchange partners which lowers their incentives to adjust these relationships to fit environmental fluctuations (Haveman, 1993). All in all, these arguments suggest that large organizations will tend to be more rigid than smaller organizations. Indeed, previous studies have shown empirically that large organizations are less likely to change (e.g., Delacroix & Swaminathan, 1991).

The two opposing views on the relationship between organizational size and change described above can only be resolved if we consider the organizational context (Haveman, 1993). Accordingly, we propose that in mature industries, where inertial pressures are strong, large organizations will do worse than smaller organizations in adjusting to shifting environmental conditions. Vice versa, in younger industries, where inertial pressures are expected to be weaker, larger organizations will be more able to keep pace with environmental changes.

Changes in interorganizational ties can be considered a type of organizational change, and, thus, structural inertia in larger organizations may reduce the speed of dissolving old ties and establishing new ones in a changing environment (Kim *et al.*, 2006). Following resource-based logics, we view the firm as a collection of resources. Given that resources play a critical role, how brokerage may benefit firm performance also depends on firm size, a commonly adopted proxy for firm resources in the organization literature. We believe it is worth including firm size in our study as a moderator for at least two reasons: 1) although previous studies on interpersonal networks have focused on properties of network members, only a limited amount of studies on interorganizational networks have explored this possibility (Shipilov, 2006), 2) despite the acknowledged role of firm size on a firm's ability to grow and survive over time, previous research has often treated size as a control variable underestimating its importance (Dobrev & Carroll, 2003). As size increases, an organization may experience complexity arising from coordinating a large number of units and managing hierarchical sets of linkages and relationships among people and units. This increased complexity leads to difficulty in reconciling different interests among individuals and groups when attempting to find new partners for core activities (Kim *et al.*, 2006). Large firms are also more inert in changing quickly their relationships due to higher path dependence in terms of alliance strategy. Furthermore, large organizational size enhances the capacity to withstand environmental shocks (Hannan & Freeman, 1977) which diminishes the incentives for drastic change – characterized by uncertainty and financial exposure – in favor of a “wait and see” approach. Conversely, smaller firms operate near an ‘extinction boundary’, whereby a random shock that merely inconveniences a giant organization can destroy a small one (Levinthal, 1991). Given their limited amount of resources – which also poses challenges in terms of partners choice and volume of new alliances they can create – margins for error are small for small organizations, especially during a period of extreme instability. Accordingly, we expect that in such conditions, smaller firms will proactively search to occupy positions rich in structural holes in order to maximize the benefits of brokerage. Taken together these arguments lead us to the following:

H2: Brokerage propensity relates negatively to performance for larger firms during an environmental jolt.

INDUSTRY SETTING

“Industries currently in the throes of quantum change include telecommunications, financial services, airline transportation, and health care. In each of these settings, discontinuous changes are restructuring the industry, relocating its boundaries, and changing the bases of competition” (Meyer, Brooks, & Goes, 1990: 93). Two decades have passed since these considerations but yet it seems that the airline industry has gone through periods of relative tranquility interrupted by shifts of both endogenous (e.g., Open Skies agreements) and exogenous (e.g., the Sars epidemic) nature. Consequently, the airline industry appears as an appropriate context for our study both because it has witnessed significant strategic changes over the last decades and because interfirm relationships have been an acknowledged influence on the industry's evolution. For example, in 2000 more than 80 percent of global airline carriers engaged in some form of alliance (Baker, 2001). The main three multilateral airline alliances are Star Alliance, SkyTeam and oneworld which control the 69 percent of world revenue passenger kilometers (IATA, 2008). These alliances involve full marketing cooperation with respect to frequent flyer programs (FFPs) and promotion (including investments in common brand name), besides joint access to airport facilities controlled by individual members (Lazzarini, 2007: 347). They also offer comprehensive code-sharing agreements involving several routes instead of bilateral agreements comprising few routes (Oum & Yu, 1998).

The airline industry is characterized by a paradox: although in operational terms is the most internationalized, in terms of ownership and control, is largely domestic. Additionally, it is a challenging one to analyze given its strict regulation rules and the enormous interest of both the public and private sector around it. The competitive pressures coming from an ever increasing globalized environment make it difficult for the airlines to recover their full costs. Moreover, the financial performance of the industry is strongly correlated with the larger business cycle. Thus, the upturns and downturns of the industry are strongly related to the changes of external environment. In recent years, a number of events particularly impacted on commercial aviation, adding to the normal market uncertainties of the industry and the larger, temporal trends that are on-going (Button, 2008). Among them, the terrorist attacks on the US in 2000, the SARS epidemic, the second Gulf War and rises in costs of aviation fuel had major implications for the global air transportation market. Crises act as catalysts for the reshaping of the airline industry both at market and regulatory levels. In this context, given the strict regulation that often disallows cross-border mergers, alliances have become the only viable way to grow.

METHODS

Data

We tested our hypotheses using longitudinal data on alliances formed in the global airline industry between 1998 and 2006. We identified an alliance as any durable collaborative activity that involved exchange of resources between firms (Ahuja, 2000). All airlines that had formed at least one alliance during the period of our study were included in the database. Data on airline alliances and their evolution are collected through several issues of the Airline Business magazine. These issues contain data on all major forms of cooperative relationships (e.g., blocked seat, code-sharing, marketing) but exclude cooperation on frequent flyer programs as well as alliances among charter and cargo carriers which are not the focus of this study. We used these data to build a series of sociomatrices. A particular matrix entry X_{ij} corresponds to an active tie between an airline in row i and an airline in row j. Thus, inactive alliances in the study period were excluded. Forming year-wise matrixes is necessary in order to create a panel dataset for the purpose of year-wise testing of hypotheses. Such approach is also particulary indicated for testing environmental change hypotheses (Koka & Prescott, 2008). Information on airlines operations were collected from IATA and ICAO statistics. More in deep, data about carriers' performance and traffic come from the World Air Transport Statistics published by the International Air Transport Association and Traffic by Flight Stage compiled by the International Civil Aviation Organization. The database includes information on individual airlines observed over time. The final sample consists of an unbalanced panel of 271 airlines, including companies that have disappeared from the business arena and those that were founded during the analysis period, for a total of 1643 observations. To this day, these carriers represent almost 80 percent of the total world passenger traffic, covering more than 80 countries in the world.

Variables

Dependent variable

We chose revenue per passenger kilometer (RPK) as the dependent variable to measure firm performance as this indicator is commonly used in the airline industry for performance measurement. RPK is expressed as the number of revenue passengers carried multiplied by the distance flown by carrier i at year t and is a measure of sales volume of passenger traffic.

We decided not to employ financial measures for two main reasons. First, both academics and policymakers have expressed concern that corporate financial reporting and disclosure are not keeping pace with a dynamic and constantly changing business world (AICPA, 1994; Wallman, 1995). Since our main interest is in exploring how different network strategies impact performance in situations of tranquility and turbulence, we believed that such concerns were even more important in our study. Second, using financial information for the global airline industry would be problematic since not all carriers are publicly traded, and in several cases not even reliable and standardized accounting information is available (Lazzarini, 2007). For our purposes, we could have employed passenger load factor, measured in revenue passenger kilometer (RPK), to its overall seat capacity (ASK). However, in our case the adoption of this measure would have led to misleading results. Following environmental jolts such as the September 11 terrorist attacks or the more recent Iceland's volcano eruptions, airlines have proved capable to balance the fall of RPKs with a reduction of ASKs. In other words a drastic, although temporary, reduction of passenger traffic was compensated with a reduction of capacity. To smooth the distribution of the dependent variable we took a log of revenue passenger kilometers when we constructed the *RPK* variable.

Independent variables

Brokerage propensity. Our independent variable, brokerage propensity, measures the degree of a carrier's network openness. To compute this measure, we relied upon Burt's (1992) network constraint. The index C measures the extent to which all of *i*'s network is directly or indirectly invested in its relationship with contact j. Thus,

$$C_{ij} = p_{ij} + p_{ij} \left(\Sigma_q \, p_{iq} p_{qj} \right)^2$$

for $q \neq i, j$, where p_{ij} is the proportion of *i*'s relations invested in contact *j* and the total in parentheses is the proportion of *i*'s relations that are directly or indirectly invested in the connection with contact *j*. Constraint is designed to capture the extent to which the focal actor's network lacks structural holes. The more constrained the actor, the fewer the opportunities for action. Because constraint has a range between 0 and 1, to facilitate interpretation, we used *1 – constraint* to directly measure the number of structural holes (Gargiulo & Benassi, 2000; Soda, Usai, & Zaheer, 2004). We employed UCINET VI to compute this measure (Borgatti, Everett, & Freeman, 2002).

Environmental jolt. The dummy variable *environmental jolt* took the value of 1 for the years 2001, 2002, and 2003 and 0 otherwise. Extending the effects of the jolt for a period of three years is a judgment based on previous studies (Madhavan *et al.*, 1998; Koka & Prescott, 2008; Wan & Yiu, 2009) and industry evidence. The global economic downturn that began at the end of 2000 with the bursting of the dot.com bubble, continued through 2003. The events of September 11, 2001 exacerbated pessimism about the future and spread from the United States to other countries as described in business and trade journals (Polzehl, Spokoiny, &

Starica, 2004). After 9/11 attacks, global demand for air travel collapsed immediately. The downturn of 2001 was perceived as the worst airline crisis ever, resulting in a "perfect storm" (Franke & John, 2011). Although people commenced flying shortly after, it was not until 2004 when pre-jolt demand level was reached. Recovery was also delayed due also to the 2003 pandemic threat of SARS which further increased our confidence in our 3-year window choice.

Firm size. Larger firms may have more resources and are also likely to make more desirable partners (Beckman, Haunschild, & Philips, 2004). Such characteristics might foster, under certain circumstances, their ability to innovate and experiment. However, in periods of extreme turbulence, large size will be associated with higher conservatism favoring small changes, if any, which could ultimately have a negative impact on their performance, at least in the short term. Firm size was operationalized as the natural logarithm of the fleet size, which is a frequently used indicator for size in the airline industry. Other measures could have been used in place of fleet size such as the number of employees, total assets or number of clients served. Concern about what measure of size should be used is especially important in cross-industry studies (Kimberly, 1976), but for studies confined to a single industry, the effects of size can be more easily disentangled (Blau & Schoenherr, 1971).

Control variables

Many other factors may influence an airline's performance. Accordingly, we control for a baseline model that includes a range of firm attributes as well as environmental characteristics. Unless noted otherwise, the control variables are time varying and lagged one year to avoid simultaneity.

Firm-specific attributes. Firms that have been in existence longer are likely to have greater market share since they had more time to develop their reputation and put their names out to the public, develop relationships with sales representatives, and so on (Zaheer & Bell, 2005). Accordingly, *firm age*$_{it}$ was used to control for possible differences in carriers' experience in the industry (Lazzarini, 2007), measured as the time elapsed, at *t* since the carrier's founding. In order to capture the network externalities stemming from airlines' membership in the existing constellations, we also controlled for *alliance member*$_{it}$, a dummy that will be equal to 1 if an airline is a member of one of the four constellations in existence during our study period (Star Alliance, SkyTeam, oneworld, Qualiflyer) and 0 if the airline is not a member of any constellation. Ecology theories predict that age is an important determinant of survival with younger organizations assumed to have higher liabilities of newness (Hannan & Freeman, 1984; Stinchcombe, 1965). To check whether such liabilities also hit companies that have less experience in managing alliances, we included *alliance experience*$_{it}$, measured as the time elapsed at *t* since the first alliance agreement signed by the carrier *i*.

Country-specific attributes. An airline's size of domestic market appears to have significant impact on its performance. Accordingly, we employ a series of country-specific controls: country's per capita GDP (*GDPcap*$_{it}$, country's *i* GDP per capita in thousands of US dollars) and population (*Pop*$_{it}$, number of inhabitants). These information are obtained from the World Bank's World Development Indicators database. Finally, we created a count variable, *institutional environment*, to account for differences within regions for each year. Following the classification provided by the Airline Business Magazine we identified six main regions: Africa, Asia-Pacific, Central/South America, Europe, Middle East, and North

America. All the above measures are calculated for each firm for every year they are in the network to enable the longitudinal testing of our hypotheses.

Year. To control for the possibility that unobserved temporal factors or other unspecified events affected the propensity of firms to form or delete ties, for each year, the variable *year* was entered as a continuous variable, and not as a dummy, otherwise we would not have been able to estimate the effect of jolts (which is constant for all firms in any given year) .

Statistical method

We used a panel design on observations running from 1998 to 2006 choosing the firm as a unit of analysis. More specifically, we focused on the egocentric network, consisting of each individual node, all other which it has relations, and the relations among these nodes. If the sample size is N, there are N units of analysis at the ego-centered level. Each actor can be described by the number, the magnitude, and other characteristics of its linkages with the other actors, for example, the proportion of reciprocated linkages or the density of ties between the actors in ego's first 'zone' (that is the set of actors directly connected to ego) (Knoke & Kuklinski, 1991). While we are interested in testing our hypotheses at the firm's ego network level, our final goal is to understand how the entire industry's relationships change following an environmental jolt. According to Koka *et al.* (2006) the macro changes at the industry network level are driven by the aggregation of numerous micro changes (changes at the firm ego network level), much as the behavior of an overall market rests on the individual behaviors of numerous market participants. Thus, we view overall network change as resting on the firms' decision to expand or close their ego networks.

To test the previous hypotheses, we estimated a random intercept effects model. The model has the following basic form:

$$y_{it} = \mu_t + \beta x_{it} + \gamma z_i + \alpha_i + \varepsilon_{it}$$

Instead of assuming that α_i represents a set of fixed parameters as in the fixed-effects model, in the random-effects model each α_i is a random variable with a specified probability distribution. Typically, it is assumed that α_i has a normal distribution with a mean of 0 and constant variance, and that it is independent of x_{it}, z_i and ε_{it} (Allison, 2005). The final model is:

$$\text{Log}\ (\mathit{RPK}) = \alpha_i + \beta_1\,(\mathit{Year}) + \beta_2\,(\mathit{Inst.\ environment}) + \beta_3\,(\mathit{Pop}_{it}) + \beta_4\,(\mathit{GDPcap}_{it}) + \beta_5\,(\mathit{Firm\ age}_{it}) + \beta_6\,(\mathit{Alliance\ experience}_{it}) + \beta_7\,(\mathit{Alliance\ member}_{it}) + \beta_8\,(\mathit{Firm\ size}_{it}) + \beta_9\,(\mathit{Jolt}) + \beta_{10}\,(\mathit{Brokerage}_{it-1}) + \beta_{11}\,(\mathit{Brokerage}_{it-1} * \mathit{jolt}) + \beta_{12}\,(\mathit{Brokerage}_{it-1} * \mathit{jolt} * \mathit{Firm\ size}_{it}) + \varepsilon_{it}$$

In the analysis, we reported significance levels based on Huber-White robust standard errors to control for any residual heteroskedasticity across panels. We obtained our estimates using PROC MIXED in SAS (version 9.1).

As an exogenous shock, the September 11 (also known as “9/11”) terrorist attacks of 2001 provided us with a natural experiment to test our hypotheses. The term natural experiment, also known as quasi-experiment, suggests that this study is an experiment and moreover that is spontaneous. Accordingly, we are interested in the variation in the group of airlines in the sample before, during and after the treatment (the environmental jolt in our case). We used dummy variables to code the three periods, with the jolt (2001-2003) as the reference period, and interacted the period dummy variables with the independent variables. Finding statistical significance of the interaction coefficients would indicate that the relationship differs between the jolt and the pre-jolt (1998-2000) and the post-jolt (2004-2006) periods (Wan & Yiu, 2009).

RESULTS

Table 3 is a matrix of the correlations, means, and standard deviations of the variables that we used in our analysis. The average airline had been in business for nearly forty years but has only eleven years of experience in managing alliances which means that although the airline industry is a relatively mature one, it is still young in terms of alliance networks. For the full panel across all three time periods in the study, both firm size ($r = 0.88$, $p < 0.001$) and brokerage ($r = 0.37$, $p < 0.001$) positively and significantly correlate with performance. Significant positive correlations existed also between firm size and brokerage ($r = 0.30$, $p < 0.001$). We assessed multicollinearity by regressing each of the variables against all other explanatory variables and then calculating a variance inflation factor (VIF), measured as one over the difference between one and R^2. While there is no formal cutoff value for determining presence of multicollinearity, statisticians sometimes suggest 2 as a threshold level above which one should be concerned. As displayed in Table 3, we found no variables to violate such level.

Insert Table 3 about here

Insert Table 4 about here

Table 4 reports the main results of the unbalanced panel data analysis that we employed to test and compare the hypothesized relationships between the jolt and the non-jolt periods. Model 1 presents the results for the baseline model. Size has a statistically significant, positive relationship with performance (model 1: β= 14493, $p < 0.001$) whereas jolt shows a significant, negative association with performance (model 1: β= -1066.51, $p < 0.05$). Model 2 introduces the brokerage variable, testing our Hypothesis 1a, which predicts that everything else being equal, brokerage is positively related to firm performance. Brokerage has a positive and significant relationship with performance (model 2: β= 2643.34, $p < 0.05$). Hypothesis 1a receives support.

In the second step, we entered the two-way interaction term to test our contingency hypothesis. Hypothesis 1b predicts that brokerage negatively relates to performance during an environmental jolt. As shown in model 3, the interactive effect of brokerage and jolt on performance is negative and significant (model 3: β= -5369.97, $p < 0.01$). Thus, hypothesis 1b receives support.

In the third and final step, we entered the three-way interaction term to test our Hypothesis 2 which predicts that larger firms that act also as brokers will show a performance decrease during the jolt period. The coefficient for the three-way interaction is negative and statistically significant (model 4: β= -4428.5, $p < 0.001$). Hypothesis 2 is strongly supported. The overall fit of the model improves substantially as compared to the baseline but also with respect to Model 2 and Model 3, as indicated by the change in the value of the -2 Log Likelihood and the other statistics. With respect to the baseline model, for example, the LR test ($\chi 2$ [L4-L1 = 3576 with $p < 0.001$ for 3 d.f.) and the AIC test (21239.6 vs. 17673.6) show a significant improvement.

We tested the robustness of the results to alternative model specifications. First, to ensure that there was no bias in the validity of the results, we estimated the random effects model using the Generalized Estimating Equations (GEE). In the case of linear models, GEE is equivalent to generalized least squares (Allison 2005). The GEE method makes no explicit assumptions about random components in the regression model, but simply allows for correlation in the dependent variable across observations over time. We assumed this correlation to be equal across time using an exchangeable correlation structure (Liang & Zeger 1986). It is worth noting that the GEE coefficients are population averaged (i.e., they describe what happens to the whole population, not a particular individual, if everyone's predictor values are increased by one unit). The results for the GEE model turned out to be qualitatively similar to those for the random intercept model and are available from the authors upon request. Second, we compared the results with those for the fixed effects model to verify whether unobserved heterogeneity might be a problem in our analysis. The coefficient estimates were obtained by using PROC GLM in SAS. Since the fixed effects approach controls for the impact of all stable factors that do not vary over time, our results estimate the influence of the variable of theoretical interest after firm level time-varying and time-invariant attributes are accounted for. The coefficient estimates for the fixed effects regression model are qualitatively similar to those obtained for the random intercept model, as can be observed in the last column of table 4.

We also ran the analysis using a different specification for our dependent variable. Following prior research that suggests the adoption of net income as a proxy for an airline's financial performance, we created the variable $\textit{Net income}_{it}$ rather than using our operational performance measure. Again, the results of this additional set of analyses did not vary appreciably from those presented here.

Finally, we re-estimated our models adopting other measures of brokerage than *constraint*. In a separate set of analyses, we used Burt's (1992: 54) *Effective Size* as an alternative measure of brokerage. This measure represents the difference between the number of a firm's partners and the average number of ties among them, not counting their ties to the firm itself. The results were consistent with our prior findings.

DISCUSSION AND CONCLUSIONS

Despite growing and continuous interest in interfirm networks, the link between a firm's position in an alliance network and its performance remains poorly understood and subject to debate (e.g., Ahuja, 2000; Baum *et al.*, 2000; Shipilov, 2006). Mixed results from empirical studies have further accentuated the need to better understand this relationship. More recently, consensus has been reached about the contingent nature of benefits that firms can obtain by occupying positions rich in structural holes but the question of the specific contingencies that have performance implications for a firm's ego network structure have not received an answer yet (Shipilov, 2009).

Our results provide evidence that the ability of firms to benefit from their positions within networks is contingent upon environmental and firm attributes. We identify and empirically assess the impact of environmental jolts and firm size on the relationship between network flexibility and firm performance. In line with previous theoretical and empirical contributions, we find that, everything else being equal, structural holes increase firm performance. A network of many non redundant contacts is the ideal locus in which to obtain valuable information from a diverse group of partners and arbitrage opportunities via the *tertius gaudens* strategy. Moreover, this finding is also supported by recent considerations on brokerage in the airline industry which suggest that firms that occupy structural holes will receive the highest returns (Gudmundsson & Lechner, 2006). However, a strong limit to this finding is the assumption of equilibrium over time. Our results illustrate that the external environment, and more notably the changes in it, can condition significantly the positive relationship between brokerage and performance. Specifically, we find that in periods of turmoil triggered by external shocks brokerage produces a negative impact on performance whereas network closure is beneficial. A network composed of partners with many redundant ties may be useful from the firm's perspective when it and its partners are faced with a common external threat (Ahuja, 2000) such as in the case of an environmental jolt. In other words, in conditions of extreme uncertainty stemming from the external environment, the adoption of a more conservative posture is a form of threat-rigidity response (Staw Sandelands, & Dutton, 1981). Instead of investing resources in more uncertain relationships such as bridging ties, opting for closure will bring better stability increasing a firm's chances of 'weathering the storm' and eventually accumulating some slack that may be used to configure a more open network once the crisis period is over. Finally, we find evidence for a rigidity of size for brokers when the environment is unstable. We will discuss this argument in more detail in the next paragraphs.

This study contributes to the network literature in several ways. First, in prior research related to network changes, scholars have largely focused on the endogenous influence of the network structure in which the firm is embedded in affecting the opportunities available to the firm to strategically position itself within the network (Koka *et al*., 2006) disregarding the role of the external environment. The limited amount of studies focusing on events as occasions for network restructuring has examined only events taking place inside the industry boundaries (e.g., Madhavan *et al*., 1998) which we have defined as endogenous jolts. In this paper, we have tried to extend this line of inquiry by focusing on exogenous jolts as a main driver of network restructuring and by looking at the performance implications of such changes.

Second, to address the theoretical puzzle regarding the optimal choice between network closure and openness we followed recent trends suggesting the adoption of a contingency approach. However, from our scanning of the literature, we recognized that even studies that have adopted contingency-based arguments, have considered the two strategies as mutually exclusive implying more or less implicitly that they could not both be enacted in a firm's life. However, we believe that even inside the industry context there is not one optimal strategy to follow at all times. Accordingly, we have suggested that one way to solve the puzzle is to take into account the contingency of time. Different time periods pose different challenges and the firms that will be able to keep the pace of time will have greater chances of surviving and prospering over time. In our study, we demonstrated how both closure and brokerage strategies can enhance firm performance but at different points in time. This point is of particular importance since pursuing both strategies at the same time could increase the chance of being "stuck in the middle" (Porter, 1980).

Another important aspect of this study is the emphasis posed on firm size. Although there is ample consensus on how much size matters for a company's growth, most papers have treated size as a control variable underestimating its relevance. We believe that in studies using a network approach, size can be a very important predictor of a firm's ability to design and orchestrate its network. As expected, size is beneficial for a carrier's performance. In a troubled industry such as the airline industry where challenges to profitability are very strong, size can bring the benefits of scale and scope that can partly lower the excessive costs airlines have to face (e.g., mixed fleet, revenue management and brand building). A bigger airline would be also able to serve a larger pool of customers through its route network or to attract complementary partners to extend its services. Moreover, a large firm's greater power may let it impose unfavorable conditions of cooperation upon its allies. Lacking the ability to coordinate their actions against the large firm, its disconnected partners may agree to the imposed terms which could ultimately enhance the large firm performance (Shipilov, 2006). We empirically demonstrated that the benefits of brokerage for a large firm hold in a stable environment but not during a crisis period. The instability created by the jolt will partly disrupt a large airline's status quo putting it in a less secure position if it adopts a brokerage strategy. On the contrary, smaller firms may have an incentive to take advantage of the window of opportunity created by the jolt in order to reinforce their position. To do so, they might be successful in breaking some of the previous ties with larger companies to establish new ones that are more advantageous to them. For example, two relatively small airlines, TAP Air Portugal and LOT Polish airlines, have been successful in enacting the aforementioned strategy. Both carriers were significantly tied to Swissair through direct ties, equity stakes and membership in the same multilateral alliance, the Qualiflyer Group. Following the events of September 11th, both TAP and LOT took advantage of Swissair's crisis and broke their ties with Swissair while forming new alliances with other significant carriers such as Lufthansa which eventually led both TAP and LOT to join the Star Alliance.

This study moves beyond research focusing on contingencies at one level of analysis. The vast majority of previous studies has focused either on environmental (e.g., Ahuja, 2000) or firm level (e.g., Shipilov, 2009) contingencies in examining the relationship between a firm's position in the alliance network and its performance. We enrich and extend previous contributions by incorporating contingencies at both levels. Although some studies on interpersonal networks have successfully undertaken this path (e.g., Cattani & Ferriani, 2008), studies on interfirm networks have seldom explored this possibility. A key strength of the network approach is its potential for multilevel analysis. Multilevel models provide a deeper, richer portrait of organizational phenomena and allow more integrated inquiry (Klein, Tosi, & Cannella, 1999). Thus, we see this analytical approach as particularly promising.

The results also suggest that networks change over time following a non linear pattern. We suggest that networks evolve according to a punctuated equilibrium in which there may be discrete stages that occur due to discontinuous changes in the environment. Although the punctuated equilibrium model has been successfully utilized to explain organizational change, our study is the first to use this model to theoretically explain and empirically test network change and its implications for performance. Future studies may replicate this study in other industries to scrutinize the environmental, network and firm effects on patterns of network change.

An important empirical contribution this study makes is the use of a natural experiment. While natural experiments hold great potential to enhance our understanding of strategic management, researchers rarely employ them (Park & Mezias, 2005). Our study provides a valuable starting point for future research on how network changes may impact performance adopting a natural experiment approach.

Managerial implications

Results from this study have also important managerial implications. Faced with increasingly challenging environments, alliance managers would like to have a clearer understanding of the benefits they can reap from their alliance networks. In other words, the challenge for managers is not only to choose with whom to form an alliance, but also to design a network that proves to be effective as a whole. Thus, they have to take into account both the dyadic and the whole aspects of their networks. Data from the global airline industry show that different network configurations produce different performance results.

Managers have various alliance design choices. The strategic design of alliance networks focuses their attention on asking: 1) what types of benefits do we want to obtain from our alliance network, 2) are we interested in building networks that enable trust but limit the inflow of diverse and fresh insights or are we more interested in networks that provide information benefits but inhibit trust development? These choices have important implications, at least for performance.

Moreover, not only different types of network positions affect performance differentially, it is also important to establish “when” to choose one network strategy or the other. As our results demonstrate, network strategies that do not fit environmental and organizational requirements can be detrimental to performance. For managers seeking to build effective alliance networks, this study may suggest that there is no optimal way suitable for all times but rather “many better ways”, the choice of which rests primarily on both environmental and organizational requirements in a particular moment. Finally, given the unpredictable nature of jolts, it is relevant to build networks that have enough flexibility to adjust and keep pace with environmental changes.

LIMITATIONS AND FUTURE DIRECTIONS

This study is not without limitations. Its results are confined to a single industry which pose limits to their generalizability to other contexts. However, our study is one of the few focusing on an industry at a global level while most of the studies are usually confined to single country or continent. Despite that, the airline industry is a mature context and is a service industry too. Less bureaucratic or younger industries as well as manufacturing industries could show different patterns of network change with different implications for performance.

Another limitation of this study which could be addressed in future studies is that it focuses only on horizontal alliances among airlines. Exploring other types of relationships, such as vertical alliances (e.g., buyer-supplier relationships) or interlocking directorates, could shed additional light on the performance implications of choosing alternative network strategies. Moreover, our study is limited to the exploration of network change within the industry but it would be interesting to explore if and how ties change between cross-industry networks following environmental jolts. In studying the moderating role of environment- and firm- level factors on the relationship between firm network position and performance, we chose environmental jolt and firm size for the reasons explained in previous sections. However, other environmental dimensions and firm-level factors may moderate this relationship. Examples of such factors could be environmental munificence and complexity at the environmental level and absorptive capacity and geographic scope at the firm level. Accordingly, more research is needed encompassing multilevel factors as intervening variables affecting the network position – performance relationship.

Moreover, our study is limited to the analysis of the consequences of network change without looking at its antecedents. Research on the organization and environment-level conditions that predict firms' propensities to modify their networks and the consequences of such actions, could begin to explore two-stage models.

Finally, the results we present are limited to a single environmental jolt as an occasion for restructuring. Following the classification of jolts provided in this paper, future research may give new insights on how and if different types of jolts modify alliance networks and with which impact on performance.

In summary, bridging the literatures on strategic fit and networks, we hypothesized and confirmed that environmental jolts and firm size significantly moderate the relationship between interfirm networks and performance. We hope our study encourages scholars to incorporate environmental and organizational conditions into future research. Further theoretical and empirical efforts replicating this approach have great potential to make important contributions to strategic management research.

REFERENCES

Ahuja, G. 2000. Collaboration networks, structural holes and innovation: A longitudinal study. ***Administrative Science Quarterly***, 45, 425–455.

AICPA. 1994. ***Improving Business Reporting: A Customer Focus***. New York: American Institute of Certified Public Accountants.

Allison, P.D. 2005. ***Fixed Effects Regression Methods for Longitudinal Data***. SAS Institute, Cary, NC.

Andrews, K. R. 1971. ***The Concept of Corporate Strategy***. Dow Jones Irwin, Homewood, IL.

Baker, C. 2001. The global groupings. ***Airline Business*** 17: 40–45.

Barney, J.B. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17: 121-154.

Baum, J.A.C, Calabrese T., & Silverman B. S. 2000. Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology. ***Strategic Management Journal***, Special Issue 21(3): 267–294.

Beckman, C. M., Haunschild, P.R., & Philips, DJ. 2004. Friends or Strangers? Firm-Specific Uncertainty, Market Uncertainty, and Network Partner Selection. ***Organization Science***, 15 (3): 259–275

Blau P.M., & Schoenherr R. 1971. ***The Structure of Organizations***. New York: Basic Books.

Borgatti S.P., Everett M.G., & Freeman L.C. 2002. ***UCINET 6 for Windows: Software for Social Network Analysis***. Analytic Technologies: Harvard, MA.

Brandenburger A.M., & Nalebuff B.J. 1996. ***Co-opetition***. Doubleday: New York.

Burt, R.S. 1992. ***Structural Holes: The Social Structure of Competition***. Harvard University Press: Cambridge, MA.

Burt, R. 2000. The network structure of social capital. In Sutton RI, Staw BM (Eds.), ***Research in organizational behavior*** (Vol. 22). New York: Elsevier Science.

Burt, R. 2002. Bridge decay. ***Social Networks***, 24(4) 333–363.

Button, K. 2008. The impact of US-EU "Open Skies" agreement on airline market structures and airline networks. ***Journal of Air Transport Management***

Cattani, G., & Ferriani S. 2008. A core/periphery perspective on individual creative performance: Social networks and cinematic achievements in the Hollywood film industry. ***Organization Science,*** 19(6): 824–844

Deeds D.L., & Rothaermel F.T. 2003. Honeymoons and liabilities: The relationship between age and performance in research and development alliances. ***Journal of Product Innovation Management***, 20: 468–484.

Delacroix J, & Swaminathan A. 1991. Cosmetic, speculative, and adaptive organizational change in the wine industry: A longitudinal study. ***Administrative Science Quarterly***, 36: 631-661.

DiMaggio P.J., & Powell W.W. 1983. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. ***American Sociological Review***, 48: 147–160.

Dobrev S.D., & Carroll G.R. 2003. Size (and competition) among organizations: Modeling scale-based selection among automobile producers in four major countries, 1885-1981. ***Strategic Management Journal***, 24: 541-558.

Franke M., & John F. What comes next after recession? Airline industry scenarios and potential end games. ***Journal of Air Transport Management***, 17(1): 19-26

Freeman, L.C. 1979. Centrality in Social Networks: Conceptual Clarification. ***Social Networks***, 1: 215-239.

Gargiulo M., & Benassi M. 2000. Trapped in your own net? Network cohesion, structural holes, and the adaptation of social capital. ***Organization Science*** 11:183-196.

Gersick, C.J.G. 1991. Revolutionary change theories: A multi-level exploration of the punctuated equilibrium paradigm. ***Academy of Management Review***, 16: 10–36.

Gnyawali D.R, Madhavan R. 2001. Cooperative networks and competitive dynamics: a structural embeddedness perspective. ***Academy of Management Journal***, 26: 431-445

Gomes-Casseres, B. 1996. ***The Alliance Revolution: The New Shape of Business Rivalry***. Harvard University Press: Cambridge, MA.

Granovetter, M. 1973. The strength of weak ties. ***American Journal of Sociology***, 78, 1360–1380.

Gray B, & Yan A. 1997. Formation and evolution of international joint ventures: Examples from U.S.– Chinese partnerships. In Beamish P, Killing JP (eds.), ***Cooperative Strategies: Asian Pacific Perspectives***, 57–88. San Francisco, CA: New Lexington Press.

Gudmundsson, S.V, & Lechner C. 2006. Multilateral airline alliances: Balancing strategic constraints and opportunities. ***Journal of Air Transport Management***, 12: 153–158

Gulati, R. 1998. Alliances and networks. ***Strategic Management Journal***, Special Issue 19(4): 293–317.

Gulati R. 1999. Network location and learning: the influence of network resources and firm capabilities on alliance formation. ***Strategic Management Journal*** 20(5): 397–420.

Gulati R, & Gargiulo, M. 1999. Where do interorganizational networks come from? *American* ***Journal of Sociology***, 104(5): 1439–1493.

Hagedoorn, J., & Osborn R.N. 1997. The institutionalization and evolutionary dynamics of interorganizational alliances and networks. ***Academy of Management Journal*** 40 (2): 261–278.

Halinen, A., Salmi A., & Havila, V. 1999. From dyadic change to changing business networks: An analytical framework. ***Journal of Management Studies***, 36: 779-794.

Hannan, MT, Freeman J. 1977. The population ecology of organizations. ***American Journal of Sociology*** 82: 929–964.

Hannan, M.T., & Freeman J. 1984. Structural inertia and organizational change. ***American Sociological Review***, 49: 149-164,

Hannan, M. T., & Freeman, J. 1989. ***Organizational Ecology***. Harvard University Press: Cambridge MA.

Harbison, J.R, & Pekar P. 1998. ***Cross-Border Alliances in the Age of Collaboration***. Booz Allen & Hamilton: McLean, VA.

Hargadon, A., & R. Sutton. 1997. Technology brokering and innovation in a product development firm. ***Administrative Science Quarterly***. 42 716–749.

Haunschild P.R., & Beckman C.M. 1998. When do interlocks matter?: Alternate sources of information and interlock influence. ***Administrative Science Quarterly***, 43(4): 815–844.

Haveman, H.A. 1993. Organizational size and change: diversification in the savings and loan industry after deregulation. ***Administrative Science Quarterly*** 38: 20–50.

Haveman, H.A, & Nonnemaker L. 2000. Competition in multiple geographic markets: the impact on growth and market entry. ***Administrative Science Quarterly*** 45: 232–268.

Haveman H.A., Russo M.V., & Meyer A.D. 2001. Organizational environments in flux: The impact of regulatory punctuations on Organizational Domains, CEO Succession, and Performance. ***Organization Science***, 12 (3): 253-273.

Henisz, W.J., & Delios, A. 2001. Uncertainty, imitation, and plant location: Japanese multinational corporations, 1990–1996. ***Administrative Science Quarterly*** 46: 443–475.

Hofer, C., & Schendel, D.E. 1978. ***Strategy Formulation: Analytical Concepts***. West, St. Paul, MN.

Ibarra, H. 1993. Network centrality, power, and innovation involvement: determinants of technical and administrative roles. ***Academy of Management Journal*** 36: 471-501.

International Air Transport Association 2008. ***IATA World Air Transport Statistics 52nd Edition***.

Kim, T., Oh, H., & Swaminathan, A. 2006. Framing interorganizational network change: A network inertia perspective. ***Academy of Management Review***, 31(3): 704-720.

Kimberly, JR. 1976. Organizational size and the structuralist perspective: a review, critique and proposal. ***Administrative Science Quarterly*** 21: 571–597.

Klein K.J., Tosi H., & Cannella Jr, AA. 1999. Multilevel theory building: Benefits, barriers, and new developments. ***Academy of Management Review***, 2: 243–248.

Knoke, D., & Kuklinsky, P. 1991. ***Network Analysis***. Sage: London, UK.

Koka, B.R., Madhavan R., & Prescott, J.E. 2006. The evolution of interfirm networks: Environmental effects on patterns of network change. ***Academy of Management Review***, 31(3): 721-737.

Koka, B.R., & Prescott J.E. 2008. Designing alliance networks: The influence of network position, environmental change, and strategy on firm performance. ***Strategic Management Journal***, 29:639-661.

Koza, M.P., & Lewin A.Y. 1998. The co-evolution of strategic alliances. ***Organization Science***, 9 (Special issue): 255-264.

Lawrence, P.R., & Lorsch JR. 1967. ***Organizations and Environments***. Harvard Business School Press, Boston, MA.

Lazzarini, S.G. 2007. The impact of membership in competing firm constellations: evidence on the operational performance of global airlines. ***Strategic Management Journal***, 28(4): 345-367.

Levinthal, D. 1991. Random walks and organizational mortality. ***Administrative Science Quarterly*** 36: 397–420.

Liang, K.Y, Zeger SL. 1986. Longitudinal data-analysis using generalized linear-models. ***Biometrika*** 73(1): 13–22.

Lin, Z., Yang H., & Demirkan, I. 2007. The performance consequences of ambidexterity in strategic alliance formations: empirical investigation and computational theorizing. ***Management Science***, 53 (10): 1645-1658.

Madhavan R, Koka BR, Prescott JE. 1998. Networks in transition: how industry events (re)shape interfirm relationships. ***Strategic Management Journal*** 19:439-459.

March, J.G. 1981. Footnotes to organizational change. ***Administrative Science Quarterly***, 26: 563–577.

McEvily, B, & Zaheer A. 1999. Bridging ties: A source of firm heterogeneity in competitive capabilities. ***Strategic Management Journal***, 20: 1133–1156.

Meyer, A.D. 1982. Adapting to environmental jolts. ***Administrative Science Quarterly*** 27(4): 515-537.

Meyer AD, Brooks GR, & Goes JB. 1990. Environmental jolts and Industry revolutions: Organizations responses to discontinuous change. ***Strategic Management Journal*** 11: 93-110.

Miles, R.E., & Snow, C.C. 1994. ***Fit, Failure and the Hall of Fame***. Macmillan, New York.

Miller D., & Friesen, P.H. 1984. ***Organizations: A Quantum View***. Englewood Cliffs, NJ: Prentice-Hall.

Miner, A.S., & Amburgey, T.L., & Stearns, T.M. 1990. Interorganizational linkages and population dynamics: buffering and transformational shields. ***Administrative Science Quarterly***, 35: 689-713.

Moch, M.K, & Morse, E.V. 1977. Size, centralization and organizational adoption of innovation. ***Sociological Review***, 42: 716-725.

Oum, T.H., & Yu, C. 1998. ***Winning Airlines: Productivity and Cost Competitiveness of the World's Major Airlines***. Kluwer Academic Publishers, Boston.

Park NK, & Mezias, J.M. 2005. Before and after the technology sector crash: the effect of environmental munificence on stock market response to alliances of e-commerce firms. ***Strategic Management Journal*** 26: 987-1007.

Perry-Smith JE, & Shalley CE. 2003. The social side of creativity: A static and dynamic social network perspective. ***Academy of Management Review***, 28(1): 89–106.

Pfeffer, J, & Salancik G. 1978. ***The external control of organizations: a resource dependence perspective***. New York, Harper & Row.

Pollock T, Porac J, & Wade J. 2004. Constructing deal networks: Brokers as network "architects" in the U.S. IPO market and other examples. ***Academy of Management Review***, 29:50–72.

Polzehl, J, Spokoiny, V., & Starica C. 2004. When did the 2001 recession really start? **Econometric series at SSRN**: http://129.3.20.41/eps/em/papers/0411/0411017.pdf

Porter, M.E. 1980. ***Competitive strategy: Techniques for analyzing industries and competitors***. New York: Free Press.

Porter, M.E. 1999. How competitive forces shape strategy. In Porter ME (eds). ***Strategy: Seeking and Securing Competitive Advantage*** Harvard Business School Press: Boston, MA; 11–26.

Powell, W.W, Koput, KW, & Smith-Doerr L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. ***Administrative Science Quarterly***, 41(1): 116-145.

Rowley, T., Behrens, D., & Krackhardt, D. 2000. Redundant governance structures: An analysis of structural and relational embeddedness in the steel and semiconductor industries. ***Strategic Management Journal***, March Special Issue 21: 369–386.

Shipilov, A.V. 2005. Should you bank on your network? Relational and positional embeddedness in the making of financial capital. ***Strategic Organization***, 3: 279–309.

Shipilov, A.V. 2006. Network strategies and performance of Canadian investment banks. ***Academy of Management Journal*** 49(3): 590–604.

Shipilov, A.V. 2009. Firm Scope Experience, Historic Multimarket Contact with Partners, Centrality, and the Relationship Between Structural Holes and Performance. ***Organization Science*** 20 (1): 85–106.

Soda, G., Usai A., & Zaheer A. 2004. Network memory: The influence of past and current networks on performance. ***Academy of Management Journal***, 47(6): 893-906.

Sørensen, J.B, & Stuart, T.E. 2000. Aging, obsolescence, and organizational innovation. ***Administrative Science Quarterly*** 45: 81–113.

Staw B.M., Sandelands, L.E, & Dutton J.E. 1981. Threat rigidity effects in organizational behavior: A multilevel analysis. ***Administrative Science Quarterly***, 26: 501–524.

Stinchcombe A. 1965. Social structure and organizations. In March JG (ed.) ***Handbook of Organizations,*** Rand McNally: Chicago, IL; 153–193

Stuart, T.E. 2000. Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. ***Strategic Management Journal*** 21(8): 791–811.

Tushman, M.L., & Anderson A. 1986. Technological discontinuities and organizational environments. ***Administrative Science Quarterly***, 31: 439-465.

Uzzi, B. 1997. Social structure and competition in interfirm networks: The paradox of embeddedness. ***Administrative Science Quarterly***, 42: 35-67.

Wallman, S.M.H. 1995. The Future of Accounting and Disclosure in an Evolving World: The Need for Dramatic Change. ***Accounting Horizons*** 9: 81-91.

Wan, W.P., & Yiu, D.W. 2009. From crisis to opportunity: environmental jolt, corporate acquisitions, and firm performance. ***Strategic Management Journal***, 30: 791–801.

Wasserman, S., & Faust, K.1994. ***Social Network Analysis: Methods and Applications***. Cambridge University Press, Cambridge, UK.

Zaheer, A, & Bell, G. 2005. Benefiting from network position: firm capabilities, structural holes, and performance. ***Strategic Management Journal*** 26(9): 809–825.

Zajac, E., Kraatz, M., & Bresser R. 2000. Modeling the dynamics of strategic fit: A normative approach to strategic change. ***Srategic Management Journal***, 21:429–453.

APPENDIX

Table 1. Summary of the theoretical model

Hypothesis	Feature on an open network	Theoretical constructs moderating the relationship between network openness and performance	Factors represented by these constructs
1b	Match with the external environment	Environmental jolts	Extreme changes in the external environment
2	Resource base	Firm size	Investment ability in network design

Table 2. A taxonomy of environmental jolts

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Incumbents ability to generate/influence a disruptive event</th></tr>
<tr><th>Strong/Present</th><th>Moderate/Absent</th></tr>
<tr><th rowspan="2">Industry Boundaries</th><th>Outside</th><td>-</td><td>Exogenous Jolt</td></tr>
<tr><th>Inside</th><td>Endogenous Jolt</td><td>Endogenous Jolt</td></tr>
</table>

Table 3. Means, Standard Deviations, and Correlations

	Variables	Mean	S.D.	V.I.F.	1	2	3	4	5	6	7	8	9	10	11
1	RPK (logged)	20172.5	34030.44	-	1.00										
2	Year	2002.13	2.49	1.12	0.08	1.00									
3	Inst environment	3.66	1.5	1.83	0.17	0.00	1.00								
4	Population	206751.98	358813.23	1.28	0.02	0.02	-0.21	1.00							
5	GDPcap	19208.01	15558.44	2.00	0.26	0.19	0.66	-0.26	1.00						
6	Firm age	37.96	23.91	1.41	0.36	0.02	-0.05	-0.26	-0.02	1.00					
7	Alliance experience	11.01	8.77	1.36	0.30	0.08	-0.10	-0.15	-0.08	0.45	1.00				
8	Alliance member	0.15	0.36	1.49	0.48	0.03	0.02	-0.11	0.12	0.44	0.31	1.00			
9	Firm size (logged)	66.24	97.2	1.69	0.88	-0.00	0.34	0.06	0.31	0.29	0.17	0.38	1.00		
10	Jolt	0.36	0.48	1.02	-0.06	-0.02	0.00	0.01	-0.06	-0.06	0.04	-0.00	-0.03	1.00	
11	Brokerage	0.45	0.3	1.4	0.38	0.01	0.06	-0.06	0.02	0.32	0.37	0.38	0.30	-0.00	1.00

N= 1643. Correlations larger than +0.13 or smaller than −0.13 are statistically significant at the 0.05 level

Table 4. Results using random and fixed effects models

Variables	Random effects		Random effects		Random effects		Random effects		Fixed effects	
	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**	
	Coeff.	**Std Err**	**Coeff.**	**Std Err**	**Coeff.**	**Std Err**	**Coeff.**	**Std Err**	**Coeff.**	**Std Err**
Intercept	1739407***	431756	749283	507474	756723	504722	858694†	498569		
Year	-899.15***	215.97	-383.94	254.87	-387.24	253.48	-440.99†	250.42	-1949.11**	637.7
Inst. Environment 1	-554.41	8667.5	-25940**	10010	-26504**	9948.19	-25398**	9762.63	Yes	
Inst. Environment 2	11198**	4927.89	-25242***	7434.42	-25037***	7387.37	-23988***	7252.55	Yes	
Inst. Environment 3	4505.95	7564.69	-21191*	9266.82	-21608*	9208.21	-20771*	9035.56	Yes	
Inst. Environment 4	3612.01	4466.06	-26706***	6848.14	-27084***	6805.34	-26091***	6679.45	Yes	
Inst. Environment 5	-1609.2	8415.6	-28593**	9829.84	-28656***	9765.71	-27086**	9582.23	Yes	
Inst. Environment 6	0	-	0	-	0	-	0	-		
Pop_{it}	0.005	0.003	0.005	0.003	0.004	0.003	0.005	0.003	0.007†	0.004
$Gdpcap_{it}$	0.35***	0.08	0.292***	0.083	0.2848***	0.082	0.3068***	0.082	0.294***	0.088
Firm age_{it}	58.03	68.57	-244.8**	83.53	-236.35**	83.09	-196.95*	82.279	-786.65***	154.09
Alliance $experience_{it}$	1536.43***	203.35	1367***	231.4	1359.02***	230.08	1329.73***	226.28	3513.59***	600.7
Alliance $member_{it}$	2528.26**	1086.66	1707.21†	1024.5	1707.21†	1025.5	1727.1†	0.023	1101.29	1018.91
$Size_{it}$	14493***	1074.92	14927***	1140.1	14917***	1135.5	15548***	1136.9	12718***	1303.34
Jolt	-1066.51*	545.43	-1282*	530.23	-3450.43***	936.16	-2189.58*	991.36	-2144.81*	977.65
$Brokerage_{it}$			2643.34*	1590.22	2643.34*	1594.15	2443.34	1599.15	2288	1701
$Brokerage_{it}$ x Jolt					-5369.97**	1913.58	-18182***	3928.61	-13660***	3981.39
$Brokerage_{it}$ x Jolt x $Size_{it}$							-4428.5***	1189.5	-3246.7**	1199.02
-2 Log Likelihood	-21235.6		-17724.1		-17699.3		-17659.6			
AIC (smaller is better)	21239.6		17728.1		17703.3		17673.6			
AICC (smaller is better)	21239.6		17728.1		17703.3		17673.6			
BIC (smaller is better)	21246.1		17734.1		17709.3		17679.6			
R^2									0.97	

N = 1643. † $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ – Standard Errors are heteroskedastic-consistent (“robust”)

ACKNOWLEDGMENTS

Three years and a half ago I started this PhD journey at the University of Bologna after having completed all my Business studies at Luiss in Rome. When you enter a new organization, it always takes time to understand its logics and culture. However, I must say that I found a very nice working environment with people at different levels often willing to help despite their busy schedules. Accordingly, I would like to thank the Department of Management at the University of Bologna for giving me the opportunity to join their PhD program.

I am very grateful to my advisory board: Paolo Boccardelli, Simone Ferriani, Cristina Boari, and Raffaele Corrado. A special “thank you” goes to Paolo Boccardelli (Luiss) for being a real mentor and introducing me to the academic world. He has been my advisor for three theses (Bachelor, Master, and Phd) now and each time he has been supportive and encouraging. I met Simone Ferriani (Bologna) almost an year after I had started my PhD. I remember being fascinated by his smart comments during the brown bag seminars which triggered my curiosity to have a chat with him while I was trying to collect my ideas before choosing the topic of my thesis. Eventually, I also made him curious about my research topic which gave me the pleasure to have him “on board”. I also thank Cristina Boari (Bologna) for sharing her long lasting experience in the academic world and for the nice conversations. I also thank Raffaele Corrado (Bologna), the “network guy”, who made me passionate about social network analysis. Even if not being part of my board, I also thank Franco Fontana (Luiss) for being a role model. I admire the passion he puts in everything he does and his entrepreneurial spirit.

A particular “thank you” goes also to Luca Pirolo (Luiss) for being a real friend, always, and to Andreas Angelopoulos (Imperial), an example of how a practitioner can be an exceptional academic. I would like also to thank Matteo De Angelis, Maria Isabella Leone (Luiss), and Riccardo Fini (Bologna) for giving me useful suggestions when I needed some help. I also thank my PhD colleague and friend Giacomo Carli for being a "good time" through this tough journey!

I am also grateful to Kostas Iatrou, Mauro Oretti, Raffaele Pasquini for providing me hands on experience and better understanding of the airline industry. Keith Mason and Zheng Lei (Cranfield University) are gratefully acknowledged for giving me the chance to collect a great part of my data at Cranfield.

Last but not least, I would like to thank all the people that crossed my path through my visiting scholar period in the United States. Spending six months at Kellogg School of Management (Northwestern University) has been an enriching experience from both a human and a professional point of view. I gratefully acknowledge the kindness and useful tips provided by Ithai Stern who gave me the chance to visit Kellogg. I thank Ed Zajac, Paul Hirsch, Klaus Weber, and PK Toh for useful suggestions on how to improve my papers. I also thank Eileen Chou, Lei (Grace) Luo, Razvan Lungeanu, Franz Wohlgezogen, Sookyoung Lee, Brian Lucas for the nice conversations during my time at Kellogg. Of course, I cannot forget to mention Victor Parpoil, Laurent Fradin and the other guys (I keep in my heart and my mind the nice moments we spent together). My deep appreciation goes to Ravi Madhavan for being an exceptional person and scholar. Finally, I want to thank Jing Sun for being always there in the last months.

This thesis is dedicated to my parents but particularly to my daddy (you deserve the best!).

CONCLUSION

The last decades have witnessed a proliferation of studies using the word “network”. Research on individuals as well as studies focusing on firms have explored the reasons and the consequences of forming ties of different types from marriage linkages for interpersonal ties to joint ventures for interorganizational ties. In other words, the focus has shifted from a single unit to the relations formed by these units. Besides this positive aspect, there has been a general confusion on how different scholars have defined their networks. In this research I tried to follow the orthodox definition of networks, a set of nodes/actors linked through some sort of ties. Given that this area of research is still under development, clarity is fundamental when defining concepts and methodologies. In the case of networks, there is still a vivid debate on whether it is appropriate to use the term network theory or to refer to a relational approach. Thus, if we are to move from an approach to a theory of networks it is important to adopt a common definition of networks.

Networks are a very powerful instrument in the hands of researchers as they can provide immediate access to multiple levels of analysis (i.e, the ego, the dyad, the triad, the small world, and the whole network). Despite that, much of the literature has emphasized dyadic considerations focusing for example on single strategic alliances instead of focusing on alliance constellations. To that respect, the adoption of a multilevel perspective has been frequently encouraged in the organization and management field and this thesis is a theoretical and empirical attempt to answer this need.

Another important aspect characterizing research related to interpersonal and interorganizational ties is the stability assumption. Cross-sectional studies may give an exact picture of the situation in a specific moment but do not help in the understanding of the dynamics characterizing the actors and their ties. Often, it takes a substantial amount of time and effort to develop trust in relationships with new partners. Accordingly, studies that explore the development of interorganizational ties can also be a useful example for managers engaging in alliance portfolio building and restructuring activities. Yet, empirical research on network dynamics has been quite sparse. A variety of obstacles such as obtaining longitudinal network data and the complexities of handling networks over time have limited our understanding of how networks emerge and evolve over time. This thesis proposes to advance our understanding of network evolution, and its causes, as well as its consequences by offering a theoretical framework and empirical evidence that investigate both the role of changes in the external environment and of firm attributes on patterns of network change. This effort is part of a general tendency in network research that encourages investigations of temporal sequences, path dependencies, and evolutionary patterns.

Throughout this manuscript, particular emphasis is given to unexpected events, the environmental jolts, that act as catalysts for change. Environmental shocks have become an increasingly rare phenomenon in the business world and as management researchers we need to provide some answers, where possible, on exit strategies from situations of deep crisis and uncertainty.

I hope this study encourages further research on the evolution and the dynamics of interorganizational networks by paying more attention to situations far from equilibrium of both exogenous and endogenous nature using longitudinal datasets and innovative tools.