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ABSTRACT

During industry emergence, collective actors may not yet exist as a mechanism for coordination. To explore whether informal network ties might fill this void, we develop an ecological model of new industries. Using simulation methodology, we obtain the following results: First, network ties increase the number of surviving firms and total industry resources. Second, the effects of network ties are of similar magnitude to those of legitimacy and resources. Third, we discover the paradox of big bets: When audience members allocate more of their resources to single firms, population size is decreased but total industry resources are increased. Finally, we discuss practical implications of our findings for policy makers who wish to encourage new industries and entrepreneurs in nascent fields.

Recognition of the importance of social context has transformed research on entrepreneurship: A focus on entrepreneurs and the firms they found has been augmented by studies of the social context of the emergence of new industries. As Schoonhoven and Romanelli (2001: 1) summarized this new approach, it focuses on "… the conditions in industries, economies, and societies that generate large numbers of new organizations being founded." Entrepreneurship researchers now look beyond individual founders and firms to model the processes and mechanisms by which information about new social forms diffuses to broader audiences (Hannan, Pólos, and Carroll, 2007). This more collective view of entrepreneurship involves a variety of social actors and frames the difficulties associated with emergence of new industries in terms of social and cultural barriers to success (Aldrich and Fiol, 1994; Schoonhoven and Romanelli, 2001). Aldrich and Baker (2001: 210) summarized the central argument well: "A new population's growth also depends on the extent to which its potential audience learns more about it and what its expected value is to the constituencies it affects." We contribute to the literature by developing a model of the very early stages of the emergence of a new population. We use this model to investigate how the interaction of audiences and firms may increase the number of surviving firms and total industry resources, enhancing the likelihood that a new industry will emerge. Importantly, we believe that this model has practical implications for both policy makers and entrepreneurs.

Our study is also intended to contribute to a dialog between theories of entrepreneurship and recent work in the ecological literature identifying ongoing processes that create links between particular audiences and specific organizational forms (Baron, 2004; Hannan, Pólos, and Carroll, 2007; Hsu, Hannan, and Koçak, 2009; Pólos, Hannan, and Carroll, 2002). Identities and audiences have been the focus of much recent literature, including health care provision in the U.S. (Ruef, 1999; 2000), the market for disk arrays (McKendrick et al., 2003), financial services in Singapore (Dobrev, Ozdemir, and Teo, 2006), the Dutch audit industry (Bogaert, Boone, and Carroll, 2006), and the American film industry (Cattani, et al., 2008; Hsu, 2006; Hsu, Hannan, and Koçak, 2009; Zuckerman et al., 2003), but all of these studies have been set within existing domains. As Ruef and Patterson (2009) demonstrated, the dynamics of identity with an emerging classification system systematically differ from those of established fields.

In the terminology of the Panel Study of Entrepreneurial Dynamics, (e.g., Reynolds et al., 2004: 265), the transition from gestation to infancy marks a key entrepreneurial organizational moment. The incredible potential benefits of these moments, both for individuals and society (Rindova, Barry, and Ketchen, 2009), should not obscure the hazards, which can be particularly acute when the founding results in creation of a firm that does not fit established categories. Hsu and Hannan (2005: 487) argued that any successful form must gain "… the attention and endorsement of their evaluative audience(s)." Industry emergence can occur only if producers and audience members can agree on categories and identity codes to understand a new activity domain (Hannan, Pólos, and Carroll, 2007). A long tradition in the study of the genesis of cultural change and support for new forms, organizations, and industries suggests the importance of network ties to understanding these processes (e.g., Becker, 1982; DiMaggio, 1987). This logic, consistent with Audia, Freeman, and Reynolds (2006: 386), recognizes that information "… is a key resource in the organizational creation process, and interorganizational networks are vehicles for the transfer of information." A focus on network ties as a mechanism of coordination also avoids presuming that there is some entity to accomplish this at the interorganizational level. Thus, rather than assume that firms in new industries can quickly create formal bodies of coordination, we suggest a different possibility. Consistent with Aldrich and Fiol (1994: 654), we assume that "…

[i]nitial collaborations begin informally, in networks of interfirm relations ..” and that some of these may “… develop into more formalized strategic alliances, consortia, and trade associations.” We do not exclude the possibility that networks may eventually contribute to the creation of interorganizational structures and actors. Instead, we focus on the likelihood that the lives of most firms in new activity domains will be, in the famous words of Hobbes, solitary, poor, nasty, brutish, and short. Thus, it is not tenable to assume that all new populations necessarily reach a stage where collective or other inter-organizational actors become important coordination vehicles.

Of course, one reason why these questions remain open despite their obvious importance is that investigating them empirically is notoriously difficult. For this reason, we employ simulation methodology, which allows us to define industry emergence with a precision that is considerably more difficult in empirical studies. Then, by creating a model that incorporates theoretically relevant conditions, such as resource constraints and networks, we are able to observe their effects on outcomes that are important for both theories of entrepreneurship and the ecology of identity, such as the number of surviving firms and total industry resources. To assess the impact of interorganizational level and collective actors, we also model variations on isomorphic legitimacy pressures (DiMaggio and Powell, 1983). The setup of our investigation is to establish contrasts among three conditions: a baseline industry emergence condition that includes only variables related to the resource environment, a condition that adds network ties, and conditions with institutional mechanisms that produce legitimacy pressures. These experiments allow us to answer the following questions: First, do network ties increase the number of surviving firms and the total resources of new populations? Second, is the magnitude of network effects comparable to the effects of resource variables? Third, is the magnitude of the network effects comparable to the effects of legitimacy pressures?

In the next section, we begin by describing the importance of the emergence of new industries and some of the difficulties that have been encountered in trying to study them. We suggest that simulation models can facilitate investigation of new industry dynamics and their emergent properties that would be difficult to measure and observe in the real world. Then, we present the results of the simulation experiments, reviewing the data that were generated and presenting models of the outcome variables. As we discuss, one finding, which we call the paradox of big bets, highlights another strength of simulation methods: The rigorous specification of assumptions and relationships in simulation models facilitates the discovery of implications that are not necessarily expected. We close our study with discussion of practical implications, particularly for policy makers and entrepreneurs, and implications for research, particularly entrepreneurship, studies of the dynamics of industry emergence, and the ecology of identity.

THE EMERGENCE OF NEW POPULATIONS

Aldrich and Ruef (2006: 180) summarized the current state of knowledge about the genesis of new industries by observing that "… few theorists have examined the emergence of populations and forms." There is little clarity on how one identifies populations of organizations (Hsu and Hannan, 2005) and considerable variation that is not well understood in the emergence of new populations, e.g., the timing between the first firms and what Klepper and Graddy (1990) define as stability. Because small organizations and emerging industries struggle to get the attention of important audiences (Mezias et al., 2010), including researchers, we know relatively little about them. Even outcomes that we can measure quite easily with fairly rudimentary observation of organizations may go unnoticed if the object of observation is a small firm in an emerging industry. The result is that we have relatively little data on emerging industries or the firms that populate them; worse still, this data quantity problem may be exacerbated by a data quality problem. This quality problem arises if some significant portion of attempts to start new industries fail, yielding data for only a few surviving populations. In this case, empirical studies of industry emergence may lead to erroneous conclusions because we observe only populations that survive long enough that data about them become available.

Faced with these problems, simulation methodology, which has a long history in organization theory (Cyert and March, 1963; Cohen, March, and Olsen, 1972; Ethiraj and Levinthal, 2004; Knudsen and Levinthal, 2007; Lant and Mezias, 1990, 1992; Levinthal and March, 1981; Lomi and Larsen, 2001; Lomi, Larsen, and Freeman, 2005; Lomi, Larsen, and Wezel, 2010; March, 1991; Mezias and Glynn, 1993; Prietula, Carley, and Gasser, 1998; Rivkin and Siggelkow, 2003, 2007; Siggelkow and Rivkin, 2005, 2006), may be particularly appropriate. Rivkin and Siggelkow (2007: 1082) offered a recent assessment of this work: "In management science, the study of complex systems has recently gained momentum as simulation tools, originally developed in biology and physics, have been applied to organizational, social, and technological settings." In this study we contribute to this long tradition by modeling the emergence of new populations and forms using simulation methodology. Thus, our work continues a stream of work that has used simulation methodology to answer fundamental questions in organizational ecology (Levinthal, 1991; Mezias and Lant, 1994), including questions relating the dynamics of resource constraints to selection (Lomi, Larsen, and Freeman, 2005) and organizational foundings (Lomi, Larsen, and Wezel, 2010).

The precision of this methodology is a good fit with a renewed interest in the concept of forms; as Hsu and Hannan (2005: 475) noted, "… the most fundamental bases of identity generally prove to be the most elusive to researchers." The strength of simulation methodology is its ability to specify an exact formulation of organizational form or identity, allowing us to model both audience expectations and firm attributes in an unambiguous manner. Because we take a population perspective, we focus on outcomes that affect organizational demography. As Aldrich and Ruef (2006: 62) observed, the selection pressures facing new organizations are 'fierce' and " … new organizations, especially those with new forms …" are unlikely to survive. Thus, the crux of the problem of industry emergence is survival. The basic imagery, which we capture in our simulation, is that a small number of firms of some new form emerge, struggle to obtain the resources necessary to survive and grow (Wiklund, Baker, and Shepherd, 2010), with the result that most fail. Because the fate of these "… struggling young firms …" (Geroski, Mata, and Portugal, 2010: 511) is particularly harsh in unfamiliar activity domains, two key indicators of new industry success are the number of surviving firms and total industry resources; these will be the two outcome variables in our study.

To model the processes that affect these variable, we turn to recent ecological theories of forms (e.g., Hannan, Pólos, and Carroll, 2007). This perspective has used the word identity as the core of the argument to emphasize the social nature of the processes by which new organizational forms come to be accepted in social systems. Accordingly, identities must be understood by reference to expectations, assumptions, and beliefs held by sets of relatively homogeneous actors called audiences. The beliefs of these audiences can be stated in terms of codes to which firms must conform if they hope to obtain resources from specific audiences (Hannan, Pólos, and Carroll, 2007; Hsu and Hannan, 2005). In our model, new industries begin with the emergence of a small number of audiences and firms with specific identity codes. The firms attempt to attract the contributions of audience members, who transfer resources to them only if they perceive that these firms conform to their preferred identity codes.

In this view, the survival of new forms in emerging industries is driven by the creation of shared values about appropriate identities and the ability to enforce them. The effectiveness of independent actors at coordinating their beliefs about identity codes will depend critically on their ability to discover (Marwell and Oliver, 1993: 2) "… mutual interests and the possibility of benefits from coordinated action." As Rao, Morrill, and Zald (2000) observed, models that presume that new industries become socially accepted merely as spillover when firms survive and grow larger are incomplete. At a minimum they miss important aspects of entrepreneurship that promote the creation of shared beliefs, information, and schemas such as categories and identity codes. Some easily observed examples of such strategies include the creation of formal collective actors such as industry associations, negotiating compromises with other industries, creating linkages with universities and established educational curricula, and organizing collective marketing and lobbying efforts. However, the ease of observing these examples may obfuscate the reality that such extra-organizational infrastructure is quite costly, requiring resources that are likely scarce in new industries. As Rao (1994) noted in his study of the emergence of the automobile industry, trade associations and collective organization were not created until many years after the first firms began producing automobiles; Mezias and Boyle (2005) found the same pattern during the emergence of the American film industry, and Bogaert, Boone, and Carroll (2006) during the emergence of the Dutch audit industry.

Despite the emphasis in the literature on third party collective actors (Oliver, 1980; Heckathorn, 1991) with much deserved attention on institutional entrepreneurship (Sine and David, 2010), we believe that the role of collective actors may be proscribed in emerging fields as opposed to mature fields (Greenwood and Suddaby, 2006). Since our model is designed to examine the very earliest points in the emergence of new industries, the organizational entrepreneurial moments when the first firms are founded, we believe that strong assumptions about the presence and power of collective actors are likely not warranted. With respect to trade associations, for example, which are a fairly minimalist form of collective organization (Aldrich, et al., 1994), we do not interpret the historical account of Aldrich and Staber (1988) to suggest that they will always be present at the earliest stages of industry emergence. This is not to say that collective actors, such as trade associations, professional societies, accreditation agencies, watchdog associations, rating agencies, or governmental bodies (see DiMaggio, 1991; Scott, 1987; Zucker, 1986; Shapiro, 1987; Rao, 1998; Zuckerman, 1999), are never important. Rather, we want to examine the possibility that, in at least some cases, these actors may not be present or at least not very active in effecting coordination during early stages of a new industry.

The possible absence of actors at the interorganizational level, however, is not meant to suggest that relations among firms, among audiences, and between firms and audiences are not important. For example, using an identity-based approach, Cattani et al. (2008) measured consensus in the audience-candidate network of the U.S. motion picture industry between 1912 and 1970. They found that it enhanced survival by allowing for broader and timelier propagation of information, reducing ambiguity about legitimate organizational identities, and abetting the prompt sanctioning of deviant behaviors. Thus, an explicit focus of our study is to evaluate the role of networks in facilitating the selection of specific forms and identities.

The basic model is simple: For new forms generally, and emerging populations specifically, audiences assess identities based on perceptions of similarity. Hannan, Pólos, and Carroll (2007: 41) discussed this process in terms of the concept of clustering and argued these clusters might form on the basis of "… relational properties, such as network ties." Ties among audience members and ties between audience members and firms should play a role in defining identity codes through their effects on the construction of similarity clusters. Hannan, Pólos, and Carroll (2007: 39) suggested that network ties among producing organizations provide "… a natural path for identifying other similar producers in a domain." In refining theories of the emergence of new industries, we argue the presence and prevalence of network ties affects the similarity of identities among these actors. Based on this presumption, we examine the effect of network ties on the number of surviving firms and total industry resources in emerging industries. To draw conclusions about the importance of these network effects, we simulate a baseline model without network ties and a model where network ties are possible to compare the results for the number of surviving firms and total industry resources. We also compare the network condition with conditions where the construction of shared beliefs about identities is coordinated at the collective level. Based on the concept of institutional isomorphism (DiMaggio and Powell, 1983), we create conditions where there are various forms of isomorphic pressures. This variety of conditions allows us to compare models of industry emergence that vary with respect to assumptions about network ties and legitimacy pressures.

AUDIENCES, FIRMS, RESOURCES, AND NETWORKS

As Mezias and Glynn (1993: 85) observed: "A computer simulation can take a complex set of assumptions, simulate a set … of processes, and represent the implications of these processes for … outcomes." We would add that it is important to highlight those aspects of the simulation that are maintained assumptions and those that are designed to explore theoretical issues. We do that here by describing first a set of maintained assumptions about audiences, firms, and resources. Although maintained assumptions are not necessarily theoretically interesting, they are important as logical checks on the theoretical framework. Further, by enacting these assumptions as parameters in a simulation and assuring that the values are determined in a manner that reflects a broad range of potential theoretical conditions, they act like 'control variables' by demonstrating that the outcomes of the model are robust across a wide range of conditions. The maintained assumptions of our model are presented here with minimal explanation as the logic is intended to be straightforward.

Since the probability that any given audience member and any given firm will hold the same identity codes can be thought of as a draw from a binomial distribution, we posit that larger numbers of audience members and firms will increase the number of surviving firms and total industry resources. Since the transfer of resources from audience members to firms with identities that match their preferences (Hsu and Hannan, 2005) is the mechanism by which firms obtain the resources to survive and grow, we posit that a higher level of average resources among audience members will increase the number of surviving firms and total industry resources. Similarly, we expect that the rate at which audience members transfer resources to firms with which they find an identity match will enhance the number of surviving firms and total industry resources. Because firm mortality occurs when firms run out of resources, we further posit that higher average levels of initial resources among firms will increase the number of surviving firms, consistent with what Fichman and Levinthal (1991) called the liability of adolescence, and total industry resources. Lastly, the rate at which firms have to consume resources to survive, which we will refer to as the firm spending rate, will decrease the number of surviving firms and total industry resources.

> Maintained assumptions about audiences: Higher initial numbers of audience members with more resources who transfer resources at a higher rate will be associated with higher numbers of surviving firms and higher total industry resources.

> Maintained assumptions about firms: Higher initial numbers of firms with more resources who expend resources at lower rates to survive will be associated with higher numbers of surviving firms and higher total industry resources.

With respect to networks and legitimacy, the theoretical variables of interest in our simulation, we do not simply posit maintained assumptions. Rather, we develop theoretical arguments and state propositions that will be tested by comparing the baseline, network, and legitimacy conditions in our simulation. Networks play an important role for emerging firms because they provide access to social resources. As Aldrich and Ruef (2006: 68) noted, "[n]ascent entrepreneurs' personal networks … affect their access to social, emotional, and material support." Emerging firms are more effective if entrepreneurs are able to manage their network activities systematically, increasing network density and diversity in their personal networks, in the firm's internal structuring, and in the firm's relations with other firms (Dubini and Aldrich, 1991: 305). Considerable empirical work has linked network ties with an enhanced number of surviving firms, particularly for young firms in emerging activity domains. Stuart, Hoang, and Hybels (1999) and Stuart (2000), in a study of the biotechnology and semiconductor industry found that network ties enhanced the number of surviving firms and total industry resources. Baum and Oliver (1992) analyzed the relations of population members to their institutional environment and found that in the very early stages the failure rate of young firms declined because such ties conferred survival advantages like legitimacy, resources, and buffering. More recently, Cattani et al. (2008) studied the audience-candidate network in the U.S. motion picture industry between 1912 and 1970, finding that increased connectivity reduced exit rates from the population.

At the conceptual level, the formal model by Hannan, Pólos, and Carroll (2007) proposed that the development of shared beliefs about organizational classes, categories, and forms can be explained by communication processes among members of the audience and producer segments (c.f. Lounsbury and Glynn, 2001). According to a review by Monge and Contractor (2003), contagion in social networks serves as a mechanism to expose people to information, attitudes and behaviors of others (Burt, 1980, 1987; Contractor and Eisenberg, 1990), and this exposure increases the probability that network members develop similar beliefs (Carley, 1991; Carley and Kaufer, 1993). We build on these arguments to claim that network ties allow audience members and firms to share information about identities; as a result of sharing this social information, actors may reach consensus about appropriate identities. If the level of agreement on identities between audiences and firms in a population increases through social contagion, then violations of identity codes occur less frequently, and audiences are more likely to support firms. Therefore, we expect the number of firms that are able to survive in the new industry will increase as the probability of network ties among firms and audiences increases. We state this formally as proposition one. Since the mechanism by which audience members enhance the number of surviving firms of producing organizations in the population is by transferring resources to them, we also argue that the total resources in the population should also increase with network ties. We state this formally as proposition two.

> Proposition 1: The higher the probability of network ties among audience members and firms, the higher is the number of surviving firms in the population.

> Proposition 2: The higher the probability of network ties among audience members and firms, the greater is total industry resources.

We have argued that network ties are relevant to the emergence of new industries because the social information that is transmitted among members of a network allows them to come to agreement about appropriate identity codes more easily. As we model legitimacy effects, they also act as a form of social information about appropriate identity codes. In the coercive isomorphism condition, a preferred type is declared for the entire population. Coercive isomorphism, according to DiMaggio and Powell (1983), involves a state authority or some other interorganizational entity with the power to sanction deviation from its prescriptions (DiMaggio and Powell, 1983). Consistent with this, our coercive isomorphism condition includes a mechanism whereby a single type is designated as preferred. Population members adjust to that type with some probability p, and this parameter is included as a variable in the analysis of the results of the simulated data.

We modeled the effect of mimetic isomorphism similarly by following the logic of the original argument; in each period of the simulation, the identity code of the most common form is visible to audiences and firms alike. Following DiMaggio and Powell (1983), mimetic isomorphism results from standard responses to uncertainty, which is a powerful force to encourage imitation: When organizational technologies are poorly understood, when goals are ambiguous, or when the environment creates symbolic uncertainty (March and Olsen, 1976), organizations may model themselves on other organizations. Consistent with this, the most common form in the population becomes the preferred identity under the mimetic legitimacy condition. Population members adjust their identity to that form with some probability p, and we include this parameter as variable in our simulation model.

Finally, we integrated the effect of normative isomorphism in our simulation model again by following the logic of the argument. Normative isomorphism, according to DiMaggio and Powell (1983 152), involves "…the definition and promulgation of normative rules," often by some form of professional association (e.g., Bogaert, Boone, and Carroll, 2006). We assume that those population members who are most successful influence the determination of what is considered appropriate. Consequently, the identity of the population members with the highest total aggregate resources becomes the legitimate form under the normative legitimacy condition. Population members adopt this identity with some probability p, and we investigate this parameter as variable in our data analysis. It is worth noting that the legitimate identity in the coercive legitimacy condition is determined in the first period and remains the same throughout each run of the simulation. By contrast, the identity preferred under mimetic and normative legitimacy processes is updated in each period. As the most frequent or most successful form changes over time, so too does the definition of the legitimate identity.

> Proposition 3: The higher the probability of legitimacy effects, the higher is the number of surviving firms in the population.

Proposition 4: The higher the probability of legitimacy effects, the greater is total industry resources.

SIMULATION ANALYSIS

Simulation routine

We follow Lant and Mezias (1992: 53) in how we create firms for this simulation: "The key assumption made in order to operationalize organizational characteristics and change is that organizations are completely characterized by four core dimensions (Hannan and Freeman 1984; Tushman and Romanelli 1985). For the sake of simplicity, it is assumed that firms have only two choices, e.g., 0 or 1, on each of these dimensions;" consequently, 16 different identities are possible (0-0-0-0, 0-0-0-1, 0-0-1-0 … 1-1-1-1). Audience members have preferences for identities defined in the same four dimensional space. For each simulation run a random integer uniform on [1, 10] determines the number of firms, and an independent draw on the same distribution is made to determine the number of audience members. The initial resources of firms and audience members are uniform draws from the integers uniform on [1, 20]. While the choice of the unit time is arbitrary, we discovered that running our simulation for 50 periods achieved considerable variation in the number of surviving firms and total industry resources; given the time frame of most startups, it is sensible to regard these units on a scale similar to months (Aldrich, 2010). Thus, we regard our simulation experiments as observations of new industries over a small number of years between the appearance of the first firms and the end of our simulation. As a cost of doing business, firms must spend a proportion of resources, randomly drawn from the distribution uniform on [0.1, 1]; this is called the spending rate. To simulate competitive pressure, the program multiplies this spending rate by the resources of the largest firm in the population to determine what each firm must spend to stay in business in each period. For example, if the population has a firm with resources of 10 and the spending rate is 0.5, then each firm in the population must expend 5 resource units to remain in business. If the resources of a firm fall to zero or below, that firm exits the population and is not replaced. Audience members search the population of firms to determine if there are any that match their preferred identities; if they find none, they exit the population, do not return, and are not replaced. If they find at least one match, they transfer a proportion, randomly drawn on the distribution uniform on [0.05, 1], of their resources. They continue transferring resources to firm(s) that match their preferred identities until they have no additional resources. All surviving firms and remaining audience members then proceed to the next period, where spending and resource transfers from audience members are repeated. This continues until all firms have gone bankrupt and the population is extinct or until period 50. This basic description constitutes our baseline condition with neither network ties nor legitimacy pressures. In Figure 1, we depict these processes as a series of steps and introduce the variants that constitute our network and legitimacy conditions. A more detailed description of the simulation is provided in the Appendix.

Insert Figure 1 about here.

1. At the beginning of the simulation, the program sets the population level parameters and creates audience members and firms. Different runs of the simulation model include parameters to test our propositions, including the probabilities that population members form network ties or adjust their identity in response to legitimacy pressures. The resource constraint parameters determine the number of initial audience members and firms in the population, the initial resource endowment of each audience member and firm, the rate at which audience members transfer resources to matching firms, and the

rate at which firms spend their resources in each period. The four values that determine identity for each firm and audience member are determined by random draws from the integers 0 and 1.

2. To contrast populations with and without networks, simulation trials are run for each. In simulation trials with networks, ties are formed by basic homophily, the tendency of people to interact with similar others (McPherson and Smith-Lovin, 1987; McPherson, Smith-Lovin, and Cook, 2001). For each actor a random binary four-dimensional vector is created, representing characteristics to define homophily, e.g., gender, age, education, or occupation. As with firm identity, we assumed that each actor could be characterized by either a 1 or a 0 on each dimension. Thus, homophily, like identity, is based on sixteen types, but these are independent of the identity type. Whether two actors, firms or audience members, form a tie depends on the similarity of their homophily vectors and the basic propensity in the population to form network ties; thus, tie formation is binomial with the probability of success (forming a tie) determined by both the probability of forming ties and the homophily between the two actors. Network ties are formed only in the first period and remain fixed until the end of a simulation trial.

3. To contrast populations with and without different isomorphic legitimacy pressures, we incorporate different conditions into various runs of the simulation. If isomorphic pressures exist in the population, members may change their identity with a probability uniform on [0,1] that is set at the beginning of the simulation and does not change. They change only if they do not already match to a legitimate identity, which is defined by the type of isomorphic pressure. In populations with coercive isomorphic pressure, the codes of the legitimate identity are randomly set in the first period and do not change in later

periods. In populations with mimetic pressure, the legitimate identity is set to the identity with the highest number of firms. In populations with normative isomorphic pressure, the legitimate identity is defined by the identity with the highest mass, i.e. the identity with the highest sum of resources across all firms. Legitimate identities under the mimetic and normative condition are updated at the beginning of each simulated period.

4. In populations with networks, audience members and firms that form ties receive information about the identities of their network partners. They adjust individual components of their identity to the identity of a random alter in their network if it is different from their own.

5. Each audience member still in the population is given the same level of resources in all periods that they were assigned randomly in the first period; these are expended fully to support firms with the same identity as the audience member during the period. If an audience member does not find a firm with its preferred identity, it exits the population, does not return, and is not replaced.

6. Once audience members find firms with preferred identities, they transfer a fraction of their resources equal to the audience transfer rate parameter. Audience members continue the firm search and resource transfer until they have no resources remaining.

7. At the end of each period, firms spend part of their current resources based on the spending rate parameter and the size of the largest firm in the population. If spending causes a firm's resources to fall to zero or below, it goes bankrupt and exits the population; there is no replacement of bankrupt firms.

8. Unless period 50 has been reached or no firms are left in the population, the program proceeds to the next period and continues with step 2. Otherwise, the program exits the simulation routine.

Simulation Output

The two dependent variables in this study are the number of surviving firms in the population and the total industry resources across all firms at the end of each run of the simulation. The independent variables are defined at the population level and are collected for each run of the simulation. The maintained assumptions concern numbers and resources of audience members and firms and the rate of transfer and spending of resources. Thus, we track initial audience count, initial audience resource level, audience transfer rate, initial firm count, initial firm resources, and firm spending rate as variables that may affect the number of surviving firms and total industry resources. We treat these like control variables in a typical empirical study; in other words, we expect them to have certain effects but do not regard these as theoretically interesting. To model resource constraints of audience members, we use three parameters: The parameter *initial audience count* defines how many audience members are created at the beginning of a simulation trial. The variable *mean initial resources of audiences* reflects the initial allocation of resources to audience members and is calculated from two randomly drawn resource boundary parameters. The parameter *audience transfer rate* determines which fraction of its resources an audience member transfers to a firm with the preferred identity. Similarly, three resource constraint parameters of firms are defined: *initial firm count, mean initial resources of firms,* and *firm spending rate*. The variables of theoretical interest are the probabilities that population members form network ties or experience isomorphic legitimacy pressures. These parameter values are uniform on 0 and 1 and remain constant during a simulation trial. The simulation routine was programmed in Visual Basic for Applications (VBA) and SQL, which are part of Microsoft Access. For the storage of our data, we used tables in Microsoft Access.

RESULTS

We ran 2500 simulation trials over 50 periods with 5 different conditions: (1) no networks, no legitimacy pressures, (2) networks but no legitimacy pressures, (3) no networks, only coercive legitimacy pressures, (4) no networks, only mimetic legitimacy pressures, and (5) no networks, only normative legitimacy pressures. Further information about these conditions is provided in the Appendix. Each trial generated observations on the number of surviving firms and total indsutry resources, which we regard as a sample drawn from an infinite population of simulation results (Levitt et al., 1994; Mark, 1998). In our data analysis, we combined the observations of the five conditions to analyze the results; thus, our sample size for the descriptive statistics reported in Table 1 and for all results reported below is 2500. Mean values of the independent variables are in the expected ranges: For example, we expected mean values for *initial audience count* and *initial firm count* of 5.5 (= (1 + 10)/2); they are 5.49 and 5.42 respectively. The mean value for *probability of tie* of 0.1 results from 500 out of 2500 simulation trials with network condition and a tie probability parameter uniform on 0 and 1; the values for the probability of isomorphic pressures are similar. The means of our dependent variables are reported at the bottom of the table. On average, the number of surviving firms per run of the simulation was slightly less than one. The average log of total industry resources in period 50, which is 2.33, indicates that the average population had a mass of just over 9 resource units, which is less than one sixth of the average population mass in period 1 (5.42 X 10.46 = 56.69). The small number of surviving firms and the low level of total industry resources result from the strong selection pressures in our simulated environment. Correlations are presented in Table 2 and show mainly non-significant correlations between independent variables and significant correlations between independent and dependent variables, which is not unusual with simulated data.

Insert Tables 1 and 2 about here.

The dependent variable in our first model, the number of surviving firms, is a count variable. We examined the test statistic for whether Poisson estimation should be replaced by the negative binomial technique to correct for over-dispersion, but this was not indicated. As our dataset contained a large number of excessive zeros, we ran both Poisson models and zero-inflated Poisson models, and we found that the same effects except the intercept were significant. However, we chose to report the Poisson models rather than the zero-inflated models for the same reasons as Beckman, Haunschild, and Philips (2004: 267): These models are simpler and more familiar to existing research, and our theory does not differentiate between populations that become extinct or not. Consequently, "… the choice of what variable to include in the logistic analysis of zero outcomes .." could not be "… driven by our theory." The dependent variable in our second model is total industry resources. The large proportion of zeros is caused by populations in which no firms survived until the end of a simulation, but in this instance a methodological solution was available that did not require differentiating between extinct and non-extinct populations: We analyzed the effects on this variable with a left-censored Tobit regression model. To ensure that the assumptions of the model better fit our data, we did a log transformation of the total industry resources. The results of these analyses are reported in Tables 3 and 4.

Insert Tables 3 and 4 about here.

The majority of our maintained assumptions are supported: In both models, the variables *initial audience count*, *mean initial resources of audiences*, and *initial firm count* had significant positive effects, while the *firm spending rate* showed a significant negative effect on the *number of surviving firms* and *total industry resources*. *Mean initial resources of firms* were not significant in either model, indicating that effects from high or low initial firm resources could be neutralized over time. As expected, *audience transfer rate* had a significant positive effect on total industry resources, but in contradiction to our prediction, *audience transfer rate* had a significant negative effect on the number of surviving firms. We will return to this result, which we refer to as the paradox of big bets, in the discussion, but the explanation follows from the implications of our assumptions. We required audience members to transfer resources to firms that matched their preferred identity until all of their resources were gone; thus, the transfer rate only affected how many resources were transferred to a single firm in a single transfer. Consequently, the higher the *audience transfer rate*, the bigger was the bet on a single firm with the result that the variance of resources allocated to firms with the preferred identity was increased. For example, if *audience transfer rate* was 0.95 and three firms had the preferred identity of an audience member, that audience member transferred 95 percent of its resources to the first firm, the remaining 5 percent to the second firm, but nothing to the third firm. Further, because we assumed that the level of firm spending required for survival increased with the size of the largest firm in the population, competitive pressures also became greater when audience members bestowed larger amounts of resources on single firms.

To test our propositions, we analyzed the effects of the probability of network and legitimacy effects from the conditions that incorporate these effects. The probabilities of network ties and different types of isomorphic pressures significantly increased the number of surviving firms and total industry resources; thus, all our propositions are fully supported. We also compared the magnitudes of different main effects and resource constraint effects. For this comparison we used standardized coefficients calculated with the Stata routine "listcoef" developed by Long and Freese (2003). First, we compared the different main effects with one another. Both in the number of surviving firms model and the total industry resources model, the effects of networks and coercive legitimacy had about the same size and were somewhat smaller than the effects of the legitimacy pressures that updated during the simulation. Second, we compared main effects with our six resource constraint effects: In both models, the effect of network ties was larger compared to the absolute values of three resource effects and smaller compared to the absolute values of the remaining three resource effects. In sum, network ties had an effect that was more or less as important as any of the effects in both models.

Robustness Checks

To assess the robustness of the results as reported above, we ran an additional 7500 simulation trials with 15 sets of conditions: with and without networks, with and without identity similarity affecting the propensity to form networks ties, with and without updating of network ties during the course of each run of the simulation, and with and without three legitimacy conditions. Further information about these conditions is provided in the Appendix. We then analyzed the same dependent variables, number of surviving firms and total industry resources, by combining the 10000 data points from all 20 conditions. The results reported in Table 5 demonstrate the robustness of our results in at least two ways: First, it introduced variations on the conditions reported in the main analysis. For example, we introduced network ties that are: (a) fixed in period 1, (b) allowed to update over time, (c) based on a random homophily matrix, and (d) based on similarity in identities; the data reported in the main results above was characterized by (a) and (c). Second, it allowed us to estimate the effects of the variables of central interest to us with the introduction of fixed effects by condition. With the data that emerged from all these runs of the simulation, we were able to estimate the effects of networks and legitimacy pressures more precisely by including a fixed effect variable for any condition that included network ties or legitimacy pressures. None of the results as we reported them above were changed by the introduction of this variety of conditions or fixed effect variables. Network ties significantly increased both the number of surviving firms and total industry resources, and the network effects were largely of comparable magnitude to the effects of resource constraint variables and legitimacy pressures.

By incorporating this wide range of conditions, we have demonstrated that the central results hold across a variety of assumptions intended to capture what we understand about the emergence of new industries. For example, if the audience members are interpreted as VC investors, then their resource transfer to matching firms in each period can be interpreted as representing their judgments about the prospects of these firms. The range of conditions also allows us to examine different assumptions. For example, the condition where network ties are based on similarity of identity types and network ties update in each period can be conceptualized as incorporating referrals among the audience members. These 'referrals' allow firms that are already similar to audience members to extend their linkages to other audience members with similar identity preferences and become more similar to them over time. By contrasting this condition with the main network model, where ties are based on homophily unrelated to identity and fixed in the first period, we learn two things: First, basing network ties on identity similarity produces a slightly more positive effect on the number of surviving firms and total industry resources. Second, we get significant positive effects of networks on the number of surviving firms and total industry resources without the stronger assumptions that network ties are linked to identity similarity.

DISCUSSION AND CONCLUSIONS

As we argued at the beginning of our study, the phenomenon of industry emergence has proven difficult to study for a multitude of reasons, most notably the difficulty of obtaining quality data. To solve this problem, we used simulation methodology to develop a model of social processes crucial to new industry emergence and to examine the implications of that model. Despite considerable discussion in the literature of the role of interorganizational actors such as trade associations and the like as a solution to the social problems of launching new industries, we pointed to both empirical and theoretical reasons to doubt the universality of this solution in nascent industries. We suggested that network ties might be a means of coordinating firms and audience member identity preferences in the absence of these collective actors. To investigate this possibility, we used simulation experiments to establish two results: First, by contrasting conditions with and without network ties, we demonstrated that network ties improve the number of surviving firms and total industry resources. Taking the results of simulation trials as representative of the general implications of the model, we provided statistical evidence of the importance of network ties and showed that their effects are largely comparable to the effects of variables to measure resource effects. Second, by contrasting conditions with network ties and various forms of legitimacy pressures, we demonstrated that the magnitudes of the effects of network ties were relatively similar to those of legitimacy effects. We can bolster our confidence in the meaningfulness of these results by going beyond comparison of standardized coefficients; we do this by plotting the effects of networks and legitimacy pressures in Figures 2 and 3, allowing us to assess the similarity of their relative effects visually.

Insert Figures 2, 3, and 4 about here.

To make these relative comparisons, we calculated the predicted values of our dependent variables from the non-standardized coefficients of the main model regression analyses. We varied the value of the network and legitimacy parameters across the distribution from which they were drawn, uniform on [0, 1]. The predicted effect of networks and the mean effect of the three legitimacy types[1] on the expected number of surviving firms are depicted in Figure 2 and on total industry resources in Figure 3. As both figures reveal, the effect of the probability of network ties and the average legitimacy effect follow very similar trajectories. There is some variation obscured by the average; the effect of some legitimacy parameters are slightly more dramatic than others. By increasing the probabilities of ties and isomorphic pressures from 0 to 1, the expected number of surviving firms can be increased for the network and coercive legitimacy effect by about 85 percent, and for the mimetic and normative legitimacy effects by somewhat more than 100 percent. Expected total industry resources increase by the factor 7 for the network effect, by the factor 7.8 for the coercive legitimacy effect, by the factor 11.6 for the mimetic legitimacy effect, and by the factor 9.4 for the normative legitimacy effect. It is also important to note that these relative effects are based on the assumption that the creation of the mechanisms of legitimacy requires no resources; we know this is unrealistic, as even minimalist organizations like trade associations (Aldrich, et al., 1994) have costs associated with them. These costs could easily

[1] We used the mean effect of the three legitimacy conditions because the lines are virtually indistinguishable in a chart with four lines. Averaging the effects of the three legitimacy conditions depicts the overall relationship accurately and yields a much more effective visual representation.

undermine any increment in the number of surviving firms or total industry resources associated with legitimacy pressures; a point that is illustrated by the strong effects of the spending rate parameter. In other words, as firms increase spending to support an inter-organizational coordination mechanism, the number of surviving firms and total industry resources will be decreased.

Figure 4 provides a visual illustration of the paradox of big bets. Here we vary the audience spending parameter across its theoretical range from 0.05 to 1. We estimate the effect of this range on both the number of surviving firms (the left Y axis) and total industry resources (the right Y axis). The estimates are computed by multiplying the mean values of all variables, except the network and legitimacy variables, by their coefficients from Tables 2 and 3. For the network and legitimacy variables, we used their theoretical means of 0.5 rather than their empirical means because the conditions where they were set to zero by definition caused the scale of this Figure to not match the other two figures.[2] As the crossing of the lines in the middle of the figure demonstrates, the trade-off between the number of surviving firms and the total industry resources of the population is inescapable. Audience members, such as policy makers or investors, who tend to make many low bets will push the emerging industry in the direction of decentralized structure and more competitors but with lower average competitive intensity (Barnett, 1997). This less concentrated industry also will be less likely to generate processes of resource partitioning (Carroll, 1985), which may be important to the continued generation of innovation as the new industry stabilizes (Mezias and Mezias, 2000). By contrast, audience members who tend to make fewer large bets, by transferring larger percentages of their available resources to single firms, will push the emerging industry in

[2] Plotting against the empirical means of these variables moves the curve downward against both Y axes, but does not otherwise change the picture.

opposite directions. The new industry will be more centralized, and there will be less competition with higher average competitive intensity, i.e., an oligopolistic or even monopolistic industry structure. These conditions would be more likely to result in resource partitioning processes much earlier in the life of the new industry. In the long run it is difficult to say which should be preferred by policy makers or investors. For example, if gaining much-needed legitimacy is driven by a density dependent process (e.g., Hannan, 1986), then small bets are to be preferred. By contrast, if legitimacy is driven by a mass dependent process (e.g., Barnett and Amburgy, 1990), then larger bets should be made. In theoretical terms, this is a clear illustration of a situation where density and mass need not to move together; this highlights at least the possibility that choices of audience members about the size of bets is, at least implicitly, a guess about whether legitimacy will be driven by density or mass.

The results of our simulation have several theoretical implications. We add to the understanding of industry emergence in the very early stages and the role of interactions and networks of audiences and firms in this phase. We have demonstrated that under a wide range of sensible theoretical conditions, network ties can systematically enhance the number of surviving firms and total resources of new industries. Our study makes also a contribution to a dialog between theories of entrepreneurship and recent work in the ecological literature identifying ongoing processes that create links between particular audiences and particular organizational forms. Specifically, social processes, including those that result from social networks and isomorphic pressures from various types of legitimacy, affect processes of identity coding and approval among audience members and firms. Thus, ecological models of identity need to account for network ties as well as offer some understanding of when legitimacy pressures might affect organizational identities. Finally, there is a clear implication of the unexpected finding that the rate at which audience members transfer resources to candidate firms affects the number of survivors and total industry resources in opposite directions. This paradox of big bets makes it clear that some conditions will produce fewer, larger firms meaning that density would be relatively lower while mass would be relatively higher. This suggests that the relationship between density dependent and mass dependent population dynamics should be investigated by future research.

Our findings also have important practical implications for policy makers and entrepreneurs during the very early stages of industry emergence: Policy makers can improve the success of industry emergence through interventions aiming at increasing network connectivity, informal communication, and coordination among population members. Similarly, entrepreneurs may benefit from more embeddedness in networks, which increases the probability that they will adopt identities approved by audience members and receive resources from them. While this is consistent with agglomeration arguments (Schoonhoven and Romanelli, 2001; Stuart and Sorenson, 2003; Saxenian, 2001), our result does not depend on geographical proximity per se. Indeed, we rely on social proximity, finding that even when the propensity to form ties is unrelated to similarity of identities, network ties still enhance the number of surviving firms and total industry resources. Clearly, social capital interventions (Fliaster, 2007), aimed at enhancing the possibilities for relationships among audience members and firms, should be implemented to promote dyadic relationships and encourage dense network structures to increase the availability of social resources. Where this can be done by encouraging geographical agglomeration, then this strategy should likely be pursued. However, given that the number of firms in young industries is often very low, it might be difficult to find enough socially similar actors that are geographically close to one another. In this situation, policy makers could promote informal communication between socially similar but spatially distant actors or between socially distant but spatially close actors through common events, talent exchange, or virtual collaboration platforms.

Our results also suggest that curricula for entrepreneurship education should include modules aiming at the development of network related knowledge, competences, and encouraging social connections among entrepreneurs. The network abilities of entrepreneurs are particularly important for their firms' successes in emerging industries because they increase the probability that larger numbers of firms survive and the total size of the new industry increases. Thus, in considering their location decisions, entrepreneurs should seek environments with high levels of interaction to the extent possible. Beyond the clear implication that dense networks are better, our results are also consistent with the view that embeddedness in networks provides critical information and audience resources. We would hazard a guess, although it is beyond the narrow confines of our theoretical simulation, that particular attention should be given to the composition of the entrepreneurial team: At least some of its members should have the characteristics of so called "network entrepreneurs" (Burt et al., 1998), and communication activities across team boundaries should be well coordinated (Ancona and Caldwell, 1990).

While highlighting these implications for future research, it is also important to mention limitations of our simulation study. A first limitation refers to methodology: We emphasized the benefits of using a simulation model and the difficulties involved in working with real datasets. Nevertheless, it remains desirable to find ways to test our propositions with empirical data in the future. The second limitation refers to the tie formation rules as we enacted them at the beginning of our simulation. Ties in our simulation model were formed by the homophily rule, and we observed a positive effect of ties on the number of surviving firms and total industry resources. In our robustness checks, we found the same results even after changing from a homophily to a similarity of identity rule and from static ties to dynamic ties that were updated throughout the simulation. Nonetheless, we have only scratched the surface; tie formation can follow many other patterns and has been shown to have important implications for the diffusion of information in a social system. For example, scale free networks have a power-law distribution of degrees that produce a small number of highly-connected hubs (Albert, Jeong, and Barabási, 1999), or typical properties of small-world networks are high clustering and small path distance (Watts and Strogatz, 1998). Thus, it would be an interesting direction for future research to test the robustness of our results to these alternate rules.

A third limitation addresses how we modeled network change; we included static networks in our main models and networks where ties were recreated anew at the beginning of each simulated period in our robustness check models. Another question of network evolution that we can explore in future work would be to incorporate change with different propensities for repeat connections or alternative rules that drive network dynamics, such as accumulative advantage, follow-the-trend, or multi-connectivity (Powell, et al., 2005). A fourth limitation of our study is that we allow only one type of isomorphic pressure in populations at a time, but in reality different types of isomorphic pressures may operate simultaneously in emerging industry. Future research can develop theoretical propositions about the interactions between the different types of isomorphic pressures, including possible conflicts among them. A fifth limitation is that we did not allow for mergers and acquisitions, which are known to be central to the dynamics of emerging industries. Of course, we would guess that mergers and acquisitions may become somewhat more important as it becomes clear that a few firms will survive the harsh new industry environment. Just as formal vehicles of coordination may become more important as the new industry grows larger both in number of firms and total industry resources, so too may mergers and acquisitions be a sign of the beginning of industry consolidation. Thus, mergers and acquisitions may be regarded as an extension that might be important to model and incorporate in future work that looks beyond the very earliest stages of industry emergence. A final limitation is based on the fact that we did not study time to stability of emerging industries; rather, we assumed that fifty simulated periods are enough for to understand the first stages of industry emergence. According to empirical data, however, time to stability may vary considerably across industries, ranging from 3 to 70 years (Klepper and Graddy, 1990). Therefore, it would be of considerable theoretical interest and practical relevance to investigate the role of different network conditions on time to stability in emerging industries.

APPENDIX: SIMULATION PARTICULARS

This Appendix provides a detailed description of the simulation routine and the 20 different conditions that we ran for this study, which are summarized in Table A-1. For our main analysis we generated data from 2500 trials over 50 simulated periods using conditions 1 to 5; for the robustness analysis we augmented these data with data from 7500 simulations using conditions 6 to 20.

Insert Table A-1 about here.

The simulation routine is organized into a simulation main routine and several simulation subroutines. The technical structure of the simulation main routine is depicted in Figure A-1, and we follow with a detailed description of each step of that figure.

Insert Figure A-1 about here.

1. The setup of simulation trials involves two steps: setting parameter values and creating audience members and firms. In the first step, the program assigns values to the resource constraint parameters (initial number of audience members and firms, their lower and upper resource boundaries, audience transfer rate and firm spending rate) and main effect parameters (probabilities of a tie and coercive, mimetic and normative legitimacy) for all simulation trials at once. Based on these parameter values, the program creates audience members and firms and assigns values to their initial resources, identity, and homophily vectors for the current simulation trial. The formulas and rules used during the simulation setup are summarized in Table A-2.

Insert Table A-2 about here.

2. The program sets the period counter to 1 and enters a loop for each of the 50 simulated periods.

3. The program examines the network conditions of the population. If the population has fixed networks and the current period is 1 or if the population has changing networks, the *tie creation subroutine* is called; in all other cases or when full convergence of identities has been reached,[3] the program directly proceeds to step 4. The *tie creation subroutine* generates a list with all non-directed node pairs between population members, both audience members and firms. We denote the population members of a single node pair as i and j. Depending on the condition, the program calculates the similarity between i and j ($similarity_{ij}$) by either comparing their homophily characteristics (in populations without identity similarity) or their identity codes (in populations with identity similarity condition). Technically, homophily characteristics and identity codes of a population member are each stored in four-dimensional vectors. We denote the vectors used for the calculation of the similarity index as V_i for population member i and V_j for population member j. Thus, we can formally state:

$$similarity_{ij} = 1 - \sum_{q=1}^{4} ABS(V_{iq} - V_{jq}) / 4$$

The program creates a tie between a node pair (x_{ij}: $0 \rightarrow 1$) with some probability, depending on the values of the parameter p_tie and the similarity index of that node pair:

$$p(x_{ij} : 0 \rightarrow 1) = p\_tie * similarity_{ij}$$

[3] This rule does not alter the outcome of processes but significantly improves the runtime of simulation trials.

4. The *legitimacy subroutine* is called in populations with legitimacy pressures as long as full convergence of identities has not been reached. This subroutine proceeds in two steps: definition of a legitimate form and adjustment of population members' identities in direction of that legitimate form. The formulas defining a legitimate form depend on the type of legitimacy in the population: In populations with coercive isomorphic pressures, the legitimate form is randomly chosen in the first period and does not change during the simulation. In populations with mimetic isomorphic pressures, the legitimate form is the form with the highest number of firm members; in populations with normative isomorphic pressures, the legitimate form is the form with the highest total resources of its firm members. If the functions for mimetic or normative legitimacy produce several solutions, one of them is randomly chosen as legitimate form. In populations with mimetic and normative legitimacy, the legitimate form is updated in each period. In the second step, population members adjust their identity to the legitimate form with some probability as defined by the respective parameter values (c_coercive, c_mimetic, or c_normative).

5. In populations with networks, the *social contagion subroutine* is called; but if no networks exist in a population, the program directly proceeds to step 6. This subroutine creates a list with all population members, arranges them in random order and examines in order of that list if changes must be made to their identities: If the current population member has network ties, it randomly chooses one alter and adjusts its identity codes to alter with probability 1 if these codes are different.

6. The program refills the resources of audience members with the initial resource values from period 1, creates a list with all audience members in the population, and arranges it in random order.

7. Following the order of this list, the program calls the *search and transfer subroutine* for each audience member. Its structure is depicted in Figure A-2, and each step is described in detail in step 8. Once the end of the list has been reached, the program proceeds to step 10.

8. The *search and transfer subroutine* starts with the calculation of the maximal transfer amount of the current audience member i (step 1 in Figure A-2), which depends on the audience member's resources at the beginning of the current period and the value of the parameter "audience transfer rate" (ATR):

$$\textit{maximal transfer amount}_i = \textit{ATR} * \textit{resources of audience member}_i$$

   Next, a randomly ordered list with firms in the population is created (step 2 in Figure A-2), and the current audience member searches all firms in order of this list until it reaches the last record (step 3 in Figure A-2). If the current firm has the same identity vector as the audience member (step 4 in Figure A-2), a resource transfer is initiated (step 5 in Figure A-2); otherwise, the program directly proceeds to step 6 of this subroutine. To calculate the actual transfer amount to the matching firm, the audience member's current resources are compared with the maximal transfer amount calculated in step 1 of this subroutine. If the current exceeds the maximal resource amount, the maximal resource amount is transferred to the matching firm, and the program directly proceeds to step 6 of this subroutine; otherwise, all remaining resources are transferred to the matching firm, and the program exits this subroutine and continues with step 9 of the simulation main routine. Once at step 6 of this subroutine, the program moves to the next record on the firm list and returns to step 3 of this subroutine. As soon as the last firm on the list has been reached, the program checks if the current audience member has found any matching firms in the population at all (step 7 in Figure A-2). If not, the audience member exits the population, the program exits this simulation subroutine, and continues with step 9 of the simulation main routine. If at least one match has been found, the program moves back to the first record on the firm list (step 8 in Figure A-2) and continues with the identity comparison in step 4 of this subroutine.

Insert Figure A-2 about here.

9. The program moves to the next audience member in the list and proceeds to step 7.

10. Resources of all firms are reduced by the same amount, which is defined as follows:

    *firm spending amount = FSR * MAX(MAX(resources of single firms), 10)*

    Firms exit the population if their resources fall to or below 0 after the spending. We imposed the assumption that the spending amount does not fall below a minimum value to avoid resources asymptotically approaching zero without ever falling below with the result that firms never exit the population.

11. If period 50 is reached or no firms are left in the population, the program ends the simulation trial; otherwise the program moves to the next period and proceeds to step 3.

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TABLES AND FIGURES

Table 1: Descriptive statistics

Variable	Mean	Std.Dev.	Min	Max
Initial audience count	5.49	2.90	1	10
Mean initial resources of audiences	10.60	4.11	1	20
Audience transfer rate	.52	.27	.05	1.00
Initial firm count	5.42	2.88	1	10
Mean initial resources of firms	10.46	4.14	1	20
Firm spending rate	.55	.26	.10	1.00
Probability of tie	.10	.23	.00	1.00
Probability of coercive legitimacy effect	.10	.23	.00	1.00
Probability of mimetic legitimacy effect	.10	.24	.00	1.00
Probability of normative legitimacy effect	.10	.24	.00	1.00
Number of surviving firms	.96	.82	0	8
Total industry resources*	2.33	1.74	0	6.86

** transformed by ln(x + 1), N = 2500*

Table 2: Correlation matrix

Variable	1	2	3	4	5	6	7	8	9	10	11
1 Initial audience count											
2 Mean initial resources of audiences	.02										
3 Audience transfer rate	.01	.03									
4 Initial firm count	.01	-.02	-.02								
5 Mean initial resources of firms	-.04	.00	.01	-.02							
6 Firm spending rate	-.01	.02	-.04	.03	-.01						
7 Probability of a tie	.00	-.04	-.01	.01	.00	-.02					
8 Probability of coercive legitimacy effect	.01	.01	-.03	-.03	-.01	.02	-.17				
9 Probability of mimetic legitimacy effect	.00	.01	.04	.03	.02	.03	-.18	-.17			
10 Probability of normative legitimacy effect	.01	-.03	.00	.01	-.03	-.02	-.17	-.17	-.18		
11 Number of surviving firms	.23	.09	-.14	.19	-.01	-.32	.07	.06	.09	.14	
12 Total industry resources*	.36	.20	.08	.12	-.03	-.56	.08	.09	.15	.14	.67

$p < .05$ for magnitudes >=.04, $p < .01$ for magnitudes >= .06, $p < .001$ for magnitudes >= .07

** transformed by $\ln(x + 1)$*

Table 3: Poisson regression predicting number of surviving firms

Independent variable	coefficient	standard error	z value	p value	standardized coefficient*
Constant	-.483	.117	-4.13	.000	
Initial audience count	.067	.007	9.34	.000	1.214
Mean initial resources of audiences	.023	.005	4.57	.000	1.098
Audience transfer rate	-.514	.076	-6.78	.000	.870
Initial firm count	.059	.007	8.30	.000	1.186
Mean initial resources of firms	.002	.005	.47	.636	1.010
Firm spending rate	-1.141	.082	-13.91	.000	.746
Probability of tie	.609	.089	6.81	.000	1.152
Probability of coercive legitimacy effect	.623	.090	6.90	.000	1.156
Probability of mimetic legitimacy effect	.702	.088	8.01	.000	1.183
Probability of normative legitimacy effect	.763	.083	9.25	.000	1.205

** exp(x standardized coefficient), N = 2500*

Table 4: Tobit regression predicting total industry resources**

Independent variable	coefficient	standard error	t value	p value	standardized coefficient*
Constant	.145	.159	.91	.363	
Initial audience count	.261	.010	26.66	.000	.361
Mean initial resources of audiences	.119	.007	17.31	.000	.233
Audience transfer rate	.354	.103	3.45	.001	.046
Initial firm count	.111	.010	11.35	.000	.152
Mean initial resources of firms	-.002	.007	-.35	.726	-.005
Firm spending rate	-4.290	.110	-38.95	.000	-.523
Probability of tie	1.936	.128	15.09	.000	.214
Probability of coercive legitimacy effect	2.040	.128	15.95	.000	.226
Probability of mimetic legitimacy effect	2.438	.125	19.56	.000	.277
Probability of normative legitimacy effect	2.228	.122	18.24	.000	.259

** fully standardized coefficient, N = 2500*

*** transformed by ln(x + 1)*

Table 5: Results from robustness check models

Results from Poisson regression predicting number of surviving firms (N = 10000)

Independent variable	coefficient	standard error	z value	p value	standardized coefficient*
Constant	.043	.059	.74	.458	
Initial audience count	.045	.003	13.51	.000	1.138
Mean initial resources of audiences	.022	.002	9.32	.000	1.093
Audience transfer rate	-.747	.035	-21.11	.000	.816
Initial firm count	.049	.003	14.61	.000	1.150
Mean initial resources of firms	-.001	.002	-.42	.673	.996
Firm spending rate	-1.219	.038	-32.17	.000	.729
Probability of tie	.185	.036	5.11	.000	1.062
Probability of coercive legitimacy effect	.712	.068	10.51	.000	1.200
Probability of mimetic legitimacy effect	.317	.065	4.89	.000	1.086
Probability of normative legitimacy effect	.364	.063	5.80	.000	1.098
Network condition	.109	.035	3.15	.002	1.045
Identity similarity condition	.029	.021	1.39	.164	1.014
Network change condition	-.035	.021	-1.68	.093	.983
Coercive legitimacy condition	-.267	.047	-5.73	.000	.891
Mimetic legitimacy condition	.064	.044	1.47	.141	1.028
Normative legitimacy condition	.029	.042	.68	.497	1.013

** exp(x standardized coefficient)*

Results from Tobit regression predicting total industry resources (N = 10000)**

Independent variable	coefficient	standard error	t value	p value	standardized coefficient*
Constant	1.161	.070	16.61	.000	
Initial audience count	.235	.004	59.13	.000	.351
Mean initial resources of audiences	.119	.003	42.30	.000	.251
Audience transfer rate	.149	.042	3.55	.000	.021
Initial firm count	.078	.004	19.64	.000	.116
Mean initial resources of firms	-.002	.003	-.65	.516	-.004
Firm spending rate	-4.550	.044	-102.57	.000	-.606
Probability of tie	.614	.044	13.98	.000	.103
Probability of coercive legitimacy effect	2.333	.080	29.05	.000	.307
Probability of mimetic legitimacy effect	1.281	.080	16.03	.000	.171
Probability of normative legitimacy effect	1.211	.078	15.55	.000	.160
Network condition	.354	.040	8.75	.000	.073
Identity similarity condition	.034	.025	1.35	.178	.009
Network change condition	-.138	.025	-5.42	.000	-.035
Coercive legitimacy condition	-.842	.052	-16.32	.000	-.188
Mimetic legitimacy condition	.052	.052	1.00	.317	.012
Normative legitimacy condition	.082	.050	1.63	.102	.018

** fully standardized coefficient*

*** transformed by ln(x + 1)*

Figure 1: Flow chart of simulation main routine

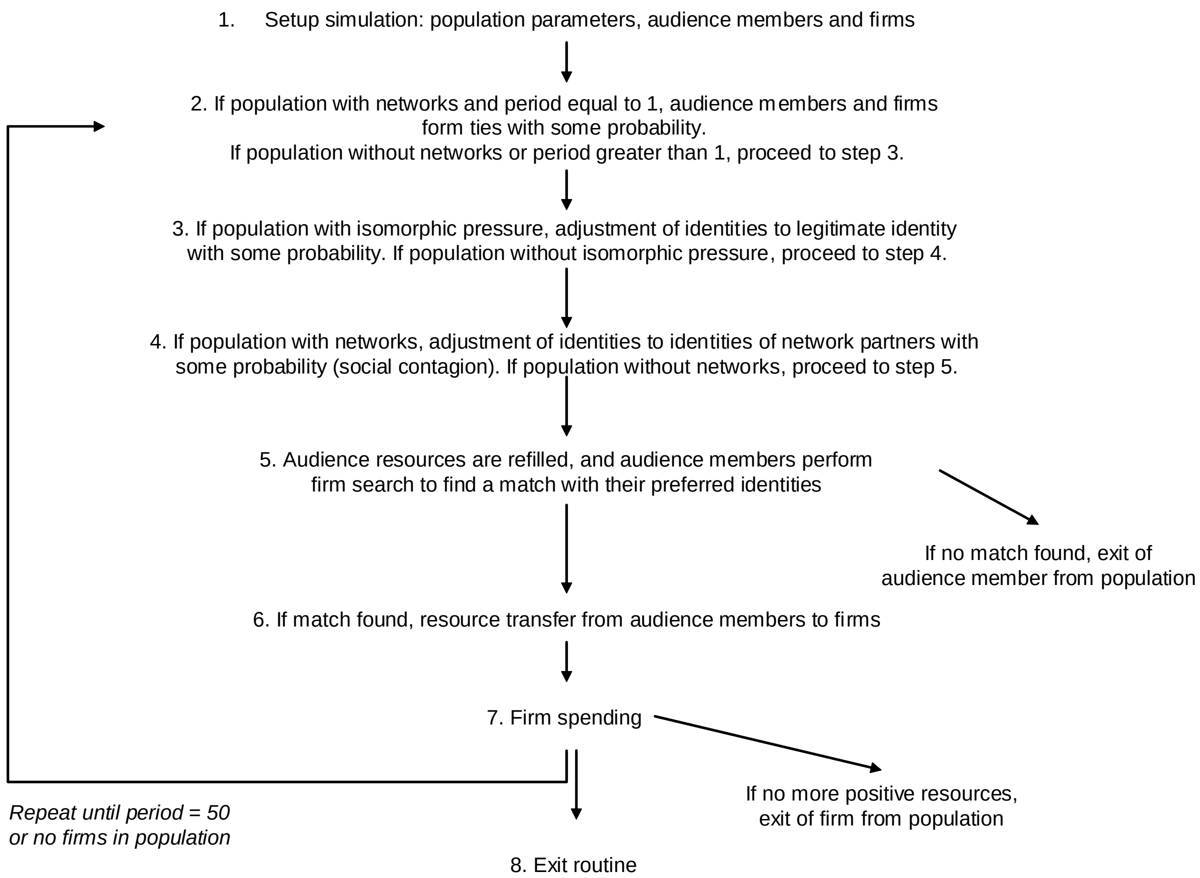


Figure 2: Network and legitimacy effects on number of surviving firms

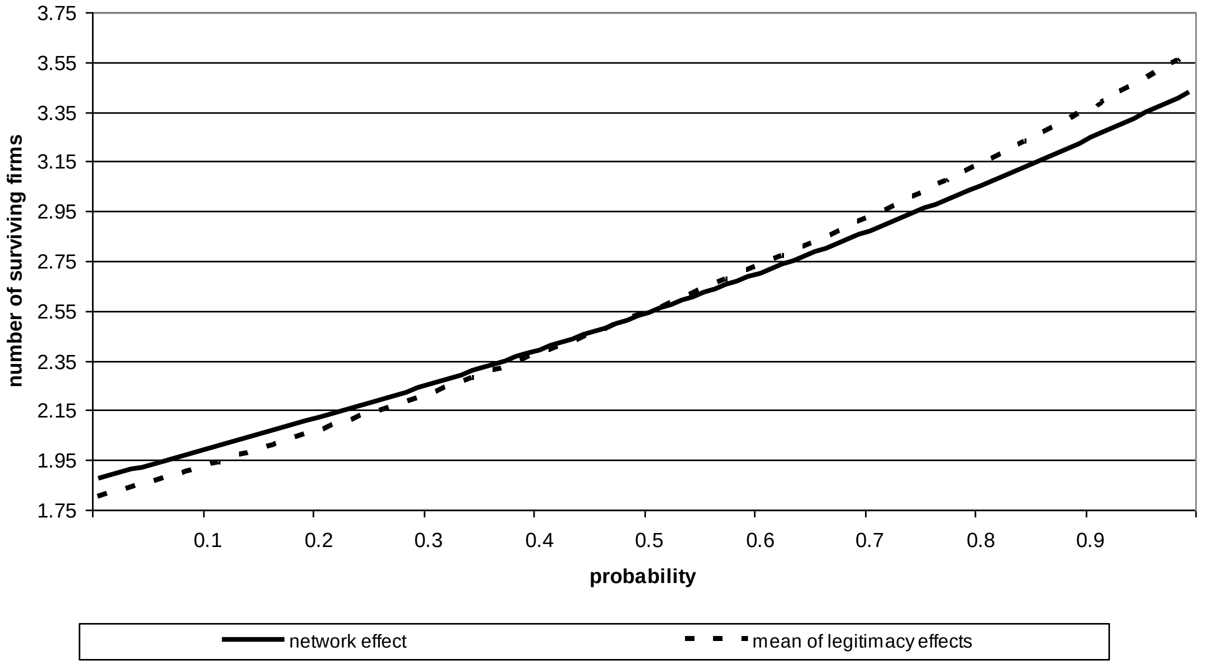


Figure 3: Network and legitimacy effects on total industry resources

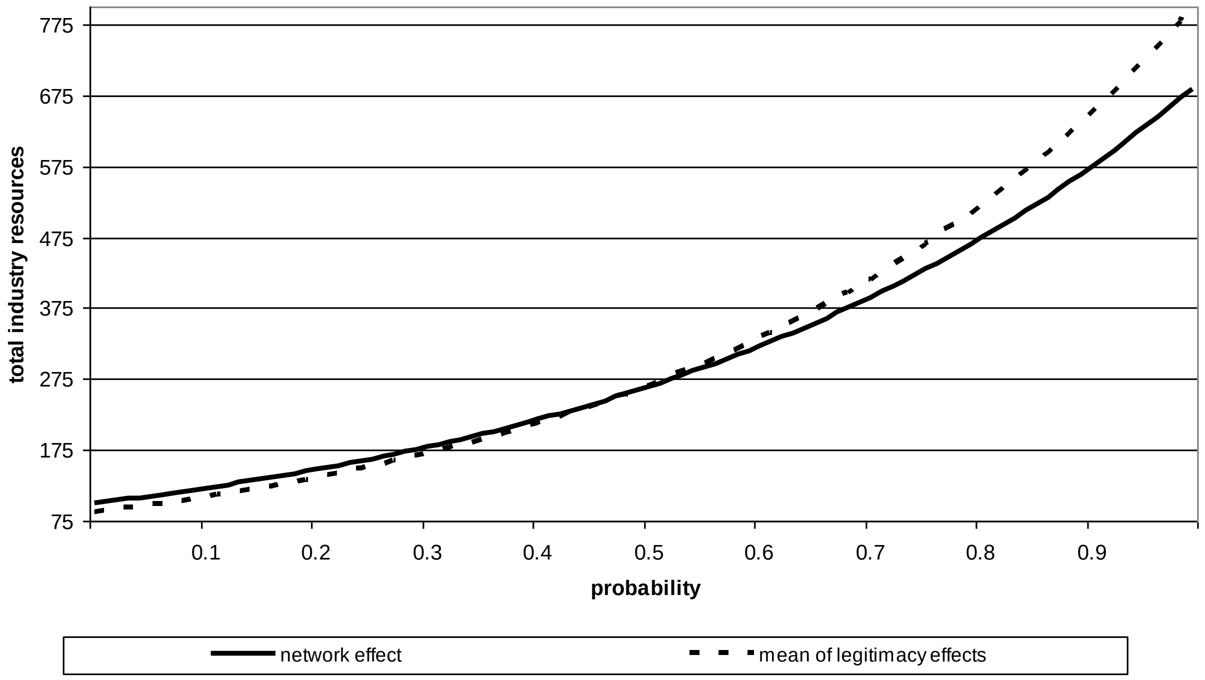
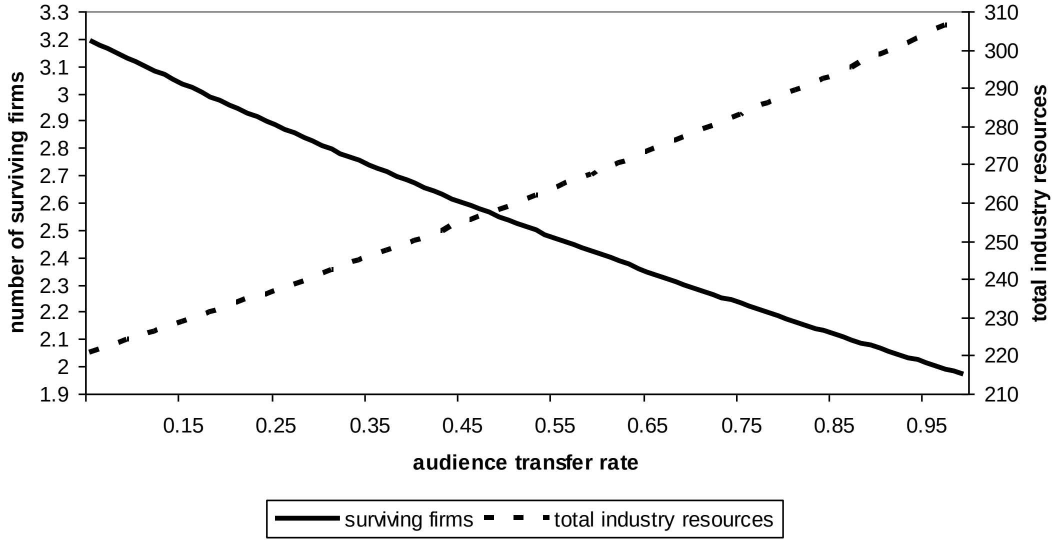


Figure 4: The paradox of big bets



TABLES AND FIGURES FOR APPENDIX

Table A-1: Conditions of simulation trials

condition*	network	network change	identity similarity	coercive legitimacy	mimetic legitimacy	normative legitimacy	n
1	0	0	0	0	0	0	500
2	1	0	0	0	0	0	500
3	0	0	0	1	0	0	500
4	0	0	0	0	1	0	500
5	0	0	0	0	0	1	500
6	1	0	1	0	0	0	500
7	1	1	0	0	0	0	500
8	1	1	1	0	0	0	500
9	1	0	0	1	0	0	500
10	1	0	1	1	0	0	500
11	1	0	0	0	1	0	500
12	1	0	1	0	1	0	500
13	1	0	0	0	0	1	500
14	1	0	1	0	0	1	500
15	1	1	0	1	0	0	500
16	1	1	1	1	0	0	500
17	1	1	0	0	1	0	500
18	1	1	1	0	1	0	500
19	1	1	0	0	0	1	500
20	1	1	1	0	0	1	500

** Conditions 1 to 5 for the main model and conditions 1 to 20 for the robustness check model*

Table A-2: Formulas and rules used in the setup simulation subroutine

1. Population level parameters	• Initial number of audience members (ACOUNT) integer uniform on [1, 10]. • Initial number of firms (FCOUNT) integer uniform on [1, 10]. • Lower and upper initial audience resource boundaries (LAR, UAR) integers uniform on [1, 20]. • Lower and upper initial firm resource boundaries (LFR, UFR) integers uniform on [1, 20]. • Audience transfer rate (ATR) uniform on [.05, 1]. • Firm spending rate (FSR) uniform on [0.1, 1]. • Probability of a tie (PTIE) uniform on [0, 1]. • Probability of a form being promoted by coercive isomorphic pressure uniform on [0, 1]. • Probability of a form being promoted by mimetic isomorphic pressure uniform on [0, 1]. • Probability of a form being promoted by normative isomorphic pressure uniform on [0, 1].
2. Creation of audience members	• Create ACOUNT audience members with four-dimensional homophily and identity vectors. • Values of homophily and identity vectors integers uniform on [0, 1]. • Initial resources of audience member integer uniform on [LAR, UAR].
3. Creation of firms	• Create FCOUNT firms with four-dimensional homophily and identity vectors. • Values of homophily and identity vectors integers uniform on [0, 1]. • Initial resources of firm integer uniform on [LFR, UFR].

Figure A-1: Technical description of the simulation main routine

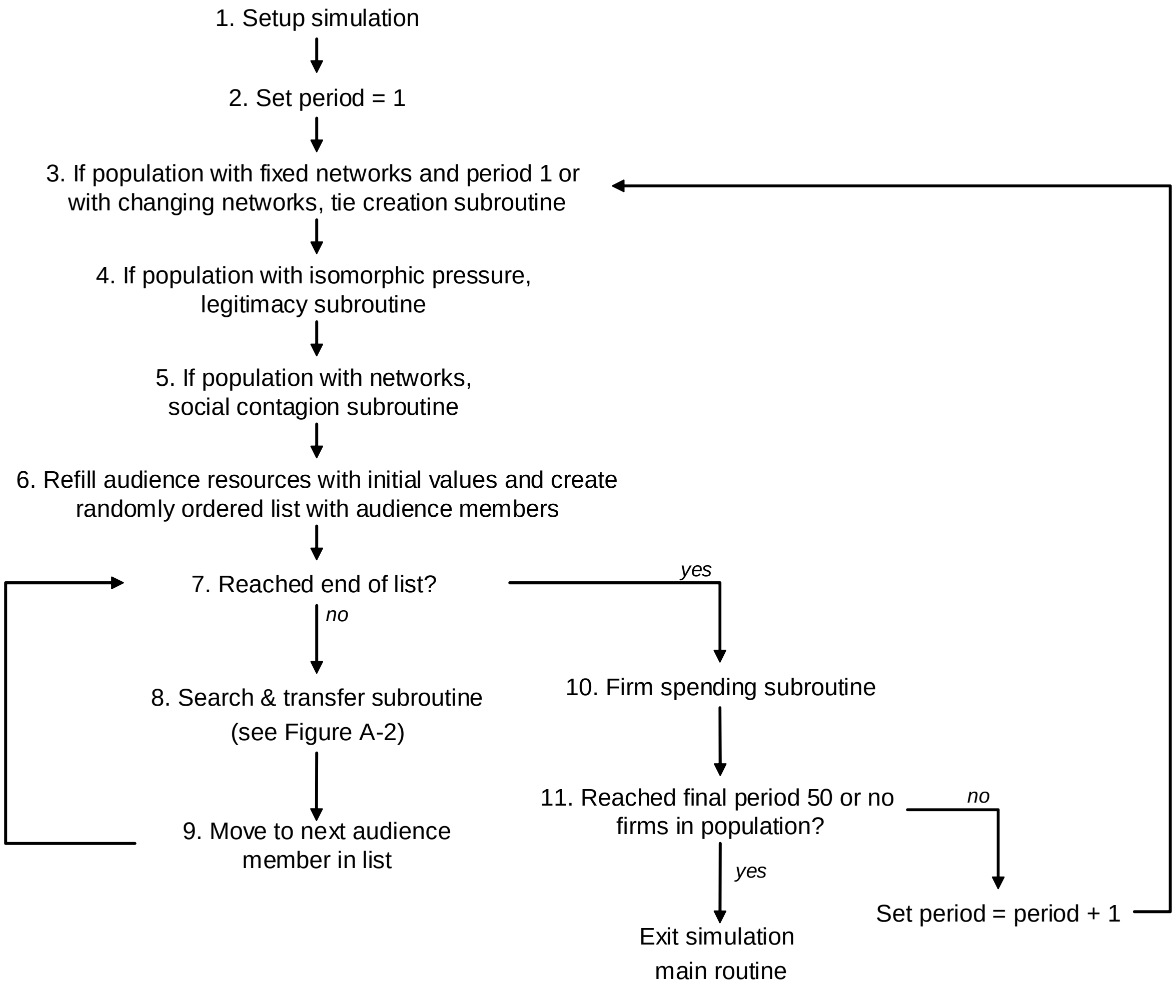
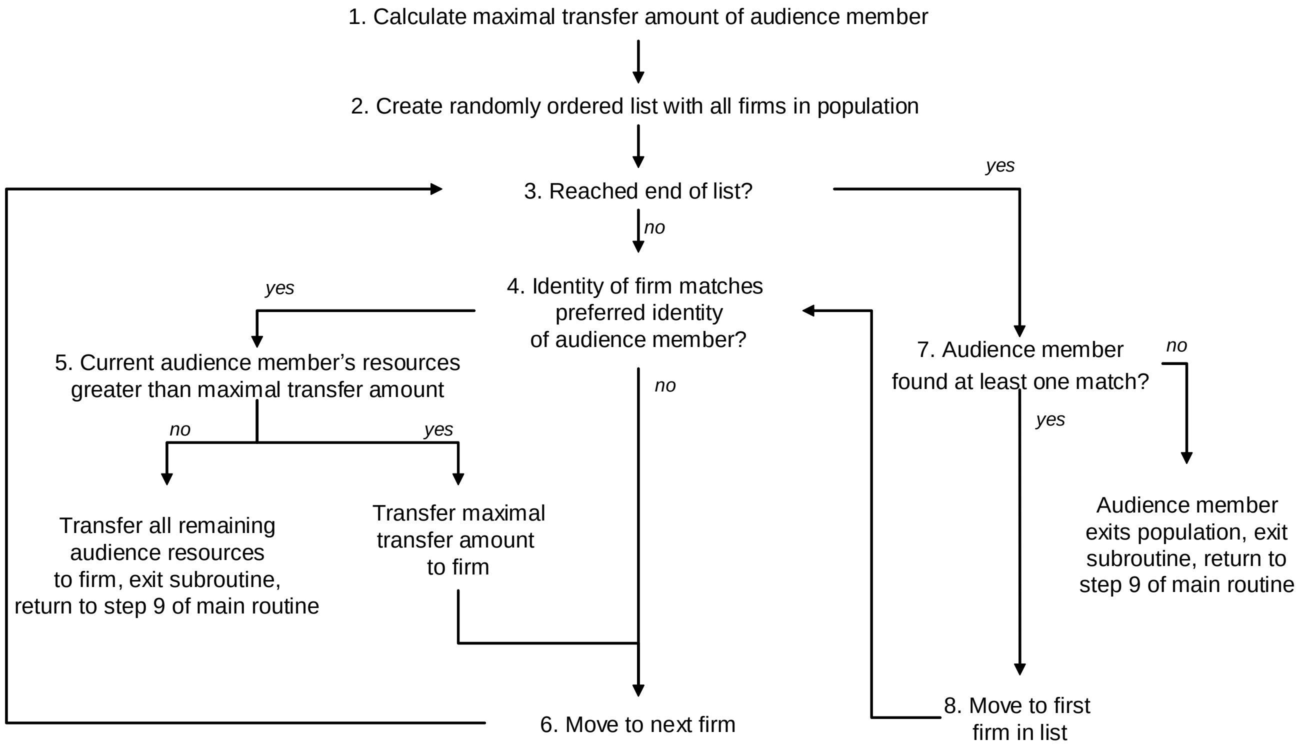


Figure A-2: Search and transfer subroutine



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