The Genesis and Dynamics of Organizational Networks

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Abstract

An extensive body of knowledge exists on network outcomes and on how network structures may contribute to the creation of outcomes at different levels of analysis but less attention has been paid to understanding how and why organizational networks emerge, evolve and change. Improved understanding of network dynamics is important for several reasons, perhaps the most critical being that the understanding of network outcomes is only partial without an appreciation of the genesis of the network structures that resulted in such outcomes. To provide a context for the papers in the special issue and with the broader goal of furthering network dynamics research we present a framework that begins by discussing the meaning and role of network dynamics and goes on to identify the drivers and key dimensions of network change as well as the role of time in this process. We conclude with theoretical and methodological issues that researchers need to address in this domain.

Classic works have theorized generally about the determinants of inter-organizational relationships (Oliver 1990, Galaskiewicz 1985) and some research has demonstrated how specific industry events shape networks over time (Madhavan, Koka, and Prescott 1998). More recent research has addressed the macro-dynamics of networks to understand how organizational fields evolve (Powell et al. 2005). However, while scholarly understanding of the factors that influence the formation of relationships between entities exists, understanding the origins and evolution of alternative types of network structures remains a research issue demanding attention: how and why do organizational (and interorganizational) networks evolve to take the forms that they do, and what are the consequences of such evolution for the organizations that comprise them? Noting this deficit Powell and his colleagues (2005: 1133) have observed that, "In the [still] most comprehensive text on network methods, there is only a paragraph on network dynamics in a section on future directions (Wasserman and Faust, 1994)."

With this introductory paper, we provide a context for the papers in the special issue, and develop an organizing framework as well as a map for research in the area of network dynamics. More specifically, we discuss why organization scholars should care about network dynamics, define the subject area of network dynamics, identify the key dimensions on which networks can change, and categorize some broad patterns of network change, including a discussion of the role of time in this process. Finally, we draw attention to some important gaps that remain in the extant literature and provide a set of key theoretical directions as well as methodological guidelines for future research in the area. We define organizational networks as representations of connections between organizations or

organizational units[1] and while our framework is principally directed at organizational networks, networks at other levels of analysis, such as the individual, are very much within its ambit.

Why organization scholars should care about network dynamics

Improved understanding of network dynamics is important for several reasons. Perhaps, most critically, an understanding of network outcomes is incomplete and potentially flawed without an appreciation of the genesis and evolution of the underlying network structures. For instance, scholars have long recognized that networks are mechanisms for the generation and conveyance of social capital – which in turn serves as a basis for social benefits (Coleman, 1988) or private advantage (Burt, 1992). However, the benefits provided by networks to their constituents and their role as sources of value, up to and including competitive advantage for firms, are dependent upon the network architecture and its evolution over time. Thus, for example, the benefits of closure in a network may be only temporary for network participants if the network is in a state of flux and is becoming more open.

Understanding network dynamics is also important because of the potential role of conscious agency by network participants in creating network structures that benefit them. In other words, some deliberate network modifying actions by network actors may have consequences at later points in time for network structure. As a consequence, recognizing the impact of such agency on network structure is critical for appropriate causal inference.

[1] At the interpersonal and intra-organizational level, Kilduff and Brass (2010) have recently offered an overview of network antecedents: spatial, temporal, and social proximities (Festinger, Schacter & Back, 1950); homophily (e.g., McPherson, Smith-Lovin and Cook , 2001); balance (e.g., Heider, 1958); human and social capital (e.g., Lin, 1999); personality (e.g., Mehra, Kilduff, & Brass, 2001); social foci (e.g., Feld, 1981); and culture (e.g., Lincoln, Hanada, & Olson, 1981). Some of these mechanisms operate exclusively at the interpersonal level while others transfer to the interorganizational level.

As scholars have noted, "[C]ross-sectional analyses of networks (can) often leave causal relations ambiguous" (Brass et al. 2004: 809).

Another reason why network dynamics matter for organizational scholars is because networks often perform significant functional roles at many levels of analysis. For instance, networks in society can serve as institutions that facilitate or constrain economic action (Coleman, 1988), as mechanisms of information or influence diffusion at the interorganizational level (Ahuja, 2000; Gulati and Westphal 2000), or as governance mechanisms that constrain opportunism and enhance trust at the intraorganizational level (Ibarra 1995). Yet, such functional effects are contingent upon the existence of specific network structures or architectures. Thus, the institutional or governance benefits of a network are likely to depend upon the network being relatively closed (Coleman 1988). A static consideration of networks may suggest that it is closed and therefore well placed to provide such governance benefits. However, if we recognize that for example, the network may represent firms in a new and rapidly expanding industry, or organizational members in a rapidly-growing firm, such a conclusion may be premature or at best, transient.

Consideration of dynamics suggests that as the number of nodes in a network grows, the number of ties required to keep the network closed grows exponentially. But such growth in the number of ties may be simply infeasible given the carrying capacity of firms or individuals. To the extent that network closure is a key requirement of networks operating as a governance mechanism, a network with many geodesically distant, unconnected nodes may not be effective in such a governance role (Dixit 2009), suggesting that the closure benefit provided by the network is transitory. Therefore, understanding how much the network – and its outcomes – change as the network evolves is critical from both positive and normative perspectives.

Different network structures and positions may also imply differential advantages or constraints for the actors embedded in the network (Burt 1992). Understanding how the architecture will evolve can help us predict and understand the changes in the distribution of benefits and constraints from the network. Thus, they help us understand the sustainability (or otherwise) of network-based advantages. For instance, the celebrated theory of structural holes posits brokerage advantages for actors with certain ego-network architectures (Burt 1992). Yet, a consideration of network dynamics suggests that under a set of fairly reasonable conditions, conscious and deliberate agency activity by alters should plug up structural holes, rendering moot any advantages that originated to ego from such structures (Buskens and van de Rijt 2008). In sum, while a static view implies stable value from networks, a dynamic view challenges its significance by questioning the sustainability of network positions.

Defining and dimensionalizing network dynamics

To explore the idea of network dynamics, we first define the concept of network architecture. The architecture of any network can be conceptualized in terms of three primitives – the nodes that comprise the network, the ties that connect the nodes, and the patterns or structure that result from these connections. Network architectures can therefore be associated with the number, identity, and characteristics of nodes; the location, content or strength of ties; and the pattern of interconnections or ties among nodes. We view the domain of network dynamics as encompassing the sources, types and implications of changes in network architecture over time.

Network architecture can change with a change in the nodes – their addition or subtraction – or in nodal characteristics, such as their capabilities, but also when ties

between nodes are either created, dissolved or modified in terms of their strength or content (i.e. what flows through them). For instance, joint ventures or alliances can be dissolved (Polidoro, Ahuja & Mitchell 2011), tie strength can change (Mariotti this issue), and ties of one kind can influence the formation and dissolution of ties of another kind (Shipilov and Li this issue). Ties can also change in terms of content, as a friendship network becomes an advice network or business associates become friends. Ties between actors could also constitute several distinct flows simultaneously in the form of multiplex ties. Moreover, the formation, dissolution or morphing of ties between nodes can in turn lead to changes in structure, or the pattern of ties.

Our overarching framework of network dynamics conceptualizes change for the nodes, ties, and the structure of ties in the network. We crucially distinguish between two levels of analysis: the levels of whole networks and ego-networks because network dynamics at each level, though related, are also distinct (Zaheer, Gozubuyuk and Milanov, 2010). Since there can be an infinite number of patterns of network ties, formal study of network dynamics demands the articulation of an underlying set of meaningful dimensions along which the structures of ego-networks and whole networks can be classified. Our framework includes three major elements (each conceptualized at the whole network and ego-network levels): one, the dimensions of network change; two, the micro-foundations of network change; and three, the micro-dynamics of network change (see Table 1). We now proceed to discuss each of these elements in turn.

Table 1 about here

The dimensions of network change

The study of network dynamics may be helped by clearly identifying the key dimensions on which networks change and indicating how these dimensions are of relevance to organizational scholars. Such an exercise would provide important benefits for advancing research. First, mapping the key constructs in a domain provides a common framework for scholars addressing related but distinct questions, thus facilitating comparison, collation and knowledge accumulation across studies. Second, dimensionalizing a construct helps in the tighter development of refutable implications. For instance, a claim about how changes in a network structure led to enhanced or decreased rates of information diffusion when framed in terms of a specific dimension of network structure (e.g. network diameter or average path length) may make the prediction more precise and replicable.

At the ego-network level the most common dimensions of variance on tie patterns for the focal node are one, its centrality, and two, the presence or absence of structural holes (often juxtaposed with its obverse, closure) in their immediate or indirect ties. Thus, at the ego level network dynamics can be reflected in increasing or decreasing centrality and increasing or decreasing structural holes (or closure). From an outcome perspective, centrality has been associated with a wide variety of potential benefits such as access to diverse information or higher status or prestige (Brass, 1985). The presence of structural holes is commonly related to brokerage possibilities (Burt, 1992; Zaheer and Soda, 2009).

At the whole network level, we identify five dimensions of changes in network architecture – one, the degree distribution of nodes; two, the connectivity of the network; three, the pattern of clustering in the network; four, network density; and five, the degree assortativity of the network. Understanding network dynamics at the whole network, as opposed to the ego-network level, then implies examining how these five dimensions change

for a given network, the processes that drive the change, and the implications of such changes from the perspective of both structure and outcomes.

The first dimension, *degree distribution of nodes,* reflects the relative frequency of the occurrence of ties across nodes or the variance in the distribution of ties in the network (Jackson, 2008). A network could have a few nodes that are characterized by many connections to other nodes in the network while many other nodes have relatively few ties. Alternatively, the ties in a network could be distributed more evenly across nodes. In organizational networks, the degree distribution has been used to signify the distribution of status, power or prestige across organizations (Gulati and Garguilo, 1999; Ahuja, Polidoro and Mitchell, 2009). Changes in the degree distribution may then be reflective of changes in the status hierarchy of the observed system. If the degree distribution becomes more peaked, for instance through a process of preferential attachment wherein new ties are distributed across nodes in proportion to their existing degree, it would suggest that a few of the nodes are becoming increasingly prominent in this social system. Understanding the evolution of degree distribution is thus important in the study of power in organizational networks.

The second, the *connectivity of the network* is captured in the diameter of a network which in turn reflects the largest path-distance between any two nodes of the network (Jackson, 2008). More generally the average path length connecting any two nodes in the network is an indicator of the connectivity or "small-worldness" of the network. As such, it is useful in understanding diffusion processes in networks, such as of information or disease. In the context of an organizational network, as the network becomes more "small-worldly," information can diffuse more quickly fostering outcomes such as innovation or creativity (Schilling 2005, Schilling and Phelps, 2007). Alternatively, as the average path length between any two nodes of a network

diminishes, it is possible that information can become more democratized and result in a reduction in the informational advantage of any single player. These are only two of many possible effects of changing network connectivity and when and under what conditions one effect dominates the other is only one of the many unanswered questions in the area of network dynamics.

In this issue Gulati, Sytch, and Tatarovickz, demonstrate how the dynamics of inter-organizational small worlds take the form of an inverted U-shaped evolutionary pattern, such that an increase in the small worldliness of a network is followed by its later decline. The small world network follows this kind of evolutionary pattern because the information regarding the availability, reliability, and resource profiles of potential partners is not perfectly distributed. As a consequence many organizations tend to economize in their search for partners by selecting those with whom they have some familiarity and stability, either directly or indirectly. However, the decline of the small world is influenced by the limited and short-term advantages of information brokerage, which reduce the actors' propensity to form bridging ties. In this way, a globally separated network is formed, which may then approach the structure of multiple isolated clusters.

Three, the *pattern of clustering* in the network refers to the degree to which the network is formed of tightly inter-connected cliques. The emergence of inter-connected subgroups or network partitions or cliques suggests that the network is being differentiated into a variety of distinct sub-networks or communities. At the interorganizational level, changes in clustering may represent the reconfiguration of clusters or constellations of firms that may be competing against each other as 'alliance networks' (Gomes-Cassares 1994). Alternatively, clique or cluster instability, for instance, maybe a precursor of a significant technological discontinuity if the network is an interorganizational technology network, or perhaps portend an imminent change in the power structure of an organization in an intra-organizational employee network.

The fourth dimension, *network density,* refers to the proportion of ties that are realized in the network relative to the hypothetical maximum possible. In organizational settings, higher network density may be reflective of network closure, a condition that in turn may be associated with the development of norms. Or alternately, increasing density could be reflected in a reduction of diversity of perspectives and choice within the network as the high proportion of realized ties provide a homogenizing influence across actors, and thus results in increasing reification of ideas.

Our fifth dimension, *degree assortativity,* reflects the degree to which nodes with similar degrees connect to each other (Watts, 2004). Positive assortativity implies that high-degree nodes connect to other high degree nodes while low-degree nodes connect to other low-degree nodes. Disassortativity, or negative assortativity, occurs when high degree nodes prefer to connect to low degree nodes and vice versa. In an intra-organizational network setting, assortativity could be driven by homophily processes and disassortavity by complementarity needs. Assortativity can also be associated with the emergence of a core-periphery structure (Borgatti and Everett, 1999) where a set of densely connected actors constitute the core of an industry while many other low degree actors constitute a periphery. Changes in assortativity might signal a shift in the resource requirements for success in the industry represented by an interorganizational network, such as when high status pharmaceutical companies began allying with low status biotechnology companies (Powell, Packalen and Whittington, forthcoming). In the next section, we examine how network changes in these dimensions are brought about by the micro-foundations and micro-dynamics of network change.

The micro-foundations and micro-dynamics of network change

We argue that the genesis and the evolutionary trajectory of networks are determined at the level of ties and nodes by mechanisms that derive from the micro-foundations of network evolution. By "micro-foundations" we mean the basic factors that drive or shape the formation, persistence, dissolution and content of ties in the network. In using this term, we are careful to not make reference to the traditional distinction in the social sciences between micro-individual and macro-organizational levels – the micro-macro divide. Rather, we include in the concept of micro-foundations the fundamental drivers of networks, which apply to networks at all levels of analysis, including the inter-organizational, intergroup and interpersonal.

We posit that in a general sense, four primary micro-foundations can be identified to explain the genesis and the evolution of networks. These micro-foundational explanations can be respectively termed as *agency* (Sewell 1992; Emirbayer and Goodwin 1994; Emirbayer and Mische 1998); *opportunity*, (Blau 1994, Giddens 1984, Granovetter 1973); *inertia* (Kim, Oh and Swaminathan 2006) and *exogenous and random* factors. *Agency* refers to the focal actor's motivation and ability to shape relations and create a beneficial link or dissolve an unprofitable one or shape an advantageous structure. *Opportunity* reflects Blau's idea of the structural context of action (Blau 1994) and includes the argument that actors tend to prefer linking within groups rather across them (Li and Rowley 2002). *Inertia* includes the pressures for persistence and change (Giddens 1984, Portes and Sensenbrenner 1993, Coleman 1988) and refers to the durability of social structures as well as the social processes by which the focal actor's actions are influenced, directed and constrained by norms and institutional pressures. Finally, we do not exclude, consistent with the view of complexity theorists, that the emergence of network structures may be a result of *exogenous* factors that emanate from

beyond the network, or from simply *random* processes, whether generated inside or outside the network (Mizruchi, 1989).

These micro-foundations operate via mechanisms that we refer to as network *micro-dynamics,* such as homophily or heterophily. These micro-dynamics cause changes in network membership through dissolution or formation of ties, changes in tie content, strength and multiplexity, as well as the transformation of nodal attributes. The complex combination of micro-dynamics at the tie and node levels in a network affects the ego network. In turn the aggregation of ego-level changes determines the structural evolutionary trajectory at the level of the whole network. At the same time, structural transformations at the whole network level create new inducements, opportunities and constraints which in turn affect the network's micro-dynamics and consequently ego level tie and nodes in the subsequent period. Thus, whole network level structural changes and the micro-dynamics at the tie and nodal ego-network levels co-evolve in a complex, interdependent fashion.

We proceed to discuss each of the micro-foundations. In principle, network changing behavior at the ego-network level can occur through one of two paths: actors may either focus on the characteristics of the nodes they link to, to form or dissolve ties and change the network in this way; or they can focus on the network's structure or pattern of ties and through their actions modify that structure. We call the former nodal change, and the latter ego-structural change. In the analysis below we identify illustrative micro-dynamics associated with each of these mechanisms. Note that a third possible locus of change is in the content of the tie. Thus, we recognize that network dynamics can also entail changes in the content of what flows through the network, or changes in the multiplexity of the network (multiple ties with different contents between the same set of actors), but for both simplicity and length reasons we ignore it here.

Agency. A key factor promoting the creation and the evolution of networks is the notion that actors purposively enact their social structures, generally referred as agency behavior (White 1992; Emirbayer and Mische 1998; Burt 2005). They do so by choosing or not choosing to establish connections with certain other actors in their networks, by forming or dissolving network links, or by strengthening or weakening relationships. In this view, actors deliberately seek to create social structures that favor them in some way. Burt's idea of structural holes as social capital is consistent with this explanation, which highlights an entrepreneurial role in the creation of this valuable form of social structure (Burt 1992). Such a conception, as Nohria and Eccles put it, "treats actors as purposeful, intentional agents" (1992: 13). As a result, network structures emerge as a result of self-seeking actions by focal nodes and their connections.

Within our framework then agency-driven predictors of network change include entrepreneurial activity driven by either or both of collective payoffs, where the benefits accrue to a collective (eg. Coleman, 1988), and nodal level pay-offs, where the benefits accrue to an individual (Burt, 1992). Emirbayer and Mische view agency as "the temporally constructed engagement by actors…which, through the interplay of habit, imagination and judgment, both reproduces and transform structures" (1998: 970). From this perspective, a useful approach to agency is one that incorporates all of these different components; it is not just about the idea that actors "could have acted otherwise" (Giddens 1979: 56) but that the actors can devise unique responses to improve their own situations in the network.

Using the micro-foundation of agency can be particularly useful in testing theories that explain how network strategies are manifested in a dynamic context. Agency behaviors and actions shape the evolution of networks through an instrumental perspective, and can be more directly interpreted as emanating from a self-interested, utility reasoning. We argue

that agency attempts to accomplish its goals through both nodal change as well as ego-structural change. Nodal change may occur through an assortativity logic via the forming or dissolution of ties to alters with specific characteristics that improve ego's position, while ego-structural change derives from the logic of modifying ego's structural dependency on the other nodes in the network.

By modifying dependency we mean that the focal actor either reduces its own dependency on alters or increases alters' dependence on itself (Pfeffer and Salancik, 1978; Sytch et al. in this issue). In a network context, this modification of dependency is achieved in several ways. On the one hand, by establishing or dissolving ties which enhance their own brokerage power, actors increase alters' dependency. On the other hand, focal actors can reduce the control and information power of other brokers by filling disadvantageous structural holes and creating ties with other alters. At the same time, agency may also be the motivation for tie dissolution, if past high cohesive network structures among similar alters are unsatisfactory and promote negative lock-in type behaviors around ego. Agency then provides the motivation to seek through more open structures a more heterogeneous set of alters by reconfiguring past schemas (Zaheer and Soda, 2009). However, agency may also drive partners to house new ties in the relational context of existing ties as this embedding could serve to foster trust worthy behavior. Thus, both brokerage and closure could be seen as micro-dynamics emerging from the agency micro-foundation that operate through the tie-pattern route.

Opportunity recognizes that much networking behavior is driven by convenience, through micro-dynamics such as referrals (Gulati, 1995; Gulati and Garguilo, 1998) or proximity (Rivera, Soderstrom and Uzzi, 2010). From a nodal perspective, opportunity is reflected in the ties formed between individuals from the same social group, or ethnic

background or those sharing a common identity or goal, or those that physically or virtually close. Thus, ethnic networks develop between immigrants from a given region, or co-workers in an office form friendship ties. Opportunity can also be manifested through prior patterns of ties. Firms form alliances with firms they have prior alliances with or with the partners of their partners. Both of these emerge from the logic of trust and convenience. A natural outcome of opportunity based ties is the formation of clusters or closed networks as the logics of referral, transitivity, and repetition, deepen the ties between a set of actors.

Inertia. Rather than being simply created or destroyed by agency or opportunity, ties also tend to persist or develop because of routines and norms or habits (for individuals) that develop in the context of an interacting set of entities. Persistence and the implied network stability also matters because the factors that impede or inhibit change in networks may be as relevant for network evolution as those that enhance change (Kim, Oh and Swaminathan, 2006). It is important to note that very often, rather than the structure itself, it is the content or the social processes flowing through the structure that acts as a mechanism encouraging network persistence. Giddens' (1984) conception of the duality of structure and action is also apropos. He views the two concepts of structure and action as acting and interacting in ways that mutually reinforce and perpetuate the social structure through a 'structuration' process (Sydow and Windeler 1998). Network persistence through inertia is the extent to which network interactions are reproduced over time and across a number of actors who develop what Giddens (1984) refers to as "structural properties" or institutionalized frameworks that are reproduced across time and space. Thus, ego network structure may not driven in such cases by teleological behaviors or judgment or reconfiguration as much as by habit and reciprocity that capture the inertial, constraining effects of prior patterns of relationships.

As with the other micro-foundations inertial tendencies in networks may emerge from either nodal change or ego-structural change. From a nodal perspective momentum or prior histories of tie formation may lead to a collaborative or networking proclivity and well-developed routines for managing networks may lead to tie stability (Kale, Singh and Perlmutter, 2000). Nodal characteristics such as organizational age or status or market dominance may also influence the degree to which firms may persist with or change their network behavior (Oh, Kim and Swaminathan, 2006). The formation of an alliance management function (eg. Kale, Dyer and Singh, 2002) in a firm may itself lead to more alliances being formed by the firm both because the unit seeks to amortize its fixed costs over a larger portfolio of alliances, and also as the need to justify its existence becomes an end in itself. At the tie-pattern level, the inter-organizational routines and norms developed between a set of networked organizations may foster the persistence of ties between them, and also the formation of new ones (Gulati, 1995).

Random/Exogenous. Ego network changes may also just come about through random factors beyond the control of ego, or exogenous from outside the network (Jackson and Rogers, 2007). For example, being nominated together for an institutional board may quite randomly create a tie between two organizations (Bell and Zaheer, 2007). When cumulated, it is conceivable that systematic patterns can be generated in the overall whole network through purely random processes at a very distant level. Thus, Watts and Strogatz (1998) demonstrated how the whole network took on small world properties when some long links were randomly added in an ordered network. However, while such structural random or exogenous factors under certain conditions may result in regular patterns at times, they do little to help us understand the social behaviors, or the micro-foundations, underlying the

creation of such patterns (Uzzi, Guimera and Spiro, 2005). Figure 1 synthesizes our organizing framework.

Figure 1 about here

We now assemble these various pieces into a composite framework in two stages. First, we focus from an ego perspective on the role played by micro-foundations of organizational networks, factors operating at the tie and nodal levels, which we connect through micro-dynamic mechanisms, changes and interactions at these elemental levels, to the genesis and emergence of different types of network architectures that are reflected as variations on the various structural dimensions of the network described earlier. Second, we suggest that these architectures in turn generate inducements, constraints and opportunities that affect micro-foundations and in turn shape the evolution of networks at the lower tie and nodal levels (see Figure 1). Thus, our framework links the elemental levels of ties and nodes to the overall structure of the whole network and vice-versa.

The core argument we make is that the micro-foundations of agency, opportunity, inertia and random or exogenous factors operate through micro-dynamics to form, dissolve or maintain ties. Common micro-dynamics include homophily, heterophily, and prominence-attraction. Thus, similarity between ego and alter (homophily) or the possibilities of complementarity (heterophily) may cause certain ties to form or dissolve. Alternatively, in situations when the quality of a product or actor cannot be independently verified, affiliation with reputable actors may be used to signal quality (Podonly 1993). Thus,

the micro-dynamic process of prominence-attraction suggests that more prominent actors may be attractive as partners because a tie with them serves as an endorsement of quality.

These changes accumulate to alter the structure or content of the whole network and are reflected in changes in the key structural dimensions of the whole network that we discussed earlier, such as connectivity, density and assortativity. The modified network structure in turn puts pressure on individual nodes and ties. These nodes then respond through the micro-foundations to initiate further changes in the network. This approach to network evolution is consistent with how many evolutionary theories address the issue of economic and social dynamics (Coleman 1990).

Soda and Usai (1999), provide an example of network genesis at industry level based on such dynamics. The normative and social pressures in the construction industry generate a "network of indebtedness," a particular form of embeddedness that captures a norm of reciprocity and the subsequent reiteration of relational patterns connecting a group of actors. As a result, the industry network grows around a single component, increasing over time in its density and connectivity. Moreover, indebtedness amplifies the entry barriers to newcomers and, in the case that reciprocity is not respected, provides for sanctions that may even include expulsion from the network. This finding is consistent with the arguments proposed by Walker and his colleagues (1997: 111): "All firms in an industry had relationships with each other…In such a dense network, information on deviant behavior would be readily disseminated and the behavior sanctioned." In synthesis, the closure of these networks strengthens the mutual monitoring capability of network actors, increasing the expected costs of opportunistic behavior (Coleman 1988).

In terms of our framework, the micro-foundations of agency, opportunity and inertia interact in the above setting. As actors form ties with alters that are themselves connected to

the network and the monitoring benefits of closure become visible, additional ties are increasingly formed between connected alters leading to greater density in the network, which in turn fosters norms that favor tie formation within the main component and further reinforces closure.

Nevertheless, such stable fully-connected dense networks are not immune to change. From Coleman's (1988) original intuition, we know that some key effects of network closure and local equilibria, such as increasing similarity and conformity among nodes, are amplified over time. As a consequence, a stable pattern of dense networks stimulates the actors to search for new and diverse ties to break with common mental models, groupthink, and unproductive lock-in. Thus, over time actors' stable embeddedness creates an unfavorable context that induces the activation of a network reconfiguration mechanism seeking for disconnections from the persistent, stable ties in the dense network (Zaheer and Soda, 2009). Over time, the network thus exhibits greater fragmentation, lower overall density, and possibly the creation of isolated clusters. Furthermore, under such conditions, bridging ties will be particularly beneficial, providing significant advantages, and therefore the motivation, to agency-driven actors. Thus we note that a full cycle operates, and agency, opportunity and inertia drive new alliances to be formed within the main component but the increased density and closure this causes in turn leads to a demand for new and diverse ties.

It is important to note that although micro-foundations are the origins of changes at the network level, this may not necessarily always appear to be the case. Thus, a network may remain structurally stable over time with relatively unchanged values of density, clustering, or small-worldliness, because the micro-dynamics might cancel each other out, for example by some ties being dissolved but compensated for by new structurally equivalent ties being formed at the same time. So, hypothetically, from an overall network standpoint a

network may remain structurally stable over time but at the tie and node level it could be quite dynamic.

Networks, time and outcomes

Relatively little research on network outcomes explicitly includes a time dimension (Burt, 2002; Soda et. al 2004; Baum et al. this issue) which, although related, is distinct from the issues of network dynamics described above but also informs them. Thus, parallel to the genesis and evolution of networks there is also a relevant theoretical issue regarding the role of time in the relationship between network architectures and network outcomes, which we address here briefly, consistent with the call to directly incorporate time into organization theory (Zaheer, Albert, and Zaheer 1999). More specifically, incorporating time into network theory would raise questions such as: Do older and newer ties and structures behave differently and hold different implications for outcomes (Soda, Usai and Zaheer 2004)? When and under what conditions do older ties and structures become ineffective? More effective?

From a network perspective, scholars have suggested that the passage of time is required for relationships to be cemented, strengthened and become imbued with trust and affect (Krackhardt, 1992). On the other hand, as network ties dissolve, reform, and the effects of accumulated obligations and reciprocity weaken with the passage of time, past relations may decline in potency. Consequently, dim memories of past ties may dilute or modify the effects of older network structures on current behaviors and performance. Thus, the question of whether network structure represents a stock of social capital, or whether it is more akin to a flow that must be currently exploited, should be an issue for research on network dynamics.

Our logic about time and network outcomes is manifested, in part, in the idea that "networks have memories" (Soda et al. 2004). In fact, current networks of relations reflect both

the past social structure and the accumulation of historical experience through past network ties. We argue that there are at least two mechanisms through which network memories can shape the evolution of current networks. First, network memory provides organizational actors the possibility of reconstructing the social structures that they experienced in the past. Second, network memories allow them to draw on the accumulated knowledge and information resources that have accrued to them through past relations. We refer to the latter as accumulated relational content.

Reconstructing social structures. By the virtue of its technological platform, a significant part of the five hundred million current users of Facebook have had a chance to re-activate – or "defreeze" – their past, often very old, relationships. Beyond the opportunities provided by technology, the extent to which the social structure can be reconstructed depends not only on the structure itself, but also on the nature of the tie, its strength, the pattern of ties it is embedded in, and the amount of time that has elapsed since the tie was last active (Mariotti, this issue). Ties could also be allowed to lay latent, to be reactivated upon need, thereby conserving networking energy (Mariottti, this issue). Beyond a point, of course, relations may have decayed to a level from which they can no longer be reconstructed. Consequently different kinds of social structures may weather time to different extents. For example, Feld (1997) shows that supportive, stronger ties are more likely to persist. The performance consequences of certain social structures may be reinforced by the passage of time while others may atrophy. Furthermore, while structure may change over time in different ways, time may also modify the nodes themselves in diverse ways, and in consequence the social structure linking the nodes (Leik and Chalkley 1997; Suitor and Ketton 1997).

Accumulating relational content. Knowledge and information that network actors accumulate over time represent resources that can be drawn on, much like the notion of intellectual capital

(Nahapiet and Ghoshal 1998). Values and norms include trust, obligations, and reciprocity, which together also shape future actions and relations (Gulati and Gargiulo 1998). Influence and affect reflect the mimetic and the emotional content of the relationship, which, too, exerts a bearing on the prospective behavior of the actors in the relation. Thus, the accumulated relational content aspect of network memory is a 'shadow of the past' which enables and influences, but may also constrain, future action in the network.

Some of the papers in the current issue address issues of time in network research directly. Thus, Baum et al. (this issue) theorize and test the idea that performance benefits of closure ties increase with age, while those of bridging ties decrease with age. Moreover, benefits yielded by hybrid network positions, combining elements of both closure and bridging, are greatest when old closure ties are combined with either very young or very old bridging ties.

However, depending on the context and the nature of outcomes considered, research is also revealing more complex dynamics. McEvily et al. (this issue) focus on the temporal and historical conditions under which bridging ties from the past affect current organizational outcomes. They explore the possibility that bridging ties may produce benefits over an extended period of time. Thus, they contrast the conventional view of rapidly decaying bridging ties with two alternative network dynamics: "accumulating" and "imprinting" and suggest that while bridging ties have accumulating effects due to learning and redeployment of cumulated knowledge, such ties also exhibit an imprinting effect whereby some, but not all, ties yield long-lasting network benefits.

Network dynamics: Open research questions

We know a great deal about the effects of organizational networks; given a network structure or network position, researchers have assembled an impressive body of theory and supporting (and sometime conflicting) empirics to help us understand what implications we

might expect to see in terms of behavior or outcomes of the organizational actors enmeshed in those networks (e.g. Ahuja 2000, Reagans and Zuckerman 2001). Yet, most of our theorizing often suggests a curiously static and passive approach on the part of these actors with respect to the network itself. While these actors respond to the constraints and opportunities of the network in many ways, empirical network research rarely considers the most direct line of attack on a constraining network – to change the network itself (Emirbayer and Goodwin, 1994).

For instance, we know that actors that span structural holes can use their position to benefit themselves as they trade information, favors and the like. Yet, this raises the natural question – do structural holes remain unfilled (Zaheer and Soda 2009)? If yes, why? What happens as other players in a network observe the returns to network entrepreneurship of the sort envisaged most notably by Burt (1992)? Would they be induced to replicate these returns by restructuring their own networks? Or would they respond by trying to partially appropriate the benefits that have emerged through side-payments rather than through restructuring the network structure? Thus, why do opportunities conferred by a network not get redistributed through the reorganization of the network and when and under what conditions do they? Burt's conception of brokerage as social capital highlights an entrepreneurial role for organizational actors in the creation of this valuable form of social structure (Burt 1992, Hargadon and Sutton 1997). At the same time, this approach is clearly static and does not illuminate the complexity of actions and micro-dynamics occurring over time. Thus, if intentional actors – agents – can purposively enact their social structures creating powerful positions, in order to understand why some specific network structures emerge, a static ego perspective offers only a partial view.

Similarly, it has often been argued that networks also serve as sources of constraint, restricting the focal actor's ability to change by embedding them in a web of relationships. Yet, one might surmise that once an actor senses this limitation it is only natural for them to try to find release from these constraints. Limited, if any, research has so far examined whether such constraints can and are removed as actors change their patterns of embeddedness in response to their survival needs in an evolving environment (Rowley, Behrens and Krackhardt 2000).

Alternatively, networks have often been argued to be a form of governance structure, a set of relationships that promotes trust and thus fills an institutional void enabling economic activity. Yet, most institutions in societies are themselves evolving, and it is likely that institutional voids are often filled by the emergence of new institutions or the strengthening of old ones. If so, are networks then redundant, their constraint costs now exceeding their opportunity benefits? Moreover, the genesis of specific network structures or architectures does not interrupt their evolution. In fact, the emergence of network architectures from micro-mechanisms and processes may create conditions which subsequently shape the evolution of the networks. Thus, what are the main evolutionary trajectories of network evolution and what are the forces operating behind them?

The above questions should clearly indicate why network dynamics might represent an important arena of work in and of itself. However, it is worth noting that in the context of business a key contribution of the network perspective is to provide a way to capture the role of sociological influences on economic decisions. Studying network dynamics may then also be an opportunity to broaden the circles of questions being asked about the role and significance of networks in business life.

To elucidate this point, we build upon the work of Blau (1964) and others to argue that within the business context we can conceive of at least four distinct types of relationships that businesses or individuals can be embedded in (see Figures 2 and 3) – hierarchical, social, referential, and market relationships. Hierarchical relationships reflect authority, affective relationships reflect an emotional or kinship bond, while market ties reflect competitive or transactional relationships, and referential ties represent certification relationships. Illustratively speaking, at the individual level an employment relationship is an example of a hierarchical tie, friendship or common club membership would be an example of an affective tie, buying a good or service from a vendor would be an illustration of a market tie, while graduating from a certain school would be a referential or certification tie. For a business, its tie with a regulator would be a hierarchical tie, its ties with a charity organization or partner may be regarded as an "affective" tie, its ties with its customers, suppliers and competitors would be market ties, while its tie with a credit rating agency would be a certification tie.

Figure 2 and 3 about here

Using this somewhat broad rubric we note that existing research on interorganizational networks has focused heavily on market ties and to a lesser degree on referential ties. How organizations develop, use and manage their hierarchical or affective ties has been examined much less. Yet, it could be argued that, from a resource dependence perspective, affective and hierarchical ties may also be critical to organizations and it is very likely that social relations are used in these arenas to achieve instrumental goals. For instance, building a social overlay over a hierarchical tie may be a natural strategy to blunt the edge of a

regulator's activity with respect to a given firm. Similarly, building "affective" ties may be an important mechanism that firms use to build employee motivation and morale or even develop a corporate identity or culture. If we are known by the company we keep, the same could be true of companies. Yet, how these forms of social bonding are influencing business decisions or affecting business outcomes is rarely studied.

Indeed, work in the special issue papers suggests that it is not just the effects of these ties on organizational outcomes that are likely to be sources of interesting questions. Quite possibly the relationships between these different forms of ties and how these ties evolve or morph over time may of itself be useful (see Mariotti and Vissa papers in this issue). What begins as an organizational market tie, may by Brieger's classic duality, stay on in as a network memory (Zaheer and Soda 2009) of individual employees and sit as a latent tie to be reactivated subsequently (Mariotti). Alternately, a casual meeting may lead to a friendship tie that becomes a hierarchical tie as a friend becomes an investor in a start up (see Vissa in this issue). Varella et al. (this issue) show how dense networks are created through the charismatic qualities of leaders, integrating social-psychological and nodal traits into the study of network creation and network outcomes.

The emergence of electronic social networks, be they through email, messaging, or personal (e.g. Facebook) or professional (e.g. Linked In) ties, represents another arena of incredible wealth from the perspective of network scholarship. How does technology change the structure of supported social networks? Using the framework developed earlier in the paper we note that how technology influences network structure can probably be analyzed in terms of its effects on the different dimensions of the network. Does it affect connectivity and reach, or also density or assortativity? How social ties emerge, morph or affect business in the context of technology enablers represents a new frontier for network research, one where data availability may not be an

issue but data-structuring and management (given the large volume of data) and the combining of data with creative and insightful theory is the real challenge.

However, this wealth of data is also making possible identification of many subtle effects. For instance, structural holes while providing access to more diverse information are also likely to be composed of weaker, lower bandwidth bridge ties (Granovetter 1973, Aral and Van Alstyne, 2011). Then whether they truly lead to more novel information reaching ego depends upon the product of two effects, one positive (disconnected alters) and one negative (lower bandwidth tie). The availability of data from electronic archives enables the separation of these component effects drawing attention to the notion that the nature of ties and their pattern may be related rather than independent and therefore establishing causality may be tricky in simple cross-sectional studies. More generally, the above observations should highlight that we are perhaps in the midst of a golden age in network research, from the perspective of theoretically interesting questions and innovative research contexts. We turn next to the empirical responsibilities that come with this privilege.

Some hygiene principles for the study of network dynamics

In the interests of developing a more solid empirical foundation for work in the area of network dynamics and indeed on networks more broadly we believe that a variety of hygiene precautions need to be considered carefully by future work. Failure to consider some of these issues has led to some degree of skepticism about the significance of extant network findings (see also Zaheer and Usai, 2004). In this section we try and identify a few basic hygiene practices that could go a long way towards improving the methodological rigor of research in this area and of the conviction with which findings can be considered. We identify five key principles.

Clear node and tie specification. In the context of organizational research a network is generally argued to be a source of some influence upon a focal actor embedded in the network. Yet, the basic definition of what nodes and ties should constitute the network is not often provided. For instance, if the argument being tested is about the effect of a embeddedness on the behavior of firms it could be argued that the various different types of firms and relationships that constitute a focal firm's inter-organizational environment are likely to have very distinct and potentially even conflicting effects, in many conceivable contexts. For instance, a firm's alliance network could include alliances with competitors, suppliers, buyers, complementors, and universities. Yet, one could argue that embeddedness in a horizontal network of competitors is very different from embeddedness in a vertical network of suppliers and buyers. Information and influence flows from these two different types of organizations and relationships may have very different meanings. Yet, often in the literature no clarity is provided as to whether the horizontal or vertical network is more relevant for studying a given effect or whether it makes any sense at all to combine all these ties into a single inter-organizational network. Thus, clarity on which nodes and ties are to be included in studying a specific problem is the first aspect of the network that needs to be addressed.

The specification of a plausible and articulated data-generation process. Most network studies require inferring a flow of some kind of content through a given network, rather than a direct analysis or observation of network content. For instance, information is assumed to flow through an alliance network but is not actually observed. For research to be credible in the network context it is important that scholars be precise about how the studied outcome can plausibly emerge from the observed network. To do that the researcher needs to specify clearly the content that is expected or presumed to flow through the

network and then build a plausible case that the network being studied would in fact generate such a flow and lead to the outcome being studied (Zaheer and Soda 2009). For instance, consider an inter-organizational network that is argued to be influencing the patenting outcomes of firms that constitute the nodes of this network. If such a network is built through analysis of technology alliances between these firms the data-generation process is relatively clear. The argument would be that technology alliances imply the formation of ties between scientists in different firms and these ties between scientists can serve as the conduit for the passage of technical information which can influence the patenting of the nodes that reflect the organizations of these scientists. Yet, if the same issue was studied but the network was constructed on the basis of ties that represented common board-of-director memberships of individuals the data-generation process is far less transparent. It is unclear that board-members would actually be well informed about the latest technical developments or have the absorptive capacity to share or transmit that information. Thus, for the outcome being studied, new technical innovations the data-generation process is inadequately specified.

Controlling for alternative explanations. In some senses this is an obvious staple for all research. However, in the context of network research this issue takes on a particular salience. A significant part of the appeal of network research for management scholars is that it illuminates the role of sociological influences in a primarily economically driven context (see Ahuja, 2007). Yet, for this very reason the threshold for scientific acceptance is higher. It is critical that research claiming a sociological network effect for a phenomenon that is primarily economic in nature should naturally control for the obvious economic determinants of this effect. Failure to do so might leave the research open to critiques that it simply reflects an omitted variable bias (if the economic effect could be argued to be

correlated to the observed sociological variables). Indeed, researchers have often had to confront the criticism that so-called social network effects are simply relabeling of already known economic effects. For instance, the argument that centrality in a network is associated with superior performance can simply be argued to be an artifact of the observation that more successful firms may be more desirable affiliations rather than that their pattern of affiliations leads to success. Thus, the reason for the success of a firm that is central in its network may simply be its market dominance or scale rather than the fact that it has many ties. Thus, controlling for scale or market dominance would be critical before claiming a network effect.

Indeed, the general point applies more broadly. Many studies in economics now examine sociological outcomes. For them the concern also plays out similarly. Such studies need to control for the likely sociological determinants of the studied outcomes. In Table 2 we capture this idea through a simple matrix. Clearly the most impressive contributions are often on the off-diagonals of this matrix. However, the burden of evidence is also highest for these. Before claiming a sociological antecedent for an economic outcome or an economic antecedent for a social outcome it is critical to control for the "more natural" or at least the "dominant" explanation. In our setting ensuring that our controls for economic explanations are robust is one way to address this concern.

Table 2 about here

The dis-equilibrium reasoning problem. A concern that can be raised about network research is that represents "dis-equilibrium" reasoning. Some actors benefit from a given network structure but others sit by and let that happen without doing anything about it – a

situation that to most economic observers of a phenomenon is simply unlikely to constitute an equilibrium. Note that network dynamics in the sense of exploring how networks evolve is a mechanism to solve precisely this problem. Building theories of actor motivations and abilities grounded in economic or psychological processes, or indeed in structural processes is one way to directly attack this disequilibrium reasoning critique. To do so network studies need to more effectively recognize the "objective functions" of various players, and also recognize that tie formation is a matching process. Modeling tie formation behaviour accordingly would be useful to increase the credibility of the research.

The causality problem. The available body of research on the relationship between network structures and outcomes is largely built on the basis of the assumption that outcomes of network structures are exogenous to the structures that created them. This assumption is troubling (Mouw, 2006). Indeed, failure to account for endogeneity, direction of causality, and unobserved heterogeneity have all been raised as possible sources of methodological error in network research (Ahuja, 2007; Sinal, 2011). As Baum and Rowley point out (2008), although the idea that structural advantages are available to occupants of certain network positions is widely accepted, this idea is based on cross-sectional studies. In reality, it is possible that some advantages precede, rather than follow, network positions. The evolutionary dynamic presented in our framework in Figure 1 also implies endogeneity between network structures and outcomes. As the framework suggests that changes in the network emerge as a consequence of motivated actors driving those changes, it becomes important to control for the econometric implications of network change, even to obtain accurate estimates of the network's effects on behavior and performance. Thus, in addition to the very important theoretical and practical reasons for drawing attention to network

dynamics, there is also an important methodological reason: separation of cause and effect may be made possible in a longitudinal context.

Modeling this endogeneity and assessing its role in driving existing results on network effects is clearly an important imperative for future research. Broadly speaking, a longitudinal research design combined with appropriate statistical methodology can potentially limit the impact of endogeneity and contribute to discover in a more appropriate and rigorous way the logic and the processes behind the relationships between network structures and network outcomes. Different statistical procedures are available to researchers to face this potential problem, but the biggest issue is finding appropriate instruments. Using exogenous shocks to identify effects is a promising arena, but finding data-contexts with clear and usable exogenous shocks will remain a challenge.

Conclusions

Empirical research on network dynamics has been quite sparse. The paucity of empirical research likely stems from challenges such as the practical difficulties posed by obtaining longitudinal network data, the complexities of handling networks over time, and a lack of attention with the theoretical and econometric handling of endogeneity concerns. In order for the field to advance, a cumulative body of empirical evidence is needed to advance our understanding about the emergence, evolution, and dynamics of networks.

In this paper we offer an overview and overarching framework for studying network genesis and evolution. This framework identifies four key components of any model of network dynamics – the network primitives (nodes, ties, pattern of connections), network microfoundations (agency, opportunity, inertia, exogenous/random), network microdynamics (eg. homophily, prominence attraction) and network dimensions (degree

distribution, connectivity, clustering, density, degree assortativity). The core idea is that in any network, evolution is driven through a process wherein the nodes are motivated by one or more of the micro-foundations to form, maintain or dissolve ties. This drive is manifested in the form of a particular micro-dynamic (eg. homophily, brokerage) that causes them to seek either specific partners or specific tie patterns. This behavior leads to changes in the network along structural dimensions (at ego and full network levels) or in the content of the network. The accumulative effect of these changes however can lead to the modes being motivated by another micro-foundation and thus starts of the process anew. Further we highlight the role of *time* in the relationship between network structures and performance and we theorize on the main mechanisms which take place in this relationship: the reconstruction of social structures and the accumulation of relational content.

By offering an overarching theoretical framework on the micro and macro evolutionary patterns of network evolution and change, we argue on how logics of creating network structures shift over time. Our effort is part of a general tendency in network research that encourages investigations of temporal sequences, path dependencies, and evolutionary patterns. A fundamental reason for our theory on network dynamics is the issue of whether networks can be considered in social sciences as epiphenomenal or whether they emerge from a set processes and mechanisms which we can systematically identify and relate to a more integrated framework.

We believe that a better comprehension of the factors that generate and shape network structures can also contribute to discovering the mechanisms and processes which drive network outcomes. Without a comprehension of the logic that drives network creation, scholarly understanding of their outcomes remains incomplete (Salancik, 1995). A more integrated knowledge of the entire chain clarifies and establishes the temporal sequencing of

causal mechanisms behind the emergence, evolution and outcomes of networks. To aid in this process and to catalyze it we have identified both, key theoretical questions, and a set of hygiene practices for the conduct of empirical work in the area.

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Figure 1: Understanding Network Dynamics

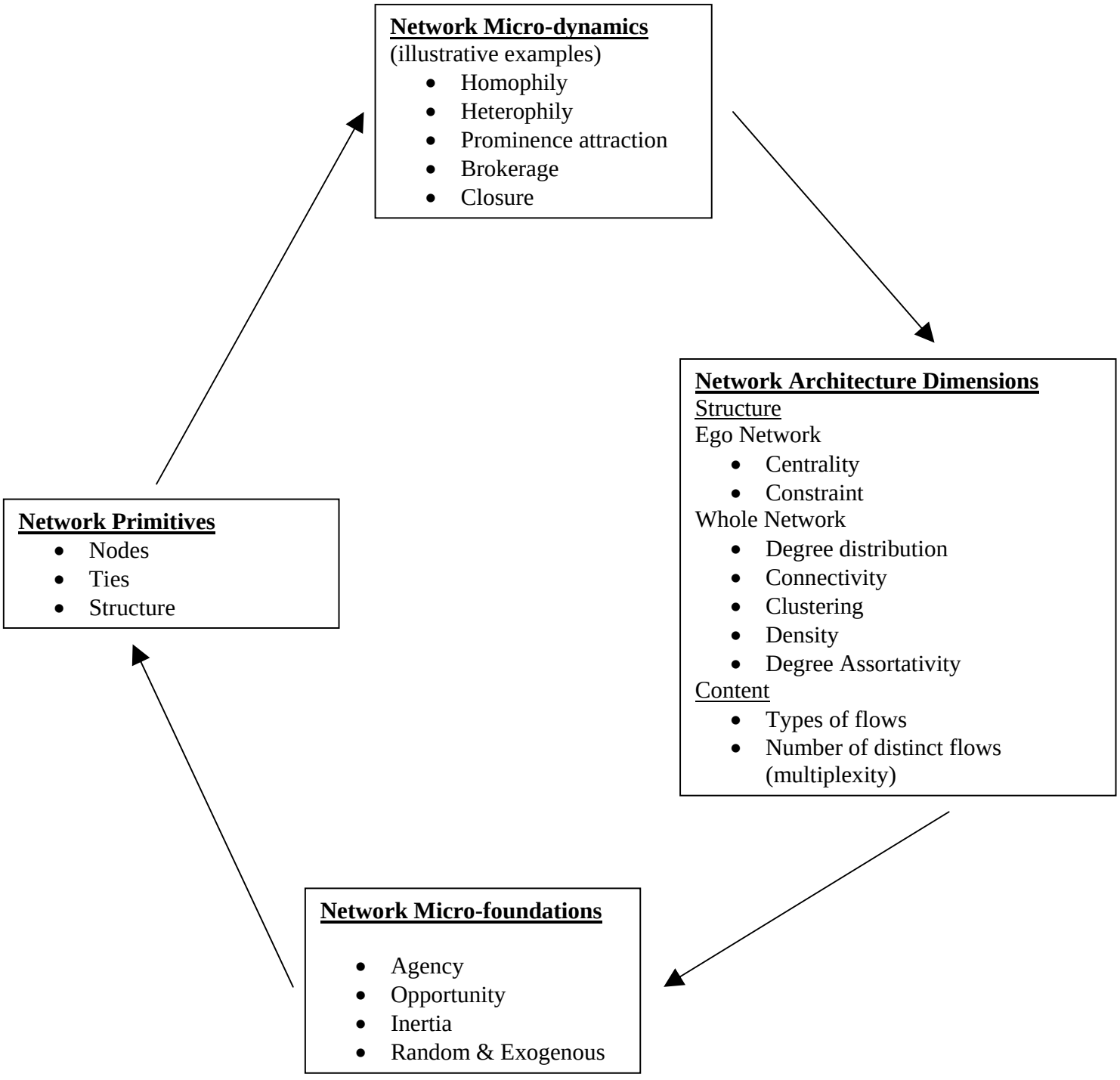

Figure 2: The Embeddedness of Individuals

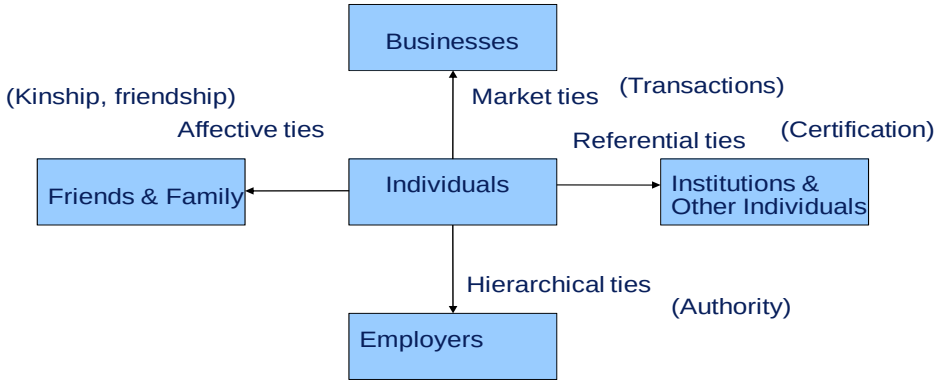

Figure 3: The Embeddedness of Business

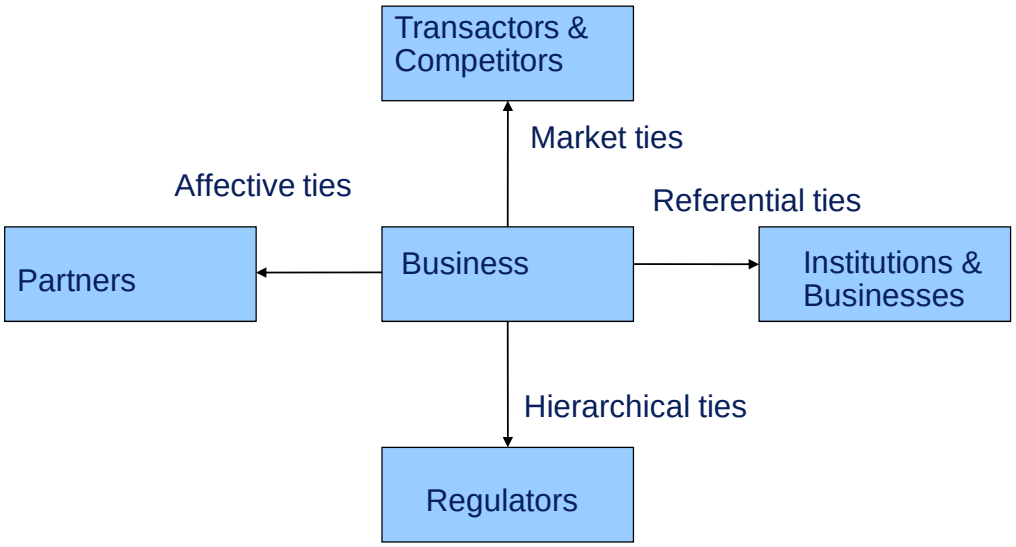

Table 1: The Foundations of Network Dynamics

Micro-foundations	Examples of Ego-level Micro-dynamics	Illustrative Prediction for Network Architecture
Agency	Nodal assortativity driven: Homophily, heterophily, prominence-attraction	Eg. Homophily driven change should lead to clique formation, and relatively high network diameter:
	Tie Pattern driven: brokerage, closure	Pursuit of closure should lead to high density, high connectivity, low variance in degree assortativity
Opportunity	Nodal assortativity driven: Proximity, common goals, common identity	Ties form within social groups more so than across them leading to clique formation
	Tie pattern driven: Transitivity, repetition, referral	Friends of friends are more likely to form ties with each other leading to triad closure
Inertia	Nodal assortativity driven: Habits, Networking propensity, collaborative expertise,	Momentum in networking behavior should lead to high variance in degree assortativity and high levels of clustering
	Tie pattern driven: Norms, Interorganizational routines	Norm and interorganizational routine driven networking behavior will lead to increasingly dense clusters with few bridging ties and hence lower connectivity
Random/Exogenous		

Table 2: Economic versus Social Outcomes

		Type of Logic	
		Economic Reasoning (Calculating, rational choice, optimization)	**Sociological Rationality** (Suppression of atomistic calculus, norm driven decision-making)
Type of Outcome	**Economic Outcome** (profits, forming a business alliance, appointing a board member)	Resource complementarity determines alliance partner choice, financial precursors influence credit availability	Network ties influence partner choice, embeddedness substitutes for contracts
	Social Outcome (deviance, affection, friendship)	Abortion laws predict crime	Cohesion fosters social behaviors, Social ties influence marriage and familial success