ENTREPRENEURIAL NETWORKS: A REVIEW, METHODOLOGY AND TYPOLOGY

by

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ABSTRACT

In this thesis I explain how research on entrepreneurial networks has been dominated by two approaches: one focussing on network structures (connections between actors) and one on network flows (exchange or transformation of resources within relationships). Using configuration theory, I then make the case for an integrated approach that considers the interdependence between network structures and network flows. To achieve this, I present three papers, the first of which has been published and the other two are being revised for publication in a journal.

In the first paper I examine the affect of network embeddedness (i.e., the degree to which social structure and processes shape economic action) on the performance of new technology based firms and argue that operationalizations of network embeddedness would benefit from incorporating structural network measures as well as measures of the attributes of individual relationships. I then present a second paper in which I describe a model and method (Q-analysis) for conceptualising and measuring variations in the structure–flow interdependence of networks. Together, the model and method facilitate richer examinations of the form and function of entrepreneurial networks. In the third paper I develop a typology of four network configurations based on variations in network structural complexity and network flow complexity. I then describe how different network management capabilities are suited to each of the network configurations. Together these three papers provide contributions that will help researchers to study how structure-flow interdependence affects the configuration, multiplexity (i.e., how multiple flows interact within and across relationships) and evolution of entrepreneurial networks.

Keywords: technology entrepreneurship, new technology-based firms, entrepreneurial networks, network embeddedness, structures, flows, interdependence, configuration theory, typology, coordination, brokering, performance, Q-analysis

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CHAPTER 1: INTRODUCTION

There is growing interest in entrepreneurial networks among management scholars. This is because networks are considered central to the formation (Cooper & Dunkelberg, 1986; Aldrich, Rosen, & Woodward, 1987; Dubini & Aldrich, 1991) and performance (Yli-Renko & Autio, 1998; Baum, Calabrese & Silverman 2000; Lechner, Dowling, & Welpe, 2006) of entrepreneurial ventures. Thus, entrepreneurial networks are seen as important as mechanisms for initiating and attaining sustainable wealth. However, a significant impediment in our understanding of entrepreneurial networks is that studies tend to focus on only one core aspect of the network – its structure or its flows.

Research on network structures describes how actors are connected, and research on network flows describes how multiple resources and activities overlap within relationships. Attempts to jointly study structures and flows in networks have been limited to studying portfolios of very limited selection of types of flows, or by treating structural and flow measures as independent variables (Lechner, Dowling, & Welpe, 2006; Ostgaard & Birley, 1994; Rothaermel & Deeds, 2006). The structural approach reveals that a more central position in a network structure is related to performance while treating all relationships the same (e.g., Baum, Calabrese, & Silverman, 2000; Soh, 2003; Zaheer & Bell, 2005). In contrast, the flow approach reveals details of how individual relationships evolve and how flows interact within them while downplaying the context of the network structure (Hite, 2003; Larson & Starr, 1993; Yli-Renko, Sapienza, & Hay, 2001). Since structures are artefacts of network flows, and the meaning of each flow is given in context of the structure, it makes little sense to study them independently. Thus, I argue it is important to consider both network structures and flows, and their interdependence, so as to holistically understand how the network functions as a coherent whole (Bliemel & Maine, 2008; Hoang & Antoncic, 2003). To do so, I present a theoretical approach, conceptual model and method, that will help researchers to develop richer descriptions and analyses of entrepreneurial networks.

1.1 Outline of the Three Papers

The three papers in this dissertation explore an integrated approach to studying the structures and flows of entrepreneurial networks and their interdependence. The first dissertation paper (Chapter 2), titled “Network Embeddedness as a Predictor of Performance for New Technology-Based Firms” (Bliemel & Maine, 2008), reviews the embeddedness literature and highlights a mismatch between theory and method regarding operationalizations of embeddedness. In general, embeddedness is the degree to which social structure and processes shape economic action (Uzzi, 1996), and can be operationalized as a function of the structure of relationships and their strength, where strength is often measured in temporal or affective terms, or in terms of the volume of flows in the relationship. The logic of embeddedness argues that strong relationships are more reliable and lead to greater chances of survival, but come at the cost of redundancy; while weak relationships provide access to novel resources and lead to more innovation, but are volatile and do not provide a sustainable competitive advantage. More of either type of relationship is not always better, and there are diminishing returns to increasing the number or strength of relationships, i.e., diminishing returns to embeddedness (Granovetter, 1985; Uzzi, 1997). Embeddedness logic reveals the necessity for both strong and weak relationships for firms to survive and grow, causing the entrepreneur to select which relationships to nurture and where to focus their limited managerial resources.

The paper illustrates the propensity of research on the networks of new, technology-based firms (NTBFs) to focus on attributes of network structures or individual relationships, and shows that it is common to test only linear models within either perspective (structural or the relational). However, linear models cannot account for the possibility that there are diminishing returns to embeddedness and contingency factors are often omitted. The review highlights the balance that entrepreneurs seek in managing a portfolio of network relationships and concludes that inverted-U shaped performance relationships or interacting variables are most consistent with the logic of embeddedness, and thus more accurate in predicting their impact on a diverse selection of firm performance metrics.

The second paper (Chapter 3), titled "In Search of Entrepreneurial Network Configurations: Using Q-Analysis to Study Network Structures and Flows," builds on the gap identified by the first paper, and provides an integrated approach to studying entrepreneurial network structures and flows. This is done by combining three contributions. First, this paper introduces configuration theory (Greenwood & Hinings, 1988; Miller & Friesen, 1984) as a theoretical lens which focuses attention on interrelations between elements or components, an issue central to studying the interdependence of structures and flows. By acknowledging interrelations between structural and flow elements, a much richer understanding is gained of how they combine to create holistic, congruent and realistic configurations, and how these configurations work. This enables inductive investigation into when or why performance is contingent on certain actor, resource or activity elements in the configuration, and on their interrelations with other elements.

A second contribution of this paper, is that it presents a conceptual model of entrepreneurial networks adapted from industrial marketing (Håkansson, 1989). This model disaggregates entrepreneurial networks into three key elements – actors, resources, and activities – which, taken together are the building blocks of any network configuration. Connections between the actor elements describe the structure, interactions between the resource and activity elements describe the flows, and interrelations between structural elements (i.e., actors) and flow elements (i.e., resources and activities) describe the interdependence of structures and flows.

The third contribution is the introduction of Q-Analysis (Atkin, 1974) as a single, set-theoretic method with which to analyze entrepreneurial network configurations, and identify key elements and key interrelations. The Q-Analysis method was specifically designed to study interdependence of structures and flows in complex systems, and creates tables of hierarchically grouped structural and flow elements that preserve the qualitative labels of each element. Using this output, much richer descriptions of entrepreneurial network configurations are possible, with which to perform cross-case comparison and develop new theories regarding how and when certain elements and interrelations contribute to or inhibit performance. While not intended for theory testing, the Q-Analysis method can generate quantitative measures regarding structural complexity and flow complexity with which to place firms in the typology developed in the third paper.

The third paper (Chapter 4), titled: “A Typology of Entrepreneurial Network Configurations: Integrating the Complexity of Network Structures and Flows,” develops a theoretical typology of entrepreneurial network configurations by contrasting high and low levels of structural complexity and flow complexity, where structural complexity is defined by the number of actors that are connected in the network, and flow complexity is defined by the number of flows in the network that interact. High structural complexity reflects a dense or cohesive network structure, whereas low structural complexity reflects fragmentation or a hub-and-spoke structure. High flow complexity reflects multiplex flows, and low flow complexity reflects independent flows. For each of the four archetypical configurations in the typology (*clusters*, *cliques*, *communities* and *crowds*), network management capabilities are identified that are aligned with the structural and flow complexity conditions that define the configuration.

More specifically, *brokering* capabilities are identified that are aligned with structural complexity conditions, and *coordination* capabilities are identified that are suited to flow complexity conditions. The brokering capabilities are further distinguished between *exploitive brokering* (Burt, 1992; Walker, Kogut, & Shan, 1997) capabilities that are aligned with low structural complexity with which to leverage intermediary positions between others, and *explorative brokering* (Hargadon & Sutton, 1997; Obstfeld, 2005) capabilities that are aligned with high structural complexity with which to leverage the interactions between other actors to generate opportunities and explore new combinations of resources. Similarly, the coordination capabilities are further distinguished between coordination by *standardization* capabilities, aligned with low flow complexity conditions, which are used to lay down the ground rules and terms of engagement (Gulati

& Singh, 1998; Larson, 1991, 1992), and coordination by *mutual adjustment* capabilities, aligned with high flow complexity conditions, which are used to get relationship partners to make special efforts to increase the value of the relationship (Larsson & Bowen, 1989; Lorenzoni & Lipparini, 1999; Thompson, 1967).

This typology has direct implications for entrepreneurs about which network capabilities are most appropriate to develop or exercise. In general terms, capabilities "can be used to enhance existing resource configurations in the pursuit of long-term competitive advantage, [and] to build new resource configurations in the pursuit of temporary advantages" (Eisenhardt & Martin, 2000). In this case, the typology identifies specific brokering and coordination capabilities with which the entrepreneur can enhance or build their network configuration, depending on current or anticipated levels of structural complexity and flow complexity. For each configuration, the interdependence of structures and flows is explored and it is argued that lower levels of interdependence are associated with more incremental change. Consequently, this typology also provides a backdrop with which to study of entrepreneurial network evolution.

As a whole, this dissertation provides the foundation for new findings and theories regarding how entrepreneurial networks work, how they vary, how they evolve and which capabilities matter for managing them. The integrated approach introduced here, enables holistic research on entrepreneurial network configurations by providing conceptual models, methods and theories that match the complexity of the phenomenon (Gartner, 2001; Zahra, 2007). Consequently, this integrated approach opens up new opportunities in at least three areas. First, it improves the predictive power of network research, by adopting an approach based on configuration theory. This improvement is because the approach is aligned with exploration of how network structures and network flows are interdependent, to provide detailed, coherent and realistic images of networks (Meyer, Tsui, & Hinings, 1993; Snow, Miles, & Miles, 2005). The predictive power of a configuration is based on this coherence, as networks must attain a certain level of internal consistency and external fit to be viable and effective (Meyer, et al., 1993; Miller & Friesen, 1984). Second, the integrated approach presented here can help pull apart layers of multiplexity to see how flows interact within and across relationships, and thus how they add to the structure-flow interdependence. Multiplexity can be a source of conflict or synergy when flows interact within and across relationships. Third, the methodology and typology presented here can provide important insights on how network configurations evolve.

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CHAPTER 2:

NETWORK EMBEDDEDNESS AS A PREDICTOR OF PERFORMANCE FOR NEW TECHNOLOGY-BASED FIRMS

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Keywords: network embeddedness, growth, technology entrepreneurship, NTBFs, new technology-based firms, networks, performance

Abstract

The logic of network embeddedness has been widely used in the technology entrepreneurship literature in recent years, yet its operationalization and use are neither well understood nor agreed upon. This paper provides a literature review of the logic of network embeddedness as it has been invoked and operationalized to predict the performance of New Technology-Based Firms (NTBFs). We find that: 1) existing studies, both inside and outside of the technology entrepreneurship literature, employ the logic of embeddedness and operationalize network embeddedness in vastly different ways; 2) empirical NTBF studies frequently use linear and unidimensional measures when invoking embeddedness to explain NTBF performance; and 3) surprisingly few studies rationalize NTBF performance using curvi-linear methods, interaction effects or contingency factors that account for firm contexts and firm constraints. All other operationalizations are subject to unbounded conclusions, thus overlooking the costs of maintaining network relationships. The studies that consider such constraints support the logic of network embeddedness, in that there is a growth-stage appropriate portfolio size and composition that leads to superior performance.

Network embeddedness appears to be a useful predictor for NTBF performance when operationalized at both the dyad and network levels and accounting for firm characteristics and environmental conditions. Without accounting for such firm and environment specific variations, the predictive value of network embeddedness is far lower. An appropriate operationalization of embeddedness for predicting the performance of NTBFs should take both the relative benefits and the relative drawbacks of strong and weak ties into account. We propose that it should also account for the limited capacity of the firm to engage in external exchanges of either strength. With such contingencies, network embeddedness can guide executive's decisions in managerial resource allocation, and policymakers in industry networking activities to stimulate regional firm growth.

2.1 Introduction

This paper reviews and assesses the explanatory power of network embeddedness on the performance of new technology-based firms (NTBFs). Comparatively little is known about how NTBFs draw upon external actors to become the larger technology organizations commonly researched in the management literature. Greater understanding of these developmental stages may yield high impact strategies and policies. NTBFs are thus widely considered to be the most worthwhile level of analysis for entrepreneurship studies (Davidsson & Wiklund, 2001; Venkataraman, 1997). Entrepreneurship scholars have expressed the need for more research on understanding the tradeoffs entrepreneurs face in managing their network (Borgatti & Foster, 2003; Hoang & Antoncic, 2003; Street & Cameron, 2007). This paper explores the benefits and limitations of embeddedness on a theoretical and operational level, reviews the current applications of embeddedness to NTBFs, and assesses the conditions under which network embeddedness is useful as a predictor of performance for NTBFs.

The commercial potential of new technology-based firms is neither automatically achieved nor wholly dependent on luck. In other words, superior technology does not guarantee superior commercial success. Commercial achievement depends on the ability of the management team, prior knowledge, location and access to complementary assets (Maine, Shapiro and Vining, 2008; Echols & Tsai, 2005; Sabel, Herrigel, Kazis, & Deeg, 1987). This latter variable is particularly important (Teece, 1986). In fact, given how much the NTBF is dependent on complementary assets, managing the environment may be more important than managing the organization (Aldrich & Pfeffer, 1976). For example, lack of NTBF performance may be attributed to over-development of technologies with insufficient time spent listening to potential customers (Pellikka & Lauronen, 2007) or securing complementary assets (Maine & Garnsey, 2006). To be highly successful, NTBFs must discover, stake out and grow market niches, and thus usually consider alternatives to the extant value or supply chains. This suggests that the performance of NTBFs is contingent on a diversity of exchanges with their environmental ties.

The concept of embeddedness emerged from sociology research on the interdependence of social structure and general behaviour (Blau, 1957; Coleman, 1958; Emerson, 1962). Embeddedness logic became more broadly employed in the 1980s, appealing in particular to entrepreneurship scholars. More recently, within the management literature, embeddedness has been broadly defined as the “process by which social relations shape economic action” (Uzzi, 1996). The use of network embeddedness has become even more prevalent in the past decade, with more detailed empirical studies enabled by the development and proliferation of sophisticated computer software tools.

Network embeddedness provides a measurement of a firm's relation to its environment through an aggregate measure of the quality and quantity of firm ties. As such, the construct of embeddedness has been used in the technology entrepreneurship literature as an explanation for the rate of firm foundings (Aldrich, Rosen, & Woodward, 1987; Cooper, 1985; Cooper & Dunkelberg, 1986; Stuart & Sorenson, 2003), stability and survival (Lorenzoni & Ornati, 1988; Uzzi, 1996, 1997), growth (Lechner & Leyronas, 2007; Wood, Watts, & Wardle, 2004; Yli-Renko & Autio, 1998) and lack of performance (Gargiulo & Benassi, 1999, 2000; Graebner, 2005). Despite the frequent use of embeddedness logic, we have found that its operationalization and thus also conceptual merit are exceptionally diverse. In particular, the construct of embeddedness as it relates to technology entrepreneurship appears to be poorly understood, as the diverse range of approaches demonstrates (Bell, 2005; Britton, 2004; Elfring & Hulsink, 2003; Gulati & Higgins, 2003; Hite, 2000; Keil, Autio, & Robertson, 1997; Lechner & Dowling, 2003; Rowley, Behrens, & Krackhardt, 2000; Yli-Renko & Autio, 1998). Thus, our first contribution is to survey and assess existing arguments and operationalizations of network embeddedness within the field of technology entrepreneurship.

Our second contribution is to address the question "How does network embeddedness relates to the performance of NTBFs?" To do so, first, key embeddedness arguments and measures at the tie and network levels are reviewed. Next, the dependent variables used to measure NTBF performance (success metrics) are surveyed. With this context, we analyze how adequately existing operationalizations represent embeddedness logic and explain the impact of embeddedness on NTBFs. The paper concludes with a discussion of our findings and implications for further research.

2.2 Review of Network Embeddedness Concepts

Network embeddedness brings together consideration of the strength of ties between two entities, also referred to as dyads, and several network level concepts regarding the number and arrangement of ties. On the tie level, strength is based on attributes of the relationship itself (Granovetter, 1973), without assessing the value of the resources at either end of the tie.[1] This tie level phenomena and exchange governance system is commonly referred to as relational embeddedness (Hite, 2003; Uzzi & Lancaster, 2003) or social embeddedness (Jack & Anderson, 2002; Uzzi, 1999). The content exchanged can be either more objective, such as information, goods and services, or more subjective, such as norms, trust, cognition, political incentives and cultural preferences (Aldrich & Zimmer, 1986; Zukin & DiMaggio, 1990).[2] On the network level, the patterns of exchange provide the context for exchange through the individual tie (Portes, 1998). We concentrate on relational (tie level) and structural (network level) embeddedness because they are most commonly linked to an NTBF's ability to enter or shape an emerging market (Hite & Hesterly, 2001; Larson, 1991, 1992; Yli-Renko & Autio, 1998). While separated for explanatory purposes, they are in fact heavily interrelated concepts.

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[1] This study maintains emphasis on the dynamics of exchange and leaves interest in the quality of the resources held by the other partner for social capital researchers (Coleman, 1988; Lin, 1999, 2001; Portes, 1998).

[2] These economic and social facets of exchange have also been referred to as traded or untraded interdependencies (Storper, 1997; Tallman, Jenkins, Henry, & Pinch, 2004).

2.2.1 Relational Embeddedness

The strength of individual ties is the crux in tie-level theories about relationships, strategic alliances, and the interdependence of organizations. Tie strength can either enhance or compromise firm performance. This is true whether the tie is strong or weak, and contingent on conditions such as sparseness (or density) of the network, or the dependence on the tie for accurate and timely information on a business deal (Talmud & Mesch, 1997). Individual ties are the source of much of a firm's novel information and exploration of new opportunities. Weak ties are considered to be the main means through which new information between clusters of strong ties are transmitted, and are occasionally referred to as bridging weak ties (Granovetter, 1973). Their counterpart, strong ties, are often attributed with high degrees of redundancy, trust, joint problem solving, of information or the ability to transfer complex knowledge (Granovetter, 1983; Uzzi, 1996, 1997). Each tie type has their respective benefits and drawbacks regarding opportunism and trust.

In networks of strong ties, if an associate is seen to be struggling to survive, others often sacrificially redistribute enough of their work-load to them in support of survival (Lorenzoni & Ornati, 1988; Uzzi, 1996, 1997). Additionally, strong ties exhibit some economies of time (Uzzi, 1999), meaning that, as the relationship grows stronger, the same outcomes can be achieved with decreasing levels of effort, or that marginally better outcomes can be achieved with the same strength of tie, thus perpetuating the survival of the NTBF. Strong ties are also less susceptible to opportunism than weak ties (Dubini & Aldrich, 1991). Survival is of course a necessary condition for success.

However, the growth of the NTBF is of equal or greater interest as a performance indicator.

The growth of an NTBF can find its origins in either strong or weak ties. For example, the entrepreneur may first develop an exploitable strong relationship with an owner of a strategic resource, thus gaining access to a basis for a sustainable competitive advantage (Barney, 1991), only to later profit from redistributing the resource via weak ties. Conversely, the entrepreneur may first explore their weak ties in hopes of being the first to discover and seize such competitive advantages. These are diametrically opposed strategies that each require time and effort to pursue. Note that the time and effort required to maintain a strong tie is greater than that required to maintain a weak tie (Granovetter, 1983), and that time devoted to one tie takes away from time available to another tie (Uzzi, 1996). This causes a tension between the exploration and exploitation strategies of the entrepreneur. This tension or balance is recognized in many of the embeddedness arguments, but rarely captured in the subsequent operationalizations (Elfring & Hulsink, 2003; Gargiulo & Benassi, 2000; Rowley et al., 2000; Ruef, 2002; Uzzi, 1999; Yli-Renko, Autio, & Sapienza, 2001).

For measurement of tie strength, Granovetter first suggested that "the strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (Granovetter, 1973:1361). Specific to NTBFs, Zhao and Aram draw on prior literature to propose that tie strength can be measured by only two components, the amount of resources exchanged and the frequency of contact between two organizations (Zhao & Aram, 1995). They operationalize tie strength using subjective accounts of resource exchanges and the relative time spent in a relationship during an average work week. Of the three components of tie strength they mention from Granovetter's 1973 article (frequency of contact, reciprocity, and friendship), they concur with Nelson in arguing that frequency of contact alone may be a sufficient measure of tie strength (Nelson, 1989; Zhao & Aram, 1995). More recently, McEvily and Marcus proposed that many of the measures used to determine the strength of a tie are highly correlated (McEvily & Marcus, 2005), providing further support that any one measure may suffice in testing embeddedness theories.

The use of a single measure for tie strength is not uncommon. In his study of small business managers, Dollinger exclusively uses the single measure of relative time spent during an average work week as an approximation of tie strength (Dollinger, 1985). Similarly, in their study of partnerships of Biotech firms, Powell, Koput, and Smith-Doerr exclusively use the time since inception of an NTBF's first research and development tie as the sole measure of tie strength (Powell, Koput, & Smith-Doerr, 1996). They use this measure as an approximation for the cumulative time spent in the relationship, and implicitly as a proxy for the NTBF's ability to manage ties with increasing emotional intensity, intimacy and reciprocity.

For operationalizations, there is an apparent tendency to rely heavily on the temporal components of tie strength, despite all the arguments for affective components. Some of the methodologically more rigorous studies have further considered symmetry or reciprocity checks to compare both partners' perceptions of tie strength, when exploring subjective measures (Marsden & Campbell, 1984). While more objective measurement of tie strength is desired by the quantitative minded researcher, it may prove difficult to elicit access to such detailed multiplexity data for reasons of confidentiality (Uzzi, 1999).

In summary, relational embeddedness includes consideration of the benefits and drawbacks of the strength and weakness of a tie, and is frequently operationalized using temporal measures. New opportunities are generally recognised through a firm's weak ties. If the relationship is deemed productive by both parties of a weak tie, that tie may develop into a strong tie. Such strong ties enhance an NTBF's chances of survival and often form the basis for an NTBF's growing network.

2.2.2 Structural Embeddedness

Analysis at the network level ranges in complexity from considering only the ties between the focal firm and their direct partners (ego-networks), through to considering the total sum of all possible ties between all actors in the network (whole networks). All actors in the network would include partners of the focal firms' partners to which the focal firm has no direct connection. Networks themselves can also be categorized according to the content of ties, for example: information networks, exchange networks, and networks of trust (Johannisson, 2000). In this paper, we focus on operationalizations of the embeddedness of ego-networks that consider the aggregated benefits and drawbacks of all ties in the portfolio.

There are several network level dimensions that are related to embeddedness. Most of them can account for some balance of benefits versus drawbacks, or balance of strong versus weak, thus progressing beyond research that would otherwise conclude "more is always better". The simplest quantifiable measure of whole networks usually includes the size (or range) , as measured by the number of direct ties a firm has (Zhao & Aram, 1995), and the density, as measured by the ratio of ties present in a network to the number of potential ties (Granovetter, 1976). These measures only take tie structure into consideration, and not the qualities or strengths of the ties. They thus provide an incomplete picture of network embeddedness. Nonetheless, inferences can be made using these measures. For example, a sparse network might imply that there are few ties (strong or weak) between firms and thus is likely related to negligible network embeddedness.

Diversity is one of the most popular structural measures of ego-centric networks (Aldrich et al., 1987; Baum, Calabrese, & Silverman, 2000; Lee, Lee, & Pennings, 2001; Liu & Duff, 1972; Ruef, 2002; Uzzi, 1999). The diversity measures used are typically constructed of a ratio of one type of tie to the total sum of ties in the ego-network. The typology of tie types is entirely up to the author and can include any number of classifications such as strength, direction in the supply chain, geographic distance, multidimensional distance, or profession. Because the measure itself is virtually universal, the limitless number of variations creates a drawback in comparing studies. Nonetheless, measuring diversity is aligned with the logic of network embeddedness, which argues that a balanced mix of tie types is preferred for the firm to be able to accommodate opportunities as they arise through weak ties, while relying on a foundation of strong ties for survival and efficient exploitation.

Somewhat more advanced mathematical concepts exist to determine the relative position of a firm in their network., most notably, betweenness (Freeman, 1977), centrality (Freeman, 1977, 1979) and structural holes (Burt, 1992, 2005). Each of these concepts assesses the degree to which the focal organization is a hub through which exchanges between others in the network must flow. In their simplest form, they only account for the existence of ties, and thus address structural but not network embeddedness. However, they can be modified to include weightings of ties according to tie type or strength. Burt's research on managerial networks indicates that being in the centre of a homogeneous network can be a burden, while a similar position in a heterogeneous network may provide net advantages (Burt, 1992). The antithesis to these concepts is probably best captured by cohesion, which is defined as "the minimum number of actors who, if removed from a group, would disconnect the group" (Moody & White, 2003).

While betweenness, centrality and structural holes usefully describe a firm's position in a network structure, they do not explicitly describe the quality or interdependence of the ties contained within the network. Some of the earliest attempts to capture the interdependence of firms and the events or resources they control are weighted sums of the events or resources of interest to the focal firm divided by the number of other firms to which they are connected. This measure can be calculated reciprocally for any pair of firms (Emerson, 1962; Marsden, 1983).

Few attempts have been made that combine centrality concepts with such measures of tie quality. Three network embeddedness concepts that we believe can account for both the quality and quantity of relationships in the ego-network are (1) coupling (Baker, 1990; Uzzi, 1996), (2) the complementarity ratio (Uzzi, 1996, 1999), and (3) network efficiency (Baum et al., 2000). Coupling is the sum squared proportion of exchanges with each of a focal firm's partners. The complementarity ratio is the average coupling of the partner firms to their respective ego-centric networks, also called second-order coupling. Network efficiency is the degree to which every type of tie is under- or over-represented in the focal firm's direct network. These three measures all account for constraints associated with building and maintaining ties and thus are more useful operationalizations of network embeddedness and more useful predictors of NTBF performance.

2.3 NTBF Performance

The concept of network embeddedness in the technology entrepreneurship literature owes its roots to earlier entrepreneurship literature that focused on the individual and his sources of influence to operate a small to medium sized enterprise (SME). In the mid- to late 1980's, entrepreneurship scholars began to use network embeddedness logic to explain firm foundings and incremental performance (Aldrich et al., 1987; Cooper, 1986; Cooper & Dunkelberg, 1986). Since that time, technology entrepreneurship scholars have attempted to use variations of embeddedness logic and operationalization to explain virtually every stage of a firm's lifecycle, from founding to failure (Jarillo, 1989; Rowley et al., 2000).

Before explaining NTBF performance, it needs to be measured, and that is rarely straightforward. Commercial performance measurement of NTBFs is more complicated than that of larger corporations. Traditional performance metrics such as ROI and ROA generally do not apply until the NTBF has reached some level of maturity. NTBF performance measurement is also complicated by the research intensive nature of many NTBFs, which translates into negative cash flows in their early years. Additionally, NTBFs are often privately held, making it difficult to elicit detailed and audited financial data. Not surprisingly, sales and employee growth are the most popular performance metrics for NTBFs, (Baum et al., 2000; Maine, Shapiro, & Vining, 2008; Niosi, 2003; Wood et al., 2004; Yli-Renko & Autio, 1998), followed closely by patent growth (Ahuja, 2000; Baum et al., 2000).

In the absence of detailed growth data, some NTBF performance metrics are based on the time until a particular event occurs. For example, in the Biotech industry, the time to IPO (Gulati & Higgins, 2003; Hsu, 2004; Stuart & Sorenson, 2003) and IPO capitalization (Stuart, Hoang, & Hybels, 1999) are common success metrics. Firm survival is also a widely used performance metric for SMEs and NTBFs (Lorenzoni & Ornati, 1988; Pfeffer & Salancik, 1978; Uzzi, 1996, 1997; Yli-Renko, 2005). Once NTBF performance has been measured through one of these methods, scholars attempt to explain such performance. Those explanations employing embeddedness are reviewed in the next section.

2.4 Analysis of Existing Empirical Studies

Embeddedness in networks is an increasingly popular theoretical basis to explain the performance of individuals within firms and the performance of firms within industries (Borgatti & Foster, 2003; Hoang & Antoncic, 2003; Street & Cameron, 2007). Early entrepreneurship literature focussed on the psychology of the entrepreneur and his relation to a vague environment, essentially a single tie between the entrepreneur and an aggregate amorphous ‘environment’ entity. This changed in the late 1980s, when entrepreneurship scholars began to investigate the degree to which entrepreneurs and their actions are embedded in their idiosyncratic environment. By the early 1990’s, embeddedness was described as “a very useful standpoint for criticizing neoclassical models, but when turned around to provide concrete propositions it suffers from theoretical vagueness” (Portes & Sensenbrenner, 1993). Through the contributions of several network scholars, there is an increasing consensus on the logic of network embeddedness, “yet the conceptualization of the concept and its operationalization remain underdeveloped” (Johannisson, Ramirez-Pasillas, & Karlsson, 2002), and precise meanings remain elusive (Cope, Jack, & Rose, 2007). We agree with Rowley et al. in that “Research, however, has produced contradictory and confusing implications regarding how firms should be embedded in networks” (Rowley et al., 2000), and believe that a large proportion of this confusion can be traced back to a mismatch between embeddedness theory and operationalization. This mismatch can be at least partially attributed to the adoption of sociological concepts with an individual unit of analysis to a firm unit of analysis. Constructs and measures need to be adapted to entrepreneurship when leveraged from related areas of research (Zahra, 2007). As the origins of embeddedness lie in the sociology literature, this study reviews early formative studies which employ both the individual and the SME as units of analysis, and then proceeds to a review of more recent empirical adaptations of network embeddedness with the NTBF as the unit of analysis.

2.4.1 Search Methodology

Our search was bibliometric because we aimed to provide a comprehensive review of the concept of network embeddedness as it has been invoked and operationalized to predict the performance of New Technology-Based Firms (NTBFs). Comprehensiveness was important as we were searching for gaps in existing constructs.

The search was made more complex because the concept of embeddedness originated in the sociology literature and has since been widely adopted by and tailored to many other literatures, which may not cite one another. To ensure that relevant papers were not missed, the review was conducted using two approaches; a more traditional, organic, snowball approach, and a subsequent systematic keyword search approach (as found in Tranfield, Denyer, & Smart, 2003). While we found the systematic approach useful in reassuring the exhaustiveness of the search, ultimately the snowball method captured the most informative and relevant results (Table1).

The snowball approach began with keyword searches for “NTBF”, and “social networks” using Web of Science’s web interface. Many of the articles discovered in these initial keyword searches included SME firms in their scope of entrepreneurship, sought to explain the rate of firm founding and failure, and had a broad mix of social network concepts and measures. Further articles were explored by following forward and backward citations of articles, and by exploring the publication streams of authors. The theoretical foundations of this snowball set of articles were explored by reviewing the publications they referenced, including book chapters and conference papers, where available. These theoretical foundations were predominantly seminal works in sociology (i.e., Blau, 1957; Coleman, 1958; Emerson, 1962; Lewin, 1935). This process enabled us to gain understanding of additional related concepts and keywords for a subsequent more comprehensive keyword search.

Following the citation trails of the articles in this snowball sample was done by noting citation counts using Web of Science when possible, or by resorting to Google’s Scholar service. Articles with high citation counts (absolute and per annum) that related to the performance or level of innovation of an individual or firm in context of their use and development of their network were considered for the next steps; other articles in sociology were not explored for this study. The reverse citations of the highly cited publications were then followed to reveal articles not already in the snowball sample, if they related to the phenomena of NTBFs and external relationships. Following these reverse citations led to the inclusion of several articles from the social capital and economic geography literatures. These additional articles further informed us about the social mechanisms and physical or virtual structures that aid the development of NTBFs. Many of these studies showed strong parallels in their arguments to the initially discovered NTBF and social network articles.

While following the reverse citations of articles in the snowball sample, the authors and co-authors of exemplary articles were noted and searched for to uncover further publications in their publication stream related to the same phenomenon. These thematic and author searches revealed a total of 50 articles, of which 27 were empirical NTBF studies, and the rest a mix of theoretical and empirical studies considering the individual or the SME as the unit of analysis.

After the snowball approach, more systematic keyword searches were performed (Tranfield, Denyer, & Smart, 2003), based on the keywords that emerged out of the snowball approach. This approach provided greater confidence that relevant articles had not escaped the snowball approach. These additional keyword searches were performed using EndNote’s direct connection to Web of Science. Keyword searches in the Web of Science database for “social capital” revealed 6,235 hits, while “embeddedness” revealed a somewhat more manageable 1,430 hits. Because entrepreneurship deals with the early stage launch of firms, it can encompass both the individual and the firm as a unit of analysis, further convoluting searches for relevant literature. Despite the growing popularity of network embeddedness, still more studies essentially paraphrase the logic or provide potentially useful operationalizations, without explicitly using the terminology, making keyword searches problematic. The results of these keyword searches in comparison to the snowball technique are compared in Table 1, and revealed no additional empirical NTBF studies. The two sub-sets of revealed articles are summarized in Table 2, for empirical NTBF studies, and Table 3, for related key embeddedness studies, respectively.

Table 1: Comparison of search method results.

Method	*Search strings*	*Total hits*	*NTBF Hits reviewed in Table 2*		*NTBF/SME/Classic Hits reviewed in both Tables 2 and 3*	
			Total	*Comment*	*Total*	*Comment*
Snowball	N/A	~400	27	All of Table 2	50	All of Table 2 & 3
Specific words and 16 management journals*	Embeddedness + (technology, venture, or entrepreneur)	82	5	-	7	Incl. Uzzi 1997 in ASQ and Uzzi & Gillespie 2002 in SMJ
General words and 16 management journals*	"Embeddedness"	208	N/A	Continued with more specific words	N/A	Continued with more specific words
Specific words and all journals	Combinations of 'firm performance', 'empirical', 'entrepreneur' and 4 specific types of embeddedness**	36	3	Already part of snowball sample	3	No new ones beyond NTBF hits of same method
	Above search plus replacing 'growth' for 'firm performance'	77	5	Already part of snowball sample	5	No new ones beyond NTBF hits of same method
	'Entrepreneur' and 4 specific types of embeddedness	78	2	Already part of snowball sample	3	1 new: Uzzi & Gillespie 2002 in SMJ
General words and all journals	"Embeddedness"	1430	N/A	Few NTBF, with no further addition to the snowball sample	N/A	Did not read and analyze all papers

* AMR, AMJ, ORG SCI, SMJ, AJS, ASQ, ET&P, JMS, JOM, SOC NW, JBV, HBR, CMR, RP, E&RD, SBE

** Structural, relational, social and network

2.4.2 Analysis

We find that a number of relevant studies employ network embeddedness logic, while not necessarily making reference to the phenomenon in those terms. Conversely, numerous studies were found that apply embeddedness jargon, but do not provide insight into what comprises network embeddedness, or how one might operationalize it. The concept and logic of network embeddedness as explained here is a cross-level phenomenon. It is thus informed by tie level and network level arguments. Of the 50 studies identified here, 6 are exclusively on the tie level, 19 are exclusively on the network level, and the remaining 25 include a combination of both levels.

Table 2: Details of Personal and SME Embeddedness Studies

Study	*Unit of Analysis*	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Chung and Fischer (1999)	Person	Theoretical	Network	IV: Strength of ethnic identity, ethnicity of strong and weak ties	Differences in shopping behavior within the "same" cultural or ethnic group	Theoretical	ethnic behavior is also contingent on ethnicity of ties	YES	YES	NO
Portes and Sensenbrenner (1993)	Person	Theoretical	Both	Sources of social capital include a variety of extrinsic factors that marginalize an ethnic group, and thus cause them to join forces in pursuit of opportunity	Personal fulfillment, economic actions, counter measures to social marginalization	Theoretical	Social capital can have positive and negative effects. Positive are usually within the ethnic group, and negative are towards the ethnic group by the rest of society	NO	YES	NO
Granovetter (1985)	Person	Theoretical	Both	Individual relationship strength and participation in networks	Economic action	Theoretical	Social pressure on a tie or network level inhibits short-term opportunism, while facilitating (non-contractual) economies of scale. Embeddedness ranges from under- to over-embeddedness, neither of which exhibit net benefits	NO	YES	YES
Marsden (1983)	Person	Theoretical	Both	Proportion of events weighted by importance to focal organization, and ability of other to conceive event	Dependence (e.g., resource availability)	Theoretical	Dependence assumed linear on tie level, and can be asymmetric. Aggregated: Independence can not exist, over-dependence is bad, too. Dense networks are wasteful	YES	NO	YES
Coleman (1958)	Person	Theoretical	Network	Probability of others' actions, number of other actors	Interdependence ratio	Mathematical	Behavior is a (curvilinear) result of personal and social decisions. Akin to a mathematical model of Lewin's field theory (1951)	YES	NO	NO

Table 2: Details of Personal and SME Embeddedness Studies (Continued)

Study	*Unit of Analysis*	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Gargiulo and Benassi (2000)	Person	Quantitative	Network	CV: workload, weak ties; IV: cohesion (lack of structural holes)	Coordination failures (negative performance): Non-correlation between task dependence communication measures:	19 managers surveyed about 73 projects	Contingency: pursuit of new opportunity through a new business unit, new tasks and new interdependencies. Over-communication with (old) weakly dependent ties leads to not servicing (new) stronger interdependencies, and thus communication failure	YES	YES	NO
Gargiulo and Benassi (1999)	Person	Quantitative	Network	CV: workload, weak ties; IV: cohesion (lack of structural holes)	Coordination failures (negative performance): Non-correlation between task dependence communication measures:	19 managers surveyed about 73 projects	Contingency: pursuit of new opportunity through a new business unit, new tasks and new interdependencies. Over-communication with (old) weakly dependent ties leads to not servicing (new) stronger interdependencies, and thus communication failure	YES	YES	NO
Marsden and Campbell (1984)	Person	Quantitative	Dyadic	IV: Closeness, frequency and duration, breadth (complexity) of topics, mutual confiding	Strength (self-reported)	2000+ random surveys on the streets of multiple cities	Closeness (emotional intensity) is best measure of strength. Complexity and reciprocity are potential components, frequency and duration may not accurately represent cumulative time	YES	NO	NO
Liu and Duff (1972)	Person	Quantitative	Both	Homophily-heterophily of demographic mix in neighborhood	Knowledge diffusion	360 interviews	Contingency: Heterogeneous neighborhoods have higher rates of diffusion than homogeneous ones	NO	YES	NO

Table 2: Details of Personal and SME Embeddedness Studies (Continued)

Study	*Unit of Analysis*	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Gnyawali and Madhavan (2001)	SME	Theoretical	Network	IV: Centrality, structural autonomy, structural equivalence, network density	Action likelihood, response likelihood	Theoretical	Centrality increases probability of actor taking action decreased probability of competitor's reaction. Autonomy increases probability of actor's action and competitor's reaction. Structural equivalence decreases probability of actor's action and increases probability of competitor's reaction	NO	YES	NO
Baum and Dutton (1996)	SME	Theoretical	Both	Cultural, Structural, Cultural and Institutional Embeddedness	Economic action	Theoretical	Multiple arguments about how firms (re)act and form strategies as influenced by their (executives) context	NO	YES	YES
McEvily and Marcus (2005)	SME	Quantitative	Both	CV: learning orientation, network structure, regional associations, firm size; IV: relational embeddedness: joint problem solving (supported by prior trust and fine grained info transfer)	External acquisition of competitive capabilities (technological compliancy)	234 Surveys (very qualitative)	Stronger ties lead to more acquisition of capabilities. However, since everyone else is doing it, it may not provide a competitive advantage (eg in terms of exploitation)	YES	NO	NO
Uzzi and Gillespie (2002)	SME	Quantitative	Both	IV: relational embeddedness with bank: duration, multipliexity, (inverse) network size	Proportion of early (vs. late) payments	NSSBF data: 3404 firms surveyed and interviewed	Older relationships results in more early payments. More multiplex relationships lead to more early payments. More ties to banks result in fewer early payments	YES	NO	NO

Table 2: Details of Personal and SME Embeddedness Studies (Continued)

Study	*Unit of Analysis*	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Johannisson, Ramirez-Pasillas and Karlsson (2002)	SME	Quantitative	Both	Ties between firms, membership in associations	Cluster characteristics (similar to Keroack, Ouimet and Landry, 2004)	29 largest of 100 firms, 20 bus. Assoc., 49 soc. Assoc.; Marsden-Campbell 1984-like measurement	More firms relate to one another through more networks and associations. Different levels of embeddedness are described (firm-to-firm, firm-to-institution, and firm-to-firm by mutual membership in an association)	YES	NO	NO
Chell and Baines (2000)	SME	Quantitative	Both	Self reported networking type; consulting of family, friends, other business owners; use of professional service providers; business associations	Prosperity	200 phone interviews, split across 2 towns	Weak tie networking is associated with growth. Strong tie networking is ALSO associated with growth. Stronger correlations for knowledge based businesses	YES	YES	NO
Uzzi (1999)	SME	Quantitative	Both	CV: various organizational, market and loan characteristics; IV: Multiplexity and duration of the relationship, network complementarity (sum of squared proportions)	Securing of a loan, and cost (interest) of the loan	2300 records analyzed	Linear with duration, and U-shaped with network complementarity	YES	NO	YES
Talmud and Mesch (1997)	SME	Quantitative	Network	IV: Non-redundancy of ties, proportional density, political ownership, change in density	Survival, change in rank of firm, new firm entrants	Input-output tables of 41 industries in Israel 1977-1986	More non-redundancy of ties leads to a more stable industry. More dense ties is more stable	YES	NO	NO
Uzzi (1996)	SME	Quantitative	Both	CV: network size; IV: First order coupling by relative sales, second order coupling	Survival (probability of failure)	484 firms' economic exchanges over 1 year	Linear with first-order coupling, inverted-U shape for second-order network coupling	YES	NO	YES

Table 2: Details of Personal and SME Embeddedness Studies (Continued)

Study	*Unit of Analysis*	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Lorenzoni and Ornati (1988)	SME	Quantitative	Network	Regional economic output per firm	Cluster growth, firm characteristics	20 years of observation plus macro-economic data	Regional economic performance (and maturity) increases with the number of firms and their inter-relationships. Firms start with some core resource, and then draw increasingly more on external resources for growth and development	YES	NO	NO
Aldrich, Rosen and Woodward (1987)	SME	Quantitative	Both	IV: Network size, density, diversity, intensity	Founding, profitable	165 surveys	Developing contacts leads to founding, but not growth. Maintaining contacts leads to growth, but not foundings. Stronger core ties lead to faster profitability. Older firms benefit greatly from large networks	YES	YES	NO
Cooper and Dunkelberg (1986)	SME	Quantitative	Dyadic	Prior employment (knowledge and contacts)	Path to ownership in current business	1756 questionnaires	New business was most related to having had parents own a business, or prior involvement in a related business	YES	NO	NO
Dollinger (1985)	SME	Quantitative	Both	IV: Network size, tie type, CEO's time per tie type, time spent internally, business associations	Sales, net income, profitability index	52-58 Surveys	More time spent with external contacts increases performance. Unspecified contacts and business associations matter most. Customer contact is negative	YES	YES	NO
Uzzi (1997)	SME	Qualitative	Dyadic	Trust, Fine grained info transfer, Joint problem solving	Probability of Failure	Ethnographic	Performance is contingent on the strength (embeddedness) of the tie and the performance of the partner (if embedded to a firm that fails, one might fail as well)	YES	YES	NO

Table 3: Details of Empirical NTBF Embeddedness Studies

Study	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Bell (2005)	Quantitative	Network	CV: market share; IV: Cluster membership, centrality of informal (managerial) and formal (institutional) ties	Innovativeness (subjective 5 point scale)	77 firms in Investment Funds Institute Canada database and inter-related management and boards; expert report on innovativeness	Membership and managerial centrality significant after controlling for market share	YES	NO	NO
Zaheer and Bell (2005)	Quantitative	Network	CV: Age, Innovation; IV: ties, structural holes, closure, ego-innovation moderates structural holes, alter-innovation moderates structural holes	Market share	77 firms in Investment Funds Institute Canada database and inter-related management and boards; expert report on innovativeness	Structural holes increase performance, more so if moderated by ego-innovation	YES	NO	NO
Britton (2004)	Quantitative	Network	CV: Age, IV: R&D expenditures, foreign ownership	Export intensity	Survey of 61 firms listed via NRC	More R&D leads to more exports contingent on ownership. Domestic firms export more. Foreign owned firms use local firm to access local market	YES	YES	NO
Keroack, Ouimet and Landry (2004)	Quantitative	Both	Descriptive socio-metric study of Quebec City Optics/Photonics cluster: Density, Strength of ties to firms and associations	Distinct groupings or clusters; Cluster performance is compared to 6 other optics/photonics clusters	58 firms, all interrelated by survey of ties strength	Firms prefer strong ties to research institutes, and weak ties to schools and government. Innovativeness of a cluster driven by local research, not local demand	YES	YES	NO
Gulati and Higgens (2003)	Quantitative	Network	CV: firm size, age; Moderator: market (hot/cold); IV: VC prestige (especially for cold market), underwriter prestige (especially for hot market), strategic alliances (especially for cold market)	IPO performance	299 firms in database had IPO	VC prestige only significant in combination with market. Underwriter prestige significant as is, and in interaction with market	YES	YES	NO

Table 3: Details of Empirical NTBF Embeddedness Studies (Continued)

Study	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Stuart and Sorenson (2003)	Quantitative	Network	CV: market (hot/cold), human population by zip code, age of industry, VC cash received, rounds, patents held; IV: Geographic location, proximity to VCs, research universities (ideas) and related enterprises (labor)	Founding, time to IPO	All US biotech firms. VCs, biotech patents and research universities	Proximity to other biotech firms leads to more foundings, followed by proximity to VCs and universities. Minor diminishing effect of proximity as industry ages. Time to IPO accelerated by amount and rounds of funding. Competition effect contingent on strength of companies	YES	YES	NO
Ruef (2002)	Quantitative	Both	CV: SIC code; IV: Strong ties, weak ties, directed ties, network diversity, team size, team diversity, industry experience	Innovation (patent applications, new designs, products, supplier linkages, entry into new niche)	Survey with 440-760 valid responses	Younger is more innovative. Weak ties are better. More directed ties (towards abstract discussions) are better. More network diversity is better. Membership in high-tech SIC's is better	YES	NO	NO
Yli-Renko, Autio and Sapienza (2001)	Quantitative	Dyadic	CV: firm age, size, % of sales, % international sales; IV: major customer: Social interaction, relationship quality, and customer referrals lead to knowledge acquisition which leads to greater performance	NPD, technological distinctiveness, lower sales costs	235 (out of 936 identified) firms returned survey	More socializing is better, but quality of relationship inhibits knowledge acquisition. Referrals increase knowledge acquisition. Knowledge acquisition leads to exploitation performance	YES	YES	NO
Lee, Lee and Pennings (2001)	Quantitative	Network	CV: firm age, size, environmental munificence, industry experience; IV: Internal: Entrepreneurial orientation, technological capabilities (patents and quality control), financial resources; External: partnership ties, sponsorship ties; Interaction of Internal and External	Sales, lagged by 2 years	137 replies from Korean. Small Med Bus Assoc	Some main effects: Technological capabilities, financial resources and access to VCs increases performance. Strong interactions for VC and university ties with all internal capabilities	YES	YES	NO

Table 3: Details of Empirical NTBF Embeddedness Studies (Continued)

Study	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Rowley, Behrens and Krackhardt (2000)	Quantitative	Both	CV: Industry, country, firm size; IV: strong ties (in sparse ego-networks); Sparseness (in environment that demand high investment in exploration); Density (in environment that demand high investment in exploitation), Strong ties (environment demanding exploitation), Weak ties (environment demanding exploration), Strong (work against exploration); Aside: only strategic partners considered in analysis	Return on assets	528 semiconductor ties; 130 steel	Strong tie density important in steel industry, but not semi-conductors. Semi-conductor performance increases with weak ties, and density*strong	YES	YES	NO
Baum, Calabrese and Silverman (2000)	Quantitative	Network	CV: initial patents, human vs. non-human biotech, legal status (e.g., NPO), firm age, financial munificence, talent supply; IV: (at founding year) Network size, efficiency, alliances with potential rivals (negative), scope advantage, innovative capabilities of allied potential rivals	Revenues, employees (R&D and non), R&D expenses, patents	142 Canadian Biotech firms; secondary data	Each initial tie was beneficial, except government labs for revenues, and industry associations on all DVs. More efficient networks are better. Partnerships with rivals only beneficial if they are highly innovative (# of patents), but low in scope of patents.	YES	YES	NO
Stuart, Hoang and Hybles (1999)	Quantitative	Network	CV: patents, new drug applications, prior alliances, non-VC investors, firm age, pre-IPO capital raised, biotech stock index; IV: Prominence of strategic partner, equity and debt investors; Moderator: uncertainty of firm's quality	Time to IPO, capitalization of IPO	301 firms in databases	More alliances are better. More equity investors are better. More technological prominence of equity partners is better, especially for younger firms	YES	YES	NO
Autio and Yli-Renko (1998)	Quantitative	Dyadic	Descriptive study of how NTBFs create value; Figure 11: Intensities of technology flows by exchange type	Diffusion of innovation	392 surveyed firms	Importance of tie to parent decays over time. NTBFs seek maintaining high-value exchanges, not growth through high-volume (contingency on profit or growth motive)	YES	YES	NO

Table 3: Details of Empirical NTBF Embeddedness Studies (Continued)

Study	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Stuart (1998)	Quantitative	Network	CV: firm age, sales, slack, financial performance, prior relationships; IV: Technological prestige, crowding	Alliance formation	Patent and firm alliance database	More prestige and crowding leads to more alliance formation, albeit at a diminishing rate. interaction between crowding and prestige	YES	YES	YES
Zhao and Aram (1995)	Quantitative	Both	IV: Range (diversity of resources received, not # of alters), intensity	Growth	6 case studies in China	"The more widely the entrepreneur casts a net [..], and the more intense the relationships [..], the more likely the entrepreneurial firm will be to gain the resources it needs.". Moderate intensity more prevalent with high growth than high intensity, though	YES	YES	NO
Ostgaard and Birley (1994)	Quantitative	Both	IV: Propensity to network, activity (number of ties, time spent networking), density, intensity (age of tie), content	Match between owner's networking and firm's strategies	220 (out of 423) surveys across two UK counties	6 distinct clusters of "network strategies", most popular firm type (#5) has no clear strategy, is described by "balanced strategic orientation", and has highest average employment. More innovative firms have fewer (larger) customers	YES	YES	NO
Roure and Keeley (1990)	Quantitative	Network	IV: Completeness of founding team, technical superiority, expected time for product development, buyer concentration	VC's IRR	36 Surveys and interviews	More complete and more superior is better. Time to develop and buyer concentration have inverted-U shape	YES	NO	YES
Feeser and Willard (1989)	Quantitative	Network	IV: relatedness to prior employment, size of incubator, private/public incubator ownership	Sales Growth Rate 80-85	42 surveys	More related is better, Bigger 'incubator' is better, public incubators are better	YES	NO	NO
Jarillo (1989)	Quantitative	Dyadic	IV: Sales/assets, sales/employee, gross margin	Growth rate 1972-1977, and 1977-1982	Analysis of 1902 companies from Compustat database	More asset parsimony (sales/assets) is related to faster growth. Contingency: stronger effect for smaller firms	YES	NO	YES

Table 3: Details of Empirical NTBF Embeddedness Studies (Continued)

Study	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Cooper (1986)	Quantitative	Both	IV: Prior form and location of employment (knowledge and contacts)	Characteristics of entrepreneur's business	Literature review, incl. multiple surveys by others	Similarity to prior job is better; prior ownership is better. high proportion had entrepreneurs as parents, remained in same geography as previous employer, and had previously owned a firm	YES	NO	NO
Hite (2005)	Qualitative	Both	Descriptive study of evolution of ties to full embeddedness via 6 sub-components of relational embeddedness	Application of recent development of embeddedness theory to case studies	8 firms interviewed, incl. 17 individual entrepreneurial partners	Description of multiple paths to full embeddedness. Multiple paths and contingencies considered	NO	YES	NO
Elfring and Hulsink (2003)	Qualitative	Both	IV: Mix of strong and weak ties (network embeddedness), moderated by founder, firm and innovation characteristics	Survival and performance	3 cases, exploratory, incl. discussion of strong and weak tie benefits and drawbacks	Degree of radicalness moderates use of strong or weak ties. Weak usually associated with discovery, strong with securing access and gaining legitimacy	NO	YES	NO
Lechner and Dowling (2003)	Qualitative	Both	Descriptions of 7 most important ties over time; Questions role of strong and weak ties, and change in the relational mix	Sales growth	10 case studies	Strong ties are better in that "successful development [..] depends on a core of stable relations", but they are not formed easily	YES	YES	NO
Yli-Renko and Autio (1998)	Qualitative	Both	Description of NTBF embeddedness into an initial network and subsequent bridging to other networks	Firm and cluster development	5 sample cases	"In becoming immersed in a network, the crucial step seems to be establishing the initial intensive linkages [...] Growth of the firm may be facilitated or constrained by the network."	YES	YES	NO
Keil, Autio and Robertson (1997)	Qualitative	Both	Discussion of roles of economic and technological control in deregulation of Finnish Telekom space	Technological evolution, adoption and standardization	Single case on industry evolution	More technological control leads to more financial control	YES	NO	NO

Table 3: Details of Empirical NTBF Embeddedness Studies (Continued)

Study	*Method*	*Level*	*Measures Used*	*Performance*	*Sample and Method Details*	*Findings*	*Linear*	*Contingency*	*Inverted-U*
Saxenian (1991)	Qualitative	Both	Essay on the evolution of Silicon Valley post 1980's recession; IV: Reciprocal sales, business environment	Network structure, firm survival, diffusion of technology	50 in-depth interviews	Network structure inadvertently resulted out of fear of becoming dependent on potentially failing firms (20% rule). Flip-side: "Silicon Valley's systems makers are increasingly dependent upon their suppliers for the success of their own products."	YES	YES	NO
Larson (1991)	Qualitative	Network	Strength, reciprocity, number	Perceived performance of alliances (incl. benefits and risks)	Ethnographic, 50 interviews, 4 firms, 7 alliances	Moderate number of dense strong ties, plus a number of weak ties	YES	YES	NO

The summaries in Table 2 and Table 3 demonstrate the diversity of studies which explicitly invoked network embeddedness logic, operationalized embeddedness, or provided a proxy for it. Others did not explicitly mention embeddedness, but applied the same (network embeddedness) logic, and provided comparable operationalizations. Columns in Tables 2 and 3 include the method (qualitative or quantitative), the level of analysis (dyadic, network or both), measures used for independent variables and performance, a summary of their conclusions, and whether the study reports different embeddedness-performance relationships (unconditional linear, contingent linear, and inverted-U shaped).

While clear categorization of measures was not always possible, the studies were marked as containing one of 29 different measures related to embeddedness logic that emerged from this literature review.[1] On average, each study used 3.1 different measures. Conversely, each measure was invoked an average of 5.3 times. The most frequently used measures were network size (15 times), network density (13 times), and tie type (11 times).

The studies summarized in Table 2 include research on the actions of individuals and SMEs, and span qualitative and quantitative methods, and theoretical contributions. The simplest way to summarise them is to say that context matters. The studies are summarized in reverse chronological order, and grouped by their respective unit of analysis. Judging by citation counts on Web of Science and Google Scholar, the best known studies in this table provide the foundation for network embeddedness logic (e.g.,

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[1] Tables of the dyad and network level measures are not included due to space constraints, but are available from the authors.

Granovetter, Uzzi, and Portes & Sensenbrenners's theoretical contributions), backed up by examples of how one might possibly measure the strength of individual ties (e.g., Marsden & Campbell's quantitative work) or the aggregate strength of a portfolio of ties (e.g., Uzzi and Gargiulo & Banassi's quantitative work). In this sub-set of 23 studies, 13 span both levels of analysis (i.e., they consider both the quality and quantity of ties). Nine of the 13 exhibit an inverted-U shape regarding performance. These studies indicate that embeddedness should be expected to abet performance until a certain level, above which embeddedness is expected to be detrimental to performance.

Focusing exclusively on the empirical NTBF studies (Table 3), we observe a diverse mix of approaches and find that existing empirical NTBF studies frequently use proxies for network embeddedness when examining NTBF performance. Of the 27 empirical NTBF studies, 25 contain linear models and conclusions. Six of these are exclusively linear models, while the rest are augmented by a contingency factor or inverted-U shape relationship. Nineteen of the studies contained a contingency factor, of which 2 were exclusively a contingency model, and 3 contained an inverted-U shape relationship based on either a linear or contingency model. The large number of linear studies is of concern as their conclusions can lead to unbounded business policies that make "more is always better" type assumptions.

Table 3 shows that not a single NTBF study explicitly considers an inverted-U shaped relationship, in combination with both the dyad and the network levels of measurement. The closest match is a qualitative study that describes the contingent benefits and drawbacks of strong and weak ties (Elfring & Hulsink, 2003). In many cases, consideration of an inverted-U shaped relationship was supplanted by a linear variable of the mix of heterogeneity of ties or matched pairs statistics. Such linear models can approximate an inverted-U shape if their scale ranges from 100% homogeneity (strong or weak) on one end and heterogeneous or mixed measure at the other end (Keroack, Ouimet, & Landry, 2004; Larson, 1991; Stuart et al., 1999; Zhao & Aram, 1995).

In our assessment, the studies that provided the clearest logic, best operationalization and thus explanation of NTBF performance include interaction effects or contingency factors that account for environmental conditions and firm constraints. A notable example is the inclusion of the completeness of the founding team as a variable (Roure & Keeley, 1990). Where network embeddedness is operationalized as the ratio of strong to weak ties, an (approximated) inverted-U relationship of network embeddedness to performance has been found (Uzzi, 1999, 1996; Saxenian, 1991; Elfring & Hulsink, 2003). This operationalization supports the arguments provided, that network embeddedness is a multidimensional and multi-level concept, and that more is not always better.

2.5 Discussion and Conclusion

Network embeddedness appears to be a useful predictor for NTBF performance when operationalized at both the dyad and network levels and accounts for firm characteristics and environmental conditions. Relevant firm characteristics may include firm growth stage, revenue model, strategic focus, and completeness of founding team. Relevant environmental conditions may include industry maturity, industry velocity, diversity of firm ties, and proximity of a firm to a cluster of related organizations.

Without accounting for such firm and environment specific variations, the predictive value of network embeddedness is far lower. With such contingencies, network embeddedness can guide firm managers in resource allocation and policymakers in industry networking activities to stimulate regional firm growth.

In the nascent interest in network embeddedness within the technology entrepreneurship and sociology literatures, there is currently a broad range of interpretation of which key variables to measure. Studies range from proxies that focus on the internal or cognitive capacity to manage external relationships (Dollinger, 1985; Lee et al., 2001), through to explicitly measuring portfolios of social (Elfring & Hulsink, 2003; Keroack et al., 2004; Ruef, 2002; Zhao & Aram, 1995) or economic exchanges (Rowley et al., 2000; Uzzi, 1996). Dunbar's research on the ability of apes and humans to mentally keep track of a limited number of relationships between all members in a tribe (Dunbar, 1992) reflects the same logic, and was more recently popularized through the popular business press (Gladwell, 2000). Overall, while the logic of network embeddedness has been broadly adopted, little consistency is found in the operationalizations linking network embeddedness to NTBF performance.

In addition to this disconnect, we find that the choice of operationalization in empirical NTBF studies is frequently conceptually problematic. In many cases, the operationalization accounts for only one kind of exchange (social or economic), and context dependency is taken for granted, resulting in conceptually problematic recommendations such as "more is always better". The use of density to operationalize network embeddedness is problematic since it lacks consideration of tie strength, and it includes all the peripheral ties beyond the scope of action of the NTBF. Similarly, the choice of network size as the operationalization is flawed if it does not account for the relative strength of each tie, and the direct and opportunity costs required in managing the ties. Such operationalizations lead to recommendations for managers to infinitely increase their network size without consideration of the quality, context, or costs of each additional tie.

An appropriate operationalization of embeddedness for predicting the performance of NTBFs should take both the relative benefits and the relative drawbacks of strong and weak ties into account. In terms of benefits, strong ties can be relied upon to aid the NTBF with start-up, growth and survival. The main benefit of weak ties is the greater opportunities they provide for firm growth. A broad range of weaker ties allows a firm to be exposed to many potential avenues for growth without heavy commitment of time or other resources. In terms of drawbacks, strong ties require a heavier commitment and can lock a firm into time wasting activities. As an additional drawback, strong ties general provide redundant information to the NTBF. Weak ties have their own drawbacks, in that they are not as reliable, leading to opportunistic activities which may disadvantage the NTBF.

The creation and maintenance of both strong and weak ties consume managerial time and firm resources. More of either strong or weak ties is not always better. Thus, linear arguments and operationalizations of network embeddedness are not particularly useful for predicting the performance of NTBFs. The appropriate level of network embeddedness for a firm is contingent on the life stage of the firm, the industry, and the firm's current relational mix of ties.

Of the existing operationalizations of network embeddedness reviewed in this study, three consider both the tie and network levels of embeddedness in a way that directly reflects the logic of network embeddedness. These are Baum et al.'s network efficiency, Uzzi's coupling and Gargiulo and Benassi's task interdependence measure (Baum et al., 2000; Gargiulo & Benassi, 2000; Uzzi, 1996). All three include some form of tie strength and normalization thereof. Baum et al.'s operationalization weights tie categories by the number of ties of each existing category, and can account for ties missing in any category. Uzzi and Gargiulo et al.'s operationalizations weight each tie by the relative proportion of exchange by each tie. These studies provide the most compelling logic and most consistent operationalization of network embeddedness for use as a predictor of NTBF performance. They can thus demonstrate that both under-embeddedness and over-embeddedness lead to poorer NTBF performance.

Beyond being multi-level and contingent on firm and environmental characteristics, network embeddedness is also multi-dimensional. This begs the question as to how to measure the strength of inter-organizational ties before combining them into a network level measure. We find multiple measures of tie strength intriguing, particularly for technology-based firms. For example, Keil and his colleagues considered not just economic interdependence, but also technological interdependence (Keil et al., 1997). Similarly, Gargiulo and Benassi's research on how being embedded in a network can inhibit adaptation to a new setting compared communication structure with task-dependence structure to determine where communication failures were occurring (Gargiulo & Benassi, 1999, 2000). Beyond the convention of aggregating multiple dimensions of tie strength into one measure, further work to develop multi-dimensional, multilevel aggregate measures of network embeddedness would be useful.

This literature review also reveals a gap in the network embeddedness literature. Even those studies with the most compelling logic and consistent operationalization do not consider the total capacity of the firm to engage in external exchanges. In addition to the increasing support that there are increasing then diminishing returns to most network measures (e.g., size or intensity), the literature also suggests that the capacity to maintain a network is a dynamic capability (Deeds & Hill, 1996; Dyer & Singh, 1998; Lechner, Dowling, & Welpe, 2006; Lorenzoni & Lipparini, 1999; Rothaermel & Deeds, 2006), that can be supported through investment in technology or appropriate skill development. The mismatch between network embeddedness logic and subsequent operationalization is likely an artefact of the embeddedness construct having been adopted with little adaptation from the sociology literature.

As adopted from sociology, one might reasonably assume that similarly experienced individuals have relatively the same capacity to engage with their environment. Firms, however, can vary greatly in their ability to engage with or enact their environment. This is problematic because existing operationalizations would measure the same level of network embeddedness regardless of the size, maturity, or relational capacity of the firm. Thus, similar values of network embeddedness across firms would fail to reveal the relative degree of connectedness of firms, relative to their capacity to connect. For example, if a small start-up and a large R&D conglomerate had similar measured levels of network embeddedness as operationalized in the studies reviewed here, the implications on performance may still be quite different. In the case of the start-up, they may be spending too many of their resources maintaining their network at the detriment of the technological core that constitutes their strategic advantage. Conversely, the larger conglomerate may be better off developing their network in order to leverage their substantial internal resource base and superior absorptive capacity. Because of this shortcoming, exploration of network embeddedness from a resource based view would be a fruitful area for future research.

Limitations to this review include the assumption of causation and consideration of only the two levels of embeddedness studied as predictors for NTBF performance. We have assumed causation from the level of embeddedness in a network structure to the performance of the NTBF. Nonetheless, we acknowledge that network structure may be an antecedent of performance or even spuriously altered as a result of the free will and actions of the entrepreneur. Entrepreneurs may want to weigh the short and longer term consequences of their actions, and take action with either performance or network development as a consequence, as reflected in the structuration perspective (Jack & Anderson, 2002; Sarason, Dean, & Dillard, 2006), and effectuation perspective (Sarasvathy, 2001).

We have also limited the levels of our analysis to the dyad and the network levels. In reality, embeddedness may span more levels as indicated in some of the earliest studies on embeddedness and social capital (Zukin & DiMaggio, 1990). Drilling down on the individual, embeddedness may also include cognitive aspects of the entrepreneur (Simsek, Lubatkin, & Floyd, 2003). Modern communication methods have also opened the possibility of virtually embedded ties to exist with little to no immediate consequences of severance, and limited maintenance requirements (Lawrence, Morse, &

Fowler, 2005; Morse, Fowler, & Lawrence, 2007). We have only written about how entrepreneurs relate to other individuals or firms, while in fact they can also be embedded to institutions (Baum & Oliver, 1992; Johannisson et al., 2002). For sake of providing a more focused overview, we have not included the cognitive or institutional levels and acknowledge this as a limitation of our study.

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CHAPTER 3:

IN SEARCH OF ENTREPRENEURIAL NETWORK CONFIGURATIONS: USING Q-ANALYSIS TO STUDY NETWORK STRUCTURES AND FLOWS

A combined version of Chapters 3 and 4 was reviewed and rejected at the Journal of Business Venturing with the recommendation to separate the papers and resubmit both to the same journal. The Executive Summary section and formatting of the references complies with the submission requirements for the Journal of Business Venturing. A subsequent version of the combined paper won the Best Paper award for the 4th European Conference on Technology Management in Glasgow, Scotland, September 8, 2009 under co-authorship of Martin J. Bliemel, Ian P. McCarthy, and Elicia M. A. Maine.

Keywords: entrepreneurial networks, configurations, Q-analysis, configuration theory, structures, flows, interdependence

Abstract

Configurational research is concerned with how elements of organizational systems combine to produce distinct organizational forms, which cannot be deduced by examining these elements separately. We suggest that, due to conceptual and methodological constraints, studies of entrepreneurial networks have largely overlooked this approach, instead focusing either on the structural perspective or flow perspective. Consequently, we neither have an understanding of how structures and flows combine to form entrepreneurial network configurations, nor how these configurations evolve over time. In response, we introduce a conceptual model and the Q-analysis method for inductive studies of entrepreneurial network configurations.

3.1 Executive Summary

Entrepreneurs and their organizations are embedded in networks that influence their performance. As these networks are a heterogeneous phenomenon, understanding the causes and consequences of their diversity is an important research area. In the fields of strategic management and organizational science the study of organizational diversity has produced configuration theory (Greenwood and Hinings, 1988; Miller and Friesen, 1984), which advocates that “organizations are best understood as clusters of interconnected structures and practices, rather than as modular or loosely coupled entities whose components can be understood in isolation” (Fiss, 2007, p. 1180). We argue that configuration theory has largely been overlooked by prior research on entrepreneurial networks with studies focusing either on the structural perspective (i.e., actors only) or the flow perspective (i.e., resources and activities only). Consequently, we suggest that entrepreneurial network configurations should also studied as integrated systems of elements (actors, resources and activities), as opposed to independent elements or systems of only one element type to be studied separately. The interdependence of network structures and flows causes changes in structures to trigger changes in flows, and vice-versa; a phenomenon referred to as “domino effects” (Hertz, 1998). We argue that an integrated approach is important to entrepreneurial network research in that it accounts for network structure-flow interdependence, and thus provides a more holistic and realistic image of how such networks function and evolve.

In this paper we review the entrepreneurial network literature to highlight the focus on network structures or on network flows. The structural perspective focuses on *who* is a part of the network (i.e., which actors) and their positions and interconnections (e.g., Shepherd, 1991; Soh, 2003; Zaheer and Bell, 2005). Structural research ranges from considering only the portfolio of connections an entrepreneur has with other actors, to considering how all the actors in the network are interconnected. The flow perspective focuses on *what* types of resources are involved in individual relationships, and *how* these resources are used, exchanged or transformed and interact (e.g., Larson, 1991; Larson and Starr, 1993; Yli-Renko, Sapienza and Hay, 2001). Both these network perspectives have proven to be theoretically significant and highly relevant to entrepreneurial practice. However, by concentrating on only one perspective at a time, we know very little about how the elements of both perspectives are interrelated to produce network properties that go beyond those observed by studying each perspective separately. For instance, the structural perspective informs us of the interconnections[1] between actors, but is based largely on a single type of flow, and the flow perspective informs us of how relationships can consist of multiple interacting types of flows, but is based almost entirely on dyadic alliances.

By combining both perspectives, we gain an understanding of when and how flows interact across relationships, thus enabling insight into how the entrepreneurs manage the synergies and conflicts caused by these interactions, and thus how they manage the interdependence of network structures and flows. This integrated perspective is essential for properly identifying different entrepreneurial network configurations based on structural and flow properties, for, as argued by Dess, Newport and Rasheed (1993, p. 776), the configurational approach requires "researchers to express complicated

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[1] We use "connections" to refer to the portfolio of relationships an entrepreneur has with others, and "interconnections" to refer to all the relationships in the network, including those directly between other actors.

and interrelated relationships among many variables without resorting to artificial oversimplification of the phenomenon of interest”.

We argue that one of the main reasons why existing research on entrepreneurial networks has not simultaneously examined both network structures and flows is because the conceptual models and methodologies currently employed constrain researchers to focus on only one of these perspectives, rather than on both together. As expressed by Hoang and Antoncic (2003, p. 177): “current work seeking to explain entrepreneurial success is limited by considerable conceptual vagueness regarding the resources [..], and how we measure the networks that provide those resources.” In structural research, for instance, the network is conceptualized as a pattern of actors and interconnections and typically involves using quantitative methods such as social network analysis, regression analysis, or structural equation modeling that discount the qualities of each relationship. In flow research, relationships are conceptualized as dynamic and complex phenomena and typically studied using qualitative methodologies such as case studies and ethnography that discount the structural context of the relationships under investigation. Applied to network research, a configurational approach requires models and methods that can express, describe, and analyze a variety of relationships and the various (interacting) flows in them, in order to develop a holistic, coherent and realistic image of networks (Meyer, Tsui, and Hinings, 1993; Snow, Miles and Miles, 2005). To explain the limitations of the structural and flow perspectives, and the benefits of the integrated perspective, we use an illustrative example that describes the network for the entrepreneurial venture Cambridge Display Technologies. This example also highlights how changes in structure affect flows and changes in flows affect structure, thus drawing attention to how networks evolve when structure-flow interdependence is acknowledged.

To address the problem of studying entrepreneurial networks as configurations of multiple elements of various types and their interrelations, we propose a conceptual model of networks and introduce the Q-analysis method (Atkin, 1974). The conceptual model is adapted from Håkansson's (1989) network model, and shows how different types of network elements (i.e., actors, resources, and activities) are interrelated to create both the structures and flows in a network. The Q-analysis method is a comparative method based on set-theory. It provides a mathematical language for analyzing the interrelations between these network elements and describing the structure-flow interdependence. Like other comparative methods, such as qualitative comparative analysis (Ragin, 2000; Fiss, 2007), this method is not used to test theory, but to help researchers inductively develop and refine theory from complex qualitative data. We use a simplified version of the illustrative data to explain and demonstrate the Q-analysis method and concepts.

In summary, in this paper we follow other theory-method papers (DeSanctis and Poole, 1994; Fiss, 2007; Jack, 2010) and provide a contribution that urges and guides entrepreneurial network scholars to develop more holistic descriptions of entrepreneurial network configurations based on network structures and flows. We hope this will conceptually and methodologically facilitate studies of the diversity and evolution of entrepreneurial network configurations (as well as other types of social and inter-organizational networks). We also hope our contributions will aid in the development of more accurate and insightful predictions about how entrepreneurs develop and manage different network configurations to improve the performance of their ventures.

3.2 Introduction

Networks are important to entrepreneurs for accessing external resources such as venture capital, advice, intellectual property, materials and revenues. Such resources are essential for establishing firms (Birley, 1985; Aldrich, Rosen and Woodward, 1987, Kanter, 1983) and for overcoming liabilities of newness and smallness (Stinchcombe, 1965; Stuart, Hoang and Hybels, 1999). Networks are also considered essential organizational mechanisms that both reflect and enable the strategic goals of entrepreneurs (Ostgaard and Birley, 1994; Hill and Birkinshaw, 2008; Hoang and Antoncic, 2003).

In common with research on social networks (see: Borgatti and Foster, 2003), research on entrepreneurial networks has adopted either a structural perspective that focuses on the diversity of actors (e.g., Baum, Calabrese and Silverman, 2000; Lechner Dowling and Welpe, 2006; Rothaermel and Deeds, 2006) or on the interconnection and positioning of similar actors (e.g., Soh, 2003; Zaheer and Bell, 2005; Al-Laham and Souitaris, 2008), or has adopted a flow perspective that examines the transformation and exchange of resources and their interactions within individual relationships (e.g., Larson and Starr, 1993; Yli-Renko, Sapienza and Hay, 2001). Consequently, we know relatively little about how the characteristics of these two network perspectives combine to influence the "causal texture" (Emery and Trist, 1965) or "patterns" (Mintzberg, 1979; Miller and Friesen, 1984) that define the overall form, function, and performance of entrepreneurial network configurations. We suggest that this gap exists because quantitative methods used in the structural perspective, such as social network analysis, regression analysis and structural equation modeling, are ill-suited for analysing and diagnosing configuration variance. Such methods are unable to capture the multitude of interrelations in organizational and inter-organizational configurations (Fiss, 2007; Short, Payne and Ketchen, 2008). Also, the qualitative methods used for studying network flows, such as ethnography and case study analysis on individual relationships, do not capture the structural context of the relationship or interactions of flows across relationships. Studying both the structures and flows thus requires mixing qualitative and quantitative methods (Jack, 2010), which still misses their interdependence, or the use of an integrated approach, such as Q-analysis, for describing and measuring how the different elements are interrelated to define the form and function of the systems.

We suggest there at least three reasons why it is important to study both the structure and flows of entrepreneurial networks. First, understanding the interdependence of structures and flows is central to the configuration approach, which focuses on understanding organizations as “clusters of interconnected structures and practices” (Fiss, 2007, p. 1180). This allows us to describe and measure network configurations in a more holistic manner, instead of assuming they consist of independent components. Second, an integrated perspective helps us to understand how multiplexity, which is “the layering of different types of exchange within the same relationship” (Hoang and Antoncic, 2003, p. 169), exists in a network: we refer to this as “network multiplexity”. Network multiplexity is important, because, when flows in one relationship interact with flows in other relationships in the same network, this significantly affects the form and function of the network. Third, jointly studying structures and flows is important for investigating how networks evolve, since a new relationship can provide a new flow and impact other flows, and changes in flows can impact which relationships the entrepreneur decides to build, maintain or terminate.

We present our arguments and contributions in two sections. In the first section, we review the dominant entrepreneurial network research perspectives and representative studies. Then, using an existing case study as an illustrative example, we explain the relative benefits and limitations of the structural perspective, the flow perspective, and our proposed integrated perspective. In the second major section of our paper, we outline our conceptual model, which is adapted from Håkansson's (1989) network model, and explain how it disaggregates entrepreneurial networks into three key elements – actors, resources and activities – which, taken together, are the structural and flow building blocks of any network configuration. We then present and demonstrate the Q-analysis method (Atkin, 1974). To do this, we use data based on a simplified version of the illustrative example to describe the interrelations between network actors, resources, and activities, and thus also the structure-flow interdependence. The method is used to form hierarchically grouped elements that describe the configuration as a holistic and coherent system of interrelated parts and explicitly considers the interdependence of network structures and flows.

3.3 A Review of Entrepreneurial Network Research Perspectives

Our review of the research on entrepreneurial networks draws upon Borgatti and Foster's (2003) typology of the network paradigm in organizational research to examine the extent to which entrepreneurial network research focuses on network structure or network flows, as well as which methodologies were used. Table 4 provides a summary of some of the studies that exemplify each network perspective. After reviewing the existing entrepreneurial network studies, we discuss the advantages of taking a configuration approach, which involves studying both network structures and network flows.

The entrepreneurial network literature depicts the complexity of entrepreneurial networks using descriptors such as “patterns” (Greve and Salaff, 2003) or “constellations” (Lorenzoni and Ornati, 1988; Shepherd, 1991). There have also been classifications of entrepreneurial networks (Bensaou and Venkatraman, 1995; Belussi and Arcangeli, 1998; Hite, 2003; Lechner et al., 2006; Rothaermel and Deeds, 2006) and related new venture strategies (Woo, Cooper and Dunkelberg, 1991; Ostgaard and Birley, 1994; Clarysse, Wright, Lockett, de Velde and Vohora, 2005; Hill and Birkinshaw, 2008).

Table 4: Entrepreneurial network perspectives, methods and approaches

Focus of Network Measures or Descriptors	**Methods and Assumptions**
Structural Perspective: Portfolios of Relationships	
Use of the network (product innovation, distribution, cost leadership, marketing, responsiveness to customers) (Ostgaard and Birley, 1994)	→Cluster analysis of survey data: Independent and single purpose relationships
Range and intensity of networking (Zhao and Aram, 1995)	→Case study: Contacts can provide multiple benefits and are independent of each other
Relational mix by relationship type (Lechner, Dowling and Welpe, 2006)	→Regression of survey data: Types of ties are mutually exclusive and single purpose
Alliance types and experience combine to shape relational capabilities (Rothaermel and Deeds, 2006)	→Regression of BioScan and US Patent and Trademark Office data: Types of ties are mutually exclusive and single purpose
Intensity of networking (Watson, 2007)	→Regression of Australian Bureau of Statistics data: Relationships are mutually exclusive, but can be sources of referrals beyond their functional purpose
Structural Perspective: Positions in Structures	
Reciprocity and density (Lorenzoni and Ornati, 1988)	→Theory development: Single purpose relationships
Betweenness (reachability) (Dubini and Aldrich, 1991)	→Theory development: Contingent on diversity and density of partners
Constellations (high power firm central to multiple subordinate firms) (Shepherd, 1991)	→Case study: Supply chain relationships
Centrality (Soh, 2003)	→Tobit analysis of Social Network Analysis measures of Network World data: Similar competing actors in a relatively mature industry
Centrality, diversity and number of ties (Al-Laham and Souitaris, 2008)	→Exponential model of new tie formation: Single purpose relationships
Flow Perspective: Transmission and Transformation of Resources.	
Trust (as a facilitator of product advances, administrative process improvements and rapid response times) (Larson, 1991)	→Ethnography: Focus on “unusual cooperative alliances”
Contractual governance flexibility (Yli-Renko, Sapeinza and Hay, 2001)	→Regression of survey data: Focus on single “key customer” relationship
Proximity and friendship (Bollingtoft and Ulhøi, 2005)	→Ethnography: Collaboration within single incubator. Personal and business relationships are intertwined

3.3.1 Structures or Flows

Structural studies focus on the composition of relationships an entrepreneur has with other actors. Some structural studies create lists of actor types in a network, such as customers, suppliers, potential employees, consultants, trade associations, competitors and shareholders, and study the relative importance of each type (see the Structural

Perspective: Portfolios of Relationships section of Table 4). Such studies reveal the diversity of actor types it takes to launch a new venture, but treat each relationship and their flows as being independent. Other structural studies portray the interconnections between actors, including the entrepreneur, but only look at one type of actor, such as suppliers (Uzzi, 1996), bankers (Uzzi, 1999), R&D partners (Powell, Koput and Smith-Doerr, 1996; Al-Laham and Souitaris, 2008), board members (Zaheer and Bell, 2005), or, more generally, strategic alliance partners (Soh, 2003).

Structural studies are useful for investigating how fragmented or cohesive network structures are, which can be expressed in terms of structural complexity: low complexity networks have few interconnected actors and resemble hub-and-spoke or wheel structures (Markusen, 1996, Freeman, 1979) with many otherwise disconnected fragments, while high complexity networks are more cohesive and have many interconnected actors and resemble clique structures (Luce and Perry, 1949; Knoke and Kuklinski, 1982). Although these studies show that the structure of relationships among actors is important, they typecast actors into providing uniplex or one-dimensional flows, thus omitting interactions of flows of different types within or across relationships, and thus also provide very limited insight into the effects of structure-flow interdependence and the subsequent evolution of network configurations.

Findings from structural studies include that favorable positions can be achieved by being in dense (Lorenzoni and Ornati, 1988; Gnyawali and Madhavan, 2001), larger (Zhao and Aram, 1995; Watson, 2007), or more reachable networks (Dubini and Aldrich, 1991). Similarly, having connections to high-powered firms (Shepherd, 1991), occupying central network positions (Soh, 2003, Al-Laham and Souitaris, 2008), and bridging multiple unconnected parties (Burt, 1992; Zaheer and Bell, 2005) are all considered to be beneficial to entrepreneurial performance. Together, these findings support a core argument in the structural perspective, that entrepreneurial action is enabled or constrained by the quantity and structure of connections between actors. However, because structural studies reduce relationships to single measures of tie strength (binary or variable), they are limited in their ability to account for multiplexity within relationships, and omit interactions of different types of flows across relationships because they are not designed to consider them.

In contrast to structural studies, flow studies focus on how multiple exchanges occur within a single dyadic relationship. While this perspective reveals interactions of flows within individual relationships, it omits the greater structural context in which the relationship exists, and thus also interactions of flows across relationships. For example, Larson's (1991) research on the evolution of dyads examines how any given relationship develops over time, but does not consider how the relationship in question may be complementary to, enabled by, or in conflict with other relationships. In general, flow studies focus on how resources are exchanged (e.g., transfer of goods and cash) and transformed (e.g., recombination of knowledge), and consider dyadic multiplexity (i.e., when two actors have multiple relations with each other) (Larson and Starr, 1993; Hite, 2003), thus overlooking the interactions and effects of different types of flows across the network as whole. In comparison, an integrated structure-flow perspective would consider the full range of actor types to which the entrepreneur is connected, the diverse activities and resources these actors provide, and how these flows interact within and across relationships.

3.3.2 The Case for Structures and Flows

We argue that jointly studying the structure and flows of entrepreneurial networks is important for three reasons. First, understanding the interdependence of network structures and flows is central to the configuration approach. The configuration approach argues that organizations are "best understood as clusters of interconnected structures and practices, rather than as modular or loosely coupled entities whose components can be understood in isolation" (Fiss, 2007, p. 1180). In other words, and applied to networks, it is necessary to simultaneously consider both the structural and flow elements so as to develop holistic and coherent images of networks (Meyer et al. 1993, Snow et al. 2005). By holistic we mean that the network is conceptualized as a single system of interrelated elements - actors (structural perspective), and activities and resources (flow perspective) - as opposed to studying these elements separately. By coherent we mean that, from the numerous different combinations of structural and flow elements that might be hypothetically possible, only a fraction will be viable and interesting. Holistic and coherent images of network configurations provide predictive power as these attributes are associated with internal consistency and external fit, which are, in turn, related to network viability and effectiveness (Miller and Friesen, 1984; Meyer et al. 1993).

Second, an integrated perspective helps to understand more complex instances of multiplexity. As traditionally studied, multiplexity refers to two or more different types of relationships occurring between the same actors (Beckman, Haunschild and Phillips, 2004; Hoang and Antoncic 2003; Wasserman and Faust 1994). For example, when an entrepreneur and investor are connected only in terms of cash, this is a uniplex relationship; but if the same two actors are also supplier and customer to each other, then the relationship is multiplex. As the relationship becomes more multiplex, complementary interactions between flows can be leveraged to unlock synergies. In the aforementioned example, the cash from the investors helps assure the survival of the new venture, so that it can continue to provide the goods or services the investors are interested in as customers. It may also be that the interactions between flows can cause conflicts. In our example, if the investors attempt to use their influence on the entrepreneur to prevent them from supplying other investors they are in competition with, this may serve the investors' agenda, but will impede the performance of the entrepreneur, since their market share is restricted.

Existing research has largely examined multiplexity within individual dyadic relationships (Larson, 1991; Larson and Starr, 1993; Yli-Renko, Sapienza and Hay, 2001), and those studies which have examined multiplexity across more than a single relationship are limited to two or three types of intangible flows within corporations (Lazega and Pattison, 1999; Gargiulo and Benassi, 2000). By using the model and method proposed in the next section, we argue that it is possible to examine multiplexity across multiple relationships, and how it affects the interdependence of structures and flows. Multiplexity across relationships is also reflected in the "domino effects" concept (Hertz, 1998), in which changes in one relationship trigger changes in other relationships, In this paper, we refer to multiplexity within and across network relationships, i.e., at the network level, as "network multiplexity" to distinguish between existing notions of multiplexity solely within individual dyadic relationships and notions of multiplexity that span multiple relationships.

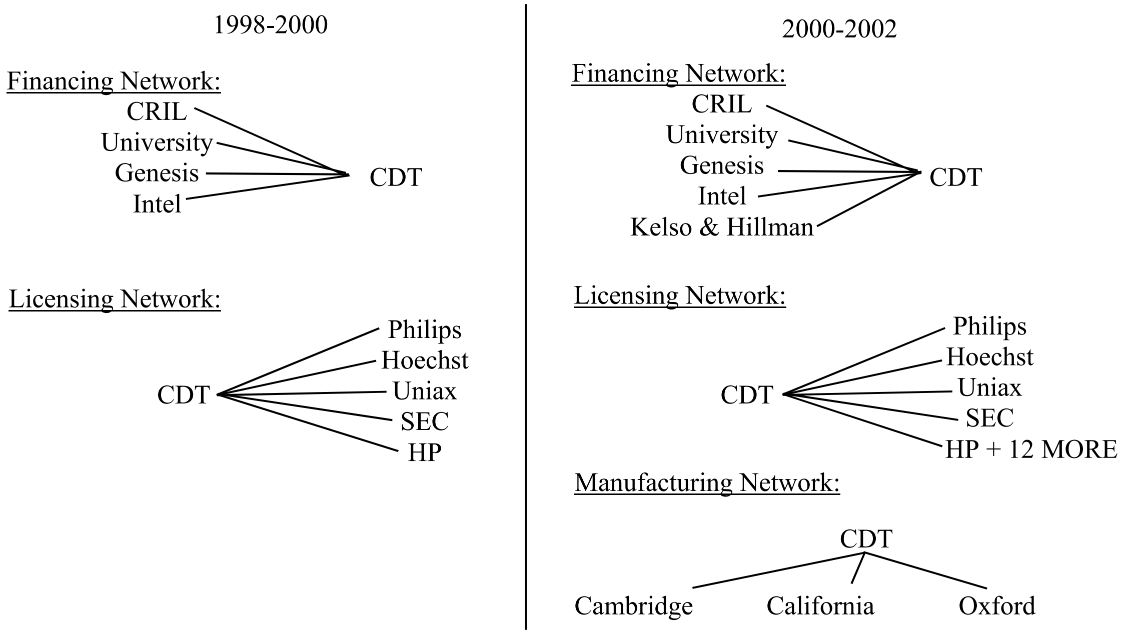
Third, we suggest that jointly studying structures and flows can provide important insights on how network configurations evolve. Networks and configurations are dynamic (Hite and Hesterly, 2001; Lechner, Dowling and Welpe, 2006), and their propensity to change into one configuration or another will be influenced by synergies and conflicts that exist due to the interdependence of structures and flows. By focusing solely on structures or solely on flows, only one part of what is changing in a network is considered in isolation of the interrelated parts. An integrated approach provides a basis for understanding how changes in flows affect structure, and how changes in structure affect flows: together these interdependent changes can be used to identify and describe network configurations across time, and to predict the performance of new ventures. For instance, in emerging markets and emerging technology sectors, it is not reasonable to assume that either structures or flows can be held constant, because emerging markets and technologies are characterized by entrepreneurs who are continually forming new relationships to influence the development and adoption of their products. These new relationships and constantly changing flows are the basis of survival and competition until standards emerge.

To elaborate on the importance of jointly considering network structures and flows, we provide an illustrative example using case study data for Cambridge Display Technologies (CDT) (Maine and Garnsey, 2006). The example demonstrates how the relationship with a new investor triggers new relationship and flows in other areas of the network. Figure 1 represents the structural perspective. In each column we see how the entrepreneur draws on multiple but uniplex and independent flows, e.g., financing or licensing, for two periods (1998-2000 and 2001-2002), and see how interconnections across different actor types are omitted. Cash flows to CDT via connections in the financing network, intellectual property (IP) flows between CDT and licensees via connections in the licensing network, and materials flow between CDT and manufacturers via connections in the manufacturing network. CDT is in a position to aggregate and broker flows across disconnections within each of the networks. Furthermore, while CDT is a common node in all networks, interaction of flows across networks is not explicit; cash, IP, and material flows are independent. While the structural approach would link the number of actors in the initial network with an increase the number of actors in the subsequent network, it would remain silent on how one network relates to another.

Table 5 and Table 6 indicate the flow perspective for the same network for the same periods. The relationships are simplified in that the table describes a typical relationship of each type, instead of summarizing the details of each individual relationship. The relationships from Figure 1 are depicted as multiplex, yet still independent dyads, and show what resources are flowing (e.g., cash, equity, reputation, IP, materials or products) and the different activities (e.g., financing, R&D, management, and production) associated with each relationship type. This perspective shows that the complexity of relationships can increase, as seen by the investors increased involvement in providing managerial advice. However, this perspective does not show how the flows in one relationship interact with flows in another relationship, even through some of the resources are present across relationships.

Figures 2 and 3 indicate an integration of both perspectives, and show both the structural and flow properties. The integrated perspective incorporates observations that structures can increase in the number of actors involved, and that flows can increase in their degree of interaction. It also provides a foundation for studying how flows are brokered across actors (e.g., cash from investors and licensees is used to establish manufacturing subsidiaries and their production runs), and how changes in structures and flows are interdependent. For example, the new investor (i.e., a structural change) not only increased the flow of cash (i.e., a change in flow), but also resulted in advice to the entrepreneur to change their business model (i.e., a new flow) by using the additional cash to finance the development of manufacturing subsidiaries (i.e., new addition to the structure and new flows). Neither the structural or flow perspectives alone would have captured these structure-flow interdependencies in this example.

Figure 1: Structural perspective of CDT[2]



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[2] Multiple ties stemming from one actor, without connection to each other, depict brokerage opportunities.

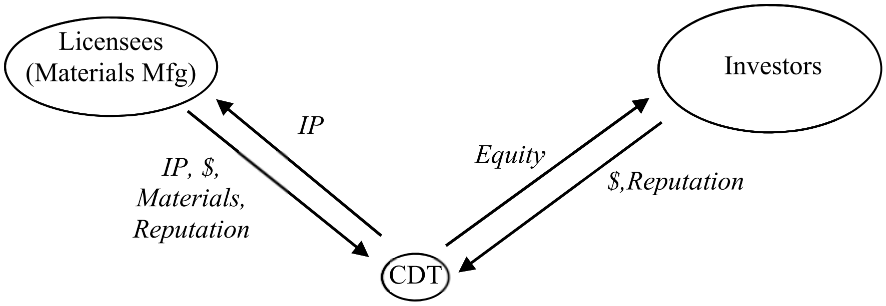
Table 5: Flow perspective of CDT 1998-2000

Dyad (and direction)	Flows	
	Resources	Activities
CDT ↔Investors	Equity, cash, reputation,	Financing
CDT ↔Licensees	IP, cash, materials, reputation	R&D

Table 6: Flow perspective of CDT 2000-2002

Dyad (and direction)	Flows	
	Resources	Activities
CDT ↔Investors (original, Kelso and Hillman)	Equity, cash, reputation, advice	Financing, management
CDT ↔Licensees (original +12 more)	IP, cash, materials, reputation	R&D
CDT ↔ Manufacturing subsidiary	IP, cash, products	Production

Figure 2: Integrated perspective of CDT 1998-2000[3]



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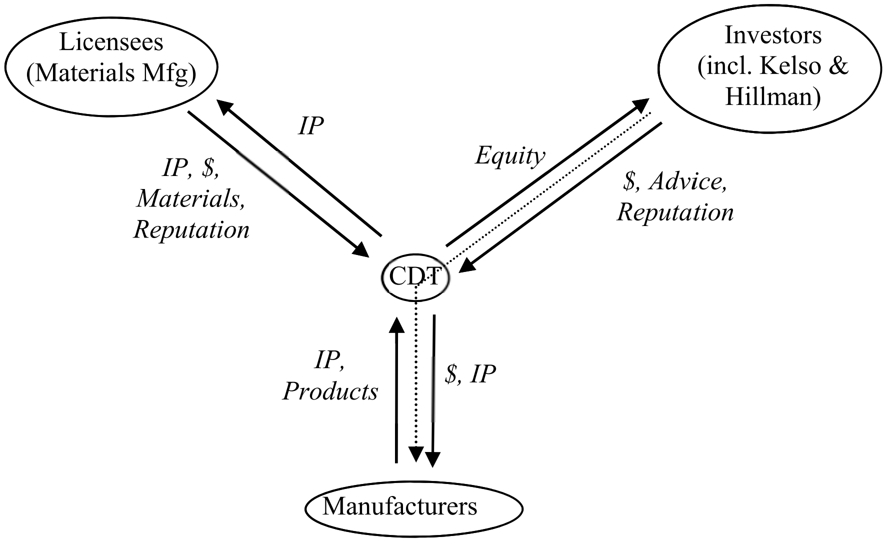
[3] Brokerage opportunities are indicated by flows that must go through CDT to get to their destination.

Figure 3: Integrated perspective of CDT 2000-2002[4]



Given the importance of generating new insights into network configurations, network multiplexity and network evolution, why have entrepreneurial networks not been studied through an integrated perspective with respect to structures and flows? We believe that studies on entrepreneurial networks have tended to focus on either network structures or network flows, and not on their combined interaction, in order to simplify the conceptual model and subsequent method used. A focus solely on structures or solely on flows is attractive because it is much easier to model, analyze, and discuss a network in terms of a single perspective, rather than as a complex system of two interdependent perspectives. The price for this simplicity, however, is that the description of the network neither captures the full complexity of the phenomenon nor represents it in a realistic and coherent manner (Zahra, 2007). In comparison, the configuration theory lens is used to investigate how interrelations between organizational elements form distinct, holistic and viable organizational systems (Dess, Newport and Rasheed, 1993; Fiss, 2007), and how these elements "take their meaning from the whole and cannot be understood in

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[4] Interdependence of CDT's creation of a manufacturing subsidiary using Kelso & Hillman's advice and funding is indicated by the dotted line.

isolation" (Meyer, Tsui and Hinings, 1993, p. 1178). Thus, the configuration approach applied to entrepreneurial networks integrates the structure and flow perspectives by emphasising that structure and flow elements combine to form configurations that influence entrepreneurial performance.

Just as the theoretical perspectives currently applied to entrepreneurial networks are not able to deal with an integrated approach, the most common methods used to study networks are ill-suited for jointly analyzing both structures and flows. Recent reviews (Stuart and Sorenson, 2007; Jack, 2010) report that there are concerns with the reliance on either the existing quantitative methods for examining network structures (e.g., social network analysis) or on qualitative methods (e.g., ethnography and case study analysis) for examining network flows when trying to generate a more complete understanding of the complexity and evolution of entrepreneurial networks. We agree with these reviews, and conclude that research on either network structures or flows inaccurately portrays the reality of entrepreneurs who are in the process of simultaneously developing their networks and new ventures, and that new research designs and methods need to be introduced that can address these gaps. Without an integrated approach, research may be limited to incremental studies using existing methods with only marginally significant findings. We hope that an integrated network approach can unlock new research areas and explain new network phenomenon. To explore the potential of an integrated approach, the following sections introduce an integrated network model and demonstrate the Q-analysis method.

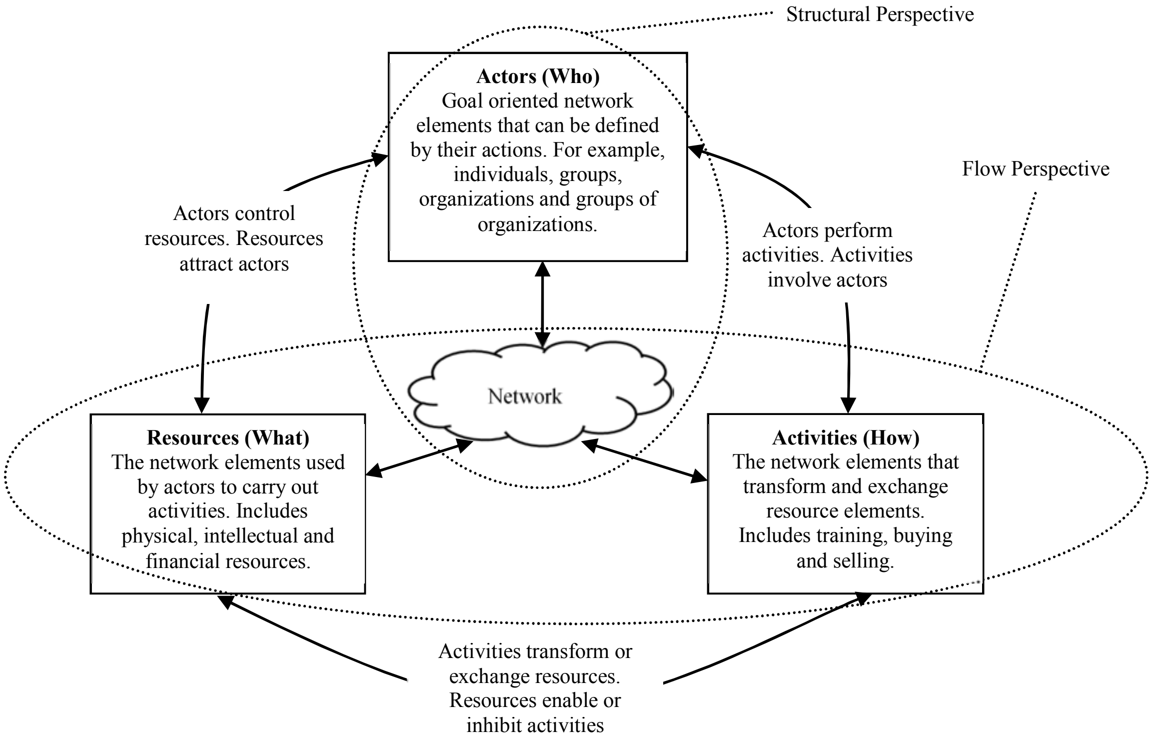
3.4 Proposed Model and Method

In this section, we present a conceptual model and method that is intended to facilitate and guide entrepreneurship scholars to develop more holistic descriptions of entrepreneurial network configurations based on interrelated structure and flow elements. The model and method are congruent with the configuration theory approach and specifically focus on interrelations between structures and flows.

3.4.1 Conceptual Network Model

Our conceptual model of entrepreneurial networks (see Figure 4) is adapted from industrial marketing research (Håkansson, 1989). It is a model that allows us to view entrepreneurial networks as a system of "*actors* linked together by their performance of complementary or competitive […] *activities*, which implies that certain *resources* are processed as a result of other *resources* being consumed" (p. 16, emphasis added). In alignment with configuration theory, the model shows the interrelations between three types of network elements: actors, resources, and activities. Håkansson (1989) used this model to explain how all of these network elements are necessary for an industrial network to function, and that they are not homogenous, resulting in different types or configurations of networks. In their literature review, Slotte-Kock and Coviello compare multiple literatures on networks as they may relate to entrepreneurship, and highlight Håkansson's conceptual model for reasons similar to the three key arguments presented here (2010). They express structure-flow interdependence, network multiplexity and network evolution in terms of "mutuality of tie and network development", "network [as] multiplex adaptive systems", and the need to "understand change within relationships, as well as across relationships, and the impact on the wider network" (Slotte-Kock and Coviello, 2010).

Figure 4: Conceptual model of interrelated network elements, structures and flows



Following other studies by Håkansson and his colleagues, we use the model to differentiate the interrelations between actor elements (i.e., "bonds") that form the structure, from the interrelations between resource elements (i.e., "ties") and activity elements (i.e., "links") that form the flows and their interactions (Dubois and Håkansson, 1997; Håkansson and Snehota, 1995). This is in contrast to the social network literature which uses a variety of terms similar to these to describe only actor-actor interrelations. Also, while this model has predominantly been applied with a focus on only one of the three element types (Dubois and Håkansson, 1997; Håkansson, 1990; Håkansson, Lind, 2004), we use this model to show that there can be interrelations between any combination of actor, resource and activity elements, simultaneously. This simultaneous consideration of all three element types allows multiple actors to be associated with any given flow, allows multiple flows to overlap via common actors, and can explicitly account for interrelations between structural and flow elements, and thus structure-flow interdependence,. Furthermore, this network model is congruent with Hoang and Antoncic's "general" definition of a network as "consisting of a set of actors and some set of relationships that link them" (2003, p. 167), wherein the "set of relationships" linking these actors are described by additional resource and activity elements that give the relationships meaning. This emphasis on the interrelations of individual elements is directly analogous to configuration theory's central premise that a configuration as a whole is defined by the combination of all its components and interrelations.

3.4.2 The Q-Analysis Method

To analyze and measure how the elements in our network model combine to generate different levels of structural complexity and network multiplexity, we introduce and demonstrate the Q-analysis method (Atkin, 1974). This method should not to be mistaken for multivariate Q-techniques (Miller, 1978) or other similarly named methods (see also Blackburn, 1982 for "q-analyses" unrelated to Atkin's original work). Q-analysis is a set theoretical method (Ragin, 2000; Fiss, 2007) that layers multiple interrelated sets of elements to identify configurations. It is a method that was specifically developed to jointly study the structures and flows of systems and offer a mathematical language for describing and measuring the interdependence between a system's structure (often referred to as the "backcloth") and its flows (often referred to as the "traffic") (Atkin, 1974; Gould, 1980; Casti, 1989). Consequently, we argue that it can be used to examine structure-flow interdependence, because it treats structures as artefacts of flows, and vice versa (Atkin, 1977; Johnson, 2005).

The Q-analysis method has been used to study structures and flows in a diverse range of systems including human-database interaction (Jacobson, Fusani and Yan, 1993), television network programming (Jacobson and Yan, 1998), urban planning (Atkin, Johnson and Mancini, 1971), regional development and agriculture (Gaspar and Gould, 1981), organizational configurations (Atkin, 1980; Rakotobe-Joel, McCarthy and Tranfield, 2003), and social networks (Freeman, 1980; Doreian, 1979, 1981, 1986; Spooner and Batty, 1981). However, as far as we know, the Q-analysis method has not, as of yet, been used to study entrepreneurial networks.

Applied to networks, the Q-analysis method involves developing layers of multiple sets of network elements. Each set describes which elements occur within the set, and permits elements to occur across sets, which means that the sets partially overlap. These sets may be activity-centric, and centered around entrepreneurial activities such as financing, product development, or accessing external infrastructure. They may also be resource-centric or actor-centric. For example, Atkin's (1980) study of a network of managers in a single firm started with an actor-centric tabulation of responsibilities held by a set of six executives. Relationships between managers could then be inferred as a consequence of joint responsibilities.

Using these (partially overlapping) sets, Q-analysis produces descriptions of configurations as groups of elements that are hierarchically ordered according to which and how many sets the elements belong to and share with other elements. The method is both inductive and analytical in nature. It is inductive in that it can be used to describe the degree to which elements interrelate and form the hierarchical groupings. This description provides a basis for researchers to explore how network elements are interrelated and develop theories that explain how these interrelations give rise to variations of structures and flows in individual networks or groups of networks. Q-analysis is also analytical in that it uses different vector measures to describe the complexity of the structures and flows, thus making it amenable for descriptive quantitative analysis of how configurations vary.

In addition to describing individual configurations, the method is used to aggregate groups of configurations to contract and compare them, much like case study analysis (Yin, 1994; Eisenhardt, 1989). An exemplary Q-analysis study that contrasts and compares larger numbers of cases include investigation of differences in access to infrastructure and farming practices of 250 farmers in Portugal (Gaspar and Gould, 1981), each described by 39 structural and flow elements. For purposes of explaining the mechanics and usefulness of the method with regards to simultaneously studying structures and flows, we will only look at two cases, each with small numbers of structure and flow elements.

3.4.3 The Incidence Matrix (λ) and the Connectivity Matrix (Q-Matrix)

Following similar papers that provide theory-method contributions (DeSanctis and Poole, 1994; Coviello, 2005; Fiss, 2007, Jack, 2010), we demonstrate the method using simplified examples to maintain focus on the method and not on interpretation of the results. To explain and demonstrate the mechanics of the Q-analysis method and how it can be used to study the interdependence of network structures and network flows, we present a simplified version of the illustrative example above. By comparing and contrasting the network configuration for both periods, we also provide guidelines on how the method may be used to study the evolution of network configurations.

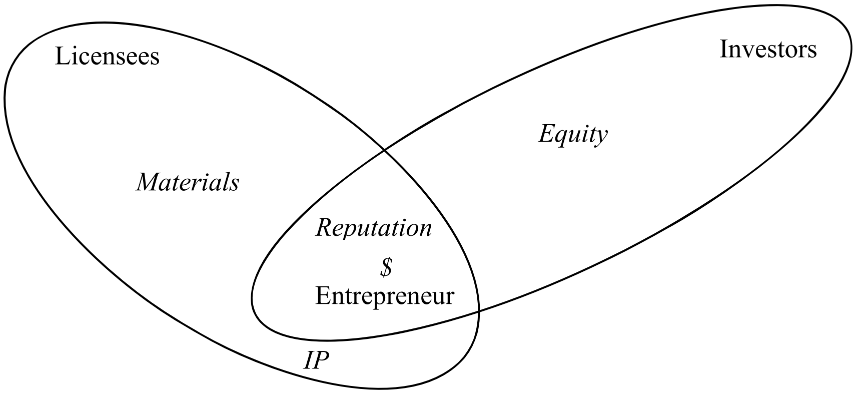
The first step in Q-analysis is to develop an incidence matrix, λ, which presents the data in terms of which network elements (*m* rows) occur in which sets (*n* columns). To keep our illustrative example simple, we limit the network to fourteen elements which relate to different entrepreneurial functions. To illustrate the method, we will initially feature only two relationships from the first period (1998-2000), one representing licensing and one representing investment, as depicted in Figure 2. We will then feature relationships of all three kinds from the second period (2000-2002), including a representative manufacturing relationship. As depicted in the example incidence matrix (Table 7), each function is described by a set of actor, resource, and activity elements, and represented by a column of entries indicating which elements are present (1) or absent (0).

Table 7: Example incidence matrix 1998-2000

	Set (by entrepreneurial function)			Elements	Element Type	
	Investment	Licensing	Manufacturing			
	1	1	0	entrepreneur	Actors	Structural Elements
	1	0	0	investors		
	0	1	0	licensees		
	0	0	0	manufacturers		
	1	0	0	equity	Resources	Flow Elements
λ =	1	1	0	cash		
	1	1	0	reputation		
	0	1	0	IP		
	0	1	0	materials		
	0	0	0	products		
	0	0	0	advice		
	1	0	0	financing	Activities	
	0	1	0	licencing		
	0	0	0	manufacturing		

Central to the Q-analysis method, and the task of understanding the interdependence of network structures and flows, is that the notion that an incidence matrix contains partially overlapping sets of structural and flow elements. Elements are interrelated within and across sets, and are used to describe structural interconnections between actors, and interactions between flows. In the example, three of the ten elements (*entrepreneur*, *cash*, and *reputation*) are shared across the two sets, indicating a relatively simple network structure (only two actors other than the entrepreneur) with flows that are multiplex within and across each relationship. If drawn as a Venn diagram, the layered sets in the incidence table look like Figure 5. Later in this section, we will explore how the configuration of this network changes when the investors increase their level of involvement by providing advice to the entrepreneur to use their capital towards developing manufacturing relationships.

Figure 5: Venn diagram representation of the incidence matrix 1998-2000



To determine which network elements occur in which sets, there are two approaches: crisp sets and fuzzy sets (Ragin, 2000; Fiss, 2007). With our example data (Table 7), we use crisp sets, with the binary values "1" to indicate that a network element is related to the other network elements in the same set, and "0" to indicate when a network element is not part of that set. Fuzzy sets on the other hand, use threshold measures to specify the extent to which element is a member of one or more sets (Fiss, 2007). Fuzzy sets can be used for more nuanced assessments that allow researchers to identify potentially meaningful distinctions based on partial membership of sets. For a more detailed account of how one might re-code ordinal or scalar data in fuzzy sets to binary values, see Ragin (2000) and Fiss (2007).

To establish how all the elements in a network are interrelated, the next step is to convert the *m* by *n* incidence matrix (λ) into an *m* by *m* connectivity matrix, or Q-matrix. This matrix summarizes which network elements (both structural and flow in nature) cooccur within and across sets, indicating interrelations of those elements (see Table 8). The connectivity matrix is calculated as $Q = \lambda\lambda^T - II^T$, where I is an identity matrix with the same m by n dimensions as λ. Mathematically, this step is virtually identical to the matrix algebra used in two-mode network analysis (Faust, 1997; Borgatti and Everett, 1997; Borgatti 2009).

Table 8: Example connectivity matrix 1998-2000

entrepreneur	investors	licensees	manufacturers	equity	cash	reputation	IP	materials	products	advice	financing	licencing	manufacturing	
1	0	0	-	0	1	1	0	0	-	-	0	0	-	entrepreneur
	0	-	-	0	0	0	-	-	-	-	0	-	-	investors
		0	-	-	0	0	0	0	-	-	-	0	-	licensees
			-	-	-	-	-	-	-	-	-	-	-	manufacturers
				0	0	0	-	-	-	-	0	-	-	equity
					1	1	0	0	-	-	0	0	-	cash
						1	0	0	-	-	0	0	-	reputation
							0	0	-	-	-	0	-	IP
								0	-	-	-	0	-	materials
									-	-	-	-	-	products
										-	-	-	-	advice
											0	-	-	financing
												0	-	licencing
													-	manufacturing

The result of this algebraic transformation is a symmetric matrix of all elements versus all elements, which provides two key pieces of information. First, the values on the main diagonal are the *dimension levels* or *q-levels* of each element. These values indicate how many additional sets each element occurs in, other than the first set it appears in. In other words, the dimension level is a measure of how many sets are overlapped by a particular element, minus one to exclude the first set in which it appears.

This value describes the level of prominence of an element within the overall configuration, but does not say anything about how many other elements it is related to, only how many sets it overlaps (which may not include other elements). This overlapping reflects the nexus in our conceptual model of entrepreneurial networks (Figure 4), where network flow elements (resources and activities) combine to add meaning to the structural connections between actors, and flows may involve any number of actors.

The second key piece of information in the connectivity matrix is contained in the values on the off-diagonal that indicate the dimension level of the interrelation between any two elements and specify how many sets the pair of elements have in common (minus one). This dimension level is significant as it can be used to measure the interdependence of individual network elements, regardless of type. At the intersections of actor elements with other actor elements, these values represent the structural interconnections in the network. If no relationship exists between any two network elements, this is indicated by a "-" in the appropriate intersection in the connectivity matrix. Collectively, these values may be used to form a measure of structural complexity. At the intersections of flow elements with other flow elements, this represents multiplexity or interactions between flows. For flow elements within the same relationship, these values can be used to form a measure of multiplexity within that relationship. At the network level, the values at all intersections between flow elements can collectively be used to form a measure for network multiplexity. The values at intersections of structural and flow elements collectively represent the structure-flow interdependence, and can collectively be used to form a measure of structure-flow interdependence.

In our example data, the *entrepreneur*, *cash* and *reputation* elements are interrelated with all other elements in the network. As a result, we could omit them from the analysis, just as the set-theory method omits conditions that are present across all cases because such elements have limited descriptive value (Fiss, 2007). Such omission assists in more clearly distinguishing exclusive sets of elements, but can also lead to misinterpretation of the results if they are not taking into consideration. In the case of our example, we will leave them in to maintain detail of which flows interact within and across relationships via these common elements. Omission of elements from the analysis is done by zeroing all the values in the element's row in the incidence matrix, and recalculating the connectivity matrix. As a result, the reduced connectivity matrix would more clearly reveals which elements (other than those omitted) are interrelated to form the configuration.

3.4.4 Equivalence Classes and the Q-Table

The next step in Q-analysis is to identify equivalence classes[5] which are used to summarize which elements are interrelated and form groups within the overall configuration. This is done to identify the relative prominence of each group, and qualitatively describe the network fragmentation. Equivalence classes are groups of structural elements and flow elements in which the elements are all directly or indirectly interrelated at the same dimension level. There may be multiple mutually exclusive equivalence classes at any given level. Equivalence classes are formed for all dimension levels, and constitute a hierarchy that summarizes which elements are interrelated at

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[5] Equivalence classes are not to be confused with structural equivalence (Burt, 1987), which focuses only on actor elements, and exists when any two actors are connected to all other actors in the same way.

which level and thus which interrelations are more or less prominent. The maximum number of equivalence classes is equal to the number of sets in the incidence matrix, and would occur if there were no overlap of elements across the sets. Existence of more than one equivalence class indicates fragmentation in the network.

Identifying equivalence classes at each dimension level involves reviewing which values in the diagonal and off-diagonal intersections in the connectivity matrix exceed the given dimensional level. If the value in an off-diagonal intersection exceeds the given dimension level, then both those elements are in the same equivalence class. Other elements join a given equivalence class if they interact at that dimension level with at least one other element in the equivalence class, as seen by reviewing the remaining off-diagonal values. These equivalence classes or groups of elements consist of partially overlapping cliques, where cliques are completely interrelated sets of elements (Luce and Perry, 1949; Knoke and Kuklinski, 1982). At each dimension level, the mutually exclusive groups of elements that comprise each equivalence class are contained within curly brackets – { }. More detailed Q-analysis will also summarize the partially mutually inclusive groups of elements that comprise cliques within each equivalence class, as noted by angle brackets – < > (Johnson, 1990). The equivalence classes are summarized for each dimension level in the Q-table in Table 9.

Table 9: Example Q-table 1998-2000

q-level	Q	Q*	Equivalence Classes
1	1	0	{<entrepreneur, cash, reputation>}
0	1	0	{<entrepreneur, investors, equity, cash, reputation, financing>, <entrepreneur, licensees, cash, reputation, IP, materials, licensing>}

In reviewing the elements in our example, if we focus on the *entrepreneur* element in the connectivity matrix (Table 8), its value of 1 on the main diagonal indicates that it is a one-dimensional element. This means that the *entrepreneur* is associated with only two sets of elements (e.g., both the investment and licensing sets in the incidence matrix) and that their role in the network is thus interdependent of other elements both these sets. At dimension level 1, the *entrepreneur* element is joined by the *cash* and *reputation* elements to form one equivalence class, as shown by their listing in the same curly braces in Table 9. This implies that the cash and reputation in one relationship is interdependent of the other relationship. In other words, reputable investors are providing cash because they see that the IP licensing business model is feasible and with reputable licensees. Vice-versa, IP licensees engage with the entrepreneur because they see they have adequate financial backing by reputable investors. At dimension level 0, all the elements form one equivalence class, which can be broken down into two partially mutually inclusive sets, that each provide more detail about the flows involved in those relationships. A closer look at the elements in the equivalence class at dimension level 0 confirms that the two sub-classes have the *entrepreneur*, *cash* and *reputation* elements in common, reaffirming which elements are at the root of the interdependence of flows in each of the two featured relationships.

3.4.5 The Structure Vector (Q) and Obstruction Vector (Q)*

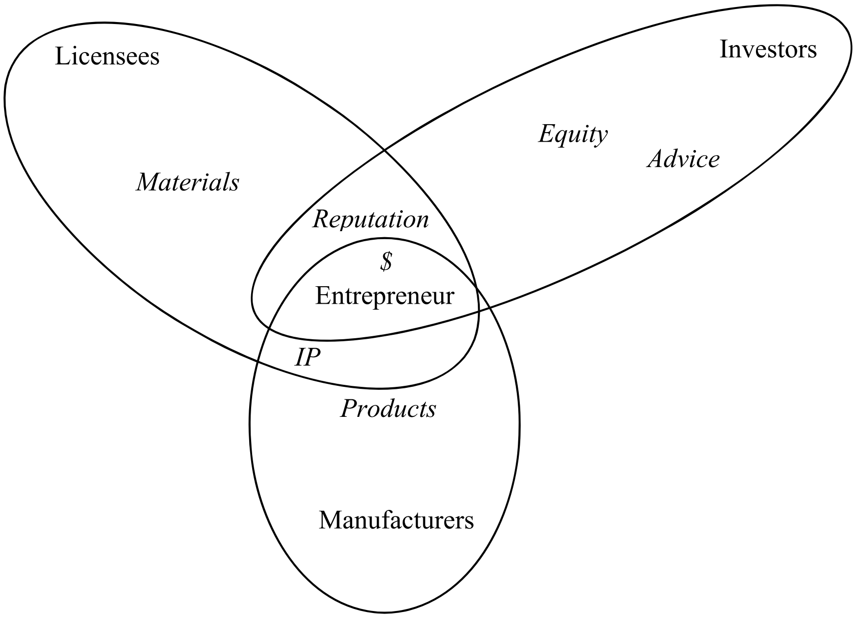
The second and third columns of Q-table (Table 9) contains two vectors that describe the complexity of a network’s structure. The first vector, the structure vector (*Q*), is a count of how many equivalence classes there are at each dimensional level. We suggest that it indicates the degree of structural complexity in network, which is the extent to which a network is comprised of multiple independent network components (i.e., the network is fragmented), somewhat comparable to the fragmentation measures used in structural network studies (Soh, 2003; Zaheer and Bell, 2005; Rosenkopf and Schilling, 2007; Koka and Prescott, 2002). Fragmentation is associated with communication failures (Gargiulo and Benassi, 2000), strategies to enhance network control (Emerson, 1962; Burt, 1992), and differences in overall network performance (Labianca and Brass, 2006; Oh, Labianca and Chung, 2006).

The second vector is the obstruction vector (Q^*), which is a variation of the structure vector, in that it counts the number of obstructions between the equivalence classes at each dimension level. It is calculated by simply subtracting the unit value 1 from the structure vector at each dimension level. Gaps in the structure are called q-holes, and are conceptually analogous to structural holes (Burt, 1992). An obstruction number of 3 (as in the initial version of the illustrative example) indicates that it would take at least 3 more interrelations to merge the 4 equivalence classes such that flows in any one part of the network configuration are at least indirectly interdependent on all other flows at the given dimension level. The higher the value in the obstruction vector, the greater the number of gaps or q-holes in the network, and thus the greater the number of independent flows at the given dimension level.

3.4.6 Comparison of Configurations

To build on the example data, let us now consider the example for the second period (2000-2002), which includes the investor providing advice related to the entrepreneur launching manufacturing subsidiaries. The data for the network in the second period, as schematically depicted in Figure 3, are visually represented by the Venn diagram in Figure 6, and tabulated in the connectivity matrix in Table 10. The Venn diagram visually describes the overlapping presence of the elements in each relationship summarized in the incidence matrix for the same data.

Figure 6: Venn diagram representation of the incidence matrix 2000-2002

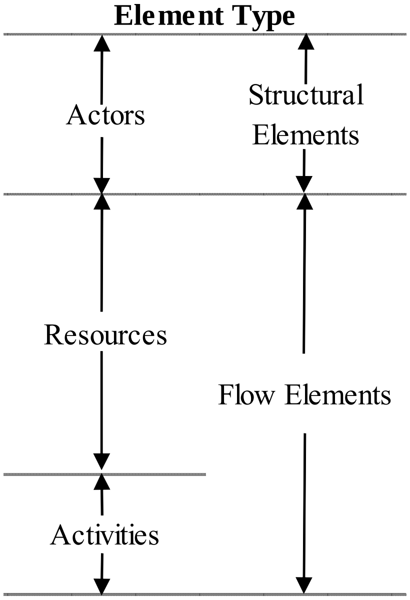


We now see the relationship with the *investors* involving exchanging *advice*. In this simplified evolution, this change is simultaneous to the addition of the *manufactures* to the network, whose relationship is described by the exchange of *cash*, *IP* and *products*. These simultaneous changes and the overlapping cash flows between the entrepreneur, investors and manufacturers, reflect the structure-flow interdependence between these actors and their related flows. Additionally, *IP* is now part of the relationships to the *licensees* and the *manufacturers*, thus increasing the multiplexity within and across relationships.

Table 10: Example incidence matrix 2000-2002

Set (by entrepreneurial function)

$$\lambda = \begin{array}{cccl} \text{Investment} & \text{Licensing} & \text{Manufacturing} & \textbf{Elements} \\ 1 & 1 & 1 & \text{entrepreneur} \\ 1 & 0 & 0 & \text{investors} \\ 0 & 1 & 0 & \text{licensees} \\ 0 & 0 & 1 & \text{manufacturers} \\ 1 & 0 & 0 & \text{equity} \\ 1 & 1 & 1 & \text{cash} \\ 1 & 1 & 0 & \text{reputation} \\ 0 & 1 & 1 & \text{IP} \\ 0 & 1 & 0 & \text{materials} \\ 0 & 0 & 1 & \text{products} \\ 1 & 0 & 0 & \text{advice} \\ 1 & 0 & 0 & \text{financing} \\ 0 & 1 & 0 & \text{licensing} \\ 0 & 0 & 1 & \text{manufacturing} \end{array}$$



Because the *entrepreneur* and *cash* elements are present across all three sets in the incidence matrix, we see their dimension level increase to 2 in the new connectivity matrix (Table 11). While the reputation element remains present in two sets, the IP element is now also present across two sets, so they are both of dimension level 1. These increases in dimension levels and the increasing complexity of interrelations to other elements within and across sets are summarized in increasingly hierarchical equivalence classes in the new Q-table (Table 12).

Table 11: Example connectivity matrix 2000-2002

entrepreneur	investors	licensees	manufacturers	equity	cash	reputation	IP	materials	products	advice	financing	licensing	manufacturing	
2	0	0	0	0	2	1	1	0	0	0	0	0	0	entrepreneur
	0	-	-	0	0	0	-	-	-	0	0	-	-	investors
		0	-	-	0	0	0	0	-	-	-	0	-	licensees
			0	-	0	-	0	-	0	-	-	-	0	manufacturers
				0	0	0	-	-	-	0	0	-	-	equity
					2	1	1	0	0	0	0	0	0	cash
						1	0	0	-	0	0	0	-	reputation
							1	0	0	-	-	0	0	IP
								0	-	-	-	0	-	materials
									0	-	-	-	0	products
										0	0	-	-	advice
											0	-	-	financing
												0	-	licensing
													0	manufacturing

Table 12: Example Q-table 2000-2002

q-level	Q	Q*	Equivalence Classes
2	1	0	{<entrepreneur, cash>}
1	1	0	{<entrepreneur, cash, reputation>, <entrepreneur, cash, IP>}
0	1	0	{<entrepreneur, investors, equity, cash, reputation, advice, financing>, <entrepreneur, licensees, cash, reputation, IP, materials, licensing>, <entrepreneur, manufacturers, cash, IP, products, manufacturing>}

The single equivalence class at dimension level 0 in the Q-table for the second period shows that the flows in all three relationships interact. The elements in the equivalence classes at dimension level 1 and 2 reveal specifically which elements are the ones that cause the interactions. While the *entrepreneur* and *cash* are common to all three relationships, and thus essential to how the network configuration is structured and operates, the network can be partitioned by whether the relationships involve *IP* or *reputation*. In comparison, in the first period, *reputation* was a central element (present at the highest dimension level possible), and *IP* was only peripherally involved, and *manufacturers* and their *products* were not present.

Overall, the Q-tables provide a mix of qualitative and quantitative outputs that describe which elements are more or less central to the configuration (e.g., at which dimension level they are part of an equivalence class), as well as specifically which other elements they are interrelated to in a hierarchical manner. The interrelations between elements requires consideration as to which elements are structural elements and which are flow elements to interpret how complex the structures and flows are at each possible dimension level. For example, when comparing the two Q-tables, there is an increase in the structural complexity through the addition of the *manufacturers* element. This increase in structural complexity is associated with an increase in flow complexity within the relationship to the *investors* (occurring simultaneously to the addition of the *advice* element), as well as an increase in the overall flow complexity for the network, as seen by the increase in dimension levels of the cash and IP elements.

We have demonstrated the method using a simplified example, to focus on the mechanics of the methodology and avoid becoming distracted with interpretation of the results and the temptation of subsequent theory development. In the following sections, we provide more general guidance regarding how the method can be used to develop theory regarding structure-flow interdependence, multiplexity and evolution.

3.5 Discussion: Application Issues and Theory Development Opportunities

The main purpose of creating the matrices and tables described above is to generate descriptions and measures of structure-flow interdependence for inductively developing new theory about how network configurations vary and influence entrepreneurial outcomes. In particular, the connectivity matrix (see Section 3.4.3), the Q-table (see Section 3.4.4), and the structure vector (see Section 3.4.5) provide data for describing and comparing network configurations, as commenced in Section 3.4.6. The remainder of this section discusses the application of the Q-analysis methodology, how to contrast and compare results, and the theory development opportunities the methodology provides.

First, we offer advice for gathering data and interpreting results for the purposes of inductive theory building. In terms of data collection, Atkin (1975, p. 4-5) states that the method requires researchers to "look for comprehensive data in the first place and then examine the (mathematical) relations which are inherent therein in the second place." To this regard, the substantive knowledge and theoretical interests of the researcher will guide which sets of networks to sample across and which elements to include in those sets. If starting with qualitative data, the sets can be based on separate stories, press releases or similar texts, and the elements can be drawn out using open and closed coding techniques (Corbin and Strauss, 1990; Ryan and Bernard, 2003). For inter-coder reliability, coding schemes may be compared among researchers on the same project. A more quantitative approach would be to use name-generator surveys, common in social network analysis methods (Wasserman and Faust, 1994), in which a different set of names is generated for each type of flow (see: Lazega and Pattison, 1999 for an example of layering of 3 types of communication within a corporation).

Regarding sample sizes, Q-analysis may range from a descriptive study of only one case with a limited number of sets of only a few elements, as with our example, to comparing vast numbers of cases, sets and elements, limited only by the ability to collect data, write an algorithm, and have the computational power to produce the matrices and tables. As with most methods, more data can produce richer insights, but can also become a methodological burden to analyze and interpret the results. Instead of analyzing each case separately, large data sets can be segregated into groups of similar cases, which might then be amenable for qualitative comparative analyses (Ragin, 1987; Fiss, 2007).

The development of theory using set-theory methods such as Q-analysis depends on interpretation of the results combined with substantive knowledge of the phenomenon at hand (Fiss, 2007). The basics of interpreting the Q-tables involves taking note of (1) which elements occur at which dimension level, and (2) the dimension levels at which elements are interrelated and thus grouped into equivalence classes. To make Q-tables more comparable across sets of cases, the dimension levels can be expressed in terms of a percentage of the maximum dimension level (Gaspar and Gould, 1981). Differences between cases and differences between what might be expected based on substantive knowledge provide the basis for questioning existing and developing new theories. In the examples provided here (based on data from the CDT case), the investor's role beyond providing cash was brought to light, and might form the basis of new theories regarding investor management.

More generally, the model and method described in this paper present researchers with three opportunities for theory development central to jointly studying structures and flows. We now discuss these opportunities, citing benchmark studies that used Q-analysis in fields outside of entrepreneurial network research. First, we see a key opportunity in the identification of salient network configurations based on both structural and flow conditions. An exemplary Q-analysis study for reference here is the investigation of the configurations of farmers' businesses and their advice seeking network among other farmers (Gaspar and Gould, 1981). The authors begin with a Q-analysis on the entire aggregated dataset and a typical example case study in order to better grasp the general phenomenon at hand. This was followed by Q-analysis of two groups of cases selected according to the age of the farmer (top and bottom quartile). The differences in the configurations highlight the differences in business models between older farmers, who had been around long enough to own land, raise any type of animal, and could afford to plant longer term crops like trees, versus the business models of younger farmers who were restricted to leasing parcels, and thus focused on raising a limited diversity of animals and shorter term crops. This led to theory about land ownership effects and policy implications about capital spending and promoting the use of new irrigation systems in the region. A similar technique could be used to identify promising entrepreneurial network configurations for a range of external conditions and strategic goals.

Second, the area of network multiplexity, while offering exciting opportunities for entrepreneurial network research, remains under–researched in all fields and lacks empirical examples. In his example of 12 executive managers, Atkin (1980) argues that partially overlapping responsibilities of managers can complicate the process of making capital allocation decisions. When multiple managers are interrelated via their responsibilities, capital allocation across managers to fund initiatives for which they are responsible may create conflicts or synergies if one initiative is funded at the expense of the other, and if their outcomes are interdependent. Responsibilities, however, are not flows; they only imply flows. The lack of empirical work in the area of entrepreneurial network multiplexity is one of the reasons we selected the example used here, to demonstrate how the multiple flows the investors are involved in affects other relationships and creates network multiplexity. If performance data were available for multiple networks, one might be able to investigate how the overall performance of the network may be contingent on overlapping involvement of specific actors across specific flows. Depending on the context (e.g., industry), the overlapping involvement may be a source of conflict and inhibit performance, or be a source of synergies and increase performance. By comparing and contrasting case studies within and across contexts, such analysis may identify high and low performance configurations and reveal strategies by which the entrepreneur can manage conflicts or synergies across actors in their network (i.e., how they can manage network multiplexity).

Lastly, we see theory development opportunities in the area of entrepreneurial network evolution. Q-analysis has been applied to study the evolution of social network structures; for example, friendship networks of social scientists (Freeman, 1980) and re-analysis of the Deep South women's group data (Doreian, 1979, 1986). In both cases, the research was conducted to see how the social structure changes over time and is influenced by events, without differentiating between relationship types or flows. Such research could be extended to include multiple flows through our proposed model by being more explicit about the resources and activities involved in each relationship or event (assuming they vary across events). Such an extension would give new relationships (through subsequent events) more meaning, and provide greater clarity about how and when old relationships fade from the network and new ones are formed, depending on the current network configuration. As shown in our CDT example, relationships involving one flow may impact the formation or termination of other relationships involving other flows. By extension, such network evolution research may reveal structural and flow conditions that trigger the addition or removal of relationships, and their impact on the rest of the network.

As network configurations evolve, configuration theory can account for interrelations between specific structural and flow elements, without assuming or imposing a linear sequence of evolutionary steps or a globally optimal final outcome. There is a common limitation with manipulating Q-analysis for longitudinal research, in that it is a descriptive and cross-sectional method, not designed for longitudinal purposes. However, as with all other cross-sectional methods, it can be used to conduct inter-temporal analyses which can then be compared to infer causal linkages over time (Doreian, 1979, 1986).

Regarding exploration of the diversity of evolutionary paths, these are incorporated in the concept of equifinality (Doty, Glick and Huber, 1993; Gresov and Drazin, 1997), which posits that the same configuration can evolve from different initial conditions and by different paths of development, and that multiple configurations may be equally effective (though not necessarily all performing at a globally maximal performance). Analysis of equifinality supported by the Q-analysis methodology can thus challenge more linear or sequential evolutionary paths and processes in entrepreneurial network research (Hite and Hesterly, 2001; Schutjens and Stam, 2003; Yli-Renko and Autio, 1998). One caveat with using the concept of equifinality is that effectiveness is measured in different ways and the same effectiveness measures are not necessarily of equal importance across all firms (Galunic and Eisenhardt, 1994). For example, Gresov and Drazin (1997) explain that, when faced with the twin demands of product innovation and production efficiency, younger entrepreneurial firms focus on product innovation while more mature firms struggle to reconcile both. Overall, configuration theory maintains that configurations will vary in their composition, their initial conditions and evolutionary paths, and that multiple configurations may achieve the same level of effectiveness (assuming the effectiveness or performance measures are comparable across configurations). Each of these aspects can be explored in greater detail using Q-analysis.

3.6 Conclusion

Network-based studies are an important part of entrepreneurship research. However, we argue that prior research on these networks has been limited by structure-only perspectives or flow-only perspectives, which individually are unable to analyze the full complexity of a network configuration. In response, we introduce a conceptual model and method for describing and measuring how the structural elements and flow elements of an entrepreneurial network are interrelated (using partially overlapping sets of actors, activities and resources) to define the form and function of an entrepreneurial network configuration. We posit that an integrated approach which jointly considers network structures and flows is central to the configuration approach, and the task of studying network diversity, network multiplexity and network evolution.

3.7 References

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CHAPTER 4:

A TYPOLOGY OF ENTREPRENEURIAL NETWORK CONFIGURATIONS: INTEGRATING THE COMPLEXITY OF NETWORK STRUCTURES AND FLOWS

A combined version of Chapters 3 and 4 was reviewed and rejected at the Journal of Business Venturing with the recommendation to separate the papers and resubmit both to the same journal. The formatting of the references complies with the submission requirements for the Journal of Business Venturing. A subsequent version of the combined paper won the Best Paper award for the 4th European Conference on Technology Management in Glasgow, Scotland, September 8, 2009 under co-authorship of Martin J. Bliemel, Ian P. McCarthy, and Elicia M. A. Maine. A subsequent version of this paper was published in the Regional Frontiers of Entrepreneurship research 2010, proceedings for the 7th Annual AGSE Research Exchange, University of the Sunshine Coast, Queensland, Australia (ISBN: 978-0-9803328-6-5) under co-authorship of Martin J. Bliemel, Ian P. McCarthy, and Elicia M. A. Maine.

Keywords: entrepreneurial networks, configuration theory, structures, flows, typology, capabilities

Abstract

There is significant literature on how entrepreneurs' networks vary in terms of their structural *or* flow properties. In this paper, we follow configuration theory, and argue that the characteristics and evolution of entrepreneurial networks is best studied by considering variations in both the structural *and* flow properties. We develop a typology that examines how variations in the structural complexity and the flow complexity of an entrepreneurial network combine to define four network configuration archetypes. We

then explain how the conditions of each network configuration have important implications for how entrepreneurs broker and coordinate their networks.

4.1 Introduction

Networks are essential to entrepreneurs for establishing firms (Birley, 1985; Aldrich, Rosen and Woodward, 1987) and for overcoming liabilities of newness and smallness (Stinchcombe, 1965; Stuart, Hoang and Hybels, 1999). In reviewing the entrepreneurial network literature, we find that existing studies largely concentrate on only one of the two dominant network perspectives – structural and flow (Bliemel, McCarthy and Maine, 2009). The structural perspective focuses on the diversity of actors in the entrepreneur's network (e.g., Baum, Calabrese and Silverman, 2000; Lechner Dowling and Welpe, 2006; Rothaermel and Deeds, 2006), or on patterns of interconnections between actors (e.g., Soh, 2003; Zaheer and Bell, 2005; Al-Laham and Souitaris, 2008). This perspective, however, omits details of individual relationships and reduces them to uni-dimensional measures. The flow perspective examines the exchange and transformation of resources and the interactions of such flows within individual relationships (e.g., Larson and Starr, 1993; Yli-Renko, Sapienza and Hay, 2001). This perspective treats relationships as multi-dimensional (Hite, 2003) or "multiplex" (Hoang and Antoncic, 2003), but omits the structural context in which they exist.

Following configuration theory (Meyer, Tsui, and Hinings, 1993; Miller, 1996; Short, Payne and Ketchen, 2008), we argue that structures and flows of entrepreneurial networks are interdependent properties. This interdependence is important because (i) it is central to the configuration theory view, in which system properties "coalesce or configure into a manageable number of common, predicatively useful types" (Miller, 1986: 236); (ii) it helps us understand network multiplexity (i.e., how flows interact within and across relationships) and (iii) and the interaction between these properties affect how networks evolve.

Given this importance (and relative neglect) of the interdependence of network structures and flows, we develop a typology of four entrepreneurial network configurations which we call *clusters*, *cliques*, *communities*, and *crowds*. The dimensions of the typology are high and low conditions of network structural complexity and network flow complexity. We define structural complexity as the extent to which actors in a network are interconnected: high structural complexity being when all of the actors are interconnected, and low structural complexity when only a few of the actors in the network are interconnected. We define network flow complexity as the extent to which flows in a network interact: high flow complexity being when many flows in the network (within and across relationships) interact, and low flow complexity when few flows are relatively simple and independent. The degree to which structures and flows are interdependent varies with the level of structural complexity and flow complexity, and is explored for each configuration in the typology.

We argue that these conditions of network configuration in our typology will benefit entrepreneurs with different network management capabilities. Following the literature on capabilities (Grant, 1996; Eisenhardt and Martin, 2000), we define a network management capability as the ability to leverage or reorganize network resources so as to generate opportunities and capture value for the venture. More specifically, we focus on two types of network management capability: a *brokering* capability that is suited to structural complexity conditions, and a *coordination* capability that is suited to flow complexity conditions.

We present our arguments in three sections. First, we review the literature related to how entrepreneurial networks vary in terms of their structures or flows, focusing on the opportunities that this work presents for taking a configuration approach that integrates both structures and flows. Second, we present our typology by defining its dimensions – network structural complexity and network flow complexity – and describe how high-low conditions of these dimensions combine to define four different network configurations. We then explore how the conditions of each network configuration are suited to related network management capabilities (network brokering and network coordination) and provide illustrative examples of entrepreneurial networks that typify each configuration. Third, we conclude with a summary of our contributions and a discussion of the future research opportunities afforded by our typology.

4.2 Theoretical Background

Studies on entrepreneurial networks, like those on social or inter-organizational networks, have tended to focus on either structures or flows, rather than both (Borgatti and Foster, 2003; Hoang and Antoncic, 2003; Bliemel and Maine, 2008; Jack, 2010). As a result of not addressing both network structures and network flows, findings also do not address their interdependence, thus providing only a limited image of what networks are, how they vary, and how entrepreneurs use and develop them (Bliemel and Maine, 2008; Jack, 2010, Slotte-Kock and Coviello, 2010). Prior conceptualizations in the literature describe networks as “patterns” (Greve and Salaff, 2003) or “constellations” (Lorenzoni and Ornati, 1988; Shepherd, 1991) and take a very sequential approach to how they mature from one pattern or constellation to another (see also Yli-Renko and Autio, 1998 and Hite and Hesterly, 2001 for further examples of sequential development).

However, despite this interest in entrepreneurial networks, their diversity and evolution, and the fact that a number of studies have used configuration theory in other areas of entrepreneurship (Bantel, 1998; Korunka, Frank, Lueger and Mugier, 2003; Wiklund and Shepherd, 2005), research on entrepreneurial networks has largely overlooked configuration theory. The few studies that employ configuration theory to examine entrepreneurial networks treat their structures and flows separately and resort to cluster analysis (Ostgaard and Birley, 1994; Bensaou and Venkatraman, 1995), which does not explicitly consider interrelations of multiple components that form the configuration. Our paper is in response to several reviews that call for more comprehensive and holistic examinations of entrepreneurial networks and yet only make casual reference to networks as configurations without formally acknowledging configuration theory (e.g., Hoang and Antoncic, 2003; Brass, Galaskiewicz, Greve and Tsai, 2004; Pittaway, Robertson, Munir, Denyer and Neely, 2004).

Configuration theory is based on the premise that the different properties of organizational systems coalesce or configure. Thus, different organizational configurations “take their meaning from the whole and cannot be understood in isolation” (Meyer, Tsui and Hinings, 1993; p. 1178). We argue that, in terms of studying entrepreneurial networks, a configuration approach would involve understanding how variations in the structural and flow properties of network combine to define a variety of coherent and viable network configurations. The interdependence of structures and flows is most apparent at the relationship level, where flows are inherently dependent on the actors involved in exchanging or transforming them, and each actor's participation in the network is defined by the flows in which they are involved. Structure and flow interdependence can also occur at the network level and vary according to the extent to which a relationship is dependent on the rest of the network, and vice-versa. For instance, "if a particular component performs its role poorly or somehow takes unfair advantage of another component, then it can be removed from the network [..] However, removal of a component means that the [entrepreneur] must find a replacement part or encourage one of the remaining components to perform the missing function" (Miles and Snow, 1986, p. 65-66).

As argued in a related theory-method paper (Bliemel, McCarthy and Maine, 2009), we suggest studying the diversity of entrepreneurial networks is important for at least three reasons. First, examining the interdependence of network structures and network flows is central to the configuration approach, which advocates understanding organizations as "clusters of interconnected structures and practices" (Fiss, 2007, p. 1180). This facilitates the identification of more holistic, coherent and realistic images of networks (Meyer, Tsui, and Hinings, 1993, Snow, Miles and Miles, 2005), instead of assuming they consist of independent properties (e.g., structures and flows) or their elements (e.g., actors, resources and activities). Second, an integrated approach helps us extend multiplexity, which is "the layering of different types of exchange within the same relationship" (Hoang and Antoncic, 2003, p. 169), to a network of relationships, i.e., how flows in one relationship are interdependent on those in another. Third, jointly studying structures and flows is important when investigating how networks evolve, since a new relationship can provide a new flow that is interdependent on other flows, and changes in flows can impact which relationships the entrepreneur decides to build, maintain or terminate (Miles and Snow, 1986; Slotte-Kock and Coviello, 2010). Thus interdependence will shape the evolution of entrepreneurial network configurations over time.

4.3 A Typology of Entrepreneurial Network Configurations

In this section we construct our typology, first by defining its dimensions, network structural complexity and network flow complexity, and then by describing two network management capabilities that are suited to these dimensions. For each configuration we provide illustrative examples of real networks and explore implications for structure-flow interdependence and network evolution.

4.3.1 Structural Complexity and Flow Complexity Dimensions

The structural complexity of networks is the extent to which actors are interconnected in the network, and can be measured in terms of network density (Gnyawali and Madhavan, 2001) or closure (Coleman, 1988). High structural complexity characterizes entrepreneurial networks in which most or all of the actors are interconnected, such as in cliques (Luce and Perry, 1949; Knoke and Kuklinski, 1982). When faced with high structural complexity, the entrepreneur needs to consider how each additional connection or actor may affect the extant interconnections between actors, and how to leverage these interconnections. High structural complexity is associated with greater support and greater inertia (Aldrich, Rosen and Woodward, 1977; Dubini and Aldrich, 1991), but also with more redundancy (Burt, 1992; Hoffmann, 2007). Low structural complexity characterizes entrepreneurial networks in which there are few if any interconnections between actors in the network, such as core-periphery (Kogut, 2000), hub-and-spoke (Markusen, 1996), or star or wheel (Freeman, 1979) structures. Such low structural complexity networks are fragmented, in that, without the entrepreneur, the remaining actors would be completely disconnected. With such a network condition, the entrepreneur needs to consider how the disconnections or structural holes (Burt, 1992) between actors can be leveraged. Low structural complexity is associated with preferential access to more diverse resources (Burt, 1992; Hoffmann, 2007), but also with higher risks if key relationships fail (Larson, 1992; Baum, Calabrese and Silverman, 2000).

Network flow complexity is the extent to which flows in the network interact[1]. It can be measured by the average level of multiplexity (i.e., a collection of exchanges) within relationships in the network (Beckman, Haunschild and Phillips, 2004; Hoang and Antoncic 2003; Wasserman and Faust 1994). High flow complexity characterizes entrepreneurial networks in which many of the flows in the network interact (within and across relationships), and is typified by networks which involve high degrees of inter-organizational interdependence. Structurally, these networks can range in complexity from few sparse strategic alliances as seen in the biotechnology industry (Baum, Calabese and Silverman, 2000), through to the densely interconnected alliances seen in the guided missile industry (Rosenkopf and Schilling, 2007). High flow complexity is associated with strategic alliances or complex relationships that confer greater strategic

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[1] Flow complexity is the same as multiplexity at the network level, or network multiplexity (Bliemel, McCarthy and Maine, 2009). In this paper we use the flow complexity label for consistency in technical terms across both axes of the typology.

advantage and unlock synergies (Larson, 1991; Larson and Starr, 1993). In contrast, networks with low flow complexity have relatively few flows that interact. Because the flows are largely independent, they can simply be aggregated and redistributed, without much regard for conflicts of interest between those involved in the flows and without the need for complex governance mechanisms. This is the case for wholesaler entrepreneurs, as for example specialty food importers, who source goods from multiple suppliers and redistribute them to multiple retailers for resale purposes, none of which are essential (Olsen and Ellram, 1997; Brüderl and Preisendörfer, 1998; Hoffmann, 2007), or for entrepreneurs who liberally build their network in pursuit of new ideas (Dubini and Aldrich, 1991; Kelley, Peters and O'Connor, 2009). Low flow complexity is associated with arms-length relationships that are relatively easy to manage (Williamson, 1981; Håkansson and Lind, 2004).

4.3.2 Network Management Capabilities Related to the Typology Dimensions

We define a network management capability as the ability to leverage or reorganize network resources so as to generate opportunities and capture value for the venture. A network management capability can be viewed a dynamic capability that entrepreneurs use "to enhance existing resource configurations in the pursuit of long-term competitive advantage, [and] to build new resource configurations in the pursuit of temporary advantages" (Eisenhardt and Martin, 2000, p. 1106). It is dynamic because it resides at the highest level of the hierarchy of capabilities (Grant, 1996) and is used to restructure, reorganize and reconfigure how other functional capabilities, competencies and resources relate to each other. Maintaining our focus on the affects of network structural complexity *and* network flow complexity, we now explain types of network management capabilities suited to each dimension.

The network management capability we suggest is suited to managing variations in structural complexity is *brokering*. We define this capability as the ability to perceive and manipulate disconnections in the social structure, and benefit from maintaining, or closing them. This network management capability is focused on the interconnections between actors, and is congruent with alliance management capabilities (Hoffmann, 2007; Schreiner, Kale and Corsten, 2009). However, our definition is more specific regarding the network structure, than such capabilities, in that the brokering capability includes manipulating the interconnections between actors in the network, and draws more explicitly on network structure research (Burt, 1992; Kogut, 2000; Hargadon, 2002). In contrast, alliance management capabilities are limited to the portfolio of relationships between the entrepreneur and other actors, but not the interrelationships between other actors. Furthermore, we suggest that low and high conditions of structural complexity require entrepreneurs to engage in what we call *exploitive brokering* and *explorative brokering,* respectively.

We define exploitive brokering as the ability to perceive and take advantage of opportunities due to a lack of interconnections between actors (i.e., many structural holes). It is a network management capability used by a *tertius gaudens*, the “third who enjoys” (Simmel, 1950; Burt, 1992), to leverage their intermediary position between others and channel the flow to their own benefit (Burt, 1992; Walker, Kogut and Shan, 1997). This form of brokering reflects a process by which the entrepreneur makes a choice and selects from whom to receive flows and to whom to redistribute them (March, 1991). In doing so, the entrepreneur benefits from a lack of connections between these actors, and thus strives to maintain low structural complexity. The benefits to exploitation are relatively certain with respect to their values, variability and timing (March, 1991), and depend on there being an opportunity to appropriate value or collect rents in the process of brokering flows between the disconnected actors (Burt, 1992; Kogut, 2000). Exploitive brokering is most common in situations resembling zero-sum games in which one person's gain is another's loss (Kogut, 2000).

In contrast, we define explorative brokering as the ability to perceive and take advantage of opportunities due to interconnections between actors. It is a network management capability used by a *tertius iungens*, the "third who joins" (Obstfeld, 2005), to leverage and create new connections between actors to generate opportunities and explore new combinations of resources (Hargadon and Sutton, 1997; Obstfeld, 2005; Kelley, Peters and O'Connor, 2009). This form of brokering involves a process by which the entrepreneur searches and experiments with new combinations of flows (March, 1991). In doing so, the entrepreneur may benefit from an abundance of interconnections between actors and their associated resources (Barney, 1991, 2002; Reed and DeFillippi, 1990; Black and Boal, 1994), and thus strives to maintain high structural complexity. However, the benefits to explorative brokering will be more variable than those due to exploitive brokering (March, 1991), and follow a more iterative process of introducing new interconnections between actors (i.e., maintaining high structural complexity).

In terms of network flow complexity, we suggest that a network management capability suited to this dimension is network *coordination,* which we define as the ability to manage interactions of flows and multiplexity within or across relationships.

This extends previous definitions of coordination capabilities that focus on managing interacting flows within relationships (e.g., Walter, Auer and Ritter, 2006; Schreiner, Kale and Corsten, 2009). Coordination can be broken down into multiple components, such as synchronizing, planning and controlling, and is correlated to relational skills, partner knowledge, and internal communication (Walter, Auer and Ritter, 2006).

In terms of a network coordination capability that is suited to low and high levels of flow complexity we propose network coordination by *standardization* and network coordination by *mutual adjustment,* respectively. Network coordination by standardization is defined here as the ability to minimize the interactions of flows and the level of interdependence by routinizing the relationship (Ritter, Wilkinson and Johnston, 2004) and establishing simple terms of exchange. Examples of such routinization are specifying the ground rules and terms of exchange between actors (Larson, 1991, 1992; Gulati and Singh, 1998) and minimizing the information exchange required (Dyer and Singh, 1998). Coordination by standardization can also be reflected in the form of standardized resources. For example, standardization of products makes them "easier to handle" (Håkansson and Lind, 2004). When the resources are standardized, "[their flow] will [occur] independently of each other in any specific sense, but they will be highly dependent on their common standardized product" (Håkansson and Lind, 2004, p. 53). This form of coordination reflects a process by which the entrepreneur controls monitoring and governance costs, and increases efficiencies, as for example by providing templated contracts and simple terms of exchange. In standardizing the flows and keeping them independent, the entrepreneur benefits from a lack of interaction between them, and thus strives to maintain the low flow complexity.

In high flow complexity conditions, standardization would sacrifice value creation opportunities and degrade the performance of the network, whereas mutual adjustment generates synergies which increase the performance of the network. Coordination by mutual adjustment applies to situations where there are more interactions between flows, causing greater interdependence of the actors involved in those flows. In other words, "more complex forms of interdependence require greater mutual adaptation between agents" (Thompson, 1967: 55). This form of coordination reflects a process by which the entrepreneur generates synergies (Dubois and Håkansson, 1997; Harrison, Hitt, Hoskisson and Ireland, 2001), which result in a more integrated system (Lorenzoni and Lipparini, 1999). These synergies are unlocked by the entrepreneur convincing the actors responsible for the synergizing flows to mutually adjust. An increase in synergies across flows results in greater interaction between them, and thus higher flow complexity. Yet high flow complexity causes the coordination requirements to increase, due to the "difficulties associated with decomposing tasks and specifying precise division of labor" (Gulati and Singh, 1998, p. 784), and thus superior coordination capabilities are appropriate with which to foster mutual agreement about roles and responsibilities. Frequent seminars and inter-company meetings may provide a forum for such coordination through mutual adjustment (Lorenzoni and Lipparini, 1999).

4.4 A Typology of Entrepreneurial Network Configurations

By combining high-low variations of structural complexity and flow complexity, we present a typology of four entrepreneurial network configurations, which we call *clusters*, *cliques*, *communities*, and *crowds*. These configurations are summarized in Figure 7, described in detail below and illustrated using examples. For each configuration, we identify which combination of brokering and coordination capabilities are suited to it.

Figure 7: Typology of entrepreneurial network configurations

Network Structural Complexity

	Low	High
High	**Crowd** Conditions Dense network of actors with flows that are simple and independent (e.g., initial networks formed by first-time entrepreneurs) Capabilities Explorative brokering and coordination by standardization	**Clique** Conditions Dense network of actors with flows that are multiplex and interdependent (e.g., packaging machinery manufacturers) Capabilities Explorative brokering and coordination by mutual adjustment
Low	**Cluster** Conditions Fragmented network of actors with flows that are simple and independent (e.g., software and firms) Capabilities Exploitive brokering and coordination by standardization	**Community** Conditions Fragmented network of actors with flows that are multiplex and interdependent (e.g., InnovationXchange and CDT) Capabilities Exploitive brokering and coordination by mutual adjustment

Network Flow Complexity

4.4.1 Cluster Network Configuration

The first network configuration we consider is described by low structural complexity and low flow complexity conditions, and is located in the bottom-left quadrant of the typology. We call this the *cluster network configuration* because the actors are lumped into clusters around the entrepreneur. Each cluster contains similar actors according to the type of flows in which they are involved, but are otherwise not directly connected to each other. In this configuration, the entrepreneur coordinates flows that are independent of each other, and brokers these flows between actors who are otherwise disconnected. This means that the entrepreneur is in the position to aggregate and redistribute flows without further need for consideration of complementarities or conflicts between them. For this configuration, the structure-flow independence is moderately low. Should an actor and their associated flow exit the network, then the entrepreneur may need to replace both simultaneously, or else suffer only a marginal impact on the flows throughout the rest of the network. Changes in the cluster configuration are likely to be incremental by adding new actors and their flows in a standardized manner, with an objective of achieving economies of scale or scope. More drastic changes may occur if flows become more complex, or if a new flow becomes interdependent on existing flows, thus creating a source of synergies or conflict.

The network management capabilities suited to the network conditions of the cluster network configuration are exploitive brokering and standardizing. Because entrepreneurs with the cluster network configuration benefit from keeping others apart and by keeping each relationship efficient, they may seek economies of scope by diversifying the type of actors to which they are connected, or seek economies of scale by offering their standardized terms of agreement to more actors similar to those already in their network. Such entrepreneurs act as hubs and add little value to the flows, leaving them largely unchanged. Failure to maintain their position and keep others apart may result in the entrepreneurs being disintermediated, and others discovering their sources of novel flows, thus losing their competitive advantage (Burt, 1992, 2004; Zaheer and Bell, 2005).

An entrepreneur whose network typifies this configuration is a software company. For example, in the software industry, evidence suggests that it is better to have relationships with many (potentially competing) firms, than it is to become overly reliant on fewer partners, even though they may individually be substantial channel partners (Lavie, 2007). In order to avoid conflicts or favouritism, each of the partners is provided essentially the same standard terms of engagement. Because these terms have been standardized, maintaining each relationship requires fewer managerial resources, which means the entrepreneur can increase the number of relationships and achieve economies of scale. More specifically, Lavie (2007) gives the example that game developers may try to balance a distribution relationship with Sony, with similar relationships with Microsoft and Nintendo, resulting in diminished bargaining power for Sony and a wider market reach for the game developers. The network conditions for the cluster configuration thus indicate that there are advantages to selecting whom to form relationships with in context of other (potentially competing) relationships, and advantages to keeping the relationships equitable.

4.4.2 Clique Network Configuration

The second network configuration is described by high structural complexity and high flow complexity conditions, and is located in the top-right quadrant of the typology. We call this configuration the *clique network configuration* because of its agreement with other definitions of cliques (Luce and Perry, 1949; Knoke and Kuklinski, 1982), i.e., it consists of close-knit actors whose multiple reciprocal interdependencies result in common interests, views and patterns of behaviour, which collectively enable or constrain their performance. In this configuration, the entrepreneur brokers relationships between actors, thereby maintaining or increasing their interconnection, and explores ways in which their flows can be combined to unlock synergies, thereby maintaining or increasing flow interactions.

Of all the configurations, this is the one with the highest level of structure-flow interdependence. Changes in flows in the clique configuration may be gradual while the entrepreneur fosters consensus between all the actors in order to resolve all the related flow interactions (Jack and Anderson, 2002). Such consensual change may be accelerated if there is a culture of collective action that promotes mutual adjustment (Uzzi, 1996; Lorenzoni and Lipparini, 1999; Lipparini and Sobrero, 1994). Structural changes in this configuration such as removing or adding an actor and their relationships are likely to trigger quantum shifts (Miller and Friesen, 1984) or multiple punctuated equilibria (Gersick, 1991) in how the network operates.

The network management capabilities suited to the network conditions of the clique network configuration are explorative brokering and mutual adjustment, because the high level of interconnectedness between actors and the high level of interaction of flows provide the conditions for exploring opportunities in combination with unlocking synergies. This means that the entrepreneur is in the position to facilitate exploring novel permutations and combinations of actors and their available flows, by leading everyone towards a greater, synergistic outcome. Because high flow complexity is “reciprocal” in nature (Thompson, 1967; Larsson and Bowen, 1989) and a change in one flow could impose changes in other flows, the entrepreneur needs to foster mutual adjustment of all actors involved (Dubois and Håkansson, 1997) in order to avoid conflicts and to unlock synergies across interacting flows. At the extreme, the clique configuration entails every actor being involved in every flow, which can be very dysfunctional if actions are always vetoed, or very empowering if consensus is reached.

This network configuration is exemplified by the networks of manufacturing entrepreneurs in areas such as packaging machinery or textiles. These entrepreneurs typically have networks of tightly interconnected actors, who all look out for each others' interests, enabling many smaller firms to act together to bid on large projects and corner niche markets (Uzzi, 1996; Lorenzoni and Lipparini, 1999; Lipparini and Sobrero, 1994). By outsourcing functional capabilities at which they were not competitive, each entrepreneur in the network could focus on becoming more competitive on fewer capabilities. In order to provide completely assembled products, the entrepreneurs increased the structural complexity of the network, with some firms being involved multiple times along the production sequence. Simultaneously to restructuring the network, the entrepreneurs increased the complexity of the flows via "early sharing of critical information [and] a continuous flow of technical and managerial suggestions" (Lorenzoni and Lipparini, 1999, p. 331). As a result, entrepreneurs, who formed these collaborative clique networks, were able to meet the changing requirements of their multinational customers by redefining the boundaries of the firm and renegotiating the division of labour (Lorenzoni and Lipparini, 1999).

4.4.3 Community Network Configuration

The third network configuration has low structural complexity and high flow complexity conditions, and is located in the bottom-right quadrant of our typology. We call this configuration the *community network configuration*, because its network conditions reflect those of entrepreneurs who act as their own community broker (Johannisson and Nilsson, 1989; Cromie, Birley and Callaghan, 1993), connecting local pockets of expertise and isolated professionals, as seen in communities of practice (Wenger, McDermott and Snyder, 2002). For this configuration, the structure-flow interdependence is moderately high, and depends on the degree to which the entrepreneur facilitates interaction of flows across relationships to unlock synergies. While the interdependence may be significant within a select subset of relationships, flows in one subset may be independent of flows in other relationships. Because of this high but limited level of structure-flow interdependence, changes in flows can immediately impact other flows in some, but not all relationships in the network. Thus network evolution may occur in somewhat incremental phases as subsets of relationships and flows are made interdependent or dissolved, relatively independently of flows in other subsets.

In the community network configuration, the entrepreneur manages flow interactions similar to those in the clique configuration. However, the interactions are limited to smaller subsets of actors, and the flows may only be connected through the entrepreneur. As a result, the entrepreneur is in a position to be the central administrator, can still unlock the synergies due to interaction between flows, but can manage relationships separately, and thus mitigate the risk of inter-actor conflicts spreading throughout the whole network. The high flow complexity conditions provide the basis for the entrepreneur to combine, rather than simply redistribute the flows. Overall, the capabilities suited to the community network configuration are exploitive brokering and mutual adjustment. The combination of these conditions and capabilities is likely to reward structurally efficient networks, which contain relationships to all the necessary actors, but only one or a few of each type of actor, in order to provide “access to diverse information and capabilities with minimum costs of redundancy, conflict and complexity” (Baum, Calabrese and Silverman, 2000, p. 267).

An example of an entrepreneurial firm that acts as an intermediary between potential competitors to get them to collaborate around innovative proposals is the InnovationXchange (Christopherson, Kitson and Michie, 2008). By acting under strict confidentiality with each actor, these entrepreneurs are able to broker complex and synergistic proposals across relationships and help forge mutually agreeable terms of agreement by which these synergies can be unlocked. As a result, entrepreneurs like InnovationXchange are able to exploit the disconnection between others while getting select pairs of actors to mutually adjust to each other.

Alternatively, rather than the actors being brought together by the entrepreneur, they may also avoid direct contact and license or broker their flows through the entrepreneur. An example of this is the advanced materials firm, Cambridge Display Technologies (CDT), in which the investment from Kelso and Hillman was contingent on CDT using their cash to establish manufacturing subsidiaries (Maine and Garnsey, 2006). While there was no need for the investors to interact directly with the manufacturing subsidiaries, their advice to shift from a licencing model to a manufacturing model had to be taken into consideration by CDT, who then established the subsidiaries and handled the resulting flows in materials and intellectual property. As a result, entrepreneurs like CDT manage interdependent relationships with disconnected actors that require mutual adjustment via the entrepreneur, but not directly to each other.

4.4.4 Crowd Network Configuration

The final network configuration in our typology is described by high structural complexity and low flow complexity conditions, and is located in the top-left quadrant of the typology. We refer to this as the *crowd network configuration* because its conditions characterize a network in which the various actors and flows are assembled in a relatively cohesive but chaotic mass. In this case, the entrepreneur coordinates flows that are relatively independent of each other, while brokering relationships between actors. In other words, actors and their flows in this configuration are "pulled together for a given run and then disassembled to become part of another temporary alignment" (Miles and Snow, 1992, p. 67).

Because the individual actors and their flows are relatively independent of each other, this configuration tends to be quite dynamic with new actors and flows constantly joining and leaving the network. Continuously organizing the configuration can be counter-productive and can inhibit incentives to learn routines (Baum, Calabrese and Silverman, 2000), and may ultimately be unsustainable. However, in hypercompetitive environments, this continuous "morphing" may be the only survival mechanism (Rindova and Kotha, 2001). In the short-term, "it may be more important to mobilize effort around a specific set of objectives than to worry too much about what these objectives are" (Hill and Birkenshaw, 2008, p. 441). Thus, anticipating that relationships in this network configuration have a limited lifespan, an entrepreneur may choose to spend little effort on each of the individual relationships, concentrating instead on scanning for potential future opportunities.

This is the only configuration for which change is a constant. Due to the relatively high turnover in relationships in the network, it also resembles the "evolutionary network" in Belussi and Arcangeli's (1998) typology of networks, in which they correlate different network types to the lifecycle of the firm. The structure-flow interdependence is minimal because of the high degree of redundancy of relationships. For this entrepreneur to sustain an advantage, they must hone their capability with which to ferret out the potential of each new relationship in context of the rest of the network, and possibly find a way to make the benefits last, or else struggle to survive by leaping from opportunity to opportunity. As a result of the high level of redundancy across relationships and independence of flows, the capabilities suited to the crowd network configuration are explorative brokering and standardizing. By standardizing and forging redundant relationships, the entrepreneur can mitigate the risk of hazardous relationships while exploring the benefits of each relationship and combinations of relationships without major commitments.

The combination of the conditions and capabilities in this configuration suggest alignment with a follower strategy (Brüderl and Preisendörfer, 1998), in which the entrepreneur free-rides on the R&D costs borne by a pioneer in the industry, and then imitates their product by bringing together the necessary actors. The speed with which the entrepreneur can find suppliers, customers, financers and other actors in order to imitate another leader depends on their ability to bring others together and keep the relationships simple. The downside to this strategy is that it leads to the perception that the goods or services the entrepreneur provides are a commodity (Rindova and Kotha, 2001), thus making it difficult to achieve a competitive advantage or unique selling proposition.

An example of this configuration is the embryonic network of an entrepreneur who is at the start-up stage of their venture. Such entrepreneurs must spend a significant portion of their time "[exploring and strengthening] a broad range of network relationships" in order to gain favorable access to resources (Zhao and Aram, 1995, p. 366). These entrepreneurs broker new relationships, much like events organized by trade associations (Dubini and Aldrich, 1991; Kelley, Peters and O'Connor, 2009), and are seeking that initial or next opportunity to gain at least some short-term benefit, or somehow gain from the collective output of everyone in their network (Johannisson and Nilsson, 1989). Until these entrepreneur form a sustainable strategy, they remain efficient at developing relationships to access various resources in lieu of their own (Lipparini and Sobrero, 1994), and then figure out how to reconfigure them in a unique way.

In many ways they are just trying to make sense of and create order from their turbulent environment (McKelvey, 2004). While deriving a longer term advantage from this configuration is particularly difficult due to the transient nature of actors and resources, entrepreneurs with this configuration may nonetheless be trying to increase their chances of being the right person in the right place at the right time to achieve sustained performance (Denrell, 2004, 2005) simply by attempting it first.

4.5 Discussion

In this article, we have argued that research on entrepreneurial networks has been limited by applying structure-only perspectives or flow-only perspectives, which are individually unable to capture the full complexity of network configurations. In response, we have adopted a configuration approach and have combined these two dimensions of networks (structural complexity and flow complexity), to identify four different entrepreneurial network configurations: *cluster*, *clique*, *community*, and *crowd*. For each network configuration, we have described its conditions, proposed appropriate brokering and coordination capabilities, and provided an illustrative example. Focussing on the three reasons that motivated our paper, we now discuss the theoretical and managerial implications, and point to areas for future research.

4.5.1 Implications for Research

The first and central implication of our proposed typology concerns the application of configurational thinking to entrepreneurial networks. By acknowledging that network structure and flow conditions and their interdependence can vary to define different network configurations, this presents opportunities to develop richer descriptions of how networks actually vary. This in turn provides the basis for new explanations about how these variations might be suited to specific network management capabilities. The additional implication here is that greater entrepreneurial performance for a given configuration is likely *if* the network management capabilities suited to the configuration are exercised. Ultimately, the value of our typology of network configurations rests on its ability to help researchers develop interesting and accurate predictions concerning which network management capabilities will be most effective for different combinations of structural complexity and flow complexity at different points in time.

A second implication concerns the conceptualization of flow complexity at the network level (i.e., network flow complexity). By considering both network flow complexity and network structural complexity, researchers can examine how multiple flows interact across the network. While other studies have investigated two or three flows and their interactions at the network level (e.g., Lazega and Pattison, 1999; Gargiulo and Benassi, 2000), our typology provides a basis to examine the diversity of flows and interactions involved throughout an entrepreneurial network. By capturing how flows interact within *and* across relationships, researchers could examine how changes of flows in one relationship trigger changes in flows in other relationships, an effect otherwise known as the "domino effect" (Hertz, 1998). The implication here is that, by considering more complex flows and associated causal triggers and interactions, we increase the depth of understanding of network evolution. There are, however, methodological challenges to considering flow complexity, as argued in a related theory-method paper (Bliemel, McCarthy and Maine, 2009). Thus, it is not surprising to see recent literature reviews call for a more integrated or mixed-methods approach that considers interactions of flows throughout the entire network (Jack, 2010; Slotte-Kock and Coviello, 2010), i.e., considers flow complexity at the network level.

The third implication of our research concerns how networks evolve. There are two ways in which configurations change: On the one hand, there is normal adaptive (Dess, Newport and Rasheed, 1993) or evolutionary change (Miller, 1982) in which there is change within the configuration type, and on the other hand there are transitions from one configuration to another (Dess, Newport and Rasheed, 1993) or revolutionary change (Miller, 1982). Evolutionary changes were discussed for each network configuration type in Section 4.4. Our main implication here, however, is regarding revolutionary changes from one configuration (e.g., a crowd) into a different configuration (e.g., a clique).

For configurations in general, Miller (1987) suggests that the coherence of an organizational configuration makes the configuration relatively stable and robust, and that configurations face an “adaptive lag” (Miller, 1982) before making revolutionary changes. There are at least two possible causes for revolutionary change in configurations: “imperatives” (Miller, 1987) such as major changes in the organization’s environment, structure, leadership, and strategy, and “strategic drift” (Johnson, 1988), which is when there is gradually increasing inadequacy of the configuration. It is argued that, nonetheless, both causes require non-incremental, revolutionary changes in configuration (Dess, Newport and Rasheed, 1993). Since this paper provides the ability to differentiate between various network configuration types, it would be fruitful to empirically investigate how change happens within configurations (i.e., evolutionary change) and how they transition from one configuration to another (i.e., revolutionary change), and whether change between configurations is a rapid transition process, or not. While other typologies and classifications exist regarding entrepreneurs and their social strategies and networks (Miles and Snow, 1992; Ostgaard and Birley, 1994; Belussi and Arcangeli, 1998; Hite, 2003; Lechner, Dowling and Welpe, 2006; Rosenkopf and Schilling, 2007; Zahra, Gedajlovic, Neubaum, and Shulman, 2009), evolution from one type to another remains under-researched (Hite and Hesterly, 2001; Slotte-Kock and Coviello, 2010).

While it is tempting to project a lifecycle onto the typology and forecast in which sequence of types the network evolves, it may be misleading to assume such a sequential process. Embryonic entrepreneurs and their networks may be typical for the crowd configuration and pursue a more sustainable configuration (e.g., clique), but this does not mean this sequence is the rule; the entrepreneur may also launch their venture with different initial network conditions. For example, it may well be that they realize the constraints of their current clique network and seek to extract themselves from this initial network while launching their venture. Nonetheless, we can use the two distinct dimensions that comprise the typology to argue how changes along either (or both) axis may occur and transitions between network configuration types may occur.

For example, let us consider one of these embryonic entrepreneurs with a crowd network configuration. Due to the high level of structural complexity, a transition to the clique network configuration would require not just one but many of the relationships to increase in flow complexity simultaneously. This transition might occur if the entrepreneur has explored multiple simple relationships in the crowd network configuration and settled on a core group of relationships on which to build a more sustainable competitive advantage. In this case, the entrepreneur has discovered (or even created) a constellation of actors who work well together, and sees the potential of fortifying the network to unlock further synergies, possibly excluding others from joining the clique. Such a transition from crowd to clique may be celebrated by a launch event, while keeping in mind, that once mobilized as a new configuration, the process may be difficult to control if the partners have not been selected well (Johannisson and Nilsson, 1989). While there is research describing multiple processes and paths to increasing the flow complexity in individual relationships (Hite, 2005), further research is required to explore how several such changes may happen simultaneously or over a short period of time.

For comparison, let us explore a transition from the crowd to the cluster configuration, i.e., a transition due to a decrease in structural complexity, while maintaining low flow complexity. In this case, the entrepreneur may be through with exploring the potential value of (missing) interconnections between other actors, and may have discovered a pattern of disconnections between specific actor types. If the entrepreneur can exploit these disconnections by brokering resources across them, then they can begin to ignore other actor types and interconnections, and focus on scaling up the portfolio size of the different clusters they broker resources between, resulting in the cluster configuration. In comparison to the crowd-clique transition, such a crowd-cluster transition may be a more gradual process because of the ability of the entrepreneur to manage each relationship independently through standardization.

When considering cluster-community transitions, we might expect these to occur in a stepwise manner, since flow complexity increases simultaneously between pairs or small numbers of relationships. Such events may include common chicken-and-egg situations, such as when investment is required to hire senior management and investment requires presence of a senior manager. In the process, the entrepreneur may select fewer relationships to fortify and increase the flow complexity in, while abandoning other relationships from the network that were candidates for the same increase in flow complexity. The community-clique transition may also be a stepwise incremental process by which the entrepreneur expands complex bilateral relationships into multilateral relationships or alliances (Gulati, 1995; Gulati and Singh, 1998; Das and Teng, 2002).

Overall, this typology provides a foundation with which we can further investigate structure-flow interdependence, flow complexity, and network evolution. While we have focused on entrepreneurial networks, we have drawn on literature and examples from other forms of networks. Consequently, we believe this typology and many of the arguments presented here apply more broadly to inter-personal networks and inter-organizational networks. For instance, since we draw on Obstfeld (2005) and Hargadon and Sutton's (1997) work on inter-personal networks within large corporations, implications regarding the clique configuration may readily apply to such corporate networks. The extension of the typology to inter-organizational networks may be more straightforward, with the exception that the capabilities identified here may be instantiated in separate departments (Lavie, 2007), rather than individual entrepreneurs.

4.5.2 Implications for Entrepreneurial Practice

This typology has implications for independent and corporate entrepreneurs. The typology is an instrument with which the entrepreneur can become more aware of their network conditions, and question which courses of action are most appropriate. For example, the typology may help them find answers to questions, such as: Is their current configuration the one they want to have? Does it fit with their operational or business model? Should they develop capabilities suited to their current configuration, or ones suited to the configuration they want to have?

At the relationships level, entrepreneurs can use the typology to guide decisions about which relationships to forge, which to prevent, and which to terminate (i.e., how to manage structural complexity). Questions they may ask themselves include: Should they network and forge new relationships? Should they introduce others in their network to explore new combinations of resources, or should they keep actors separated and avoid becoming disintermediated? Should they cull their network and focus only on a select subset of relationships?

Similarly, the typology can be used to guide decisions about which flows to increase in complexity within or across relationships? For example, if entrepreneurs are overly dependent on a single key relationship, they may diversify risk of such dependence and attempt to standardize the relationship and replicate the terms of agreement with other actors. Alternatively, they may embrace the dependence, renegotiate and alter the flow complexity within that relationship (see also: Yli-Renko, Sapienza and Hay, 2001). Further questions may include: What is the impact of engaging in a strategic alliance on the rest of their network? Will they have to renegotiate or even terminate other relationships because of the proposed strategic alliance?

4.6 Conclusion

Network research has tended to study the complexity of networks in terms of structures only or flows only. Following other research (Hoang and Antoncic, 2003; Jack, 2010; Slotte-Kock, 2010), we argue that the interdependence of network structures and flows is important. We explain that as the structural *and* flow properties of a network will coalesce or configure to define predicatively useful types of networks, this integration helps us to understand network diversity, multiplexity and evolution. The typology of network configurations we present provides a theoretical basis to empirically test how the different network conditions, and associated network management capabilities proposed here, are related to each other and the performance of entrepreneurs. Furthermore, investigation into the reciprocal impact of changes in structures and flows, network evolution, and how these changes are related to changes in capabilities are suggested as fruitful areas for future research.

4.7 References

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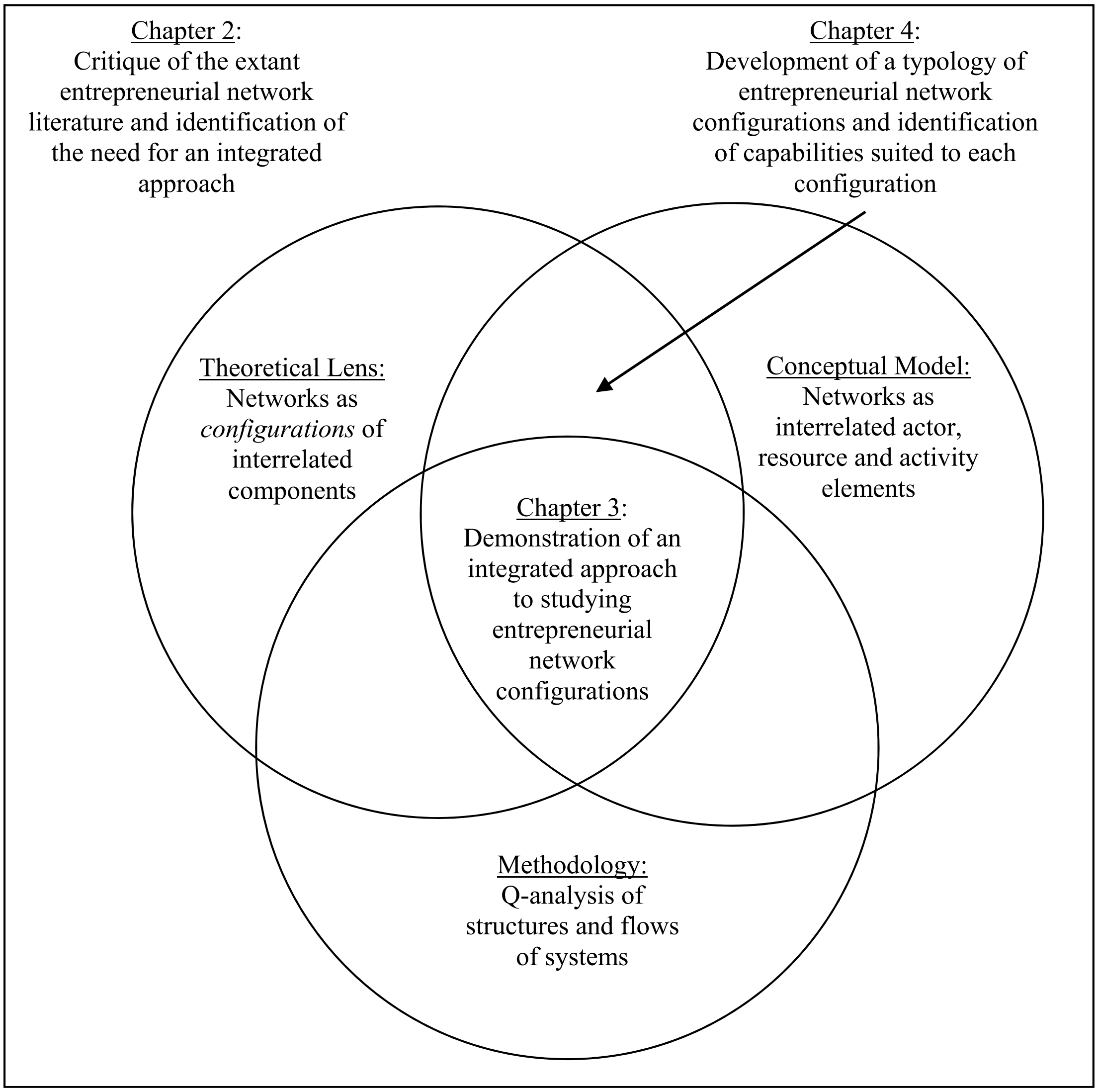
CHAPTER 5: CONCLUSION

This chapter summarizes how the three papers form a coherent contribution towards the conceptualization, identification and description of entrepreneurial networks, identifies implications for research and management, and indicates directions for future research. The coherent contribution of this dissertation is in developing an integrated approach to studying entrepreneurial network structures and flows, and is formed through alignment between three individual contributions in terms of theoretical perspective, conceptual model and method. Each of these contributions is summarized in a separate section below, followed by a summary of implications, limitations, and figure research directions.

The individual contributions complement each other to form a coherent contribution, as depicted in Figure 8. The figure visualizes (i) that Chapter 2 identifies the need for an integrated approach; (ii) how Chapter 3 fills this gap by introducing a theoretical lens, conceptual model, and method that combine to form the integrated method; and (iii) how Chapter 4 expands on the theoretical lens and conceptual model and explores implications for network management capabilities.

Figure 8: The need for an integrated approach, its components, and extension to a typology



5.1 Theoretical Contribution: Configuration Theory

This dissertation applies configuration theory (Meyer, Tsui & Hinings, 1993; Snow, Miles, & Miles, 2005) to entrepreneurial networks, to integrate the structural and flow perspectives, and provide a detailed, holistic, coherent and realistic image of networks, and is depicted by the Theoretical Lens circle in Figure 8. In this dissertation configuration theory is applied at two levels. At a micro-level the structures and flows are disaggregated into specific elements to consider all the interrelations between them (Chapter 3). Structures are described in greater detail by the connections between actor elements in the network. Likewise, flows are described by interactions between flow related elements, i.e., resources and activities. The integration of the structure and flow perspectives is then provided by consideration of how the interrelations between all the elements in the network, including those between structure and flow elements, form the configuration. At a macro-level the structures and flows are aggregated into structural complexity and flow complexity constructs, which are then contrasted and combined to form distinct configurations (Chapter 4).

5.2 Conceptual Contribution: A New Network Model

Chapters 3 and 4 of this dissertation build on the recent introduction of a network model to the entrepreneurship literature (Slotte-Kock & Coviello, 2010) that is adapted from industrial marketing (Håkansson, 1989) and depicted by the Conceptual Model circle in Figure 8. The conceptual model is unique in that it explicitly disaggregates networks into actor, resource and activity elements, which collectively combine to form the network as a whole. This model helps identify how multiple actors can be associated with the same flow(s), and how multiple flows can be associated with the same actor(s). Explicit and overlapping association of actors and flows is used here to investigate interdependence of structures and flows. The integrated model also supports analysis of network multiplexity and network evolution in a manner that simultaneously considers the structures and flows of networks.

5.3 Methodological Contribution: Q-Analysis

While configuration theory and the model are conceptually intuitive, there remains a lack of methods that focus on interrelationships of diverse elements, with the exception of recent advances in set-theory (Fiss, 2007). Chapter 3 of this dissertation introduces and demonstrates the Q-analysis method (Atkin, 1974), a set-theoretic method which is specifically designed to jointly study the structures and flows of systems, as depicted by the Methodology circle in Figure 8. The method uses multiple layers of interrelated sets of elements as data to summarize configurations as hierarchical groupings of elements. These summaries provide rich descriptions with which to compare cases, much like qualitative analysis, and lend themselves to inductive analysis and theory development (e.g., Gaspar & Gould, 1981). The method may also be adapted to provide quantitative measures of structural complexity, flow complexity, and structure-flow interdependence, making it useful for theory refinement.

5.4 Theoretical Contribution: A Typology of Entrepreneurial Network Configurations

The intersection of configuration theory and an integrative network model is explored in greater depth in the typology presented in Chapter 4 and depicted by the overlap of the Theoretical Lens and Conceptual Model circles in Figure 8. The typology is created by combining conditions of high and low structural complexity and flow complexity, where structural complexity is defined by the number of actors that are connected in the network, and flow complexity is defined by the number of flows in the network that interact. The typology integrates research on network structures and flows to create the four archetypes of entrepreneurial network – *clusters*, *cliques*, *communities* and *crowds*. For each of the configurations in the typology, specific network capabilities are identified that are suited to the conditions that define each archetype. More specifically, it is argued that *brokering* capabilities are suited to structural complexity conditions, and *coordination* capabilities are suited to flow complexity conditions.

Overall, the individual contributions integrates network structures and flows, and combine to provide a coherent integrated approach to studying entrepreneurial networks.

5.5 Managerial Implications

The conceptual and methodological contributions in this dissertation provide entrepreneurs with a new approach to reveal how and when it makes sense to form new relationships or to end them, and how and when to make relationships more or less multiplex, as well as how such decisions impact the rest of their network. The typology developed here may also be used to reveal which type of entrepreneurial network configuration an entrepreneur has, and reflect on whether it is suited to their network management capabilities. For example, in case of a mismatch of capabilities and the configuration, an entrepreneur may leverage existing capabilities and change their network configuration, or develop or acquire the capabilities that are suited to the desired configuration. For networks with high levels of structure-flow interdependence (e.g., cliques, or to a lesser degree communities and clusters), the entrepreneur may also reflect on this interdependence and assess whether it is possible to resolve conflicts and generate synergies, or else if it is best to cut losses and rebuild large portions of, or even all of, their network.

5.6 Limitations and Directions for Future Research

This research is limited in that the method has not yet been validated in context of entrepreneurial networks, and the typology has not yet been validated using field data. In advance of analyzing empirical data, it remains difficult to predict which new theories or insights will be generated through inductive research using the theory, model, method and typology introduced here (e.g., new theories regarding the evolution, management and performance of entrepreneurial network configurations). It may be that the empirical data provide the basis for a taxonomy of configurations different from those developed in the theoretical typology. Such an empirically developed typology may also not readily map onto a 2x2 typology as presented in this dissertation. It would also be fruitful to assess which network management capabilities exist, and how effective they are for different configurations, keeping in mind that capabilities are difficult to observe and remain a challenge in empirical research (Arthurs & Busenitz, 2006; Eisenhardt & Martin, 2000).

To explore the evolution of entrepreneurial network configurations, it may prove worthwhile to observe a set of entrepreneurs with the same network configuration and track the evolution of their networks over time, while taking periodic Q-analysis snapshots of the configurations. These configurations could then be used to develop theory about how and when configurations change. Configurations could also be categorized by the performance (e.g., firm failure, stasis, or growth) and used to compare the evolutionary paths and see if there are common initial conditions or evolutionary paths leading to each category of performance.

An integrated approach to studying network structures and flows has appeal to inter-organizational research, beyond the field of entrepreneurship. The theoretical perspective, conceptual model and method maybe adapted for studying related concepts that involve both structures and flows. For example, conceptual advancements like "multivocal" participants, i.e., those who are "capable of performing multiple activities with a variety of constituents" (Nelson, 2005; Powell, White, Koput, & Owen-Smith, 2005), may be furthered by such an integrated approach. Likewise, the theory, model and method presented here may assist in advancing our understanding of Adaptive Structuration Theory, the study of the interplay between technological structures or routines and social structures (DeSanctis & Poole, 1994; Jack & Anderson, 2002), and multilateral alliances (Gulati, 1995), i.e., alliances with more than one partner. Research on each of these concepts can benefit from an integrated approach to analyzing exactly who is doing what to which resources in the network.

5.7 References

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