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Who?s In for Another Round? How Inventor Networks and Idea Success Shape Each Other Over Time

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Abstract

In this study we examine how inventor networks and idea success shape each other over time. Combining static and dynamic network concepts, we examine how prior idea success affects change in size, strength, and quality of ego networks. We also look at how these three different aspects of an ego network affect future idea success. Using longitudinal data from the idea suggestion system of a multinational firm, we find support for our hypotheses: prior idea success leads to increases in network size, strength, and quality. Looking at the newly emerged social fabric of an ego idea network, we find that network size, strength, and quality, together with previous idea outcomes, all positively affect future idea success. Network size and strength have a quadratic effect on idea success, however. Intermediate levels of network size and strength are associated with a higher likelihood of future idea success. By showing how social networks both shape and are shaped by idea generation and development, we contribute to research on social networks and creativity and emphasize the dynamic interdependence of social networks and idea success.
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Who's In for Another Round?

How Inventor Networks and Idea Success Shape Each Other Over Time

Introduction

Social networks stimulate creativity and innovation. Several studies show that having weak ties and occupying brokering positions can stimulate creativity and innovation by providing access to new and non-redundant information (Burt 2004, Brass 1995, Perry-Smith, Shalley 2003, Perry-Smith 2006). Being exposed to this type of information can help generate new insights and knowledge, which can lead to more creative ideas (Fleming, Mingo, Chen 2007). In addition to providing access to information, social networks help to mobilize resources and other support for newly developed ideas (Ford 1996). Social networks composed of densely connected strong ties, for example, can help ensure support for new ideas because they facilitate the development of trust and allow the transfer of complex and tacit knowledge that is useful to develop new ideas and ensure their implementation (Hansen 1999, Sosa 2010, Reagans, McEvily 2003). We know, in other words, that social networks affect idea generation and development, and prior research has identified the theoretical mechanisms through which networks affect idea generation and development. Less is known, however, about how idea generation and development change the social networks that produced those ideas in the first place and how newly formed social networks, together with prior outcomes, affect subsequent idea generation and development (Lee 2010, Perry-Smith, Shalley 2003). We emphasize the interdependence of networks and their outcomes by examining how networks connect prior and future idea generation and development, thus demonstrating that social networks both shape, and are shaped by, idea generation and development.

We study the interdependence of networks and their outcomes in the context of intra-organizational ego networks, examining how the success and failure of ego-sponsored ideas change the ego network and how the new ego network, in turn, affects the success and failure of future ego-sponsored ideas. An ego network consists of a focal actor, termed ego, and other actors, termed alters, to whom the ego is connected (Wasserman, Faust 1994). Both the ego network structure and tie characteristics affect the productivity of ego. Burt (2004) reported that egos whose networks have many structural holes are more likely to generate ideas because their networks provide them with information benefits that are valuable for idea generation. In contrast, Obstfeld (2005) focused on the importance of dense social networks and found that connecting alters in dense social networks makes it easier for egos to coordinate action in incremental innovation projects. Shifting the focus from ego network structure to tie characteristics, Ingram and Roberts (2000) found that friendship ties between managers working for competing hotels benefit the hotels because those ties help enhance collaboration and joint problem-solving efforts. Although ego networks can be described in a number of different ways (cf. Guimerà, Uzzi, Spiro, Amaral 2005), we focus on the three most basic aspects of ego networks – the size of the network, the strength of the network, and the quality of the alters involved – and we examine how these are shaped by, and, in turn, shape the success or failure of ego-sponsored ideas.

Our study offers several contributions to research on social networks and creativity. First, we advance research on changes in network structures by examining how network outcomes shape network changes and how the modified networks, and the prior outcomes, then influence subsequent network outcomes. Much of the prior research has looked either at the effects of network structures on outcomes (e.g., Baer 2010, McFadyen, Cannella Jr. 2004, Zhou, Shin, Brass, Choi, Zhang 2009) or at how certain network structures evolve (e.g., Sasovova, Mehra, Borgatti, Schippers 2010, Soda, Usai, Zaheer 2004, Zaheer, Soda 2009). Our study is unique as we combine both dynamic and static network concepts (Perry-Smith, Shalley 2003). Studying how idea inventors assemble a large, strong, and high quality network allows us to not only show how network structures change (Borgatti, Halgin 2011) but also to identify prior idea success as a main driver of that change. At the same time, we demonstrate the consequences of the assembled and potentially reconfigured network structures for idea outcomes. We offer a fine-grained account of the interdependence of network structures and performance outcomes by focusing on the involvement of people in real ideas and using longitudinal data of ego networks organized around specific ideas that were later deemed either failures or successes. Thus, with our focus on the network of people who contributed to specific ideas and the specific outcome of those ideas, we are able to reveal how networks evolve and how that feeds in into subsequent outcomes.

Second, we provide insights into how sustained idea development can be achieved by demonstrating when and how the benefits of particular network structures and tie attributes are conducive to idea success over time (Skilton, Dooley 2010). Studies on serial entrepreneurs have focused on what serial entrepreneurs learn from their earlier ventures (e.g., Parker 2013). Similarly, research by Deichmann and Van den Ende (2014) examined the degree to which employees repeatedly generate and develop successful new ideas and how that was dependent on their prior experiences of idea success or failure. However, the role of networks that idea inventors assemble between one idea submission and the next has largely been ignored in the literature so far. We show that social networks and tie attributes (at least at intermediate levels) are not only important so as to get fresh insights and perspectives for the generation and development of a new idea, but also as mechanisms for transferring the lessons learned from a prior to a future idea. To that end, we demonstrate that informal intra-organizational ego networks, and the changes that take place in those networks in terms of network size, strength, and quality, play a key role in allowing idea inventors to continuously generate and develop successful ideas.

Social Networks and Ideas

Organizational success or failure often depends on how well organizations can harness the creativity of their employees to develop new ideas that can strengthen their position in the market. We define an idea simply as a “thought or suggestion to a possible course of action” (Oxford English Dictionary 2000). The success of an idea can be determined in different ways. We characterize an idea as being successful in the context of organizations encouraging employees to develop new ideas if the idea is approved for further development and implementation. Numerous examples of successful employee generated ideas exist, including Amazon’s employee-suggested loyalty program Prime that guarantees goods will be shipped within two days to registered customers, thus helping to turn occasional shoppers into repeat shoppers (Stone 2010). Another example of an idea suggested by employees is a membrane filtration system at GlaxoSmithKline, which was eventually adopted to reduce production costs and benefit the environment even though it was initially rejected by a line-manager (Augsdorfer 2005). The process of idea development can be divided into two stages (West 2002). The first stage focuses on the creative process that results in the generation and development of an idea, whereas the second stage focuses on the approval and implementation of an idea (Baer 2012). Although most research focuses on idea generation (exceptions are Axtell, Holman, Unsworth, Wall, Waterson 2000, Baer 2012), social networks play an important role in both idea generation and idea implementation.

First, social networks provide access to new and non-redundant information which can be re-combined and can inspire the generation and development of new ideas (Nebus 2006). Focusing on tie characteristics, some research suggests that weak ties provide access to new and non-redundant information (Brass 1995, Perry-Smith, Shalley 2003) and therefore correlate with increased levels of creativity and idea generation (Perry-Smith 2006, Zhou, Shin, Brass, Choi, Zhang 2009). Network structure is also important. Burt (2004) argues that brokers, by virtue of being a bridge between different people, are exposed to the unique and often non-redundant information that resides in different places in the network. Brokers simply have more opportunities to integrate and recombine information and thus have a higher likelihood of generating new ideas. Other scholars highlight the importance of cohesive network structures and strong ties for idea generation and development. Cohesion can be a sign of trust in the social network, and with trust individuals are usually more willing to take and share risks with others (Uzzi, Spiro 2005). Taking and sharing risks is, in turn, beneficial because it allows individuals to generate ideas and explore new ways of doing things. Furthermore, strong ties make it easier for individuals to handle and transfer complex and difficult to verify information (Hansen 1999, Reagans, McEvily 2003), and individuals connected through strong ties are more motivated to acquire and process information from each other (Sosa 2010).

Second, social networks are important for idea implementation. Ideas tend to become better when people discuss them with members of different groups, departments, or firms (Burt 2004, Kijkuit, Van den Ende 2010). By discussing and testing an idea with others, people can address deficiencies, resolve ambiguities, and improve the quality of an idea. This can increase the likelihood that an idea will be seen as valuable and, as a consequence, be approved and implemented. Another important aspect of social networks is the support and advocacy they can engender. Ford (1996, p. 1124), for example, argued that social networks are important to mobilize “support and sponsorship to move an idea forward to realization.” And the degree to which employees have strong “buy-in” relationships with potential supporters of their ideas helps them to be recognized by their supervisors as people who are successful in implementing ideas (Baer 2012). In other words, social networks provide fertile ground for both idea generation and idea implementation. We argue next that social networks are themselves shaped in the idea generation and implementation process, which can, paradoxically, make them less effective for idea generation and development in the future. To understand how ideas shape network dynamics, we examine specifically how past idea success – defined here as approval by an organization to implement an idea – affects social networks and how those reconfigured networks then affect future idea success.

Idea Success Affects Ego Networks

We begin our discussion of idea success and ego networks by describing how prior idea success affects network size, strength, and quality.

Network Size

The size of an ego network refers to the number of alters to whom the ego is connected. The success of a recent idea developed by an ego makes that ego a more attractive collaborator for different reasons. First, prior idea success serves as a strong signal of quality for alters who are deciding whether or not to partner with the ego (Hallen 2008, Perry-Smith, Shalley 2003). Prior success suggests that an ego has the knowledge and skills necessary to successfully generate and develop ideas, thus reducing the risk of partnering with that individual for new idea generation and development (Payne, Moore, Griffis, Autry 2011). Second, prior idea success makes the ego a more attractive partner because it suggests that he or she has already achieved a certain status and thus recognition within the organization. Idea success not only means that the idea is pushed further along in the implementation process but it also signals that an organization, and its leaders, value, approve, and support the idea. In a survey of shop-floor employees, Axtell et al. (2000) found that management support correlated positively with the extent to which employee ideas were implemented by the organization. Third, idea successes are often visible throughout the organization because they are publicized via internal newsletters, intranets, and idea suggestion systems, so other employees and managers can readily identify those employees who are associated with successful creative action (Amabile, Barsade, Mueller, Staw 2005). Engaging in further idea generation and development with someone who has already been successful therefore holds the promise that one will immediately gain greater recognition within the organization and will have enhanced access to information and resources.

Hypothesis 1. Idea success is associated with an increase in size of the ego network.

Network Strength

Network strength refers to the investments that ego and alters have devoted to the network through repeated collaboration on idea generation and development efforts. Investments accumulate through longer duration and higher frequency of ties in the ego network. High network strength should therefore reflect high switching costs for ego network members but also increased levels of trust, which should facilitate future collaboration (Uzzi 1997). Following this general notion, we hypothesize that prior idea success increases network strength for the following reasons. First, success is a satisfying experience for ego network members and having a satisfying experience increases the likelihood that network members will work together again (Taylor, Greve 2006). Idea success therefore increases the likelihood of continuing and increased network investment by the members of the network resulting in higher network strength. Second, collaboration on an idea that turns out to be successful confirms the network participant in the belief that valuable routines and processes have been developed that will be useful for solving new complex issues (Nebus 2006, Schwab, Miner 2008). By re-investing in subsequent idea generation and development one can leverage what is perceived to be valuable knowledge. Third, successful experiences raise expectations of future success because past behavior is believed to be indicative of similar behavior in the future (Lee 2010). Having been successful in the past is therefore a particularly strong reason for people to choose to work again with the same people which increases network strength (Perry-Smith, Shalley 2003, Uzzi 1996).

Hypothesis 2. Idea success is associated with an increase in strength of the ego network.

Network Quality

Network quality is defined here from the perspective of the ego by the quality or cumulative prior success experiences of the alters who have partnered with the ego. Network quality is associated positively with prior idea success for two reasons. First, successful alters are more likely to pay attention to the ego and new ideas being developed by the ego if that person has successfully generated and developed an idea (Perry-Smith, Shalley 2003). With increased prominence, the ego is more likely to come into contact with other high-performing actors, and is better placed to form relationships with these sought-after individuals in order to work on a new idea. A second and related point concerns the "homophily" principle: this suggests that "similarity breeds connection" (McPherson, Smith-Lovin, Cook 2001, p. 415) because similar people are often better able to appreciate and understand each other. Having similar accomplishments might mean that egos who have already had success and potential alters might be naturally drawn towards one another. This is not only because both parties expect repeated high performance from each other, but also because they share a common understanding of what will be required to achieve success with any future idea development. Therefore, from an inventor's prior idea success, like-minded alters can gauge something about values and preferences that are implicit and often difficult to verify.

Hypothesis 3. Idea success is associated with an increase in quality of the ego network.

Ego Networks Affect Idea Success

Having outlined how prior idea success affects ego network size, strength, and quality, we describe next how ego network size, strength, and quality, in turn, affect future idea success.

Network Size

The most basic way to increase the breadth of interaction in a network is to increase the number of contributors (Guimerà, Uzzi, Spiro, Amaral 2005). As the number of alters in an ego network increases, the amount of information, experiences, and resources available in the network increase as well (McFadyen, Cannella Jr. 2004, Zaheer, Soda 2009). Larger ego networks therefore allow both more deliberate and serendipitous interactions through which knowledge can be accessed and innovatively combined (Baer 2010, Hargadon, Sutton 1997, Perry-Smith 2006). A larger ego network not only provides all of its members with more opportunities to bundle their knowledge but also allows them to immediately cross-check their work and reflect on input from others – and therefore to consider an idea from different angles. A larger ego network is, in other words, collectively better able to identify and resolve any problems with an idea before the idea is formally evaluated, which increases the chances that an idea will be successful. Finally, a larger ego network is also more likely to stimulate members to consider and implement routines from other idea contributors simply because of the greater number of interactions. Increasing the volume of contacts in an ego network sets in motion a search for new collaborative arrangements and work patterns (Kane, Argote, Levine 2005). By exploring different work procedures and processes, network members engage more actively in divergent thinking and experiment with new routines and procedures, both of which are important for creative endeavors.

If ego networks continue to grow in size, however, both the ego and alters could become cognitively overwhelmed (Zhou, Shin, Brass, Choi, Zhang 2009) and it can be difficult to reach a consensus and integrate all of the different views (McFadyen, Semadeni, Cannella Jr. 2009). Without consensus, the groups remain in a brainstorming mood, endlessly generating more and more ideas but not taking any of them further because no collectively supported, concrete proposal can be formulated (Kijkuit, Van den Ende 2007). In large networks it is also difficult for individual members to have intensive one-on-one discussions because people can allocate less time and energy to each other. Moreover, large networks tend to be less stable, decreasing the willingness to cooperate and the commitment of network actors (Jehn, Shah 1997). As a result, knowledge exchanges can become more superficial, and this ultimately impairs the ability of each individual to capitalize on other people's unique knowledge and experience, hindering the development of successful ideas. In larger networks people also have to invest more time and energy in socializing, and this process of getting to know one another better may distract from the actual task of developing a high-quality idea (Moreland, Levine 1982). Finally, in network structures that are too far removed from optimal levels, people are more likely to put forward and support ideas that conform to commonly held expectations (Skilton, Dooley 2010). This has a negative effect on creativity and thus on the success of subsequent ideas.

Hypothesis 4. The association between ego network size and idea success is curvilinear (inverted U-shape).

Network Strength

By investing in the ego network, the ego and alters gradually build strong ties. Strong ties can have beneficial effects on successful idea development for two reasons. First, with strong ties, network members are more able to exchange complex and tacit knowledge efficiently with each other (Hansen 1999, Reagans, McEvily 2003). When network members have repeatedly invested in mutual relationships, they can acquire and process knowledge from one another more effectively and are also more motivated to do so (Sosa 2010). The ability and motivation to handle and transfer complex and tacit knowledge are both key ingredients of successful idea generation and development (Obstfeld 2005). Second, strong ties serve as a signal of trust and stability. When leveraging these strong bonds for idea development, network members can rely on a safety net consisting of like-minded people. This might be important for idea success because network members can take more risks; they can speak openly and reveal potentially controversial thoughts, helping to develop better ideas. It is therefore not surprising that strong ties can increase idea success by creating an atmosphere in which people are comfortable exchanging complex information and taking risks, both of which increase creativity and innovation (Amabile, Barsade, Mueller, Staw 2005, Hargadon, Sutton 1997, Obstfeld 2005, Rost 2011, Sosa 2010, Uzzi, Spiro 2005).

After a certain threshold, however, network strength can reduce the likelihood of idea success because it locks ego and alters into familiar relationships, making it more difficult to invest in new relationships that could provide access to more diverse information (Perry-Smith 2006). When people collaborate with each other repeatedly, they become increasingly similar; their shared history and convergence further suppresses the inflow of new information (Brass, Labianca 1999). Similarly, strong ties to the same alters might be for other reasons than to tap into their unique skills, capabilities, and the knowledge needed to get a new idea off the ground. Instead of looking to the potential alters who could contribute the most to the success of an idea, egos might instead focus on alters with whom they have developed strong interpersonal affect (Casciaro, Lobo 2008). As Uzzi (1997) warns, the social imperative to favor particular network partners, even when it does not make sense for the ego, is more likely to dominate egos in overly close-knit networks. Ego may also recruit alters repeatedly because of the potentially mistaken belief that previously developed routines and knowledge can be leveraged again – an assumption that is not necessarily true as different ideas may require access to different information and resources.

Hypothesis 5. The association between ego network strength and idea success is curvilinear (inverted U-shape).

Network Quality

Finally, the quality of an ego network, as defined by the number of successful ideas in which alters have been involved, increases the likelihood of idea success for three reasons. First, alters with experience of success have a frame of reference and have developed proven routines relating to all phases of developing an idea – from generation through to implementation (Gersick, Hackman 1990). Such complete knowledge of idea development from start to finish can be useful for pinpointing deficiencies in each stage of idea development and can thereby increase the chances of subsequent success. Second, having a good-quality network is useful because contributors who have experienced success themselves can evaluate and contrast the input from other alters much better with respect to how that knowledge and suggestions will help to strengthen the idea. Finally, a high network quality serves as a signal to idea evaluators and other managers that the network has been involved in high-quality work in the past. When the quality of an idea is difficult to verify or assess, the quality of the network might be an important criterion that managers take into consideration when evaluating the idea (Lee 2010). Moreover, high-quality networks can probably also count on stronger managerial backing which may allow them more freedom to explore new and even better ways of performing tasks and of organizing the resources that are critical to achieving success.

Hypothesis 6. Network quality of an ego network is associated with an increased likelihood of idea success.

Figure 1 distinguishes between the two different aspects of our study and summarizes our hypotheses.

Insert Figure 1 about here

Method

Sample and Setting

Our empirical setting is the innovation program of a large multinational energy company called "Enco" in this study for the purpose of anonymity. Enco started their innovation program to spur their employees to develop early stage ideas that might one day transform the landscape of the energy industry. The program helps innovators by providing money, connections, and guidance and is structured as follows. After a short description of an idea has been submitted, two main gates must be passed before full funding is awarded. First, proponents have the opportunity to give a short pitch about their idea in front of two team members of the innovation program. If this first screening is passed successfully, the idea proponents get some time and, if necessary, some research money to develop their proposal further. Second, having done that, they then present the idea to a broader group of experts consisting of employees from the innovation program and other internal and external individuals with expertise in specific areas relevant to the idea. The expert panel assesses the potential, viability, and impact of the idea, and decides whether and how to go ahead with the idea, including how to fund the implementation. If the idea is approved, the idea formally becomes a project. To understand Enco and its innovation program thoroughly, we visited and worked at the research site regularly, sat in on team meetings and idea assessment panels, and conducted interviews with various innovation group members and over 25 recent idea inventors.

Throughout the study, we classify a successful idea trajectory as one where an idea is selected after the second panel, and an unsuccessful trajectory as one where an idea is not accepted after either the first or second panel. Passing the second screening panel meant that a serious amount of resources was then allocated to further the execution of an idea and the idea turned into a more formal project. Given that only ten percent of all submitted ideas pass the second screening panel, it is common practice to label these ideas as "successes" within Enco. Successful ideas developed via the innovation program include one for a new imaging technology and another for a novel material that established a new market segment for Enco.

The innovation program at Enco is an independent unit in the company evaluated on the basis of its ability to identify and execute ideas that lie outside the scope of the current business strategy. The selection of ideas is based on clear criteria (idea novelty, idea value, and a plan to go ahead), which are communicated to idea inventors before they submit their idea. When providing feedback, innovation managers go through each of these criteria. The review committee always wants to give constructive feedback to idea inventors, and many value this, as was indicated by a statement by one of our recent interviewees: *"I expect that the people who evaluate my idea have a much broader overview of what's worthwhile to pursue. I've got a lot of faith in the process and think there's probably* some good reason behind a rejection.*"* The emphasis on good reasons reflects a more general sense of merit being a core value behind the innovation program and it is therefore unlikely that other factors such as power and politics play a decisive role in the screening process, although occasional individual examples obviously cannot be ruled out.

In the first set of analyses where we predict the effects of prior idea success on network size, strength, and quality, the unit of analysis is the ego. In the respective statistical models, we use individual characteristics and attributes to examine the ego's ability to assemble specific alters in his or her ego network. We focus only on relationships that emerge as people develop a specific idea. This has the advantage that we are able to base our analysis on objective, archived, longitudinal data about network structures and changes therein. It has the disadvantage that other types of relationships which people might have within or across the company are not observed. In the second set of analyses, we examine idea success based on ego network structures or attributes and characteristics, averaged across a focal ego network. The unit of analysis is therefore the ego network working on one specific idea. In addition, alters (the idea contributors) can be part of the ego network. We assume that all members of an ego network are connected to each other and that the relationships between people are symmetrical, since the discussion of an idea takes place regardless of whether a particular network actor sends or receives information (cf. Kratzer, Leenders, Van Engelen 2008). This assumption is similar to prior studies that investigated the social structure of people collaborating on the same academic paper (McFadyen, Cannella Jr. 2004), working on the same movie (Schwab, Miner 2008), or playing in the same musical (Uzzi, Spiro 2005).

Our interviews and observations at the study site confirmed that egos mentioned contributors right away when the idea was placed into the database. Further evidence from our interviews with Enco's innovation managers confirmed that only relevant contributors were listed in an ego network. We also asked specifically about other tasks that idea contributors might fulfill – for instance, providing political support to help get an idea accepted. None of our interviewees indicated that people listed on an idea were ever contacted for these reasons.

We extracted all the information from the database in November 2008. This sample consists of a twelve-year archival record of 2,352 ideas. Of these ideas, 692 were initially coded as being "in progress", which meant that people were still working on developing the idea in the phase before the first or second panel. After consulting with Enco, we classified 386 of these ideas as "failures", since no progress had been documented on them for more than four years; we excluded the remaining 306 of these ideas in progress. We also excluded ideas that were initially conceived by people external to Enco and ideas that were generated in workshops, because in workshops participants were asked to quickly generate specific solutions to pre-defined problems. Finally, we excluded all of the very first ideas (905) to come from an ego network as these would not assist us in our focus on prior performance. This data cleaning procedure resulted in an overall sample of 887 ideas proposed by 310 ego networks.[1]

Dependent and Independent Variables

Idea success. As described earlier, we classified ideas as successful (i.e., we coded the variable with a value of one) when they passed the second stage of Enco's screening process. Prior idea success refers to the idea success of the previous idea submitted by the same ego. For the second set of analyses, the individual values were summed and then divided by network size to reach a network mean for prior idea success.

Network size. We operationalized network size by counting the number of contributors in an ego network (Baer 2010, Kijkuit, Van den Ende 2010). Because there are few ego networks with more than five alters (less than one percent of all observations), we computed a network size variable where a value

[1] We checked the final sample against the wider sample for systematic bias in key dependent variables. Specifically, we conducted several Wilcoxon-Mann-Whitney tests (a non-parametric version of the independent samples t-test). The results suggest that the distribution of network size and network strength is not significantly different for in-progress ideas, externally conceived ideas, or ideas generated in workshops. Analyses also indicated that the underlying distribution of idea success is not significantly different between an ego's first idea and all his or her other ideas.

of 5 also included ego networks that ranged between 6 and 11 alters. Using this capped variable for network size in place of the uncapped variable did not, however, alter the results reported in this paper.

Network strength. To measure ego network strength, we used two indicators. Specifically, we measured the duration and frequency dimension of tie strength but did not consider the affective component of emotional closeness (Granovetter 1973) as this offers the advantage of measuring network strength in a unobtrusive and objective manner (cf. Fleming, Mingo, Chen 2007, Kijkuit, Van den Ende 2010, McFadyen, Semadeni, Cannella Jr. 2009). To calculate frequency, for every focal ego network member we counted how many times he or she worked with each member of the ego network. We then calculated the average frequency for the ego network. To calculate duration, for each member of the ego network, we did a cumulative total of the months that he or she had previously spent working with each of the other members on other ideas. Again, we averaged all these individual lengths for the ego network. Our combined measure (which is the average of the frequency and duration score for an ego network) shows a higher score when the same people worked for long lengths of time together across several ideas. Because only few network strength scores were higher than 4 (less than two percent of all observations), we computed a variable where a value of 4 also included ego networks that had scores in network strength between 4 and 17.27. The reported results remained largely identical, irrespective of whether we were using a capped or uncapped version of the network strength variable.

Network quality. To operationalize network quality, we totaled up all the experiences of idea success of alters involved in an ego network. Because there are only few cases where network quality is higher than 2 (less than two percent of all observations), we recoded the variable as 0, 1, and 2 or more alter experiences of success. Running the statistical models with the uncapped variable showed almost identical results to an analysis reported in the paper which used the capped variable for network quality.

Control Variables

Employee activity and experience. The productivity of an ego network, the number of patents it produces, and the level of prior experience among network members might be alternative indicators of performance and talent that people take into account when deciding whether or not to contribute to an idea being developed by an ego network (Uzzi, Spiro 2005, Schwab, Miner 2008). Moreover, the prior indicators could also relate to the knowledge base of an ego network (McFadyen, Semadeni, Cannella Jr. 2009, McFadyen, Cannella Jr. 2004) – a knowledge base that could enhance learning from experience (Levitt, March 1988) which, in turn, can influence idea success. To calculate productivity, we divided the total number of ideas that the ego was involved in (by initiating or contributing to an idea) by the number of months during which this person was active (from very first to last idea). To calculate productivity of the ego network, we summed all productivity scores of every network member and divided this number by the network size.

The total volume of patents an ego was involved in was measured by using records from the European patent register. We recorded the number of patents the ego was involved in prior to working on the focal idea. To calculate the network mean, we did the same for all focal ego network members and then averaged the individual scores for the ego network.[2] Finally, we counted the number of times an ego had previously been involved in developing ideas (prior idea involvement), and for the second set of analyses we did the same for all members of an ego network. For this second measure relating to the network mean, this meant that if two people had worked together previously before they came together on the focal idea, we counted all earlier collaborations as only one instance.

Idea characteristics. Where an ego has an idea that is similar to his or her previous ideas, there may be an alternative explanation as to why network structures and tie characteristics change (Schwab, Miner 2008). Moreover, concerning our dependent variable idea success, if an idea is similar to previous

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[2] We also considered whether the number of ego's joint patent submissions with any of the other network members would tie people together and thus affect change in network size, strength, and quality (we identified 10 observations where this is the case). Also for the second set of analyses, we constructed a variable measuring joint patent submissions between any of the network members (we identified 12 observations where this is the case). Results from both set of analyses are robust but given the rare occurrence of joint patents, we decided not to include this variable.

ones, then the chances of success for the subsequent idea may be lower. This could be due to the fact that the management of Enco's innovation program is looking for radical ideas; similarity could be a sign of incremental progress between two ideas. Enco defines radical ideas as breakthroughs that will change the game across the energy system. To capture the similarity to previous ideas from the same ego, we examined the titles given to the idea and we counted how many words overlapped with those used for previous idea submissions by the same ego. For the second set of regression analyses, we also calculated a similarity score for every network member relating to all the ideas he or she was previously involved in and subsequently averaged the individual scores for the ego network.

It might also be very motivating for ego network members to work on an idea that is considered as "radical" and thus of vital importance for Enco's business strategy. When an idea is classified as important in its nascent phase this could be an early sign of subsequent success. We control for this effect by including a proxy stemming from the database that measures confidentiality of an idea (dummy-coded 1 for a confidential idea). Users of the idea database have no access to detailed descriptions of ideas that have been classified as confidential.

Ideas and time. Recently submitted ideas are believed to be more salient and easier to recall (Levitt, March 1988), which could influence the composition of an ego's network because alters are more aware of an idea inventor (Schwab, Miner 2008). To control for this effect, we measured the time elapsed since previous idea: the time span between consecutive ideas. In models with idea success as the dependent variable we averaged the individual scores of each potential ego network member to reach a network mean.

Additionally, we created three time windows (1996–1999, 2000–2003 and 2004–2008), representing different years and phases during which ideas were submitted to Enco's innovation program. The second dummy was used as the reference because it appeared that in this time frame, fewer ideas were generated which could potentially influence network dynamics and idea success. Interviews with managers of Enco indicated no particular reason or explanation for the lower number of novel idea submissions during the second time frame.

We report summary statistics and bivariate correlations for the first set of analyses in Table 1, and for the second set of regression analyses in Table 2.

Insert Table 1 and 2 about here

Analysis

We use a panel approach to take into account that an ego contributes multiple, non-independent observations. To better account for unobserved heterogeneity, we estimate random effects for the panel models (cf. Ahuja 2000, Gulati 1995, Kim, Jensen 2011). In so doing, we insert additional ego-related error terms that allow observations of the same ego or ego network to be correlated.

To estimate increases in network size, strength, and quality we regressed each respective network parameter on its lagged version as well as on prior idea success (Cronbach, Furby 1970). We prefer the regressor variable approach because it is appropriate when a true causal effect between the two states of each network parameter can be expected. This is likely to be the case in our data, given that we have multiple observations across time for different ego networks. Moreover, the regressor variable approach is better for handling possible correlations of the independent variable, prior success, with the initial states of the different dependent variables (Allison 1990). Finally, we can more directly compare results of prior idea success on network size, strength, and quality and changes in these parameters. However, an alternative way is to regress change scores, thus the difference in a score between a focal and a prior network parameter, on prior idea success (Allison 1990). As there are still extensive discussions on the appropriate use of both methods (e.g., McArdle 2009), we decided that for robustness we would also run all of the analyses with this second approach. The results are identical to the ones reported in this paper except for the analysis where network size change is regressed on prior idea success.

Results

The Effects of Prior Idea Success on Network Size, Strength, and Quality

Table 3 presents our statistical analyses of how prior idea success affects network size, strength, and quality. Starting with network size, Model 1 contains the control variables. Model 2 adds prior idea success and shows that it is positively and significantly associated with network size ($b = .25, p \leq .01$). Controlling for prior network size in Model 3, the effect of prior idea success remains significant ($b = .19, p \leq .05$), thus suggesting that prior idea success is positively associated with increases in network size. Hypothesis 1 is therefore supported. Shifting to network strength, Model 5 shows that prior idea success has a positive and significant effect on network strength ($b = .15, p \leq .05$). Adding prior network strength in Model 6 shows that prior idea success is positively and significantly associated with increases in network strength ($b = .18, p \leq .05$), thus supporting Hypothesis 2, which suggested that prior idea success increases network strength and thus the investment people devote to generating and developing a future idea with ego. Similarly with network quality, Model 8 shows that prior idea success has a positive and significant association with network quality ($b = 1.29, p \leq .01$). Model 9 controls for prior network quality and shows that prior idea success increases network quality significantly ($b = 1.12, p \leq .01$). Hypothesis 3 is therefore supported: prior idea success increases the quality of the partners recruited for subsequent idea generation and development.

Insert Table 3 about here

Some of the control variables merit attention as well. The results show that when an idea is very similar to earlier ones proposed by the ego, network strength (Model 5) and change in network strength (Model 6) significantly increase. This finding suggests that people make repeated investments in the network not only based on the success but also on the content of a prior idea. Moreover, a longer time span between consecutive ideas – or, in other words, the time that elapsed between a prior and a focal idea submission – has a significant positive effect on network size (Model 2) and change in network size (Model 3) as well as on network quality (Model 8) and change in network quality (Model 9). This finding shows that the idea inventor needs some time between one idea and the next to initiate changes in the network in terms of size and quality. Finally, the productivity of the ego has a positive effect on network strength (Model 5) and change in network strength (Model 6). This demonstrates that very productive idea inventors are more successful in binding alters to their ego network.

The Effects of Network Size, Strength, and Quality on Idea Success

In Table 4 we present our analyses of how network size, strength, and quality affect idea success. Model 10 contains the control variables only, and Model 11 adds prior idea success (ego network mean). The effect of prior idea success is positive and significant ($b = 1.16$, $p \leq .01$), thus suggesting that focal idea success is partly driven by the success of the ego network members' prior ideas. Model 12 shows that the effect of network size on subsequent idea success is significant and positive ($b = .47$, $p \leq .001$), and adding squared network size in Model 13 reveals that the effect has an inverted U shape ($b = -.21$, $p \leq .01$). Hypothesis 4, which suggests that an idea is more likely to be successful when the ego network size is moderate than when it is low or high, is therefore supported. Moving to network strength, we see from Model 14 that the linear term of network strength is not significantly associated with idea success ($b = -.06$, $p > .74$). When we add squared network strength in Model 15, however, we find confirmation for the hypothesized inverted U-shaped effect of network strength on idea success ($b = -.83$, $p \leq .01$). Hypothesis 5, which suggests that the likelihood of idea success is highest at intermediate levels of network strength, is therefore also supported. Finally, our results show a positive and significant association between network quality and idea success in Model 16 ($b = .72$, $p \leq .01$). However, the effect of network quality drops below significance ($b = .36$, $p > .30$) when we add the linear and squared term of network size and strength in the full Model 17, leading us to cautiously reject Hypothesis 6. The effect of network quality becomes non-significant as soon as we add network size to the model.[3]

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[3] This finding also provides some tentative evidence of how network size, network strength, and network quality work in concert to impact idea success. Both the size of an ego network and the investment people make in that network have a separate curvilinear (inverted U-shape) association with idea success. These effects hold even when the other network parameters are controlled for thus showing that they offer unique contributions to idea success that cannot be captured or compensated by any of the other network parameters. Furthermore, in additional analyses we examined whether network size, network strength, or

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Insert Table 4 about here

To further explore the curvilinear effects, in Figures 2 and 3 we graphed the effects of network size and network strength on the predicted probabilities of idea success (calculated using Model 17, at the mean value of the continuous variables and with the binary variables set at zero). Figure 2A illustrates how the predicted probability of idea success is affected by network size (using point estimates because alters are indivisible) and suggests that the optimal ego network size is four (ego plus three alters). With increasing network size confidence intervals also increase, suggesting that idea outcomes can vary much more when ego networks are large. One initial interpretation of this finding is that with increasing network size, more possibilities arise to combine new and non-redundant information into novel, radical ideas. At the same time, coordination costs increase when there are more members of the ego network. Figure 2A also points to a potential problem in using a continuous variable for network size. Specifically, using the simple idea success rate (number of successes divided by number of submitted ideas), the highest observed success rate (0.27) is for ego networks of three, whereas the success rate for ego networks of four only is 0.13. The difference between the predicted probabilities and the idea success rate could be explained by the high success rate (0.25) of ego networks of six and above being an anomaly (only eight observations) that inflates the inflection point. To ensure the curvilinear network size effect is robust, we re-estimated the models using binary variables for ego network size, and found support for ego network size of three being optimal, regardless of whether we use different variables for size four, five, and above, or collapse them to fewer variables. The binary approach is illustrated in Figure 2B.

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network quality jointly influence idea success. We find no significant evidence, however, for any interaction effect between these different network parameters.

Insert Figure 2 and 3 about here

Unlike network size, network strength is a continuous variable and is therefore graphed as a continuous curve. Figure 3 shows that although the inflection point is well within the significant area of the graph, the lower bound of the 95% confidence interval is barely above zero and is actually below zero when network strength is above 1.6. The wide confidence interval is reflected in the relative weak significance levels in Model 17 and also directly reflected in the wide range of network strength categories that have approximately the same rates of idea success. That the confidence levels are relatively high at intermediate levels of network strength could suggest that at this level, both the benefits or disadvantages of network strength can take effect and thereby increase the spectrum of possible idea outcomes

Finally, some of the control variables provide other potentially important insights. First, idea confidentiality is positively and significantly associated with idea success. The result suggests that Enco's innovation program, in line with its goal and purpose, truly stimulates the generation and development of radical ideas – and that these ideas are also more likely to succeed, despite the high risk and uncertainty associated with such ideas. Second, longer time spans between consecutive ideas (i.e., time elapsed between ideas) have a positive and significant effect on idea success. One interpretation of this finding could be that ego networks need time for reflection in order to prepare and successfully advance a subsequent idea.

Discussion and Conclusion

Our study presents an in-depth investigation of the changes made in the social fabric of relatively small ego networks in order to generate and develop radical ideas. We contribute to the literature on social network and creativity by highlighting the specific changes in network size, strength, and quality in the time that elapses between an ego's ideas, thus answering calls for research on the co-evolution of network characteristics and their outcomes (e.g., Blatt 2009, George 2007, McPherson, Smith-Lovin, Cook 2001, Payne, Moore, Griffis, Autry 2011). The first section of our study sheds light on the changes an ego network goes through following an earlier idea success or failure. Despite the voluntary character of generating and developing ideas in our context (i.e., it is not part of anyone's job description to come up with ideas), there appears to be a fairly pragmatic and instrumental side to this type of creative endeavor. This instrumental side becomes particularly evident in the decisions people take about whom to align themselves with when they are looking to generate and develop new ideas. For instance, our study showed that prior success serves as a clear signal of the quality of the idea inventor (Lee 2010) and consequently makes him or her a more attractive and less risky collaborator to partner up with. We also show that prior idea success leads members to make repeated investments in the ego network. Hence, prior success binds people to the network. One explanation for this finding is that ego network members have a vested interest in recouping their earlier investments in the network. Prior idea success indicates that they are on the right track and that earlier developed routines, processes, or strategies were useful and should therefore be leveraged again in a subsequent idea (Nebus 2006, Schwab, Miner 2008). Furthermore, our findings show that prior success attracts people to the network who already have a history of success. Therefore, success allows egos to gain the attention of other sought-after individuals for work on a new idea.

In the second section of our paper we then explored how the newly emerged network structures, together with prior outcomes, affect subsequent idea success. Our findings illustrate that the main benefits of network size are realized when ego networks are of medium size (typically three members). While there are other studies that have also examined curvilinear network effects (e.g., Baer 2010, McFadyen, Cannella Jr. 2004, Zhou, Shin, Brass, Choi, Zhang 2009), our study is unique because it follows specific ego networks over time, allowing us to focus on people's involvement in, and contributions to, a specific idea and the subsequent outcome of that idea. This is in contrast to earlier studies which often used aggregated or cross-sectional network data, relied on perceptions of how creative people are, and had no information on idea failures. The different operationalization of network size, in particular, explains why we found an inflection point for much lower values of network size. While both Baer (2010) and Zhou et al. (2009) focus on employees within one company, as in our study, they ask their respondents much broader name-generating questions and focus on general work-related discussions. It seems plausible that networks that consist of specific relationships, as in our case, are smaller in nature. The approach taken by McFadyen and Cannella Jr. (2004, p. 739) also differs from ours in that they measure the size of a network of a scientist in a specific year as “the sum of that scientist's coauthors during the previous five years.” Cumulating relationships over time naturally increases network size. However, this accumulation would not allow us to depict the true changes in the network structure from one idea to the next. An interesting follow-up question in this regard would be to investigate why some egos continually decide to work alone rather than with a group of alters, and how they implicitly or explicitly resist collaboration with others.

We also find that intermediate levels of network strength play an instrumental role in an innovation context characterized by uncertainty, ambiguity, and tacit knowledge (Borgatti, Cross 2003, Dougherty 1992). We thereby extend the recent literature in this area, which also highlights the importance of strong rather than weak ties (Kijkuit, Van den Ende 2010, Sosa 2010). This is not to say that weak ties are not useful, but we anticipate that weak ties are likely to have a more important role in the process before a person submits an idea. In this pre-idea-generation phase, weak ties and the diverse knowledge that resides within them can be an invaluable source of inspiration (Baer 2010, Perry-Smith, Shalley 2003, Perry-Smith 2006, Zhou, Shin, Brass, Choi, Zhang 2009). When it comes to developing an idea further, however, strong ties and thus repeated investment in the network play a pivotal role. After an idea is generated, additional sources of inspiration and diverse knowledge pools become less important, and attention shifts instead towards the actual work of further developing and fine-tuning an idea (cf. Obstfeld 2005). For this task, strong ties are very useful at least to some degree because they are an important facilitator of communication flow and exchange processes (Hansen 1999, McFadyen, Cannella Jr. 2004, Nebus 2006). However, our results also show that, after a certain threshold, additional network strength reduces the likelihood of idea success. Although network strength is important so that people understand each other’s perspectives, reinvesting in the same network partners over and over again appears to unduly suppress the inflow of new information needed to get a new idea off the ground.

Finally, our results provide some tentative evidence that network quality has a positive effect on idea success. Having alters within your ego network who have experiences of success can increase your chances of subsequent idea success. This suggests that people learn from their prior successes, and that the knowledge, for instance, of how to develop an idea from start to finish can be transferred to a new idea. An alternative explanation could be that high-quality ego networks signal that they can repeatedly deliver good ideas. As a result, these networks might have more leeway and increased managerial backing to generate and develop radically different ideas again. Taken together, our results suggest that prior idea success helps idea inventors to assemble a large network, a network of high strength, and of high quality. At the same time, however, an ego network with too many members and too much network strength can be detrimental to idea success. Prior idea success can breed network structures and tie attributes that can eventually do more harm than good, resulting in a "success trap" for idea inventors. There is an opportunity for future research to further explore the conditions that allow idea inventors to continually generate successful ideas – to take advantage of a network, without entering a negative spiral. Our results give some initial clues. For instance, idea confidentiality is not significantly associated with increases in network size, strength, and quality but it does significantly contribute to subsequent idea success. As such, working on a confidential, radical idea does not alter social networks in any negative way but does help to increase the likelihood of idea success.

Together, our findings imply that prior idea success has a substantial influence on the shape of future networks and that people make informed decisions about whom to align themselves with in order to generate and develop new ideas. Our findings also provide insights about how sustained and successful idea development can be achieved (Skilton, Dooley 2010). Similar to research by Deichmann and Van den Ende (2014), we found that an earlier idea success of an ego increases the chances for subsequent idea success. Additionally, our findings demonstrate the important role of networks that idea inventors assemble between one idea submission and the next. Social networks and tie attributes are critical for idea inventors to gain access to new information and knowledge but they also are mechanisms for transferring the lessons learned from a prior to future idea. Therefore, social networks and tie attributes play a key role in allowing idea inventors to continuously generate and develop successful ideas.

The proprietary data on idea networks is an important strength of our study but also a constraint because Enco's strict policy on personal data prevented us from collecting demographic data for the people who initiated or contributed to an idea. As we noted before, organizational position, rank, or tenure could potentially be advantageous for an idea inventor at the first screening of the idea. However, the fate of an idea is determined at the second screening, and this is the marker for our success variable. At the second screening, many more decision makers were involved, including people from outside the innovation unit and from outside Enco. This should reduce potential idea selection biases based on employees' organizational position, rank, or tenure (Reitzig, Sorenson 2013). Future research should test the reasonable assumption that aspects of network content such as functional diversity might have positive implications for idea success (e.g., Reagans, Zuckerman 2001). Another interesting avenue for future research could be to examine how the skill of an idea inventor in selling and propagating ideas helps him or her to assemble a network made up of committed and motivated individuals (De Clercq, Castañer, Belausteguigoitia 2011).

Despite these limitations, our research reveals that social networks both shape, and are shaped by, idea generation and development. We demonstrate that networks and their outcomes are not independent but interdependent phenomena that co-evolve over time.

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FIGURE 1

Conceptual Framework

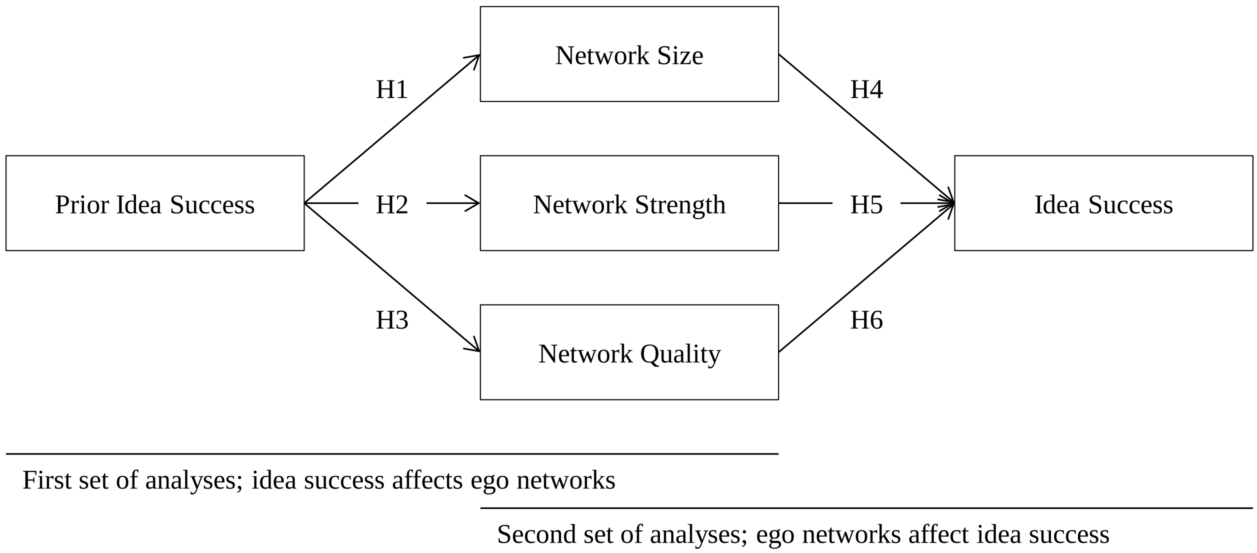
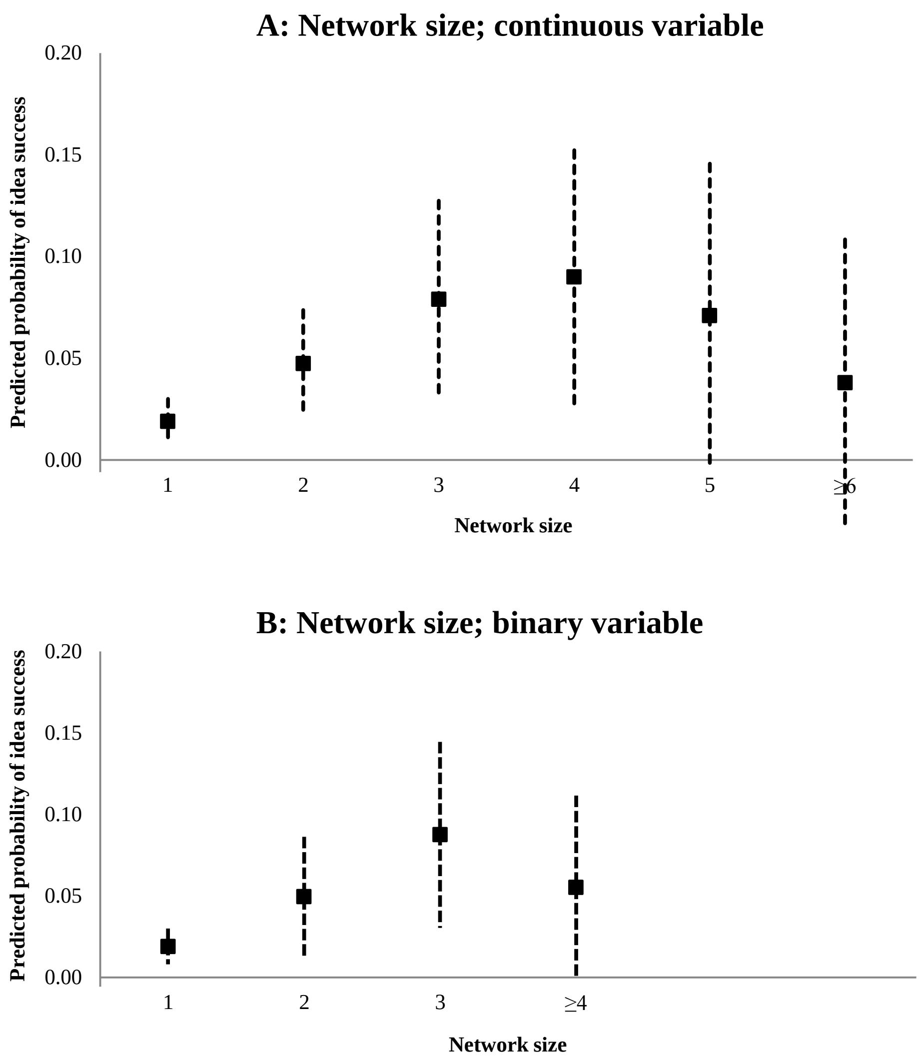


FIGURE 2

Effect of Network Size on Idea Success*

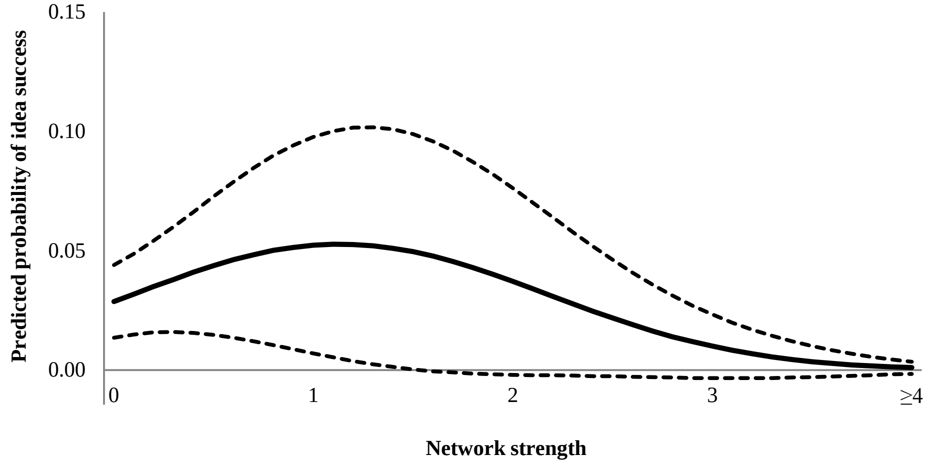


Network size	1	2	3	4	5	≥6
Observations	609	139	85	24	22	8
Idea successes	38	21	23	3	3	2
Idea success rate	0.06	0.15	0.27	0.13	0.14	0.25

* Squares indicate point estimates, dotted lines indicate 95% confidence interval.

FIGURE 3

Effect of Network Strength on Idea Success*



Network strength	0	≤1	≤2	≤3	>3
Observations	787	52	15	10	23
Idea successes	72	12	3	2	1
Idea success rate	0.09	0.23	0.20	0.20	0.04

* Solid line indicates estimates, dotted lines indicate 95% confidence interval.

TABLE 1

First Set of Descriptives*

	Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Network size	1.57	1.04	1	6															
2. Prior network size	1.58	1.04	1	6	0.42														
3. Network strength	0.18	0.69	0	4	0.45	0.37													
4. Prior network strength	0.13	0.59	0	4	0.31	0.37	0.47												
5. Network quality	0.10	0.37	0	2	0.50	0.26	0.37	0.24											
6. Prior network quality	0.08	0.33	0	2	0.20	0.42	0.19	0.30	0.39										
7. Prior idea success	0.08	0.28	0	1	0.12	0.16	0.08	0.01	0.18	0.17									
8. Productivity	0.78	1.43	0.03	9	0.07	0.08	0.21	0.21	-0.04	-0.02	-0.09								
9. Patents (ln)	0.43	0.86	0	5.12	-0.05	-0.05	0.01	0.02	-0.01	0.01	-0.03	-0.15							
10. Prior idea involvement	5.79	6.52	0	37	-0.09	-0.12	-0.03	-0.01	-0.01	0.01	-0.02	0.00	0.34						
11. Similarity to previous ideas	0.67	1.10	0	9	0.01	0.03	0.08	0.04	0.04	0.00	0.00	-0.03	0.08	0.21					
12. Idea confidentiality	0.26	0.44	0	1	-0.03	0.09	-0.02	0.04	0.08	0.12	0.10	-0.02	-0.06	-0.15	0.04				
13. Time elapsed since previous idea (ln)	1.35	1.31	0	5	0.12	0.19	-0.04	0.00	0.13	0.11	0.17	-0.41	-0.02	-0.22	-0.03	0.17			
14. 1996-1999	0.14	0.35	0	1	0.34	0.23	0.27	0.20	0.06	-0.04	-0.07	0.03	-0.20	-0.21	0.01	-0.21	0.00		
15. 2000-2003	0.68	0.47	0	1	-0.19	-0.12	-0.13	-0.08	-0.03	0.01	-0.05	0.07	0.15	0.12	0.01	0.23	-0.21	-0.59	
16. 2004-2008	0.18	0.38	0	1	-0.07	-0.06	-0.08	-0.08	-0.01	0.02	0.12	-0.11	0.00	0.04	-0.02	-0.09	0.26	-0.19	-0.68

Observations = 887, ego networks = 310.

TABLE 2

Second Set of Descriptives*

	Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Idea success	0.10	0.30	0	1													
2. Prior idea success (network mean)	0.08	0.24	0	1	0.23												
3. Network size	1.57	1.04	1	6	0.17	0.09											
4. Network strength	0.18	0.69	0	4	0.01	0.09	0.45										
5. Network quality	0.10	0.37	0	2	0.19	0.30	0.50	0.37									
6. Productivity (network mean)	0.76	1.21	0.03	9	-0.11	-0.09	0.00	0.05	-0.05								
7. Patents (ln) (network mean)	0.55	0.85	0	4.44	0.05	0.03	-0.02	-0.01	0.02	-0.19							
8. Prior idea involvement (network mean)	6.19	8.66	1	80	-0.02	-0.05	0.02	0.03	0.08	0.03	0.20						
9. Similarity to previous ideas (network mean)	0.62	1.03	0	9	-0.01	0.04	-0.04	0.09	0.06	-0.02	0.10	0.12					
10. Idea confidentiality	0.26	0.44	0	1	0.19	0.14	-0.03	-0.02	0.08	0.00	-0.05	-0.19	0.05				
11. Time elapsed since previous idea (ln) (network mean)	1.08	1.26	-1.39	4.54	0.22	0.19	0.05	-0.03	0.13	-0.36	0.01	-0.17	-0.07	0.15			
12. 1996-1999	0.14	0.35	0	1	-0.01	-0.03	0.34	0.27	0.06	-0.07	-0.21	-0.19	0.02	-0.21	-0.04		
13. 2000-2003	0.68	0.47	0	1	-0.12	-0.07	-0.19	-0.13	-0.03	0.13	0.16	0.12	0.01	0.23	-0.24	-0.59	
14. 2004-2008	0.18	0.38	0	1	0.15	0.11	-0.07	-0.08	-0.01	-0.10	0.00	0.02	-0.03	-0.09	0.33	-0.19	-0.68

Observations = 887, ego networks = 310.

TABLE 3

First Set of Regression Analyses*

	Network size			Network strength			Network quality		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**
Prior idea success		0.25**	0.19*		0.15*	0.18*		1.29**	1.12**
		(0.09)	(0.09)		(0.07)	(0.07)		(0.43)	(0.40)
Prior network quality	0.23***	0.20**	0.07	0.18**	0.17*	0.04			1.09**
	(0.07)	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)			(0.35)
Prior network size			0.13***	0.14***	0.14***	0.12***	0.44***	0.40**	0.25+
			(0.03)	(0.02)	(0.02)	(0.02)	(0.13)	(0.13)	(0.13)
Prior network strength	0.12**	0.12**	0.08+			0.38***	0.59**	0.63**	0.40*
	(0.04)	(0.04)	(0.04)			(0.04)	(0.19)	(0.19)	(0.19)
Productivity	0.03+	0.03+	0.01	0.10***	0.10***	0.06***	-0.27	-0.25	-0.18
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.21)	(0.20)	(0.17)
Patents (ln)	0.02	0.03	0.02	0.08*	0.08*	0.05*	-0.19	-0.16	-0.09
	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)	(0.27)	(0.27)	(0.23)
Prior idea involvement	-0.00	-0.00	0.00	0.00	0.00	-0.00	0.06+	0.06+	0.04
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.03)	(0.03)	(0.03)
Similarity to previous ideas	0.00	0.00	-0.00	0.04*	0.04*	0.04*	0.02	0.03	0.08
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.13)	(0.13)	(0.12)
Idea confidentiality	-0.02	-0.02	-0.03	-0.00	-0.01	-0.03	0.38	0.40	0.28
	(0.07)	(0.07)	(0.07)	(0.05)	(0.05)	(0.05)	(0.39)	(0.40)	(0.37)
Time elapsed since previous idea (ln)	0.08**	0.07**	0.05+	-0.00	-0.01	-0.01	0.27+	0.28+	0.30*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.14)	(0.14)	(0.13)
1996-1999	0.47***	0.48***	0.40***	0.37***	0.38***	0.34***	0.42	0.63	0.81+
	(0.08)	(0.08)	(0.08)	(0.07)	(0.07)	(0.06)	(0.49)	(0.50)	(0.44)
2004-2008	-0.07	-0.08	-0.06	-0.02	-0.03	0.00	-0.19	-0.33	-0.40
	(0.08)	(0.08)	(0.08)	(0.06)	(0.06)	(0.05)	(0.46)	(0.47)	(0.44)
Constant	0.19**	0.18**	0.04	-0.25***	-0.25***	-0.19***			
	(0.07)	(0.07)	(0.08)	(0.06)	(0.06)	(0.05)			
Cutpoint 1							4.80***	4.97***	4.43***
							(0.58)	(0.60)	(0.54)
Cutpoint 2							6.49***	6.68***	6.05***
							(0.67)	(0.70)	(0.63)
Log likelihood	-1191.90	-1188.27	-1176.19				-248.45	-244.05	-240.10
Wald χ^2	124.12***	130.84***	159.25***	165.91***	175.99***	398.01***		9.15**	9.57**
Wald test		7.70**	25.86***		4.02*	102.35***	-248.45	-244.05	-240.10

+ p < .10; * p < .05 ; ** p < .01; *** p < .001.

* Standard errors in parentheses; two-tailed tests. Model 1-3 are panel Poisson regressions, Model 4-6 are panel linear regressions, Model 7-9 are panel ordinal regressions.

TABLE 4

Second Set of Regression Analyses*

	Idea success							
	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17
Network quality							0.72**	0.36
							(0.27)	(0.35)
Network strength					-0.06	2.40**		1.26+
					(0.20)	(0.74)		(0.71)
Network strength squared						-0.83**		-0.55*
						(0.29)		(0.25)
Network size			0.47***	1.66***				1.52***
			(0.11)	(0.43)				(0.46)
Network size squared				-0.21**				-0.20*
				(0.08)				(0.08)
Prior idea success (network mean)		1.16**	1.21**	1.25**	1.16**	1.19**	0.92*	1.21**
		(0.43)	(0.41)	(0.42)	(0.43)	(0.44)	(0.44)	(0.46)
Productivity (network mean)	-0.31	-0.25	-0.36	-0.35	-0.24	-0.28	-0.25	-0.30
	(0.24)	(0.22)	(0.26)	(0.26)	(0.22)	(0.24)	(0.22)	(0.26)
Patents (ln) (network mean)	0.33	0.27	0.23	0.23	0.27	0.26	0.27	0.24
	(0.21)	(0.19)	(0.18)	(0.17)	(0.19)	(0.19)	(0.19)	(0.18)
Prior idea involvement (network mean)	0.05*	0.04*	0.02	0.02	0.04*	0.04+	0.03	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Similarity to previous ideas (network mean)	-0.10	-0.11	-0.05	-0.05	-0.11	-0.12	-0.13	-0.06
	(0.14)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
Idea confidentiality	1.68***	1.54***	1.46***	1.47***	1.55***	1.57***	1.50***	1.53***
	(0.34)	(0.33)	(0.32)	(0.32)	(0.33)	(0.34)	(0.33)	(0.33)
Time elapsed since previous idea (ln) (network mean)	0.26*	0.26*	0.23+	0.21+	0.26*	0.28*	0.23+	0.22+
	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
1996-1999	1.06*	1.08*	0.59	0.55	1.12*	1.04*	1.01*	0.75
	(0.49)	(0.46)	(0.46)	(0.45)	(0.47)	(0.48)	(0.45)	(0.48)
2004-2008	1.38***	1.21***	1.23***	1.32***	1.21***	1.30***	1.29***	1.41***
	(0.38)	(0.36)	(0.35)	(0.35)	(0.37)	(0.37)	(0.36)	(0.37)
Constant	-4.28***	-4.15***	-4.60***	-5.76***	-4.17***	-4.28***	-4.09***	-5.81***
	(0.50)	(0.46)	(0.49)	(0.67)	(0.47)	(0.49)	(0.45)	(0.71)
Log likelihood	-244.18	-241.01	-233.00	-228.74	-240.95	-234.11	-237.61	-223.69
Wald χ^2	50.63***	62.04***	77.18***	82.97***	61.55***	67.25***	68.73***	84.31***
Wald test		7.29**	17.28***	7.87**	0.11 [1]	8.40**	7.08** [1]	23.07***

+ p < .10; * p < .05 ; ** p < .01; *** p < .001.

* Model 10-17 are panel logistic regressions.