KNOWLEDGE TRANSFER IN MULTILEVEL NETWORKS:
CONTINGENT EFFECT OF ORGANIZATIONAL AND SOCIAL STRUCTURE

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ABSTRACT

We examine how organizational and social structure jointly influence knowledge transfer and sharing relations across organizational subunit boundaries. In an analysis of task advice relations among members of a Formula One team, we find that informal network mechanisms reinforce, complement and complete workflow dependencies implied by formal organizational structure.

INTRODUCTION

What mechanisms sustain the network of interpersonal relations through which knowledge flows across organizational subunit boundaries? With a limited number of exceptions, available attempts to address this basic question have emphasized the prominence of social networks ignoring the fundamental role that formal organizational structure continues to play in processes of knowledge creation, transfer and exchange (Tortoriello, Reagans and McEvily, 2012). Attending simultaneously to relations induced by membership in formal organizational units and relations induced by network dependence between individual is essential because – as Brass, Galaskiewicz, Greve, and Tsai (2004: 801) put it – "ties between people in different units are especially intriguing, because they create ties between organizational units. … When two individuals interact, they not only represent an interpersonal tie, but they also represent the groups of which they are members." As a consequence, a full understanding of the role of interpersonal knowledge sharing and transfer relations within organizations (the "company behind the chart") (Krackhardt & Hanson, 1993) is unlikely to be reached if the formal organizational structure ("the chart" itself) is ignored. However, the chart and what might lie behind it are rarely examined together (McEvily, Soda, and Tortoriello, 2014).

Our work speaks directly to this point. We build on the generally shared understanding of organizations as multilevel hierarchical social systems explicitly designed to focus the attention of their members and shape their social interaction (March & Simon, 1958; Simon, 1962). Our objective is to examine more closely how organizations as hierarchical multilevel settings affect knowledge sharing relations among organizational members (lower level actors) within and between organizational subunits (higher level actors) that are themselves embedded in a network of hierarchical relations.

THEORETICAL BACKGROUND AND HYPOTHESES

Interpersonal and Interunit Relations in Organizations

Task advice relations are a specific example of a social relation that is "influential in explaining the processes of knowledge creation, transfer, and adoption" (Phelps, Heidl and Wadhwa, 2012: 1155). Networks of task advice relations are generally considered as the main informal social infrastructure through which resources, knowledge, and information flow within organizations (Lazega, Mounier, Snijders, and Tubaro, 2012; Nebus, 2006; Podolny and Baron, 1997). Intra-organizational networks of advice relations are important as much as they are unavoidable because they relate directly to fundamental and recurrent activities of organizational knowledge transfer and sharing (Cross, Borgatti, and Parker, 2001).

Task advice relations that cross-cut intra-organizational boundaries are particularly important, given their systematic association with knowledge sharing and transfer across organizational boundaries, and hence with a variety of performance outcomes – including, for example, organizational productivity, competitiveness, individual creativity and innovativeness (Argote, McEvily, and Reagans, 2003; Burt, 2004; Caimo and Lomi, 2014; Cohen and Levinthal, 1990; Hansen, 1999; Reagans and Zuckerman, 2001; Tortoriello and Krackhardt, 2010; Tortoriello et al., 2012; Tsai and Ghoshal, 1998). In spite of their benefits, boundary-crossing relations are difficult to build and maintain over time. Knowledge is unlikely to flow freely across organizational boundaries encircling specialized resources, knowledge pools, and interdependencies (March and Simon, 1958).

The perspective taken by the majority of research examining the conditions under which knowledge embedded in interpersonal relations is likely to reach across intraorganizational boundaries and be transferred and shared between distant organizational members has been not completely satisfactory. Studies of advice networks, and more generally of social networks, in organizations have implicitly treated participants as members of social groups – that is as "groups that are relatively small, informal and involve close personal ties" (Freeman, 1992: 152). This conceptualization typically leads to empirical studies of single interpersonal networks where organizational structure plays little or no role and informal relations are conceived as autonomous from the more formal elements that define organizations as structured social settings (Dokko, Kane, and Tortoriello, 2014). As McEvily et al. (2014: 4) recently put it, "the surge in scholarly attention to informal social structure (…) has created a sort of amnesia about the role of formal elements in explaining the functioning, performance, and nature of organizations." One consequence of this "amnesia" is that we still know little about how formal relations of hierarchical dependence interact with informal social networks to shape knowledge sharing and transfer activities within organizations.

A more realistic approach might conceive organizations as hierarchical social systems with multiple and partially nested levels of action (March and Simon, 1958; Simon, 1996). Organizational members are typically nested within a variety of aggregates such as, for example, teams, functions, departments, subsidiaries or business units (Borgatti and Forster, 2003). Organizational members are connected to one another within and across the boundaries of these aggregates by a variety of relations. In turn, aggregate entities are connected to one another by formal – or "mandated" – relations which might be determined by technological processes shaping the workflow (Thompson, 1967), or by administrative processes through hierarchical dependence linking individuals within and across subunits (Perrow, 1970; Pfeffer, 1981). The resulting configuration of organizational units and individuals induces a multilevel network

structure, whose existence and implications organizational research has started recognizing only recently (Baum and Ingram, 2002; Brass, 2000; Brass et al., 2004).

Membership of individuals in aggregate entities implies that interpersonal and interunit relations are rarely independent of one another (Moliterno and Mahony, 2011). The most obvious implication of this lack of independence across organizational levels is that interpersonal ties may be just as easily the consequence of interunit ties. This has far-reaching consequences in the study of advice relations between organizational members. The autonomy and ability of interpersonal ties to connect distant individuals cannot be established without accounting for the powerful effect of ties between organizational subunits defined at a higher level of analysis. This claim suggests that interpersonal ties derive from the exercise of "discretion with constraints" (Kleinbaum, Stuart, and Tushman, 2013) – i.e., they are affected by the multiple social foci that organizations offer to their members (Lomi, Lusher, Pattison, and Robins, 2014).

In the next section, we start from these general considerations to derive a set of hypotheses linking formal organization structure and social structure of interpersonal advice networks within organizations.

Interdependences across Levels

A number of factors contribute to the difficulty of establishing and sustaining knowledge transfer across organizational subunits. Shared membership in organizational subunits provides enhanced opportunities and stronger incentives to form within-unit ties. This is the case because organizational subunits provide social settings (Pattison and Robins, 2002) that encourage the development of familiarity (Hinds, Carley, Krackhardt, and Wholey, 2000), supply a repertoire of shared experiences (Marsden, 1988), and facilitate the shared memory and interpretation of past events (March, and Olsen, 1975). The intended purpose of organizational design is to identify and encircle major interdependences within purpose-built subunits (Thompson, 1967). The fragmentation of knowledge inherent in the successful implementation of organizational design solutions systematically increases the cost of integrating heterogeneous resources (Tortoriello and Krackhardt, 2010). Hansen (1999) argues that such costs are induced by the time needed to cultivate relations across subunits and the attention necessary to process information generated in different and distant units. This subjective element of cost reduces further the permeability of subunit boundaries to knowledge and information that might be available in other subunits. Accordingly, we predict:

> *Hypothesis 1: Advice relations are more likely to be observed between members of the same organizational subunits.*

The image of organizations implied by this hypothesis is that of the "cavemen world" described by Watts (1999: 102) where members live in dense isolated clusters (or "caves") of strong, frequent, and redundant relations. Organizations are rarely decomposable into isolated caves: the formal boundaries of organizational subunits might contain the majority, but typically not all of the observed ties among their members.

How organizational structure affects knowledge sharing, and hence individual search for new knowledge across subunit boundaries, is likely to be contingent on the kind of task that organizational members confront (March and Simon, 1958). When the complexity of the task at hand increases, so does the range of search for alternative solutions. In this case "local search" is

unlikely to produce useful responses to complex problems – problems whose resolution typically requires access to distant knowledge sources, and diversified experiences (Nelson and Winter, 1982; Baum, Rowley, Shipilov, and Chuang, 2005; Beckman, Haunschild, and Phillips, 2004). Search for knowledge tends to be local when it concerns solutions to familiar problems (Levinthal and March 1981; Nelson and Winter, 1982). As task complexity increases, the range of the personal networks through which knowledge flows is likely to increase accordingly (Reagans and McEvily, 2003; Reagans and Zuckerman, 2001). Then, interpersonal ties are more likely to cross-cut subunit boundaries.

To better understand the social and organizational mechanisms that facilitate boundary crossing relations, it is frequently useful to interpret organizational subunits as social foci – "social, psychological, legal or physical entit(ies) around which joint activities are organized" (Feld 1981: 1016) – whose boundaries are established by design and maintained by official administrative rules, explicit systems of incentives, and formal resource allocation policies (Lomi et al., 2014). Because "most associates are drawn from focused sets" (Feld, 1982: 798), connections between organizational subunits decrease the distance between social foci. Building on Feld's original theory (1981), we claim that connected social foci are more likely to provide bridges that facilitate the development of ties across social boundaries. Accordingly, we predict:

Hypothesis 2: Advice relations are more likely to be observed between members of interdependent organizational subunits when task complexity is higher.

We postulate two multilevel mechanisms consistent with this hypothesis. The first is the tendency of knowledge between individuals to flow in the same direction as knowledge between organizational units. Since this mechanism implies that informal social structure reinforces formal organizational structure, we refer to this mechanism as multilevel reinforcing. The second is the tendency of knowledge between individuals to flow in the opposite direction of the knowledge between organizational units. Since this mechanism suggests that informal social structure supports and complements formal organizational structure by reversing the flow of information, we label this mechanism as multilevel complementing.

Hypothesis 2 argues that informal advice relations between individuals in different subunits occur, at least in part, as a natural consequence of the workflow-related activities linking organizational subunits. Yet, relations across boundaries remain costly, and fraught with difficulties and risks (Hansen, 1999). Building on earlier work by Uzzi (1996), Caimo and Lomi (2014) recently highlight the role of reciprocity in supporting boundary-crossing ties by reducing uncertainty and providing conditions of "conditional kindness" whereby advice is given under the expectation that it will be received (Fehr and Gächter, 2000). When task complexity increases so does uncertainty and the corresponding need to coordinate across organizational boundaries. By creating expectations of repeated interaction within the organization, reciprocity supports joint problem solving activities and arrangements, promotes trust (Uzzi, 1997), improves the understanding of complex problems (Tortoriello and Krackhardt, 2010), reduces the risk of opportunism (Coleman, 1988), and facilitates the transfer of private information and critical knowledge resources (Gulati, Dialdin, and Wang, 2002). Similarly to trust, reciprocity also contributes to the stability of collaborative knowledge sharing relations across boundaries (Schelling, 1960). Following this evidence, we predict:

Hypothesis 3: Advice relations between members of interdependent organizational subunits are more likely to be reciprocated when task complexity is higher.

Reciprocity in the advice network completes formal organizational structure by providing a setting for informal knowledge sharing. We refer to this mechanism as multilevel completing.

METHODS

The occasion to establish the empirical value of our argument is offered by data that we have collected on collaboration among the 118 members of the Information System (IS) division of a prominent Formula One racing team. Members of the team are responsible for designing and managing the information systems of Formula One cars. Their responsibility covers all electronic components and circuitry of the cars. Although acting as a single entity, the team is a multiunit organization. A few members are directly affiliated to the corporate unit, while the others are distributed across 24 external companies – either spin-offs or independent companies. Most companies are in charge of one area of activity only, and the areas are highly integrated and interdependent.

For its emphasis on continuous improvement and fast-paced technological innovation, and for the hyper-competitive environment that is the defining feature of professional motor sports, Formula One racing provides an almost ideal example of a setting in which knowledge sharing and transfer among members of competing teams is essential to competitive advantage and organizational performance (Argote and Ingram, 2000; Castellucci and Ertug, 2010). Also, the activities of a Formula One racing team take place under highly variable contextual conditions. Team members are involved in redesigning the cars between seasons as well as in continuously improving them race after race. Team members may also be required to deal with unexpected events or to adjust to other teams' strategic changes during the races. These two contextual conditions represent distinct cases of knowledge sharing which imply respectively lower versus higher task complexity.

We collect information on interpersonal advice relations that capture specific kinds of organizational knowledge that team members must share or transfer in the two circumstances. The first type of knowledge that we examine concerns routine organizational activities performed in the course of the average workday (i.e., knowledge shared under conditions of lower task complexity). The second type of knowledge that team members have to share concerns activities performed during the actual races of the racing season. Unlike the first, the second type of knowledge is shared under considerable time pressure and in circumstances where small mistakes, delays or coordination failures might make the difference between winning and losing a race (i.e., knowledge shared under conditions of higher task complexity). Finally, the third context originates from mandated workflow dependencies connecting the organizational units through individual members (Breiger, 1974). Unlike the prior types of knowledge, workflow dependencies are best interpreted as defining a relation between organizational subunits, rather than individuals (Brass et al., 2004; Hansen, 1999; Kleinbaum et al., 2013). Change in individual members of the team would not normally change workflow dependencies defined between the subunits – i.e., at a higher level of analysis.

To assess the effects of workflow dependency relations between organizational units on advice relations between individuals within and across units we represent each relation in network format. Then, we specify and estimate Multilevel Exponential Random Graph Models

(MERGMs) - a new class of statistical models derived specifically for the analysis of multilevel networks (Wang, Robins, Pattison and Lazega, 2013). MERGMs consist in a logistic regression-like model, which allows accounting for the interdependencies between observations – i.e., network ties – typical of relational data. We test specific mechanisms accounting for different ways in which informal advice relations observed between individuals (lower level actors) are affected by formal relations existing between organizational subunits (higher level actors) to which individuals are affiliated in the two conditions of task complexity. The multilevel network analysis that we conduct affords examination of the multiple possible connections between informal knowledge sharing networks and formal organizational structure at unprecedented levels of detail and precision (Zappa and Lomi, 2015).

FINDINGS

Results indicate that the effect of formal organizational structure on social networks is contingent on the level of complexity inherent in organizational tasks. The long-established insight that organizational boundaries tend to be impermeable to crosscutting knowledge sharing relations holds true only for lower complexity tasks. In this case, organizational subunits tend to retain interpersonal ties within their boundaries and knowledge transfer and sharing relations are unlikely to crosscut the subunit formal boundaries, thus confirming the first hypothesis

By contrast, we find that under conditions of higher task complexity knowledge sharing and transfer relations across organizational boundaries are more likely to occur between members located in interdependent subunits. We distinguish between advice relations of knowledge sharing between organizational members that complement and complete formal workflow dependencies. The first mechanism – i.e., complementing – implies a reversal of the knowledge flows across organizational levels. The second mechanism – i.e., completing – implies mutuality in interpersonal knowledge transfer and, therefore, proper knowledge sharing. In no case we find that interpersonal advice networks simply reproduce the network of formal organizational dependencies, reinforcing the formal workflow dependencies.

These results reveal a clear gap in our current theoretical understanding of how organizational and social structure jointly affect knowledge transfer and sharing processes across multiple levels. In this sense, our work may be interpreted as a first step in this direction, and offers specific analytical strategies that future research may adopt to fill this gap.

REFERENCES AVAILABLE FROM THE AUTHOR(S)