Network Evolution: The Origins of Structural Holes

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We develop and test a theory of the origins of network structures, specifically of structural holes, building and testing a theoretical framework proposing that network structures emerge from the interplay of two complementary forces: structural constraints and network opportunities. We analyze data on a co-membership network among 501 production teams in the Italian TV production industry tracked over a period of 12 years, explicitly accounting for endogeneity. We find that structural holes spanned by teams originate from the prior status and centrality of teams that members were part of in the past, in addition to structural holes spanned in the past. But a focal team spans fewer structural holes if its members were part of cohesive teams earlier and if the past teams they were connected to produced similar artistic content. We also demonstrate that spanning structural holes is associated with superior team performance in terms of greater viewership. The results support both opportunity exploitation and structural constraint explanations, although we find that homogeneity rather than diversity influences performance across structural holes.●

A great deal of organizational research has focused on the network antecedents of favorable outcomes for teams (e.g., Reagans, Zuckerman, and McEvily, 2004; Soda, Usai, and Zaheer, 2004) and firms (e.g., Ahuja, 2000a; Baum, Calabrese, and Silverman, 2000). Though research on the performance outcomes of social structures is valuable, it raises the question of precisely how social structures come about and the processes that shape their evolution over time. Without understanding the temporal sequencing and causal linkages behind the creation of networks, knowledge of network emergence and outcomes remains incomplete. A related and more fundamental reason to understand the origin of network structures is the issue of whether they are epiphenomenal or whether they emerge from a set of factors that we can systematically identify and relate to a theoretical model.

Prior explanations for the origins of network structures have typically extrapolated from research on the origins of tie formation, according to which past ties predict future ties, suggesting that structural persistence or inertia shapes the evolution of organizational networks (Walker, Kogut, and Shan, 1997; Gulati and Gargiulo, 1999). At the same time, scholars have also recognized that network structures provide a source of opportunities that help network actors arrive at favorable outcomes. These opportunities, as well as inertial constraints, are related not only to the network's structural characteristics but also to its content and nodal properties, all of which the focal actor is exposed to through its network ties (Ahuja, 2000a; Rodan and Galunic, 2004). Past networks offer actors a combination of experiences, knowledge access, prominence, and power that can open opportunities and create inducements, which in turn can influence the evolutionary pattern of network structures. While the past structure can give rise to opportunities, a structural network actor can take advantage of those opportunities in a manner that could create a favorable and valuable social structure going forward, subject, of course, to the inertial constraints that are imposed

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by the very same past structure (Stevenson and Greenberg, 2000).

For focal organizational actors, favorable network structures can emerge from a combination of the two complementary forces of structural constraints imposed by and the network opportunities provided by past network structures and positions. While some scholarly understanding of the factors that influence the formation of relationships between organizational entities exists, in this paper, we go beyond the creation of ties to focus on the evolution of structures, specifically structural holes. We focus on the genesis of structural holes because our goal is to better understand the origins of a specific type of network structure rather than that of tie formation or structures in general. Structural holes are present in an actor's network of relationships when the focal actor (or "ego") is tied to others ("alters") who are not themselves connected (Burt, 1992). Structural holes capture, like other related concepts such as weak ties (Granovetter, 1973; Hansen, 1999), range (Reagans and McEvily, 2003), and brokerage (Xiao and Tsui, 2007; Fleming and Waguespack, 2007), a key network structural property, the efficient and non-redundant access to resources and information.

We investigated these issues in a study of 501 TV productions produced and broadcast over a 12-year period in Italy. TV productions are created by temporary project teams, and the teams are interconnected by virtue of co-memberships of industry specialists in production teams. Our research context of temporary networks, in which teams are continuously dissolved and recreated over time, enabled us to test the structural and nodal conditions under which favorable network structures arise. A distinctive characteristic of our study is that we were able to capture the content of TV productions. Because we aimed to explore the origins of structural holes, capturing content allowed us to examine how network structure and content independently shape the formation of networks in future periods, which also tests an untested assumption common in the network literature that structural holes reflect content diversity (Burt, 2004). Furthermore, including the performance implications of structural holes confirms the appropriateness of our focus on this specific form of network structure.

NETWORK STRUCTURES AND PERFORMANCE IN CULTURAL INDUSTRIES

The TV production industry is recognized to be a cultural industry in the sense that it produces an aesthetic, symbolic, or expressive product (Lampel, Lant, and Shamsie, 2000). Such a product, for example, a TV movie, is a creative, non-additive, synthesis of information, ideas, and experiences of the specialists that make up the production team. In the present research, we label the essential symbolic and aesthetic characteristics of a TV production team's creative output its "content." The output of the production team is a prototype in the sense that each product is produced anew. In these situations, a product's characteristics, including its content, embody and reflect the experiences of the members of the team and are collectively "owned" by them. When these team members move to other teams at a later time, they carry with them the knowledge, ideas, and experiences accumulated over time from prior teams, like the process of transmitting tacit knowledge across organizational or unit boundaries. Concurrent team memberships work similarly to transmit knowledge across teams.

The production teams in the industry form a large network through interconnected specialists over time. Along these lines, Lampel and his colleagues (2000: 265), referring to temporary projects in cultural industries, noted, "The virtue of such latent structures is that they can provide the means whereby a network of specialists that have previously worked together can . . . efficiently reconstitute the network." The teams, and the industry network as a whole, can therefore be viewed as a connected universe of identities, values, symbols, and artistic expression (Starkey, Barnatt, and Tempest, 2000). In consequence, content flows through network ties via the individuals that connect different teams by virtue of co-memberships on teams. In the creation of a TV production, resources accessed in this manner are essential for the enhancement of the creative and idiosyncratic characteristics of the product. Naturally, concurrent links and structures provide different information to the focal teams than do past links and structures—the latter enable the flow of ideas stemming from experience, whereas concurrent links are likely to provide current information. In such co-membership networks, a focal team's alters become defined as those teams on which current team members either serve concurrently (current alters) or have served in the past (past alters).

Team members adopt a variety of different roles in the team and bring to bear a heterogeneous set of specialized task and skill capabilities on the creation and production of a movie (Baker and Faulkner, 1991). Each team is composed of a director, an assistant director, screenplay writers, the original author, actors, music creators, the producer, one or more executive producers, and so on. Thus every team is required to have the entire range of skills needed to produce a TV movie, depending on the kind of movie being produced. Except for small variations, heterogeneity in skills and roles is limited across teams but, more importantly, does not substitute for the heterogeneity of new ideas, working processes, routines, and so on that are accessed from experience on other concurrent and past teams.

For production teams, the causality between actions and outcomes on both economic and artistic dimensions is ambiguous, resulting in a high degree of uncertainty about the success of the ultimate product (Holbrook and Hirschman, 1982). The uncertainty is only resolved after the production is created, produced, and broadcast. Until that time, the production team faces a number of decisions about the process of combining multiple identities and experiences, capturing the spirit of the times, or the *zeitgeist*, diverging from or conforming to the dominant genre, theme, or content, and dealing with a key challenge of successful cultural products, that of combining the imperatives of efficiency and creativity (Hirsch, 2000). Performance in this industry is the eventual commercial success of the production. The structural holes spanned by the focal team in the network of interconnected teams, and the access to resources they can provide to the team, may make the difference between successful and unsuccessful performance.

The Origin and Role of Structural Holes

Structural holes have attracted considerable interest because they are considered a form of valuable social capital (Adler and Kwon, 2002) and thereby present a social structural antecedent for many kinds of individual, team, and organizational outcomes. Two fundamental explanations can be identified underlying the creation of social structures: the opportunities inherent in prior networks, which may enable an actor to create or recreate future structures, and the inertial constraints imposed by prior network structures themselves (Sewell, 1992; White, 1992). Constraints and network opportunities thus parallel Giddens' (1984) conception of the duality of structure and action as acting and interacting in ways that mutually reinforce and perpetuate social structure through a structuration process (Sydow and Windeler, 1998).

More precisely, the opportunities provided by networks are exploited in future periods by virtue of two independent mechanisms: one deriving from purposive action by actors and another due to opportunities provided to actors by prior positions in the network. First, actors' purposive action may create structures by forming or dissolving network links, somewhat evocative of Child's (1972) notion of strategic choice. Network actors purposively exploit opportunities arising from past patterns of behavior, which lead to experiences and knowledge that in turn motivate and enable actors to recreate and reconfigure past network positions into future beneficial ones. In this vein, Burt's (1992) conception of structural holes as social capital highlights the entrepreneurial role of the network actor in generating this valuable form of social structure.

Second, positions in past networks can provide focal actors with opportunities that shape future networks independent of actors' ability or intention to strategically exploit past positions. For instance, adopting a similar logic, Powell et al. (2005: 1140) suggested that central and high-status actors are likely to receive a disproportionate share of future ties, referring to this network evolutionary process as "accumulative advantage." Such an advantage can amplify future changes in the structural characteristics of past networks by reinforcing the brokerage position of prominent actors over time (Fleming and Waguespack, 2007).

Conversely, rather than providing opportunities that actors can exploit and shape, actors' current set of interactions also produce social structures that tend to persist and reproduce themselves over time through norms, rules, and social pressures. In turn, this process creates inertial forces that shape and constrain an actor's behavior over time (Parsons, 1951). This structural explanation suggests a strong element of stability and path dependence and emphasizes the role of inertia and relational lock-in in network dynamics, implying again that it is strongly affected by previous structures and ties (Madhavan, Koka, and Prescott, 1998). Our interest here is in building a theory around the interplay of the exploitation of network opportunities and the role of structural persistence as forces behind the emergence of structural holes.

In a temporary network like the one we studied, the reconstruction by the focal team of the structural holes that team members were spanning in the past is a manifestation of the exploitation of past network structures: structural entrepreneurs exploit past network opportunities by reactivating structural patterns that were valuable in the past. The content diversity to which actors were exposed by their past links offers focal actors an opportunity to seek a more diversified set of alters through structural holes by reconfiguring past patterns. Further, past centrality and status derived from the performance of prior teams give actors the opportunity to exercise their judgment to choose among potential future team members in a way that reinforces or enhances their favorable structural position. Status orderings and structural popularity (centrality), as Podolny (1994) pointed out, become particularly valuable signals under uncertain conditions, such as those that exist in our research context.

At the same time, networks are subject to inertial constraints or persistence. Persistence is the extent to which interactions are reproduced over time and across a number of actors who develop what Giddens (1984) referred to as structural properties, or institutionalized frameworks that are reproduced across time and space. Thus persistence is not driven by purposive behaviors, judgment, or autonomous reconfiguration but, rather, by a process that is subject to the inertial, constraining effects of prior patterns of relationships. In the temporary network we studied, the notion of persistence is typified by team cohesion. Team cohesion is an expression of accumulated past working relationships that constrains the ability, motivation, and preferences of individual actors toward preserving past patterns. Teams with high cohesion (many prior working relationships) in the past, for example, will tend to find themselves in tightly linked structures in subsequent periods because future teams that employ the cohesive members of a prior team will tend to replicate previous connections, which will result in fewer structural holes for the focal team.

Structural Holes and Past Alter Content Homogeneity

It is a truism that networks give actors access to alters' experiences, ideas, information, and knowledge (Gulati, Nohria, and Zaheer, 2000; Ahuja, 2000b). Homogeneity and similarity of content among alters provide the motivation for the core membership of the focal team, those filling its key roles, to seek out diversity in the content of future alters. This argument, drawing on the logic of network opportunity exploitation and strategic choice, implies that the team's core membership may reconfigure its network to span structural holes in future networks with the expectation of accessing the requisite diversity to avoid the problems stemming from high levels of content homogeneity among alters.

Our argument also builds on the well-accepted argument in the research on structural holes according to which content and structure are mirror images of each other. Thus structural holes may be created to reach out to alters that hold diverse and novel content. Burt (2004: 5) made this argument explicit: "The presumption . . . is that the content of ideas reflects the social structure in which they emerge." At the same time, although disagreeing over which structure is more beneficial, Coleman (1988) also linked structure and content, arguing that network closure, implied by few structural holes, is associated with increasing similarity and conformity among actors.

Because novelty and innovation are the keys to success in the TV production industry, homogeneity among the project teams from which its specialists are drawn is likely to hamper the focal actor's ability to develop a successful production. Homogeneity may also be engendered by the clumping together of specialists in genre-driven communities. Common mental models, groupthink, and unproductive lock-in to sterile ideas could begin to hurt a focal team's creative potential (Janis, 1972). Thus actors' exposure to similar content can create an unfavorable context that induces the activation of a network reconfiguration mechanism seeking a more diversified set of alters, specifically ones accessed via structural holes. Consequently we hypothesize:

Hypothesis 1a (H1a): The higher the content homogeneity among past alters, the more structural holes that will be spanned by the focal team in the present.

Conversely, one could come to the opposite conclusion in reasoning about the constraints imposed by alters' content homogeneity. When alters' content is homogeneous, routines and standard operating procedures may develop more easily within the focal team, thereby enhancing efficiency (Cyert and March, 1963). Homogeneity may also enhance outcomes because of a more accurate understanding of the skills and capabilities that other members of the project team might possess, and what has been referred to as knowing who-knows-what, or "transactive memory" in the literature, may improve coordination and limit inefficient duplication for the production task at hand (Wegner, 1986). When the focal team is locked in with a group of alters with similar content, it may enhance its proclivity to seek out similar alters in the future, rather than those accessible by spanning structural holes. Because of homophily, these alters may be connected to each other, thereby reducing structural holes in the following period for the focal team. Therefore,

Hypothesis 1b (H1b): The higher the content homogeneity among past alters, the fewer structural holes the focal team will span in the present.

Structural Holes, Status, and Past Centrality

Teams may seek to form connections with high-performing teams to signal their status to the market (Podolny, 1993; Zuckerman, 1999, 2000). More specifically, the status of a focal actor derives from the performance of the alters with whom it is affiliated (Benjamin and Podolny, 1999). Scholars have distinguished status from the economic notion of reputation, the latter being tied much more directly to the performance of the focal actor itself (Shapiro, 1983; Washington and Zajac, 2005). A signal of high status is particularly valuable when market uncertainty is high, which characterizes the Italian TV production context well, because other cues about the inherent quality of the team are missing (Podolny, 1993).

The relationship between status and structural holes has been addressed by Podolny (2005), who argued that it is reasonable to hypothesize a high correlation between the two constructs, because an actor with structural holes is by definition prominent in the overall network. But he suggested that there is "a real trade-off between the formation of ties that will add structural holes to the network and ties that augment the actor's status" (Podolny, 2005: 233), because reaching out to lower-status players may increase structural holes but reduce status, implying a negative relationship between status and structural holes. From a different perspective, Burt (1992) argued that a network position rich in structural holes, by which an actor is connected to a large number of disconnected alters, might be beneficial in establishing a positive reputation. Thus, given the ambiguity in the literature, both the direction of the relationship between status and structural holes and the possible causality between them is important to assess.

Broadly, the status that current teams inherit from the performance of past alters and the prominence gained in past social structure give teams the opportunity to exercise selection power over current alters. At least three mechanisms are likely to contribute to a positive relationship between team status derived from past alters' performance and structural holes. First, high-status teams prefer disconnected alters because teams are reluctant to embed themselves in tightly connected networks in which the risk of knowledge spillovers among cliques would be higher than in open networks. Because tightly coupled networks create generalized access among their members to such spillovers, high-status teams will prefer disconnected structures in which they can maintain more effective control over these knowledge and information resources through brokership. As well, because the products in the TV production industry are creative and artistic combinations of ideas, the high-status team may also worry that highly connected alters could "gang up" against it and therefore again might prefer a sparse network structure with plentiful structural holes. The well-established control benefits of a network broker play directly into this argument.

A second and related explanation for the creation of sparse networks by high-status teams is that when approaching potential new ties, a high-status team may be able to require exclusivity, thereby reducing the risk of knowledge spillovers from the team. Such exclusivity would also imply more structural disconnectedness in the network. Of course it is possible that low-status actors may have to pay a premium to join a high-status team, which may restrict the availability of low-status actors, but the social rank conferred by high-status teams, especially in a cultural industry context, may make this cost worthwhile.

A third mechanism that may also play a role in generating networks with plentiful structural holes for high-status focal teams essentially operates by virtue of the popularity of high-status teams that employ well-known and successful specialists. Members of low-status teams will prefer to work in a high-status team simply because of its fame, insights, and knowledge, rather than because of common alters. Therefore the likelihood that the low-status teams will be connected with each other is lower, resulting in structural holes among them. From this viewpoint, current structural holes in a focal team's networks are the outcome of high-status teams accepting disconnected specialists into their teams. This is a mechanism that relies, in addition to a focal team's exploiting opportunity, on autonomous or collateral effects of alters' behavior, although a factor operating in the opposite direction is that a limited number of high-status teams may force low-status teams to connect with one another. At the same time, high-status teams that comprise successful people from past teams are also in demand from different venues in the industry, which also would beget structural holes for the high-status team.

A similar set of arguments apply when the focal actor has been connected to central players in the past. Centrality, which has been shown to be related to performance (Tsai and Ghoshal, 1998), imparts prominence to a team and can enhance the power of the team to demand exclusivity, as well as attract disconnected others to the team, thus creating structural holes in a later period. An alternative explanation is that teams that have had a higher propensity to form ties in the past may be composed of individuals who are part of a team that is also similarly highly inclined to form ties in the current period. Thus, in addition to viewing the status of focal project teams as based on alters' past success, we also conceptualize the prominence of the team in purely network terms as its centrality. Accordingly, we hypothesize:

Hypothesis 2a (H2a): The higher the status of the focal team, the more structural holes it will span in the present.

Hypothesis 2b (H2b): The higher the past centrality of the focal team, the more structural holes it will span in the present.

Past and Current Structural Holes

One of the more fundamental themes in the literature on structural holes is the notion that the actor spanning structural holes gains brokerage and control benefits from its position. Burt (1992: 76) described control as "giving certain players an advantage in negotiating their relationships." Expanding on this theme, he invoked the metaphor of the *tertius gaudens*, from Simmel (1922), as the "happy third" that is able to play off one alter against another. The latter focuses on the arbitrage benefits of brokerage and control, which are well recognized as deriving from exploiting the information asymmetry between alters that span the structural hole.
A number of other literatures echo the notion of advantage deriving from asymmetric positions, including resource dependence theory (Pfeffer and Salancik, 1978) and transaction cost theory (Williamson, 1985).

Our argument here is that the actor bridging structural holes in the past may exploit opportunities to recreate them to maintain the asymmetry embodied in the position to gain brokerage and control benefits (White, 1992). Thus, over time, actors may endeavor to replicate their privileged position, using the social capital accumulated from their past relations (Pollock, Porac, and Wade, 2004). Although the specific holes in past structures will vanish over time with the dissolution of both the teams and the network, the core membership of the focal team may use its power to once again create holes in the team's current social structure.

The TV production industry is in a state of continuous evolution due to the inherently temporary nature of TV production projects, thereby giving structural entrepreneurs and brokers numerous opportunities to construct and reconstruct their social structures. Being able to connect with other production teams that are disconnected from each other gives the focal team a broker's control over flows of information and knowledge across teams. We formalize the foregoing arguments as follows:

Hypothesis 3: The higher the number of structural holes in the past, the higher the number of structural holes the focal team will span in the present.

Structural Holes and Past Team Cohesion

Because of inertial constraints or structural persistence, past team cohesion—the extent to which members of the current organization or team have worked together in the past—is likely to persist over time, reducing the likelihood that structural holes will be generated in a future period. When such social bonds are created, they resist rupture, and the persistence that they manifest translates into connections between teams in later periods. In turn, such bonds should generate more cross-cutting ties among alters and therefore fewer structural holes in the focal team's network.

The persistence of social structures has been a common theme in the sociological literature (e.g., Suitor, Wellman, and Morgan, 1997). Scholars have argued that social structures are created as a result of ". . . members' disciplined compliance with group expectations" (Portes and Sensenbrenner, 1993: 1325). This view suggests that social structures are formed through the reproduction of norms and behaviors embedded in past social structures (Giddens, 1984). Social structures are therefore subject to inertia and path dependence and represent stable, institutionalized patterns of relationships (Bourdieu, 1986).

Considerable research has found empirical support for the idea that social structures reproduce themselves. Moreover, individuals and organizations are more likely to enter into new relationships the more relationships they start with. Gulati (1995: 643) demonstrated that the "social context resulting from cumulative prior alliances influences [subsequent] alliance formation." Similarly, Walker, Kogut, and Shan (1997) found that patterns of interfirm relations tend to persist over time. Ties may be repeated and consequently become stronger and more durable; time nurtures and cements relations. Overall, these arguments suggest that social structures tend to persist over time, and a structure with high levels of internal cohesion generates norms, trust, obligations, and reciprocity, all of which impede and constrain its ability to change over time.

Network structures with a high degree of within-team cohesion are unlikely to get converted into structures with numerous structural holes in later periods. Cohesion implies that teams are more easily able to reach out and connect to teams with specialists who have worked with their current members in the past than with those that have not. Future teams that employ the cohesive members of a prior team will tend to make connections between scattered prior team members, resulting in fewer structural holes and, conversely, greater closure among members. This effect may also work through team members persuading their teams to hire prior coworkers to maintain and enhance the social bonds among them. Thus the effect of within-team cohesion on the genesis of structural holes among teams is created by virtue of structural persistence. Moreover, due to the nature of cultural products, identity is a crucial element that coalesces and amplifies the persistence of cohesive structures over time (Soda, Zaheer, and Carlone, 2008). As well, teams themselves may recognize the efficiency value of shared language and routines and may prefer to hire people that have worked together in the past. These individuals manifest co-memberships through fewer structural holes in the focal team's network because they are also concurrent members of other connected teams. Formally,

Hypothesis 4 (H4): The higher the past team cohesion, the lower the number of structural holes the focal team will span in the present.

Alter Content Homogeneity and Performance

Two major and opposing lines of thinking can be identified regarding the relationship between diversity or homogeneity and performance. The first is rooted in the notion that diversity and variation are beneficial for the performance of teams because they strengthen the ability of the team to deal with uncertainty, complexity, and non-additive problems. Diversity helps the team in reducing the risk of groupthink and avoiding cognitive traps (Janis, 1972; Kahnemann and Tversky, 1979). According to the structural holes perspective, structural holes should enhance performance because they capture diversity and novelty in ideas by tapping into the capabilities of alters that are disconnected from each other (Burt, 1992). Conversely, however, low diversity, or high alter content homogeneity, may actually increase quality, as we argued earlier. When past alters are homogenous in their content, it is easier for shared specialists to transfer skills, routines, and knowledge to the focal team because of content similarity in the alters' creative products. Superior outcomes may result from access to alters with similar content because of the efficiency inherent in absorbing and applying skills and knowledge that share a common base (Cohen and Levinthal, 1990). Moreover, homogeneity may benefit the process of production because of a better understanding of the capabilities of team members, also referred to as who-knows-what, or transactive memory (Wegner, 1986). Some research shows that team diversity may hurt performance, and even though creativity may be enhanced, eventual success in implementation is negatively affected (Ancona and Caldwell, 1992).

In TV production, a team with high homogeneity in alters' content is exposed through the network to specialists who are currently working in teams with similar content. As several scholars have pointed out, success in this industry requires a combination of creativity and efficiency (Lampel, Lant, and Shamsie, 2000). The potential downside of such similarity is that the creative process may be stifled by the lack of new and different ideas and opinions, and because creativity is an important element of a successful product, performance may be hindered. Conversely, the quality and knowledge-related creativity of the project team's processes may be enhanced, resulting in higher performance. Reflecting the strong opposing arguments, we propose two competing hypotheses for the effect of alters' content homogeneity on team performance:

Hypothesis 5a (H5a): The higher the homogeneity of current alters' content, the higher the performance of the focal team.

Hypothesis 5b (H5b): The higher the homogeneity of current alters' content, the lower the performance of the focal team.

Structural Holes and Performance

Even after we tease out the role of diversity, structural holes may also exert a direct effect on performance (Soda, Usai, and Zaheer, 2004). The benefits of structural holes, beyond accessing diversity and novelty, arguably operate through mechanisms of control, brokerage, and the exploitation of information asymmetries between disconnected alters, which we refer to as a competitive specialization effect. In the TV production industry, project teams are in competition with each other for favorable time slots, channels, and viewership. Structural holes can provide the focal team with the power of arbitrage and competitive intelligence about relevant competitive information that is not merely based on content, such as production costs and plans for placement with preferred channels. Aggregating such information from several alters might enable the focal team to leverage its knowledge to improve its position by competitively exploiting production or market niches that are unoccupied by other teams. Thus, even if the value of efficient routines from homogenous alter content trumps the value of novelty and idea diversity, the control benefits of spanning structural holes through a specialization effect may yet yield a positive performance effect for the focal team. Thus we hypothesize:

Hypothesis 6 (H6): The higher the number of current structural holes in the network of the focal team, the higher its performance.

METHODS

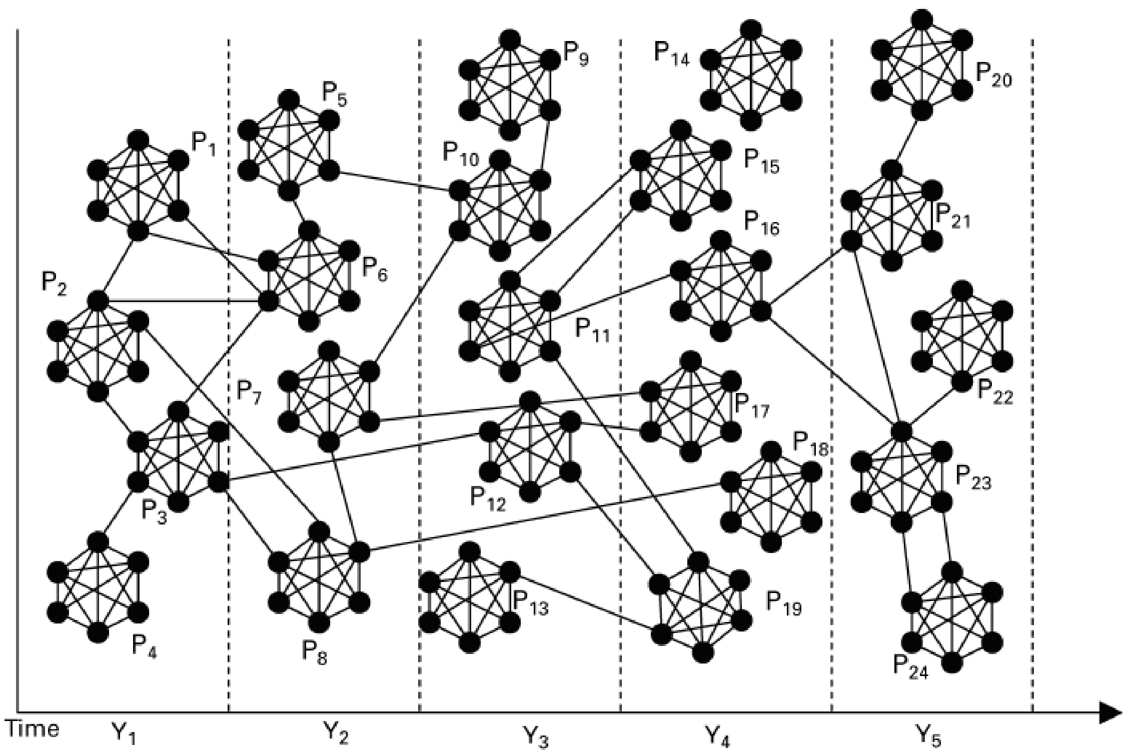
Reconciling Network Theory across Levels of Analysis

The sizable research on co-membership networks among boards, clubs, movie productions, and so on has implicitly treated the network of ties between nodes as isomorphic with individual networks (Mizruchi, 1996; Zajac and Westphal, 1996; Haunschild and Beckman, 1998). Under certain conditions, research on group or team co-memberships can in fact be regarded as isomorphic with research on individuals as network nodes. From the perspective of theory, at least three implicit assumptions underlie a shift in the level of analysis from networks of individual-level nodes to higher levels of analysis, such as teams (Zaheer and Usai, 2004). The first is what might be called the assumption of composition; the second is what we refer to as the assumption of contagion; and the third, the assumption of causality.

The composition assumption is that a tie between two teams through a single link connecting a part of one team to a part of another team represents a link between the two teams as a whole. Though clearly valid at the individual level of analysis, when the node is a single person, the underlying logic needs additional justification at higher levels of analysis. For example, the research on board interlock networks typically assumes that the co-membership link between the boards of two organizations connects the organizations themselves and influences the actions of the organizations as a whole. But close intraorganizational interactions, linkages, and communication processes need to be in place for the assumption of composition to hold at the higher level of analysis.

The teams in our industry, as we illustrate in figure 1, do form tightly coupled networks within teams. In the same vein,

Figure 1. Network structure of the TV production industry over time.



P_n = Project teams
Link across P_n = Shared industry specialists
Y_n = Years

Note: Project Team P_{19} bridges the past structural hole between P_{13} and P_{12}; Project Team P_{23} bridges the current structural hole between P_{21} and P_{22}.

Uzzi and Spiro (2005) considered Broadway musical teams fully linked cliques. Consequently, when two teams share a specialist, because coordination processes are so tightly coupled, all the members of the team are influenced by the link, and the co-membership relationship between the two teams becomes a knowledge and experience conduit for the team as a whole. Figure 1 is a representation of the industry as a network of teams that share specialists both concurrently and in the past.

The second assumption is that of contagion. Network research at the individual level assumes with some justification that network content flows through individual nodes to other nodes that are not linked directly to each other (i.e., content passes from X to Z through Y even though X and Z are not directly linked). Classic research on the diffusion of ideas through networks (e.g., Coleman, Katz, and Menzel, 1966) illustrates this phenomenon at the individual level of analysis. Again, at higher levels of analysis, it is problematic to automatically assume that a contagion process exists. To make an assumption of contagion, researchers should ideally specify theoretically or empirically, or both, the pathways through which content moves through to the indirectly connected organizational node.

In our case, as in the earlier example when two teams X and Y share a specialist (say A) and another specialist (say B) is shared between Y and Z, contagion implies that content passes between X and Z through Y. In this case again, because the team is tightly coupled, content is likely to flow through a contagion process. Compared with a network of individuals, even in tightly coupled teams, however, the contagion process may be diluted because the process is necessarily mediated through coordination and communication interfaces within the team. At the same time, the moderation of the contagion processes may amplify the brokerage power of Team Y. Structural holes in such co-membership networks may therefore be an even more potent source of explanation.

The third assumption, that of causality, focuses on the distance between cause and effect. In a network of individuals, it is easier to identify the causal chain between structural cause and effect because processes leading to individual-level behavior and outcomes can be narrowly circumscribed. When the node is a collective and complex actor, however, the causal chain is harder to tease out, and the process through which an alliance's structural content translates into firm-level performance is tenuous and rarely, if ever, specified. It is important, then, to draw out the causal chains when the network involves higher levels of analysis. But the question of causality should also consider two boundary conditions. First, causal reasoning has to take into account jointly the type of tie and the type of outcome. For example, the causal relationship between R&D linkages among biotechnology firms and firm innovation is clearly more direct than that between e-mail networks and promotion at the individual level. Second, the relationship between the boundary spanner and the organization as a whole may also influence the strength of the causal mechanisms.

Although the teams in our research are tightly coupled, critical roles also exist in the team, such as those of the producer and the director, to which intentionality can be ascribed. These characteristics, tight coupling and the existence of critical roles, help justify the actions of a team in our research as one that behaves as a unitary actor, helping satisfy the causality assumption. Finally, though these three assumptions, when satisfied, allow researchers to apply network theory across level of analysis, they are not unrelated. More precisely, contagion and composition maybe viewed as substitutable in the sense that if either condition is fully satisfied, it makes the second unnecessary.

Data and Model Lag Structure

We tested our hypotheses about the genesis and outcomes of structural holes by studying TV productions in Italy over the period 1988–1999. Our dataset includes all TV productions (TV movies, serials, and so on) produced and broadcast by any of the six national TV channels, which cover about the 95 percent of the global TV audience in Italy during this period. We collected three kinds of data. First, we gathered longitudinal data on teams, all their members, and their networks of relations from the annual reports of TV movies and serials in Italy published by the state-owned broadcaster RAI, which includes productions broadcast by all channels. Second, from the appendix of this publication, we gathered detailed synopses of each TV production to analyze the content of the productions. Third, we collected audience data for TV production teams from Auditel, an independent agency appointed to measure the actual viewership of each production. We excluded rebroadcast audience numbers to give all the productions an equal chance of reaching an audience, because older productions have a higher probability of being rebroadcast, and we wanted to use a consistent measure of performance. The dataset contains information on all the 4,793 specialists that participated in all the 501 television productions created and broadcast over that period.

Because the theoretical purpose of the paper is to reveal the mechanisms and antecedents that underlie the genesis of network structures, we needed a long enough history to have a window on the past. Thus we split the sample at the median of the data (1995), which gave us five years of current observations (1995–1999) and seven years of past data for each focal team (1988–1994). With such a split, we obtained 249 focal teams, for which we computed our endogenous variable of current structural holes. We used the remaining 252 productions from 1988–1994 to compute measures of the past. To measure these latter variables, we used a time window of seven years, which corresponds to the longest past we could obtain using 1995 as a cutoff. We moved the seven-year window across multiple years. By moving the window five times, corresponding to each of the five years 1995–99, we captured the same time span, or past, for all productions broadcast in the period 1995–1999 (e.g., for a production broadcast in 1996, we used past network data for 1989–1995 and so on).

Thus the past and current variables are based on different periods of the data—the past on the seven years preceding the focal team's production year and the current variables on the year of production; past and present measures do not share any overlapping years of network data. Moreover, it is important to remember that the focal teams themselves did not exist in the past, and to that extent, there is no scope for any kind of fixed effect or tendency of the team to exhibit autocorrelated errors over time. The lag structure adopted to develop measures of antecedent variables for the seven-year past takes the following form:

$$y_t = \beta_0 + \beta_1 \sum_{i=1}^{7} x_{t-i} + \ldots + \varepsilon_t$$

Analysis and Econometric Approach

We used a 2SLS model with a robust variance estimator to control for the effects of correlation between errors across equations due to endogeneity between network structure and performance. Although Baron and Kenny (1986) recommended the use of 2SLS only for controlling possible reverse causality from the outcome to the mediator, Shaver (2005: 339) has suggested that 2SLS "is an effective estimation strategy in a much broader set of circumstances . . . even when feedback is not a concern." He recommended its use because of the power of the methodology to handle potential correlation among error terms in the equations. The 2SLS procedure takes into account such correlations and produces coefficients that are consistent and unbiased.

Further, because our dependent variable of performance (audience share) is bounded, we adopted a tobit two-stage least squares analysis (tobit with endogenous covariates in Stata, or *ivtobit*) that provides more consistent estimates in this case than two-stage least squares without a tobit specification. Although our endogenous measure of current structural holes (efficiency) is bounded (0–1) as well, Angrist and Krueger (2001) pointed out that in a two-stage procedure, it is not necessary to use limited dependent variable estimation for the first stage, even if the endogenous variable is bounded, to generate consistent estimates in the second stage. Nevertheless, because tobit with endogenous covariates analysis estimates the second stage as a tobit model and uses OLS in the first stage, to check the consistency of our first-stage estimators, we also ran a series of tobit models for the first stage alone (our instrumental variables) to account for the bounded nature of our endogenous variable (structural holes as efficiency).

We checked the consistency of and the appropriateness of the 2SLS modeling approach with several tests. We began with the Wu-Hausman F-test and the Durbin-Wu-Hausman χ^2 tests. These are tests for endogeneity in which the null hypothesis states that an ordinary least squares (OLS) estimator of the equation would yield consistent estimates, and thus endogeneity among the regressors would not have deleterious effects on OLS estimates. Moreover, because we used a large number of instrumental variables, we also checked for the presence of overidentification of our model with a Sargan test, which provides a measure of instrument relevance for all instruments. The inability to reject the null hypothesis indicates that the model is not overidentified and is acceptable for the two-stage procedure that we used.

Analysis of TV Production Content

To assess TV production content, we analyzed the content of a synopsis of the script (three pages on average) of each production developed by the production team for the national archive of TV productions. Content analysis is a systematic, replicable technique for condensing a large number of words of text into content categories based on a set of explicit rules of coding (Berelson, 1952; Krippendorff, 1980; Weber, 1990; Stemler, 2001). Holsti (1969: 14) offered a broad definition of content analysis as "any technique for making inferences by objectively and systematically identifying specified characteristics of messages." Content analysis can be a powerful tool for determining artistic identity in cultural contexts. When the artistic result is largely based on teamwork, the script becomes the crucial document for sharing, communicating, and understanding the team's meaning and identity. TV production content in Italy is influenced by the nature of the TV market there, which is dominated by so-called generalist channels. These are not focused on specific market targets (i.e., age, education, types of productions, and so on) but offer scheduling for mass audiences. Successful TV productions are generally popular movies or series that address both the dominant values and the spirit of the time. In contrast to cinema, TV productions are simpler, more linear in the narration, and generally focused on a few popular messages.

To analyze the productions' content we first independently reviewed the scripts and arrived at a set of 19 content categories. We then invited a panel of six industry experts to validate our list of categories and variables, and based on their input, we pared down the initial list of 19 categories to 11 that capture the language, messages, narrative, and identity of a TV production, as shown in table 1. Two researchers used the final checklist to code production content independently (1 if the content of the production was consistent with a variable, 0 otherwise). We checked for interrater reliability across variables using Cohen's kappa (Cohen, 1960) to measure the degree of agreement between the raters. The K value may be interpreted as the proportion of agreement between raters after accounting for probability (Cohen, 1960). If the two initial raters did not agree, a third rater repeated the previous steps, and the value chosen was that of the majority of raters. The kappa coefficient (K) for the overall reliability of our 12 content variables was .80. This value compares favorably with the literature on using kappa, which suggests that a coefficient of .61 represents reasonably good overall agreement (Kvalseth, 1989).

Two-stage Least Square Analysis (2SLS) with Tobit: First-stage Variables

We measured *current structural holes*, our endogenous variable, as the efficiency index in the network of current ties among production teams. We used Burt's (1992) measure of efficiency, which counts the ratio of non-redundant ties to total ties for a focal team as

$$\left[\sum_{j}\left(1-\sum_{q} p_{iq} m_{jq}\right)\right] \Big/ C_i$$

Table 1

Coding of TV Production Content

Variable	Type	Content
Theme	Categorical	Detective; dramatic; life story; friendship; love; family; Bible themed; religion; sport; fantasy; power/money/career; others
Relations	Dummy	1 for love, friendship, kinship, affiliation, affinity, consanguinity, and liaison; 0 otherwise
Values	Dummy	1 for human justice (e.g., story of crime prosecutors), religion (e.g., stories about the life of saints), freedom and independence, social battles against evil (e.g., citizens or consumers against powerful organizations for environmental protection) or against social prejudice and discrimination; 0 otherwise
Pain	Dummy	1 for stories of disease, suffering, conflicts; 0 otherwise
Power and success	Dummy	1 for power, money, career, social elites; 0 otherwise
Profession of characters	Categorical	Dominant professions in which the story is set
Positive or negative characters	Ordinal	Weighted number of protagonists, antagonists, secondary protagonists
Ending	Categorical	The nature of the epilogue: happy, ambiguous, unhappy
Setting	Categorical	Context in which the story is located: Italy, Europe, abroad
Time period	Categorical	Time period in which the story is set
Schema	Categorical	The conflict schema in the sentimental relationships (Holsti, 1969)

where p_{iq} is the proportion of the focal TV production team *i*'s ties in connection with team *q*, m_{jq} is the marginal strength of the relationship between team *j* and team *q*, and *Cj* is the total number of ties for team *i*.[1] A high value of efficiency for team *i* indicates that its ego network is non-redundant and thus rich in structural holes. This measure captures the non-redundancy of *i*'s ties as the degree to which a focal team *i* has many independent ties. More specifically, this measure estimates the degree to which *q* has a large proportion of *j*'s ties, and *i* has ties with *j*.

Instrumental Variables

Past network variables. To compute past network variables, we used seven-year moving windows, as we explained earlier. As an example, to compute the past structural holes of team #273 (a 1995 production), which uses as a "past" all the 252 productions produced in the seven-year period 1988–94, we took the following steps: (1) We began with an input dataset of all ties among all industry specialists in the past time window 1988–1994, which is a 4793*252 matrix of 252 vectors, each representing a team from the past with all 4793 individual specialists, where x_{ij} equals 1 when specialist *i* is part of team *j* and 0 otherwise. (2) We then created a vector of size 4793*1 for focal team #273. (3) Next, we joined this vector to the first matrix creating a new matrix sized 4793*253, which now included all the potential past alters for team #273. (4) We then affiliated this latter matrix to make it a co-membership team-by-team matrix of size 253*253, where x_{ij} is a count of the number of specialists shared between team *i* and team *j* (in the analysis we controlled for team size). (5) On this co-membership matrix we calculated network measures (e.g., past structural holes) for team #273.

1
Mjq expresses the ratio between the interaction of team *j* with team *q* divided by the strongest of *j's* relations with any other team. Formally we have:

$$M_{jq} = \left(Z_{jq} + Z_{qj}\right) / MAX \left(Z_{jk} + Z_{kj}\right).$$

And (6) finally, we repeated this procedure for all 249 current focal teams in our dataset (the set of production teams with "pasts"). By applying the procedure described above and adopting the same efficiency measure we used for current structural holes, we measured past structural holes as the ratio of past non-redundant ties to total past ties for each focal team. We measured past team centrality as the Freeman degree centrality of the focal team in the network of past ties (over a seven-year window).

Status. Consistent with Podolny's (2005) conception of status as connections with high-performing alters, we measured the status of the focal team as the accumulation of the past performance of past alters, which we standardized to correct for its skewed distribution. In our context, the performance in terms of audience numbers and social order are strongly correlated because cultural industry performance is highly socially constructed. As well, this success flows via shared co-membership links over time, which is consistent with a sociological conception of status. Thus it is the success of the prior team that is being carried forward through an associational link—through a shared membership in the teams—and that confers status on the focal team. Moreover, because teams are composed of several specialists, including those who perform technical or lower-level tasks and are not involved in the creative expression of the production, we only selected the alters linked to the focal team by critical roles in TV production. These include the director, screenplay writers, original author, producer, and actors in major starring roles (average of six per team). To account for the decay effects of status over time, we weighted recent successes more by using a decay function based on the age of the past alters' broadcast (i.e., 1/7, 1/6, and so on). Given a focal TV production team *i* at time *t* and its *m* past alters, formally we have:

$$S_{i_t} = \sum_{j=1}^{m} \left(P_{j_n} / n \right)$$

Where *P* is the performance of $j = [1, m]$ past alters of focal team *i*; and *n* is the time lag = [1,7] between focal team *i* and past alters' team *j*.

Past alter content homogeneity. To measure the content homogeneity among past alters, we measured the content similarity among the past alters of each focal production team from the content analysis. We used the 11 content variables described in table 1 to assess the contents of the 501 TV productions in our dataset. We transformed the two-mode matrix of production by content (with dimensionality 501*12) into a one-mode production-by-production matrix, where x_{ij} is the degree of content homogeneity among productions *i* and *j*. To do so, we used the similarity procedure of UCINET VI and adopted the measure of similarity as the proportion of exact matches that computes the proportion of cases in which $x_i = y_i$ for all *i* (Borgatti, Everett, and Freeman, 2002).

Past team cohesion. Past team cohesion refers to the density of relations among the members of a team. The measure we used computes cohesion as the valued density of past ties among the members of focal teams. For current members of a focal team, it captures their previous collaborations over the prior seven years, when they were working together in the past. For a valued network like ours, each prior tie is weighted by the number of previous collaborations. For example, consider the computation of past density (cohesion) for focal team #489 produced in 1999. To measure the past density of this 1999 team, the datasets we used were (1) the input dataset, a 4793*4793 matrix containing all relations among all specialists in the past time window 1992–1998; and (2) a "blocking" dataset of size 4793*249, essentially an affiliation matrix, in which a value of 1 indicates when a given specialist (in the rows) worked on a given team (in the columns). In short, each column of the 4793*249 matrix corresponds to one of the teams and represents the composition of its members. We used the DENSITY procedure in UCINET VI (Borgatti, Everett, and Freeman, 2002), which allowed us to partition the rows of the data matrix into blocks by specifying blocking rules for the density computation. Using the dataset 4793*249, we specified column number 237 (corresponding to production #489) as a blocking vector. The output is the valued density for the square submatrix of size equal to the number of people in team #489, which is 19, thus producing a 19*19 matrix, in which the x_{ij} cell denotes the number of times specialists i and j worked together in the past. We repeated the blocking procedure 249 times (once for each team), using and changing the appropriate input dataset according to the specific past time window associated with each team.

Two-stage Least Square Analysis (2SLS): Second-stage Variables

The dependent variable is team performance. The share of viewers that watched a show is considered the most crucial performance indicator of any TV production. Audience data are collected in Italy by Auditel, an independent institution. Auditel data are used to measure the success or failure of a TV production. Given the highly skewed nature of audience numbers, we used the natural log of the audience share that watched the TV show as our measure of *team performance* and our dependent variable. We computed our independent variables, current structural holes and alter content homogeneity, following the same procedure and measures adopted for the past alters but using the network of current (rather than past) ties to identify the alters of a focal TV production team.

Controls. We used controls of several types in our analysis, beginning with a number of industry-specific factors. First, we controlled for periodicity effects by using a series of dummies corresponding to the years 1995, 1996, 1997, and 1998, with 1999 being the omitted category. Second, the six TV channels we considered (an average of 95 percent of the total audience covered) do not all have the same potential for reaching high audience levels. Two major channels broadcast the most significant events and the most popular TV news and have far higher viewership than the other channels. Accordingly, we included a dummy variable for major channel, which was set to 1 when the production was shown on either major channel and 0 otherwise. In addition, the time slot in which the TV production is broadcast likely affects the potential number of viewers. The highest potential viewership occurs in prime time, which in Italy is 8:00–10:30 P.M. We therefore also included a dummy variable to control for prime time.

To control for a potential decay effect of relations in the power of past ties, we also controlled for the age of all the ties in the network by weighting every tie by the inverse of its age. Specifically, for each team, we computed a weighted average of its past relations in which the numerator counts the number of ties in each past year and the denominator is the age of the tie (ranging from 1 to 7). Thus older ties are down-weighted relative to more recent ties. In assessing the sensitivity of this decay function, we also evaluated a number of other nonlinear functions, such as $log(x)$, $(x)^{1/2}$, $1/(x)^2$. The results were consistent across decay functions.

We also included a control for the similarity of the focal production to the industry (*similarity to industry*), which captures the extent to which the focal production mirrors the dominant genre. For this control variable, we calculated the average content homogeneity between each focal production and all productions broadcast in the same year as the focal production. We also controlled for the size of the team, which is a count of the number of different specialists it comprises. Finally, we controlled for a focal team's imitation relative to alters by capturing the average content overlap between the content of each focal team and the content of its current alters (*conformity to alters*).

Our final set of controls eliminated the possible effect on performance of certain other characteristics of TV productions. In particular, not all TV productions have similar characteristics: different formats exist (e.g., TV movies, soap operas), and the number of episodes differ. We controlled for such task characteristics by computing two additional variables: the *number of episodes* and a *TV movie* dummy. The number of episodes indicates how many episodes of the TV production were actually broadcast. The TV-movie dummy equals 1 when the production is a TV movie and 0 if it is a serial-like production (e.g., a soap opera).

RESULTS

Table 2 provides descriptive statistics and correlations for the variables.

We first tested for the appropriateness of treating current structural holes as an endogenous variable by using the Wu-Hausman F-test [6.14, d.f. (1,214); $p = .01$], and Durbin-Wu-Hausman χ^2 [6.38 (1); $p = .01$]. Both tests allow us to soundly reject the null hypothesis that current structural holes are exogenous to performance, indicating that it is appropriate to use a 2SLS specification to address the issue of endogeneity. Moreover, because we used several instrumental variables, we checked for potential overidentification in our model. The Sargan statistic provides a measure of instrument relevance, and an inability to reject the null hypothesis, as in our case, indicates that the model is not overidentified [$\chi^2 = 6.70$, (6); n.s.].

Table 2

Descriptive Statistics and Correlations*

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1. Year95	.112	.317										
2. Year96	.169	.375	−.153									
3. Year97	.237	.426	−.205	−.235								
4. Year98	.205	.404	−.183	−.209	−.282							
5. Year99	.277	.448	−.235	−.268	−.362	−.322						
6. Number of episodes	8.93	25.12	−.053	−.062	−.009	−.061	.149					
7. TV movie	.305	.461	.055	.074	.032	−.068	−.067	−.197				
8. Prime time	.867	.340	−.002	.028	−.033	.036	−.021	−.332	.047			
9. Major channel	.614	.488	.029	.092	−.076	−.066	.037	−.056	−.086	−.008		
10. Team size	25.36	7.70	−.044	−.217	−.037	.073	.172	.062	−.189	.162	−.185	
11. Similarity to industry	.674	.046	−.149	.372	.019	.145	−.329	−.053	.105	−.052	.139	−.209
12. Past team centrality	66.17	31.95	.112	.153	.139	−.271	−.097	.015	.256	−.051	−.129	.312
13. Past structural holes	.218	.129	−.008	.023	−.010	−.641	.562	.161	−.113	−.091	.104	−.027
14. Current structural holes	.255	.096	.084	.101	−.323	−.203	.346	.057	.090	.090	.038	.249
15. Status (standardized)	6.47	.10	.054	.067	.092	.687	.117	.080	−.233	−.115	.018	.277
16. Homogeneity among current alters	.673	.034	−.260	.568	.108	.141	−.484	−.106	.094	−.013	.102	−.243
17. Homogeneity among past alters	.678	.005	−.352	−.233	−.054	.405	.126	.024	−.178	.122	.079	.157
18. Conformity to current alters	.291	.112	−.129	.268	.225	−.191	−.162	.061	.020	.205	.134	.029
19. Age of relations	2.68	.617	.524	.106	−.015	−.230	−.238	−.078	.106	.057	.054	−.051
20. Past closure	.245	.450	.012	.100	−.082	.006	−.016	.059	−.137	−.340	.133	−.174
21. Team performance	2.93	.400	.104	−.014	−.068	−.007	.007	−.084	−.130	.191	.059	.056

Variable	11	12	13	14	15	16	17	18	19	20
11. Similarity to industry										
12. Past team centrality	.008									
13. Past structural holes	−.210	.258								
14. Current structural holes	−.198	.143	.332							
15. Status	.013	.364	.278	.332						
16. Homogeneity among current alters	.388	.044	−.270	−.175	−.084					
17. Homogeneity among past alters	−.001	.129	−.018	−.303	.025	−.014				
18. Conformity to current alters	.210	−.041	.167	.099	.039	.223	.137			
19. Age of relations	−.064	.053	.111	.133	.024	−.029	−.484	−.067		
20. Past team cohesion	.128	−.257	.191	−.128	.256	.142	−.071	.137	.047	
21. Team performance	−.023	−.131	.092	.166	.087	.072	.014	.053	.180	−.007

* r > |.105|, $p < .10$; r > |.125|, $p < .05$; r > |.165|, $p < .01$.

As we reported earlier, because our dependent variable is bounded, we used a tobit model with endogenous covariates. We corrected for the presence of heteroskedasticity by using the Huber-White sandwich estimator of variance in Stata (Huber, 1967; White, 1980). We also tested for potential autocorrelation, due to the possibility that past structures may be autocorrelated with current structures, using the Durbin-Watson test. We found no evidence of autocorrelation. Further, as reported earlier, we used two-, four-, and five-year time windows to assess the sensitivity of the models and found generally consistent results.

Table 3

Results of Tobit Model with Endogenous Covariates*

First stage (endogenous variable: current structural holes)	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	.135 (.181)	.178 (.164)	.165 (.163)	.023 (.163)	.002 (.159)
Controls					
Year95	.109••• (.033)	.077••• (.031)	–.012 (.036)	–.017 (.036)	
Year96	.008 (.027)	.003 (.025)	.003 (.025)	.002 (.024)	–.003 (.023)
Year97	–.164••• (.035)	–.148••• (.033)	–.149••• (.033)	–.119••• (.033)	–.130••• (.032)
Year98	–.099••• (.030)	–.046 (.030)	–.056• (.030)	.017 (.034)	.012 (.033)
Year99	–.088•• (.042)	–.059 (.039)	–.062 (.040)	–.057 (.038)	–.072• (.037)
Age of relations	.034•• (.009)	.015 (.010)	.021• (.011)	.020 (.011)	.011 (.010)
Team size	.003•• (.001)	.003••• (.001)	.003••• (.001)	.005••• (.001)	.004••• (.001)
Instrumental variables					
Homogeneity among past alters		–.004••• (.001)	–.002•• (.001)	–.001• (.001)	–.003•• (.001)
Status			.016••• (.006)	.012•• (.006)	.011•• (.005)
Past team centrality			.001•• (.000)	.001••• (.000)	.001•• (.000)
Past structural holes				.342••• (.079)	.361••• (.077)
Past team cohesion					–.043••• (.011)

Second stage (dependent variable: team performance)	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	.304 (.852)	.941 (.712)	.953 (.707)	.880 (.708)	.866 (.706)
Controls					
TV movie	–.034 (.056)	–.051 (.046)	–.052 (.046)	–.050 (.047)	–.049 (.047)
Episodes	–.000 (.001)	–.000 (.001)	–.000 (.001)	–.000 (.001)	–.000 (.001)
Prime time	.222••• (.080)	.242••• (.071)	.242••• (.071)	.240••• (.072)	.239••• (.072)
Major channel	.495••• (.049)	.492••• (.044)	.491••• (.044)	.492••• (.044)	.492••• (.044)
Conformity to industry	.092 (.616)	–.264 (.529)	–.270 (.527)	–.229 (.529)	–.222 (.529)
Conformity to alters	–.566•• (.264)	–.375• (.222)	–.372• (.221)	–.394• (.221)	–.398• (.220)
Independent variables					
Current structural holes	2.760••• (.788)	1.553••• (.487)	1.530••• (.466)	1.670••• (.437)	1.69••• (.416)
Homogeneity among current alters	2.355•• (1.018)	2.166•• (.906)	2.163•• (.904)	2.18•• (.912)	2.189•• (.913)
χ^2	144.43	175.86	176.92	177.76	179.20
Model sig. (*p* value)	.000	.000	.000	.000	.000
Log likelihood	222.74	241.62	245.28	254.35	261.36

• $p < .10$; •• $p < .05$; ••• $p < .01$.
***** Standard errors are in parentheses. These models were estimated using the robust variance estimator.

Results of the tobit 2SLS analysis are reported in table 3 for both first and second stages. Because our endogenous variable (current structural holes), measured as efficiency, is also bounded (our first stage), we ran a series of tobit models for the first stage alone as well (as shown in table 4). For the instrumental variables we hypothesized as causal factors driving the formation of structural holes, the results of the first stage of tobit 2SLS and a tobit model for the first stage alone were largely consistent. We report and discuss both sets of models below.

Model 1 accounts for controls. Model 2 introduces past alter content homogeneity. Contrary to hypothesis 1a, but supportive of H1b, past alter content homogeneity is negatively and significantly associated with current structural holes (past alter content homogeneity $\beta = -.003$, $p < .05$ for tobit 2SLS, and $\beta = -.002$, $p < .01$ for tobit alone) (all hypotheses are tested with coefficient values from the fully specified model 5). Thus focal teams with high past alter content homogeneity tend to reduce their structural holes in the current network. Model 3 includes status derived from past

Table 4

First Stage, Regression with Tobit Specification*

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	.097••	.183•••	.184•••	.082••	.120•••
	(.037)	(.037)	(.038)	(.042)	(.043)
Controls					
Year95	–.020•	–.028	–.025	.006	.006
	(.023)	(.021)	(.021)	(.021)	(.021)
Year96	–.008	–.023	–.019	.012	.017
	(.017)	(.016)	(.016)	(.016)	(.016)
Year97	–.107•••	–.117•••	–.112•••	–.078•••	–.072•••
	(.014)	(.013)	(.013)	(.015)	(.015)
Year98	–.073•••	–.036••	–.041••	.052	.062
	(.016)	(.016)	(.015)	(.024)	(.024)
Year99	–.070••	–.043	–.050	–.033	–.085•
	(.033)	(.022)	(.014)	(.025)	(.054)
Age of relations	.029•••	.010	.017	.019	.010
	(.010)	(.009)	(.011)	(.010)	(.010)
Team size	.003•••	.003•••	.003•••	.004•••	.004•••
	(.001)	(.001)	(.001)	(.001)	(.001)
Variables					
Homogeneity among past alters		–.004•••	–.003••	–.001•	–.002•••
		(.000)	(.001)	(.000)	(.001)
Status			.017•••	.012••	.013••
			(.006)	(.006)	(.005)
Past team centrality			.001•	.001•••	.001••
			(.000)	(.000)	(.000)
Past structural holes				.345•••	.389•••
				(.073)	(.072)
Past team cohesion					–.033•••
					(.011)
χ^2	96.68	137.48	145.97	168.02	176.56
Log likelihood	264.78	285.18	289.43	300.45	304.72
Pseudo R^2	.223	.318	.338	.381	.410
Sig. of χ^2 differences		< .005•••	< .05••	< .005•••	< .005•••

• $p < .10$; •• $p < .05$; ••• $p < .01$.
* Standard errors are in parentheses. These models were estimated using the robust variance estimator.

alter performance and past team centrality. The results support the prediction that the prominence of a TV production team, measured both as status (H2a) and as past team centrality (H2b), increase its ability to create structural holes in the current period (status $\beta = .011$, $p < .05$ for tobit 2SLS, and $\beta = .013$, $p < .05$ for tobit alone; past team centrality $\beta = .001$, $p < .05$ for tobit 2SLS, and $\beta = .001$, $p < .05$ for tobit alone). Model 4 introduces past structural holes (H3), which we find to be significantly related to current structural holes, ($\beta = .361$, $p < .01$ for tobit 2SLS, and $\beta = .389$, $p < .01$ for tobit). Model 5 tests the effect of past team cohesion (H4) and shows a significant and negative relationship with the creation of current structural holes ($\beta = -.043$, $p < .01$ for tobit 2SLS, and $\beta = -.033$, $p < .01$ for tobit alone). Overall, the first stage accounts for a large proportion of the variance in the formation of current structural holes (pseudo $R^2 = .41$, $\chi^2 = 176.56$, $p < .01$).

In the second stage of the tobit 2SLS, we tested competing hypotheses about the positive and negative effects of content homogeneity among alters (H5a and H5b, respectively) and of current structural holes (H6) on focal team performance. The idea that the effects of structure and content are largely independent is supported in our results. Alter content homogeneity enhances performance ($\beta = 2.189$, $p < .05$), supporting H5a rather than H5b, as do structural holes ($\beta = 1.69$, $p < .01$), supporting H6.

DISCUSSION

Although a vast research stream has examined the outcomes of network structures, relatively little attention has been paid to their origin, particularly at the organizational level of analysis (e.g., Brass et al., 2004). Such an endeavor is important because an understanding of the organizational outcomes of structure and its normative implications is incomplete without also discovering the set of factors and the dynamic processes that gave rise to structure. We focused in particular on the balance between network constraints and the exploitation of opportunities by the focal actor that underlie the creation of favorable network structures. Further, while some research on the creation of organizational ties exists (e.g., Walker, Kogut, and Shan, 1997; Gulati and Gargiulo, 1999), explanations for the creation of ties do not carry over into an understanding of the creation of structures because they gloss over the nature of the portfolio of ties and, importantly, the presence or absence of ties among the focal actor's alters.

In this paper, we offered and tested a theoretical perspective that encompasses opportunity exploitation and structural persistence as underlying drivers of structural holes and their performance outcomes. We showed that network actors are presented regularly with opportunities and inducements of varying magnitudes thanks to their positions in the prior social structure. The opportunities created by networks are not just linked concurrently with favorable outcomes at a point in time but project their shadow over the evolution of future networks. Thus past networks provide actors with experiences, social contexts, and access to knowledge that provide the opportunities and inducements that may enable actors to enact future structures, while at the same time being constrained by structures from the past. Our deep investigation of the industry context reveals that network structures emerge neither randomly nor as the epiphenomenal outcomes of single, separated dyadic interactions. On the contrary, they are the result of forces that include both the replication of past social interaction by virtue of inertia as well as the exploitation of opportunities provided by past structures.

Further, because our research context comprises temporary networks that are continually being created and dissolved over time, we could more clearly disentangle the underlying processes of both prior network-enabled recreation and constraint: the former through the active exploitation of past opportunities, and the latter influenced and limited by the inertia imposed by past structures. As well, because the temporary network organization has been considered a distinctive characteristic of cultural industries (Baker and Faulkner, 1991; Starkey, Barnatt, and Tempest, 2000), our research contributes to better understanding the mechanisms behind their creation and dynamics (Uzzi and Spiro, 2005).

In brief, our results show that alters' content homogeneity is not associated with future structural holes, but past status derived from past alters' performance, centrality, and past structural holes all lead to the formation of structural holes in future networks. Our two explanations of opportunity exploitation and structural persistence are not necessarily in opposition to each other. We showed that actors exploit actively the opportunities related to structural characteristics and the content of past networks in enacting the processes that culminate in the creation of future networks and specifically in the achievement of superior network positions for themselves (Nohria, 1992). At the same time, by virtue of inertia and constraint, highly embedded structures from the past limit the focal actor's ability to transform past opportunities into valuable current network structures.

In the search for the more specific factors that underlie the genesis of structural holes, we also explicitly tested the assumption inherent in the conceptual underpinnings of the notion of structural holes that the content of nodes reflects the structures that link them (Burt, 2004). To do so, we examined both the degree to which past alters' content homogeneity is associated with structural holes spanned by the focal team in the subsequent network, as well as the independent effects of structural holes and alters' content homogeneity on performance. Although our prediction with regard to content homogeneity driving the creation of structural holes was not supported—in fact we found the opposite of what we hypothesized—our results confirm that content and structures are related over time, but the connection between them is considerably more complex than that theorized in the literature. In particular, despite the performance benefit of structural holes and the negative effect of content homogeneity on performance, as well as the negative associations between structural holes and content homogeneity, our results supported our alternative hypothesis and indicate that the opportunity created by past exposure to alters' homogeneity does not provide a sufficient inducement to form structural holes in future networks. In particular, past alters' content homogeneity reduces rather than increases the propensity for future structural holes, which brings into question the causal information diversity-seeking rationale implicit in the conventional structural holes logic. As we theorized in formulating our alternative hypothesis, homogeneity among alters may result in fewer structural holes due to the effects of specialization and homophily, such as the clumping together of people in genre-driven communities, which would lend credence to a structural persistence argument. Future research should more deeply investigate the complex nature of the causal link behind this result.

An important precursor of structural holes that we investigated was team status, which we argued presents focal actors with the opportunities to choose among potential team members and thereby will result in favorable structures. Our results reveal that status derived from past alters' performance enhances the propensity to form structural holes. Therefore, rather than a tradeoff, as Podolny (2005) speculated, which would imply a negative relationship, status based on connections of the focal team to high-performing teams in the past in fact generates more structural holes in future networks. A possible reason for this result may be that the signaling effect of status attracts otherwise disconnected players to the focal actor. In this sense, the network becomes redundant thanks to the prominence of the focal actor, because alters flock to high-status actors independent of the information they may have obtained through network ties. Such market signaling also provides alters with legitimacy and other benefits in the marketplace (Podolny, 1993). In this manner, high-status actors are able to enhance their ability to exploit their past positions because of increased power and credibility, resulting in their being offered a wider range of choices of alters from which to choose. Our findings on past centrality and its positive effect on structural holes suggests that prominence also confers on the focal actor the power of choice to manage the network in a way that is beneficial in later periods. Alternatively, a more autonomous mechanism may be at work here by which disconnected alters seek out prominent and high-status teams.

A further element of our framework points to the role of structural holes in the past that predict the formation of current structural holes. We characterized this as another manifestation of opportunity exploitation by the focal actor. In our inherently temporary context, however, this idea implies a purposeful reactivation of favorable past structures and therefore is quite different from the notion of structural persistence. This finding means that structural holes spanned by individual specialists in the past give rise to future structural holes for the team of which they are now a part and demonstrates the strength of the focal team's ability to exploit the opportunities that result in favorable social structures.

Our overarching theoretical framework also included constraint arising from structural persistence as contributing to the creation of structural holes. Our finding on the effect of past team cohesion suggests a role for the persistence of networks over time because results showed that a major inhibitor of structural holes in the network was the presence of internal cohesion in a previous time period. Lock-in with dense, overlapping ties makes it harder for focal actors to break out of redundant network structures. Thus individual specialists who have worked together in the past will prefer to be connected in the current period to scattered prior cohesive team members across various current teams. Teams with high team cohesion in the past will tend to find themselves in tightly linked structures in subsequent periods because future teams that employ the cohesive members of a prior team will tend to replicate previous connections, resulting in fewer structural holes for the focal team by virtue of structural persistence. Overall, our results provide considerable evidence for the notion that structural entrepreneurs are able to actively exploit opportunities, although inertia and homophily also play a role, in the genesis of network structure.

An important theoretical question that arises in this context is the extent to which the exploitation of opportunities represents active agency on the part of the focal actor. White (1992: 96) articulated the notion of agency as a mechanism to recreate social structure that "induces additional agency in a chain reaction, emerging as further levels of social organization." Such a notion, as Nohria (1992: 13) put it, "treats actors as purposeful, intentional agents." Alternatively, networks may emerge more or less autonomously as a result of actors merely acting on the available choices that have materialized by virtue of their structural positions in prior networks. Although we have taken the position in this paper that the exploitation of opportunities created by positions in past networks falls somewhat short of what some have defined as agency behavior on the part of network actors (e.g., Emirbayer and Goodwin, 1994; Emirbayer and Mische, 1998), clearly this is an issue that needs theoretical and empirical resolution.

In assessing the performance consequences of structural holes, we found that alters' content homogeneity and structural holes both independently improve performance, raising the intriguing possibility that the performance-enhancing effects of structural holes derive from mechanisms other than information diversity. Specifically, control and access benefits may be at work. It is also possible that other results in the literature suggesting that structural holes are not necessarily conducive to innovation through novelty (e.g., Ahuja, 2000a) may reflect the mechanism operating here as well. In the same vein, similarity may also be engendered through common alters rather than direct connections (Burt, 1987). Consequently, rather than finding a simple direct relationship between structural holes and diversity and performance, we uncovered a complex pattern of relationships suggesting that structure and content both independently influence performance and, moreover, that it is homogeneity rather than diversity that enhances performance.

As we argued before, homogeneity may also enhance outcomes because of a more accurate understanding of the skills and capabilities that other members of the project team might possess, and what has been referred to as knowing who-knows-what, or transactive memory, in the literature may improve coordination and limit inefficient duplication for the production task at hand (Wegner, 1986). Moreover, high homogeneity can also aid the team in internalizing common knowledge and enhancing the creative product (Nonaka and Takeuchi, 1995). Another benefit of high homogeneity comes from increased efficiency resulting from knowledge similarity as team members learn from each other, share common codes, and improve on the processes of joint tasks.

Like us, Rodan and Galunic (2004) showed independent effects of structural holes and content diversity (alters' knowledge heterogeneity) on innovation performance. Our results differ from theirs, however, in terms of the positive relationship they found between alters' content diversity and performance, which supports the reasoning of structural holes, while our finding appears to counter it. A possible explanation for this result is that we investigate the redundancy of the network at the team level of analysis, where factors such as efficiency and routines, rather than the heterogeneity of knowledge, may be exerting stronger influences on performance.

Limitations and Directions for Future Research

Our data do not permit us to map an actor's network capability or its relational capability, which may dynamically influence how opportunity exploitation and structural persistence operate to create and recreate favorable structures. Nevertheless, the fact that even the temporary teams we investigated are composed of key individuals who may embody the team's capabilities reduces the extent of this limitation. Moreover, despite the possibility that our results are consistent with actors' agency, we have no direct measures of actors' agency, intentions, or motivations. Demonstrating agency more directly therefore remains a topic for future research. Another limitation of our data is that we only captured group ties as co-memberships among groups, and we cannot exclude the possibility that information and knowledge might flow through other kinds of social relationships, including friendships and other personal ties. Nevertheless, all of the industry experts agreed that co-membership is the only systematic way through which teams are interconnected and, in consequence, it presents an opportunity to systematically collect data over time on relations for the universe of productions, teams, and individual specialists.

Finally, our data are both limited and enhanced by the temporary nature of the teams that we studied. The genesis of structural holes in a network with more stable organizations may have somewhat different antecedents, although research on temporary networks provides us the opportunity to better understand the processes and mechanisms behind the creation and evolution of network structures.

An important contribution of our paper is our methodologically clear-cut examination of the effect of structures on performance outcomes, which both explores their effects over time and factors in their likely endogeneity. By treating structural holes as explicitly endogenous and using instruments to predict performance in a longitudinal model, we moved toward a deeper and more valid understanding of the relationship between network structure and outcomes. Our efforts respond to the call from Salancik (1995: 349) for a more comprehensive theory: "A network theory that accounts for the appearance and disappearance of structural holes—rather than how they can be used to advantage—and the consequent changes in interactions over time may provide us with a better understanding of how collective action is organized." Our results help resolve the question of how structural holes emerge in a context of networks in flux over time. We showed that opportunity exploitation by the focal organizational actor and structural persistence combine to generate structural holes in future networks, and more generally, we developed and tested a holistic theory of the evolution of network structure.

Future research should build on our results to further investigate the source of the benefits from spanning structural holes, beyond the access to diverse content, which could also be studied as an outcome of structural holes. In terms of the genesis of network structures, we identified a series of factors that contribute to the creation of structural holes through a longitudinal analysis. Even as we advance scholarly understanding of network dynamics, much more work is needed to further explore the processes and conditions through which network structures of various kinds, not just structural holes, are formed. A more comprehensive set of explanations may arise from the integration of a structural perspective, which we have adopted, combined with frameworks used in related fields, such as that on the processes of group and team formation and, more broadly, on group dynamics.

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