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Entrepreneurial Behavior of Academic Scientists: Network and Cognitive Determinants of Commitment to Grant Submissions and Award Outcomes

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We employ the individual-opportunity nexus perspective to conceptualize entrepreneurial commitment of academic scientists as the pursuit and attainment of external grant funding. We develop and test a model of network characteristics and cognitive biases that predict the likelihood that scientists will commit to a grant opportunity and the likelihood of receiving an award. Using data from our national survey of faculty, we find that the illusion of control and overconfidence reduce grant submissions but increase awards. Collaboration network size increases submissions and awards. Strong ties are positively related to submissions and smaller networks of strong, highly capable collaborators receive more awards.

Introduction

Entrepreneurial behavior is widely thought to occur at the nexus of enterprising individuals and valuable opportunities (Shane & Venkataraman, 2000; Venkataraman, 1997), where entrepreneurs decide to pursue opportunity. Despite the widespread utility of this perspective to explain opportunity recognition in a business setting, rarely has this approach been applied to academic entrepreneurship. Academic entrepreneurship is defined here as the scientist's *pursuit and exploitation of opportunity to create something of value* (Shane, 2003). Entrepreneurs are individuals that are more inclined to exploit opportunity (Stevenson & Jarillo, 1990). By extension, academic entrepreneurs are individuals that proactively seek and secure resources to explore new scientific or technological opportunities.

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The literature on decision making by academic entrepreneurs has largely focused on decisions to patent, license, or create a new venture from the scientist's knowledge production as part of a commercialization process (Audretsch & Stephan, 1996; Krabel & Mueller, 2009; Shane, 2004). While the risk-taking, innovative, and proactive nature of scientists' grant-seeking behavior is recognized as academic entrepreneurial activity (Louis, Blumental, Gluck, & Stoto, 1989; Mars & Metcalfe, 2009; Mars & Rios-Aguilar, 2009; Stephan, 1996), prior work has not examined the pursuit of grant awards from the perspective of the individual-opportunity nexus.

Even though grant-seeking behavior is an expected dimension of the academic work, scientists vary substantially in the extent to which they commit to pursue grant opportunities and the degree to which they are successful. Some scientists commit to and receive no grants, while others are very active. Those individuals who seek to develop more proposals, well beyond what may be required, are undertaking entrepreneurial activity in order to obtain resources to build their research organization or lab. More grant resources provide rewards such as autonomy, greater articles, inventions, visibility, and recognition. Moreover, because entrepreneurial grant-seeking behavior occurs within a collaborative context, decisions to commit to the pursuit of a grant likely depend on both the collaboration network and on individual factors.

Hence, the paper examines whether the same factors thought to influence business entrepreneur's decisions about pursuing commercial opportunities also explain scientists' decisions to pursue grant opportunities and the decision outcomes. In particular, we study how social networks and cognitions—two categories of factors often recognized in the literature to explain entrepreneurial behavior—influence scientists' commitment to pursue opportunities for external grant funding for academic research, where commitment is operationalized as the number of grant opportunities pursued in a given period of time.

Social networks, defined as the structure of interpersonal relations in which the individual is embedded, provide information, resource, and reputational benefits (Adler & Kwon, 2002) that matter for entrepreneurial decisions (Aldrich, Zimmer, Sexton, & Smilor, 1986; Hoang & Antoncic, 2003). Cognitive characteristics, those factors that influence how people think and make decisions, enable individuals to manage uncertainty and risk inherent in pursuing opportunity; some cognitions may be overrepresented in entrepreneurs (Baron, 2004; Krueger, 2003). Although social networks and cognitive characteristics matter for entrepreneurial decisions, they are rarely considered simultaneously. The work of De Carolis and colleagues is an exception (De Carolis, Litzky, & Eddleston, 2009; De Carolis & Saparito, 2006). As a result, there is a need to assess empirically the combined contribution of both of these factors—networks and cognitions—to explaining commitment to pursue grants and grant success, which represent entrepreneurial decisions and decision outcomes, respectively.

We proceed first by developing literature-based hypotheses to explain commitment to opportunity pursuit and success in the context of academic science, and then by testing these hypotheses using interpersonal egocentric network, cognition, and grant activity data from our 2007 survey of 1,598 scientists randomly selected from six fields of science and engineering at Carnegie-designated Research I universities in the United States. Network results indicate that scientists reporting larger collaboration networks or a higher proportion of strong ties in the network submit more grants. Also, scientists reporting larger collaboration networks that have a smaller proportion of strong, more capable collaborators receive more grant awards. Two cognitive biases—illusion of control and overconfidence—were found to reduce the number of grant opportunities pursued and increase the success of these pursuits.

Overall, these findings partially support literature-derived expectations that networks and cognitions determine commitment to pursue opportunities and the success of those efforts. However, the findings also support a more complex model of entrepreneurial behavior within a collaborative environment. Implications of these findings for theory and practice are presented in the Conclusions.

Model Development and Hypotheses

Cognitive and Network Determinants of Entrepreneurial Behavior

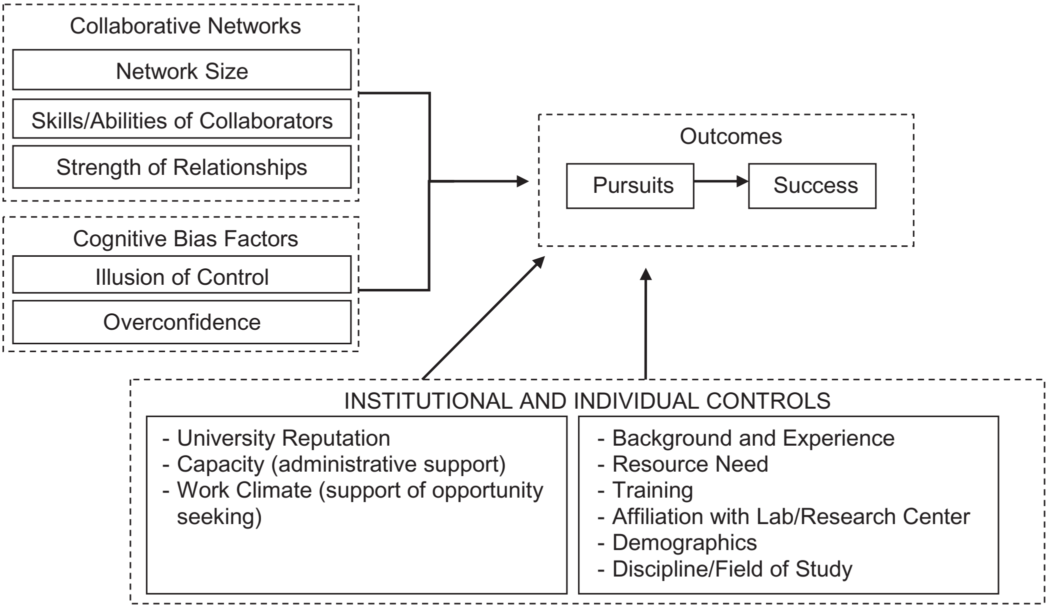
The entrepreneurial process is viewed as a multiphase process that begins with the discovery and evaluation of opportunity, proceeds through the acquisition of resources and strategy development, and culminates in performance (Eckhardt & Shane, 2003; Shane, 2003; Shane & Venkataraman, 2000; Venkataraman, 1997). Similarly, the pursuit of grant funding in academic settings includes all phases of the entrepreneurial process. When scientists decide to pursue opportunities, they must expend effort to develop and submit a proposal for funding within a highly uncertain resource environment that depends upon the assessment of quality and importance by peers and funding organizations. The success of the decision to commit is measured as the grant award; funding to undertake new research that may or may not produce new knowledge, the primary currency of science. Therefore, studying grant proposals and awards provides a rare glimpse into early stage entrepreneurial decisions to commit to pursue opportunities and the result of the decisions.

The pursuit of new scientific knowledge requires human capital and equipment inputs (Katz & Martin, 1997), and because university provision of these inputs has been in a steady decline (Slaughter & Leslie, 1997), the conduct of academic science and engineering research is largely dependent upon funding from government, industry, and foundation grants and contracts (Bozeman & Gaughan, 2007). While scientists must continuously seek funding opportunities, commitment to pursue a potential funding opportunity requires both the awareness of a source of funding and the ability to effectively access the knowledge and ideas necessary to develop a novel, scientifically defensible, and feasible proposal. Kirzner (1973) posits that opportunity seeking depends upon the alertness of people to new information and toward unnoticed, potentially valuable, and available resources. The social network literature emphasizes the importance of individuals' embeddedness in networks of relationships for their exposure to new information (Granovetter, 1973, 1985). Hence, some network structures may aid the alertness of entrepreneurs to opportunities. Additionally, networks provide the necessary additional human resources to undertake entrepreneurial activity (Aldrich & Kim, 2007). Commitment to pursue an opportunity likely depends upon the entrepreneur's perceived ability to access information embedded in their networks (Casson, 1982). The outcome of the commitment decision may depend on the entrepreneur's ability to obtain necessary inputs into the proposal.

Meanwhile, a largely distinct literature uses cognitive theory to explain entrepreneurship. It views entrepreneurial decisions to be judgments made under uncertain conditions using decision-making heuristics that bias judgments in predictable ways (Tversky & Kahneman, 1974). Here, entrepreneurs are better able to perceive and pursue opportunities because they are better suited to making decisions under uncertain conditions with incomplete information. Inclusion of both social network and cognitive theory in our study recognizes their potential independent contributions to entrepreneurial decisions. We ask: Controlling for network structure and resources, do cognitive biases determine

Figure 1

Hypothesized Model of Network and Cognitive Effects on Grant Outcomes



the commitment to and success of the pursuit of grants? Also, controlling for cognitive biases, do network structure and relationships predict the commitment to and success of grant submissions?

Figure 1 graphs a representation of network and cognitive determinants of entrepreneurial decisions. It includes three structural characteristics of the entrepreneur's collaborative network—size, strength of relationships, and abilities of the research collaborators—that are expected to predict the pursuit and success of funding opportunities. Additionally, the model includes cognitive factors of illusion of control and overconfidence, which have been found to be important predictors of entrepreneurial decision making in prior research. The model also includes controls for other exogenous factors such as the experience of the individual, and the characteristics of the department and institution that may play a role in shaping the decision to pursue opportunity. Each factor is discussed in more detail later.

Collaborative Networks and the Decision to Pursue Opportunity

A scientist's collaborative relationships are analogous to the work relationships examined in the business literature on entrepreneurship. A scientist's collaborators are coinvestigators on grant proposals, coauthors on research activities, and advisors or mentors in support relationships. Collaborative research is the norm in science. "No longer can the single scientist in a laboratory of boiling beakers follow a viable research agenda" (Emmert & Crow, 1989, p. 408). The increasing problem-oriented focus of research requires integration of complementary expertise and resources that typically come from multiple individuals (Katz & Martin, 1997). The three hypotheses that follow consider the effects that network structure and relationships have on decisions to commit to and resulting success of grant submissions.

Number of Collaborative Ties. Network theorists suggest that each relationship between individuals represents a potential conduit for information, tangible and intangible resources, advice, and support (Scott, 2004). By aggregating information available from networks, entrepreneurs may use their networks to recognize opportunities (Stuart & Sorenson, 2005) and, because goal-directed information search is difficult and chance is essential in procuring information (March, 1994), each relationship increases the chances of receiving useful information (Cross & Sproull, 2004). Also, each network tie increases the possibility of receiving diversified information and securing information regarding complementary assets (Greve, 1995), know-how (Brown & Butler, 1995), advice, and support (Birley, 1985). Casson (1982) theorizes that the ability to synthesize information about profit opportunities from many different sources is a key element of entrepreneurial behavior. Prior empirical research indicates that larger social networks enable entrepreneurs to recognize more opportunities and better enable them to advance to later stages of new business founding (Greve; Singh, Hills, Lumpkin, & Hybels, 1999).

In an academic science research setting, collaborative ties are thought to increase access to information and resources important to the conduct of science including expertise within and across disciplines (Katz & Martin, 1997), research material and equipment (Thorsteinsdottir, 2000), funding (Heffner, 1981), and prestige and visibility (Crane, 1972). "Collaboration may also bring about a clash of views, a cross-fertilization of ideas which may generate new insights or perspective that individuals, working on their own, would not have grasped (or grasped as quickly)" (Katz & Martin, p. 15). The greater the number of collaborators in a researcher's network, the greater the likelihood that the researcher has access to complementary skills, knowledge, and resources. Evidence suggests that this access leads to higher productivity and better quality outputs. Specifically, empirical studies have found that larger research collaborations are associated with more research grants and publications (Defazio, Lockett, & Wright, 2009; Fox & Mohapatra, 2007; Lee & Bozeman, 2005; Sandstrom, 2009), and coauthorship on publications has been found to increase the value of research production as measured by earning impact per citation (Diamond, 1985).

The similarities between these two sets of literature indicate that scientist entrepreneurs would benefit from larger networks in much the same manner as business entrepreneurs. Larger networks provide alert entrepreneurs more information about opportunities available. They also provide greater access to scarce resources required to successfully exploit opportunities (e.g., develop competitive proposals). As a result, scientist entrepreneurs will be more likely to commit to undertaking a larger number of proposals and, due to greater average skills and resources, larger networks will result in better outcomes (e.g., more grant success). Based on these arguments, we hypothesize:

> **Hypothesis 1a:** Academic scientists with larger collaborative networks will be more likely to submit grant proposals.
>
> **Hypothesis 1b:** Academic scientists with larger collaborative networks will be more likely to receive grant awards.

Strong Ties. A second characteristic of networks is tie strength, which reflects the length of time, the emotional intensity, the intimacy or mutual confiding, and the reciprocity in the relationship (Granovetter, 1973). The stronger the relationship, the more likely the linked individuals will exchange resources (Lin, 2001). Further, strong ties are potentially more useful in situations where tacit knowledge exchange is important (Nahapiet &

Ghoshal, 1998; Uzzi, 1997), such as for the production of novel grant proposals. Also, strong ties are often associated with trust, defined here as "the faith that an event or action will or will not occur" (Lin, p. 147). Trust can reduce transaction costs, particularly the monitoring and negotiating costs inherent in social exchange, and increase the depth and richness of exchange relations (Powell, Cummings, & Staw, 1990; Saxenian, 1991). Trust has also been found to be a strong predictor of resource and knowledge exchange (Hoang & Antoncic, 2003; Larson, 1992), and is particularly important in highly complex tasks facing strong time constraints (Powell et al.; Uzzi). As trust in an individual's network increases, the probability that network members will be willing to supply needed resources will increase, thereby increasing the willingness of the entrepreneur to commit to exploiting opportunities.

Alternatively, weak ties are characterized by a lower frequency of interaction and are typically used for exchange of simpler, more explicit information (Cross & Sproull, 2004; Granovetter, 1973). Cross and Sproull argue that a weak tie is more likely to provide problem solutions than problem reformulation and validation because these exchanges take more time and effort. Also, because a person does not interact frequently with a weak tie, it is likely that weak ties provide access to more unique information than do strong ties (Burt, 1992; Granovetter).

The literature is marked by a debate on the relative value of strong versus weak ties to the entrepreneur. Strong, trusted ties can provide information that an individual believes to be accurate (Shane, 2003), which is important for opportunity discovery or beating the competition (Casson, 1982). Additionally, trusted contacts allow the entrepreneur to explore concepts without fear that the idea will be "stolen" by the social relation. Strong ties such as friendship relations may be easily accessed, low-cost links that allow the entrepreneur to gain legitimacy and resources required for success (Starr & MacMillan, 1990). Strong ties have been found to positively influence the persistence of individuals in the start-up phase of new business ventures (Davidsson & Honig, 2003), explain firm survival (Bruderl & Preisendörfer, 1998), and predict greater profitability among young firms (Aldrich, Rosen, & Woodward, 1987). Alternatively, the diverse information flows characteristic of weak ties have been found to improve the entrepreneur's ability to recognize opportunities (Singh et al., 1999). Given these benefits, several authors argue that a mix of strong and weak ties is optimal (Burt, 2005; Uzzi, 1997). For example, strong ties have been found to be more beneficial in a stable environment, while weak ties are more beneficial under conditions of greater uncertainty (Rowley, Behrens, & Krackhardt, 2000).

While little empirical research exists on the differential effects of strong and weak ties on academic scientists' research activity, there are several reasons to predict that strong ties will increase their commitment to exploit opportunities. First, tacit knowledge is important to the conduct of research due to the breadth and complexity of theories, methods, and equipment. Scientists having strong relationships with collaborators may be better able to formulate novel ideas and approaches, which could lead to greater efficiency in producing competitive proposals and higher likelihood of receiving grant awards.

Second, much of the simpler, more explicit information thought to be accessed through a weak tie is also available to a scientist through other alternative sources. For example, information about funding opportunities, previous awards, research skills of scientists, and previous research is public information accessible through web and literature search and does not necessarily require an interpersonal relationship to be gathered. Hence, the public nature of the explicit information about funding opportunities may reduce the potential benefit of weak tie relationships to collaborators.

Finally, similar to business persons, scientists are concerned about ideas being "stolen" by others because the pursuit of grant opportunities is a competitive process. The level of trust in collaborative relationships would enhance the scientist's ability to protect their ideas from competitors until research funding is obtained—thus increasing the likelihood of committing to the development of new proposals and increasing the likelihood of being funded. Therefore, we predict the following:

Hypothesis 2a: Academic scientists that have more strong ties in their collaborative network will be more likely to submit grant proposals.

Hypothesis 2b: Academic scientists that have more strong ties in their collaborative network will be more likely to receive grant awards.

Skills and Abilities of Collaborators. Characteristics of individuals in the network may reflect the quality of the information and resources that can be accessed (Scott, 2004). More-experienced people may provide better advice and more accurate information that benefit the discovery of opportunity. Relationships with successful individuals may increase access to resources needed to exploit an opportunity, thereby increasing the probability of success. Ties to people with entrepreneurial experience can also provide reputational value that signals the level of underlying investment risk to potential resource providers (Shane & Cable, 2002; Stuart, Hoang, & Hybels, 1999).

For the academic scientist, access to an experienced set of collaborators through professional networks can be important for decisions to commit to opportunity exploitation. As with other types of knowledge-production activities, conduct of academic research often requires integration of information from several viewpoints, disciplines, or methods to address complex problems. A scientist with access to a more capable set of network contacts may be more able to propose a new approach to solving a research problem (Katz & Martin, 1997). Further, the higher the level of expertise in the scientist entrepreneur's network, the better the information or advice may be—a benefit that may increase the willingness of the scientist to commit to developing a grant proposal and the probability of an award. Experienced scientists would be able to point out gaps in the proposed research that, if filled, would improve its quality. It is also plausible that reputational effects derived from the credentials of collaborators would improve the scientist's ability to garner grant support and thereby increase her willingness to commit.

The grant-getting ability of the collaborator, relative to the scientist, encapsulates the components of experience, expertise, and knowledge, relative to the scientist's own abilities as we hypothesize:

Hypothesis 3a: Academic scientists that have higher grant-getting ability in their collaborative network will be more likely to submit grant proposals.

Hypothesis 3b: Academic scientists that have higher grant-getting ability in their collaborative network will be more likely to receive grant awards.

It is also appropriate to consider an interaction between strong ties and grant-getting ability because it is possible that when close ties are also more capable, the scientist will derive more benefit; that is, the scientist would be able to gain input from high-quality ties, and thereby be more willing to commit to submit more proposals and more likely to produce high-quality outputs. Although we did not develop a formal hypothesis for this interaction, the empirical model includes this interaction to explore this possibility.

Cognitive Factors

Recognizing the important role of subjective judgment in entrepreneurial behavior (Casson, 1982; Krueger, 2003), this paper also tests the effect that cognitive biases have on commitment to and success of grant submissions. Entrepreneurs often face situations that are new, unpredictable, and characterized by an absence of historical trends, past performance, and other information to reduce the levels of uncertainty at a relatively low cost (Busenitz & Barney, 1997). In addition, they often face time pressures to act before the window of opportunity closes (Baron, 1998). In such settings, where more comprehensive and cautious decision making is not possible, biases and heuristics provide an effective basis for decision making (Schwenk, 1986; Tversky & Kahneman, 1974). In particular, previous research argues that the biases of illusion of control and overconfidence directly influence perceptions of opportunity (Busenitz & Barney; Keh, Foo, & Lim, 2002; Simon & Houghton, 2002; Simon, Houghton, & Aquino, 1999). We examine whether these two cognitive biases also predict commitment to exploit opportunities and the success of proposal submissions in academic science.

Illusion of Control. Individuals exhibiting illusion of control believe they have more control over chance outcomes than they actually do; they perceive lower levels of risk related to opportunities (Langer, 1975; Langer & Roth, 1975). This decision bias occurs because people seek to master their environment to avoid the negative consequences of having no control and because people have difficulty distinguishing chance- from skill-related events (Langer). For example, individuals with high illusion of control tend to believe that choosing a lottery number, rather than being assigned one, increases the probability of winning the jackpot.

Entrepreneurs may be more prone to illusion of control bias than other individuals (Duhaime & Schwenk, 1985; Hogarth, 1987). By perceiving an ability to anticipate events that affect the outcome of opportunity pursuit, such as market demand or competitive entry that are likely outside their control, entrepreneurs may evaluate the hazard inherent in the situation in a more favorable light (Duhaime & Schwenk). More specifically, illusion of control may lead the entrepreneur to underestimate competitive response, overestimate demand, and misjudge the need for complementary assets (Simon & Houghton, 2002). There is some empirical support that entrepreneurs with higher illusion of control perceive lower risk and pursue more opportunities (Houghton, Simon, Aquino, & Goldberg, 2000; Keh et al., 2002; Roux, Pretorius, & Millard, 2009). Also, recent research by De Carolis et al. (2009) found illusion of control to be positively related to progression of a new business venture.

Although to our knowledge the effect of illusion of control on commitment to pursue grants has not been studied, its application to the grant decision environment is a reasonable and appropriate extension. Competition for external funds in academic science involves several elements of chance that create uncertainty such as the unpredictability of reviewer acceptance of the proposal idea, the specific interests of the funding agency, and the number and strength of competitors. Under these uncertain conditions, scientists that have stronger beliefs in their ability to predict uncontrollable elements of opportunity pursuit may perceive less risk in submitting an award, which could positively influence the likelihood of their commitment to pursue a grant opportunity.

Additionally, the decision contexts within which scientists generate grant proposals is less time constrained and somewhat less uncertain than is normally found in the literature. Grant opportunities are often offered more than once such that scientists could wait to submit a proposal or resubmit a failed proposal. Therefore, it is possible that illusion of control bias may capture what the scientist has learned as a result of repeated submissions to granting agencies within a specialized area of research. Research is beginning to uncover a relationship between experiential learning and business entrepreneurship (Corbett, 2005). Learning would lead to a more careful assessment of proposal opportunities, thereby raising the likelihood that the grant will receive an award. Therefore, we offer the following hypotheses.

Hypothesis 4a: Academic scientists with higher illusion of control bias will be more likely to submit grant proposals.

Hypothesis 4b: Academic scientists with higher illusion of control bias will be more likely to receive awards.

Overconfidence. Overconfidence is an overly optimistic perception relative to the facts at hand. It can occur because individuals base their certainty on the ease with which they can recall reasons for confidence and the tendency to seek supporting evidence instead of disconfirming evidence (Plous, 1993). There is some literature showing that individual decision making is influenced by overconfidence (Busenitz & Barney, 1997; Fischoff, Gilovich, Griffin, & Kahneman, 2002). For example, entrepreneurs that exhibit higher levels of overconfidence assess business scenarios more positively (Palich & Bagby, 1995) and assign higher probabilities of success to their own ventures (Cooper, Dunkelberg, & Woo, 1988).

Behavior based on overconfidence bias is generally theorized to be associated with risk reduction. Overconfident individuals who more strongly treat their assumptions as facts may underestimate risk and demonstrate a greater propensity to pursue opportunity (Busenitz, 1999; De Carolis & Saparito, 2006; Palich & Bagby, 1995; Schwenk, 1986). Prior fieldwork has shown that overconfident entrepreneurs introduce riskier products (Simon & Houghton, 2003) and overconfident venture capitalists invest in riskier ventures (McArthy, Schoorman, & Cooper, 1993).

While we do not expect the relationship between overconfidence bias and judgments about grant submissions to be substantially different from prior work, it is important to recognize that the grant-seeking decision context is different than those explored in other literatures. The continuous nature of grant submission and resubmission may lead to learning effects in which overconfidence bias is reduced and more closely approximates the risk involved in the decision to commit to pursue a grant. This continuous nature may also mean that the academic entrepreneur has the option to wait for a better opportunity. Nevertheless, as in the previous section, we continue to follow the majority of the literature when we posit our last hypothesis.

Hypothesis 5a: Academic scientists with higher overconfidence bias will be more likely to submit grant proposals.

Hypothesis 5b: Academic scientists with higher overconfidence bias will be more likely to receive grant awards.

Methods

Data Collection and Sample Characteristics

The data for this paper come from our national survey of academic scientists in six fields: electrical engineering, physics, chemistry, biology, earth and atmospheric sciences, and computer science. The population for the survey includes all men and women faculty at the ranks of assistant, associate, and full from the six fields in the 151 Carnegie-designated Research I universities in the United States. Of the 151 universities, two universities (Yeshiva University and Columbia Teachers College) were excluded because they did not grant doctoral degrees. Names of scientists were collected from departmental websites of the 149 remaining universities and manually entered into a database, along with data on rank, gender, and field. Rank was listed on the faculty page or in the university directories. Gender was determined through a combined analysis of first name and photograph.

From this population, a stratified sample of 3,667 faculty was selected based on three strata: field, rank, and gender. Women were oversampled because women represent a small percentage of the population of interest. Rank distribution is nearly proportionate to the population with the target sample being 50% full professor, 25% associate professor, and 25% assistant professor. Once the sample was chosen, students finalized the collection and input of complete address information. Sample weights were calculated using the inverse of the probability of selection and employed in calculating all results presented later.

The survey was implemented online using Sawtooth Software® (Sawtooth Software, Inc., Orem, Utah), posted as a webpage and completed by participants online. Individuals were invited to the survey via traditional mail with a series of personalized email follow-ups. Each of the invitations provided individually assigned user identification and password, and directed the individual to the survey website. In addition to the social network questions, respondents were asked about their research activities, including grant submission and success rate, teaching and committee responsibilities, attitudes about and involvement in interdisciplinary research, work environment, and detailed demographic and academic background questions. Overall, the survey took between 30 and 45 minutes to complete.

Of the 1,774 completed surveys, 176 were removed because of ineligible rank or discipline, resulting in 1,598 usable surveys and an overall response rate of 45.8%. The final regression subset, after observations with missing values were deleted, consists of 1,262 academic scientists.

This study is unique in that it gathers data on egocentric networks and knowledge exchange at a national scale, which allows exploration of the respondents' relationships with the individuals in the respondents' collaborative and advice networks, but not the global network of which individuals are members (Wasserman & Faust, 1994). Through the use of detailed survey questions, respondents describe their networks for select activities and their relations with network members (Burt & Minor, 1983; Marin, 2004). As a result, the survey captures multiple dimensions of the collaborative and advice networks that are not accessible through existing data such as bibliometrics.

The survey instrument collected network data using a series of *name-generator* and *name-interpreter* questions. Respondents were first asked to write in the names of key collaborators or advisors in research collaboration, as well as advice and support networks into five name-generator questions. Collaborator names were gathered by asking two name-generator questions: "Over the past 2 years, which individuals *at your university* have been your closest collaborators" and "Over the past 2 years, which individuals *outside your university* have been your closest collaborators?"

Once the survey respondent provided names in each of the name-generator questions, the names were piped forward into a series of *name-interpreter* questions, for which the respondent was asked to respond. Name-interpreter questions addressed the type of the collaboration undertaken with the collaborator, details about the level of relationship and origin of acquaintance, closeness of research expertise, communication frequency, grant activity, and general demographics. Alter-level data were converted to respondent attribute data by summing alter records for network size variables and aggregation of mean for all other aspects of an individual's network.

Dependent Variables: Grant Submissions and Grant Awards

To measure grant-seeking behavior, we specify two different dependent variables to distinguish grants submitted from grants received. *Grant submission* is measured as a count of the number of grant proposals the respondent submitted during the past 2 years as a principal investigator. Likewise, *grant success* is measured as a count of the number of these submitted proposals that received awards. Because receipt of an award is contingent upon applying for funding, *grant submission* is also an independent variable in the equation predicting *grant success*.

Independent Variables

Network Factors. *Grant network size* was measured as the number of unique individuals with whom the respondent worked on grant proposals. In addition to constructing the size of the collaborative network, the connections among the scientists were also used to assess two different characteristics of respondent's networks: tie strength and grant ability. Based on Marsden and Campbell (1984), *network tie strength* was measured as the proportion of the scientist's grant writing collaborator ties who the respondent considered to be "close friends." The higher the number, the stronger the tie.

Network grant ability reflects the perceived ability of the network contact to get grants relative to the respondent's own ability and is measured as the average response across the network ties to the name-interpreter question, "Compared to your own ability to obtain grant funding, how would you assess the ability of the people you named to obtain grant funding?" This item is scored on a 3-point scale from "much better than me" to "much worse than me" and is reverse-coded. The higher the number, the more grant-getting ability in the network relative to the respondent's grant ability.

In addition, the model incorporated an interactive variable for strong ties that were also perceived to be more capable of obtaining grant funding. *More able strong ties* was measured as the number of unique individuals whom the respondent considered to be "close friends" and "much better than me" in their ability to obtain grant funding. This variable was included to assess whether there is an interactive effect over and above the main effects of *tie strength* and *grant ability*.

Cognitive Bias Factors. Prior entrepreneurship experiments have examined the association of cognitive biases with evaluations of simplified business case studies (Keh et al., 2002; Simon & Houghton, 2002). However, experimental designs may lack meaningful monetary incentives and provide subjects with especially salient signals that would not occur in more natural environments (Schwarz & Mark, 1994). In contrast, we studied actual entrepreneurial decisions that are ill structured, thus enabling us to circumvent the biases that could have resulted from prior experimental designs. To do so, we developed two cognitive bias variables, *illusion of control* and *overconfidence*, and included them in the estimations. *Illusion of control*, which is the tendency for people to treat chance events as controllable outcomes, is measured using an index constructed using four questions adapted from Simon et al. (1999) and Langer and Roth (1975). It measures the subject's perceptions of her own ability to predict certain uncontrollable outcomes associated with grant proposals. Each item is scored on a 4-point scale from strongly agree to strongly disagree. Items one, two, and four were reverse-coded. The Cronbach's alpha correlation for the index was .602, which is just at the threshold of reliability, although lower thresholds are sometimes acceptable (Cohen, Cohen, West, & Aiken, 2003; Santos, 1999). The specific questions are:

1. I can usually predict which of my grant proposals will be funded.
2. I am pretty good at estimating who I will be competing against for grant funding.
3. The success of federal grant awards is heavily determined by pure chance.
4. I am pretty good at predicting what reviewers will criticize in my grant proposals.

Overconfidence is the tendency to be more certain than is realistic given the underlying data (Bazerman, 2006; Plous, 1993). To measure this tendency, we adapted a format used in prior work that assessed confidence levels through responses on general items (e.g., "What percent of new car buyers use some form of financing to buy their car?" [Keh et al., 2002; Simon et al., 1999]). Responding to the call from these researchers to capture overconfidence using a more specific measure, we asked respondents about the likelihood that the first submission of a proposal to a federal granting agency in his or her field would receive an award. To normalize across fields, we measure *overconfidence* as the difference between the respondent's score and the mean response of all other respondents' scores in his or her field of science divided by the standard deviation of field scores. A positive score indicates overconfidence and a negative score indicates underconfidence.

Control Variables

Several control variables were used in the empirical analysis. G*rant submissions* was included in the model predicting *grant success* because submitting a grant proposal is a prerequisite to receiving a grant award. We expect that individuals who have more grant submissions may be more likely to receive grant awards. *Institutional reputation*, *department reputation*, and *affiliated with center* are included to control for possible institutional effects on *grant submissions* and *grant success*. *Number of courses taught* (Cole, 2007) and *number of committees* were included in the model in consideration of capacity constraints. We expect that scientists have a generally fixed capacity to commit to research, teaching, and service, and that individuals who teach more classes or serve on more committees may be less likely to pursue new research projects.

Five-year publications average was included in the models predicting grant submissions to control for possible differences in prior research funding. It was also included in the models predicting *grant success* to control for possible differences in scientist's reputation. *Department resource requested* was included to control for possible departmental effects on grant submissions and grant success. It was measured as the proportion of seven types of department resources that the respondent has requested in the past year from the department including graduate students, travel money for conferences, additional lab space, equipment, software, special classroom facilities, and administrative support for grant writing. Dummy variables for each of the six scientific fields were included in the models because of potential field-based differences in grant opportunities or success (Becher, 1994). Biology is the reference category.

Dummy variables for *foreign* and for academic rank (*assistant*, *associate*, and *full*) were used to control for possible differences in entrepreneurial behavior based on immigrant status (Portes, 1995) and experience (Hsu, 2007; Lowe & Ziedonis, 2006) and possible differences in grant-funding expectations. Full professor is the reference category. *Female* is included as a dummy variable to control for possible gender differences in networks (Rhoten & Pfirman, 2007; Torres & Huffman, 2004) and entrepreneurial behavior (Burt, 2000; Stephan & El-Ganainy, 2007). A control variable for *age* is included because past research has shown that individuals' ages can affect their cognitive processes (Taylor, 1975), particularly the overconfidence of entrepreneurs (Forbes, 2005).

Estimation

The estimation applied negative binomial regression because the dependent variables are counts of grants submitted and grants awarded that contain many zero values and large positive skews (Hilbe, 2007). Negative binomial models utilize a distribution that characterizes the probability of observing any discrete number of events, given an underlying mean count of events.

Endogeneity is of primary concern when attempting to establish the direction of the relationship between network structure and outcomes (Mouw, Cook, & Massey, 2006). For example, exchange and dependency theories posit that individuals are more likely to forge network ties with others if there are resources they need from others and if there are resources that they can offer those others (Monge & Contractor, 2003). Thus, it is possible that more outcomes lead to more grant collaborations instead of vice versa.

To test if network size and grant activity are endogenous, we apply a two-stage residual inclusion model (2SRI) that is suggested by Wooldridge (2003) for estimation of nonlinear models with endogenous covariates and further discussed by Terza, Basu, and Rathouz (2008). Examples of the use of 2SRI are also found in Kenkel and Terza (2001) and Gavin, Adams, Manning, Raskind-Hood, and Urato (2007). The 2SRI estimator is similar to the well-accepted linear two-stage least squares estimator, except that in the second-stage regression, the endogenous variables are not replaced by first-stage predictors. Instead, first-stage residuals are included as additional regressors. The residuals should capture the unobserved systematic component of the variation and correct for any bias in the coefficients for network size. The selection of instruments to identify the model is driven by the three criteria: (1) The instrumental variable should be highly correlated with grant network size, (2) uncorrelated with the error term of the grant outcomes model, and (3) uncorrelated with grant outcomes except through network size.

For the current study we specify one instrument—scientist holds a joint appointment. This choice of instrument is justified in an appointment in a second department means the scientist could meet new collaborators and potentially enlarge their network, and yet there is no reason to believe that joint appointment is causally related to grant submissions or success except through the medium of network size.

Results

Descriptive statistics and tau correlations are presented in Table 1. We first note that the standard deviations of each of the dependent variables *(grant submission* and *grant success)* greatly exceed its mean, which indicates overdispersion and validates the regression method used. A frequency analysis of grant submissions found that 88% of all respondents submitted at least one grant application in the past 2 years, and 67.5% of respondents received at least one grant award in the past 2 years. Correlations are generally modest, although the correlation between grant success and submission is high at .57. This finding supports the inclusion of grant submission as controls in the estimation of grant success.

Table 1

Descriptive Statistics and Kendall's Rank Correlations†

Number	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Grant submissions	1.00													
2	Grant success	0.57	1.00												
3	Grant network size	0.11	0.11	1.00											
4	Grant ability	0.02	–0.04	0.47	1.00										
5	Tie strength	0.01	0.04	0.35	0.28	1.00									
6	More able strong ties	0.01	–0.02	0.30	0.35	0.53	1.00								
7	Illusion	–0.11	0.09	0.05	–0.03	0.06	0.00	1.00							
8	Overconfidence	–0.08	0.09	0.01	–0.02	0.02	–0.03	0.20	1.00						
9	Institution reputation	–0.03	0.01	0.02	–0.01	–0.05	–0.06	0.02	0.08	1.00					
10	Department reputation	–0.04	0.02	–0.02	–0.06	–0.01	–0.03	0.07	0.09	0.64	1.00				
11	Affiliated with center	0.06	0.08	0.08	0.00	–0.01	0.00	0.05	0.02	0.03	0.00	1.00			
12	Number of courses taught	–0.01	–0.03	–0.04	–0.03	–0.02	0.01	–0.05	–0.05	–0.08	–0.08	–0.04	1.00		
13	Number of committees	0.03	0.06	0.07	0.01	0.06	0.04	0.02	0.03	–0.03	–0.02	0.05	0.10	1.00	
14	5-year publication average	0.16	0.20	0.12	0.01	0.06	–0.01	0.04	0.03	0.04	0.07	0.16	–0.13	0.11	1.00
15	Department resources requested	0.03	–0.02	0.06	0.06	0.01	0.03	0.00	–0.04	–0.06	–0.08	0.01	0.06	0.04	–0.04
16	Assistant professor	0.09	–0.05	0.02	0.15	–0.02	0.02	–0.09	–0.07	–0.02	–0.07	–0.05	–0.11	–0.29	–0.18
17	Associate professor	–0.02	–0.03	0.04	0.04	0.05	0.07	0.00	–0.04	–0.09	–0.09	0.00	0.14	0.05	–0.06
18	Chemistry	0.07	0.01	–0.01	0.09	–0.02	–0.04	–0.04	–0.02	–0.06	–0.08	0.01	–0.03	0.07	0.11
19	Computer science	–0.04	–0.05	0.00	–0.03	–0.02	0.01	–0.09	–0.01	0.02	–0.02	0.01	0.04	–0.07	–0.19
20	Earth atmospheric science	–0.02	0.07	0.04	–0.02	0.07	0.05	0.12	–0.02	0.05	0.08	–0.07	0.10	0.01	–0.03
21	Electrical engineering	0.07	0.05	–0.03	–0.07	–0.07	–0.01	–0.06	0.03	0.00	–0.03	0.07	0.08	–0.06	–0.01
22	Physics	–0.07	–0.05	0.02	0.04	0.00	0.00	0.07	–0.03	0.00	0.03	0.07	–0.09	0.00	0.18
23	Biology	–0.01	–0.02	–0.03	–0.01	0.03	–0.02	–0.01	0.05	0.00	0.02	–0.08	–0.09	0.04	–0.07
24	Female	0.01	0.00	0.06	0.04	0.07	0.05	–0.04	–0.06	0.02	0.02	0.02	–0.07	0.07	–0.01
25	Foreign born	–0.11	–0.01	–0.02	–0.04	0.09	0.06	0.15	0.05	–0.01	0.01	0.00	0.03	0.13	–0.07
26	Age	–0.14	–0.03	–0.11	–0.16	–0.04	–0.06	0.07	0.06	0.03	0.06	0.01	0.10	0.17	0.01
27	Joint appointment	0.06	0.07	0.13	0.05	0.05	0.03	–0.03	–0.01	0.12	0.06	0.12	–0.06	0.07	0.10
Observations		1,557	1,363	1,363	1,449	1,449	1,449	1,598	1,529	1,530	1,574	1,572	1,598	1,584	1,584
Mean		4.73	2.12	0.42	2.31	0.51	0.19	0.16	2.44	0.00	2.69	2.65	0.22	3.42	3.64
Standard deviation		5.47	2.86	0.35	2.28	0.37	0.31	0.46	0.49	1.00	0.76	0.76	0.42	1.12	2.10

Number	Variables	15	16	17	18	19	20	21	22	23	24	25	26	27
1	Grant submissions													
2	Grant success													
3	Grant network size													
4	Grant ability													
5	Tie strength													
6	More able strong ties													
7	Illusion													
8	Overconfidence													
9	Institution reputation													
10	Department reputation													
11	Affiliated with center													
12	Number of courses taught													
13	Number of committees													
14	5-year publication average													
15	Department resources requested	1.00												
16	Assistant professor	0.09	1.00											
17	Associate professor	0.02	–0.38	1.00										
18	Chemistry	0.02	0.01	0.00	1.00									
19	Computer science	0.00	0.00	–0.02	–0.21	1.00								
20	Earth atmospheric science	0.01	–0.02	–0.01	–0.22	–0.21	1.00							
21	Electrical engineering	–0.02	0.01	0.06	–0.18	–0.17	–0.18	1.00						
22	Physics	–0.04	0.01	–0.02	–0.21	–0.20	–0.22	–0.18	1.00					
23	Biology	0.02	–0.01	–0.01	–0.21	–0.20	–0.22	–0.18	–0.21	1.00				
24	Female	0.07	0.04	–0.03	0.03	–0.01	0.02	–0.02	–0.01	–0.01	1.00			
25	Foreign born	0.02	–0.17	0.01	0.05	–0.06	0.14	–0.18	–0.10	0.12	0.05	1.00		
26	Age	–0.07	–0.53	–0.08	–0.03	0.01	0.04	–0.11	–0.01	0.09	–0.07	0.17	1.00	
27	Joint appointment	0.02	–0.07	–0.03	–0.05	0.04	0.01	–0.02	–0.04	0.06	0.05	–0.02	0.03	1.00
Observations		1,589	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,575	1,574
Mean		3.76	0.32	0.27	0.28	0.18	0.16	0.18	0.13	0.17	0.17	0.46	0.65	48.04
Standard deviation		5.36	0.25	0.44	0.45	0.38	0.37	0.39	0.34	0.38	0.38	0.50	0.48	10.07

† Tau-b correlations greater than .05 are significant at $p < .05$.

Network Factors

Table 2 contains the results of first- and second-stage negative binomial regression estimations on grant submissions and grant success. We first consider the network predictions, hypotheses 1–3, before examining the cognitive effects. As expected in hypothesis 1, grant network size significantly increased grant submissions and grant success. This indicates that scientists with more collaborative ties are more likely to submit and receive grants. The Terza test for endogeneity of the network size variable in the two equation model of grant submissions shows that network size is not endogenous to grant

Table 2

Results of Negative Binomial Regression Analyses

	Grant submissions				Grant success			
Variables	First stage		Second stage†		First stage		Second stage†	
Network factors	Coefficient	S.E.	Coefficient	S.E.			Coefficient	S.E.
Grant network size (hypothesis 1)			0.06	(0.02)***			0.06	(0.01)***
First stage residual			0.10	(0.31)			0.14	(0.28)
Tie strength (hypothesis 2)	0.26	(0.10)**	0.36	(0.19)*	0.20	(0.11)*	–0.02	(0.15)
Grant ability (hypothesis 3)	2.75	(0.12)***	–0.66	(0.84)	2.69	(0.13)***	–0.69	(0.76)
More able strong ties	–0.01	(0.04)	–0.03	(0.09)	0.01	(0.04)	–0.21	(0.11)**
Cognitive bias factors								
Illusion of control (hypothesis 4)	0.19	(0.06)***	–0.28	(0.10)***	0.22	(0.06)***	0.38	(0.08)***
Overconfidence (hypothesis 5)	0.01	(0.03)	–0.10	(0.04)***	0.01	(0.03)	0.09	(0.03)***
Grant submissions					0.01	(0.01)*	0.10	(0.01)***
Control variables								
Institution reputation	0.00	(0.06)	–0.03	(0.07)	–0.01	0.06	–0.03	(0.05)
Department reputation	–0.01	(0.05)	–0.01	(0.07)	–0.01	0.05	0.08	(0.05)*
Affiliated with center	0.21	(0.07)***	0.09	(0.10)	0.20	0.07***	–0.03	(0.09)
Number of courses taught	–0.03	(0.03)	0.08	(0.04)*	–0.02	0.03	0.04	(0.03)
Number of committees	0.02	(0.02)	0.03	(0.02)	0.02	0.02	–0.01	(0.02)
5-year publication average	0.01	(0.00)***	0.01	(0.01)	0.01	0.00***	0.01	(0.00)
Department resources requested	0.23	(0.11)**	0.11	(0.15)	0.21	0.12*	–0.29	(0.12)**
Assistant professor	–0.32	(0.11)***	–0.14	(0.18)	–0.29	0.11**	–0.20	(0.13)
Associate professor	–0.12	(0.08)	–0.24	(0.13)*	–0.09	0.08	–0.12	(0.09)
Chemistry	–0.18	(0.10)*	0.06	(0.15)	–0.18	0.10*	–0.16	(0.12)
Computer science	0.24	(0.10)**	–0.37	(0.13)***	0.26	0.10**	–0.12	(0.12)
Earth atmospheric science	0.27	(0.09)***	–0.06	(0.16)	0.27	0.09***	0.03	(0.11)
Electrical engineering	0.22	(0.11)**	–0.39	(0.13)***	0.25	0.11**	0.07	(0.11)
Physics	0.11	(0.10)	–0.44	(0.13)***	0.10	0.10	–0.14	(0.10)
Female	0.03	(0.05)	–0.12	(0.07)*	0.03	0.06	0.05	(0.05)
Foreign born	–0.02	(0.07)	–0.17	(0.08)**	0.05	0.07	0.17	(0.06)***
Age	–0.01	(0.00)***	–0.02	(0.01)***	–0.01	0.00**	0.00	(0.01)
Instrumental variable								
Joint appointment	0.33	(0.08)***			0.30	(0.08)***		
Constant	–1.02	(0.36)***	3.38	(0.53)***	–1.22	(0.40)***	–0.94	(0.47)**
Model characteristics								
Number of observations	1,310		1,289		1,151†		1,151†	
Log likelihood	–13,167		–21,397		–11,782		–11,844	

* $p < .10$, ** $p < .05$, *** $p < .01$.
† Excludes observations where PI grant submissions is zero.
PI, principal investigator; S.E., standard error.

submissions or grant success, as the coefficient of the predicted residuals are not significant in either of the second-stage models. Therefore, there is no indication that more grants or more grant success leads to more network ties.

Hypothesis 2a was supported in that tie strength is significantly and positively associated with the likelihood of submitting a grant. However, no support was found for hypothesis 2b as tie strength is not significantly related to receiving a grant award. In hypotheses 3a and 3b, we predicted that scientists with higher levels of relative grant-getting ability in their networks would be more likely to pursue grant opportunities and receive grant awards. Contrary to this prediction, we found that network grant ability was not significantly related to grant submissions or to grant success.

Additionally, we found that interaction effect of strong ties and higher grant ability decreases the likelihood that a grant will receive an award. This suggests that researchers having more highly able close friends in their collaborative networks may be both less-experienced principal investigators (PIs) and less able to challenge or stimulate the more experienced close colleagues to develop novel or competitive ideas. It is possible that when PIs are more dependent upon strong, capable ties, they are also less effective entrepreneurs as they are not able to develop persuasive means of capturing opportunities.

Cognitive Bias Factors

Results for the two cognitive variables—illusion of control and overconfidence—provide further insight into scientific entrepreneurship. Hypotheses 4 and 5 predicted that individuals with higher illusion of control and higher overconfidence, respectively, would be more likely to submit grant proposals and more likely to receive them. We found that individuals with high illusion of control are less likely to submit a grant proposal (hypothesis 4a), but more likely to receive a grant award for those that they submitted (hypothesis 4b). Overconfidence bias also had the same effects.

In sum, controlling for the rank, field, and other important factors, we found strong support for the influence of *network size* (hypotheses 1a and1b) and partial support for the effect of *network tie strength* (hypothesis 2a). The influence of *grant ability* (hypotheses 3a and 3b) was not supported, although we found that *more able strong ties* reduced the likelihood of receiving an award. Finally, the cognitive factors of *illusion of control* (hypotheses 4a and 4b) and *overconfidence* bias (hypotheses 5a and 5b) were positively related to receiving an award, but reduce the likelihood of submitting a grant.

Discussion

The purpose of this study was to understand how cognitive biases and social network factors affect the likelihood that academic scientists commit to exploiting more opportunities and have more success. The paper is situated within the entrepreneurship literature and makes use of recent research, indicating that social networks and cognitions affect entrepreneurial behavior. At the same time, it seeks to broaden the conceptualization of academic entrepreneurship to include pursuits of external funding for research by recognizing that some scientists pursue more opportunities and are more successful than others.

On the network side, our findings suggest that it is the size and strength of relationships with collaborators and not the ability of these collaborators that matters for scientists' decisions to commit to pursue grant opportunities, measured as the number of grant submissions in the recent past. Findings on network size are consistent with prior work, showing that larger networks produce relatively more research grants and publications (Defazio et al., 2009; Fox & Mohapatra, 2007; Lee & Bozeman, 2005; Sandstrom, 2009). Findings on tie strength confirm prior empirical work, showing that strong ties are important when tacit knowledge and accurate information are needed for opportunity discovery and competitiveness (Aldrich et al., 1987; Bruderl & Preisendörfer, 1998; Davidsson & Honig, 2003). Networks with more strong, trusted ties provide resources, and enable confidential exploration and development of new ideas, an element that may be particularly important in the open, collaborative environment of academic science.

Network variables are also important predictors of grant awards. Larger collaborative networks are associated with more awards, and scientists with stronger ties to highly capable collaborators in their networks are less likely to receive grant awards. While the first finding supports prior work found in the literature (Defazio et al., 2009; Fox & Mohapatra, 2007; Lee & Bozeman, 2005; Sandstrom, 2009), the second finding is unexpected. We had anticipated (although we did not develop a formal hypothesis) that the interactive effect of strong and highly skilled ties would be at an advantage; PIs would be able to obtain more resources for the development of competitive proposals, and their ties would have high reputations, which would increase the likelihood of receiving an award.

However, it is possible that two factors in this study cause an opposite effect. First, skill of collaborators is measured as the respondent's assessment of the skills of his or her collaborators in comparison with his or her own ability. When a scientist assesses others to be more able, he or she is comparatively less able. Second, when ties are strong, a less-able PI may be in a weak position to influence collaborators. Strong ties hold resources that persuade the PI to commit to the pursuit of awards, but if the PI is less skilled, he or she may be less able to extract and integrate the right resources in the most novel or competitive ways.

Findings for cognitions showed that scientists with high illusion of control and overconfidence were more successful, which was expected, but they were also less likely to pursue opportunities, which was not expected. The results, given that the models control for experience, reputation of the institution, and other individual and institutional effects, challenge current understanding that individuals high in cognitive biases are more likely to commit to pursue high-risk actions because they perceive them to be less risky (Houghton et al., 2000; Keh et al., 2002; McArthy et al., 1993; Roux et al., 2009; Simon & Houghton, 2003). Here, it is important to again mention the recurring and collaborative nature of entrepreneurial opportunity in science; funding opportunities become available on a repeated basis such that scientists are able to pass up one and wait until a better one comes along.

Stepping back from the two sets of findings, it is important to think about the overall results of the model. Consideration of cognitions and networks within a single empirical model enables a more complex explanation of the factors that affect commitment to pursue opportunities and their success. The independent effects of the cognitions and networks operate side by side to encourage commitment to pursue funding opportunities. After controlling for strong ties and networks size, both of which imply access to resources, individuals are seen to be more risk averse preferring to engage the valuable resources within their networks only when an appropriate opportunity arises. The recurring submission process creates a special case entrepreneurial context, one that may be more predicable than a business context, and strong tie networks may provide a collaborative group with whom the entrepreneur confers before committing to pursue grants.

Nevertheless, cognitions are key assets as a PI. Controlling for the resources available in their collaborative networks, scientists that demonstrate high illusion of control and overconfidence are more successful because they are more likely to actively search for the best opportunities and then, when they commit, are able to garner the necessary blend of resources that result in novel and competitive proposals. When scientist PIs are less risk averse but are also embedded as weak leaders in strong tie networks, they are likely to be less effective either because they are not able to bring out the optimal combination of resources from their network, or because they are viewed as less capable and therefore less fundable. Overall, these findings show a complex integration of entrepreneurial determination combined with a collaborative context in which network-based resources must be accessed wisely and with consent.

Pursuing an opportunity requires the commitment of not only the entrepreneur but also the consent of the entrepreneur's collaborators. This suggests a revised model of academic entrepreneurship in which the entrepreneur and the collaborators operate in a system of checks and balances. The entrepreneur may want to pursue the high-risk action more frequently than others—but they have to convince their network of collaborators to join in the pursuit. An optimum combination—PIs with strong cognitive biases and large, trusted collaborative networks—leads to fewer grants submitted but more award means that on average.

Our study of collaborative networks and cognitive biases in the context of university-based science extends previous research on entrepreneurial decision making in both scope and depth and, hopefully, further simulates investigation on academic entrepreneurship. We have identified certain contextual factors that may matter for the influence of networks and cognitions on commitment to pursuing opportunities and on the likelihood of success. Future work should examine other network characteristics such as structural holes and network density, and cognitive characteristics such as risk propensity and representativeness. Future research could also address some of the limitations of this study including its cross-sectional, egocentric design; longitudinal designs would provide a better understanding of these effects over time, while global network designs would account for network effects two or three steps removed from the individual. A natural extension of this study would also look at network and cognitive effects at other phases in the entrepreneurial process.

The current research provides a much more complex perspective of the academic scientist's decision environment, one that relies both on the collaborative network and on the cognitions of the individual. The result is a welcome contrast with the collaboration-oriented frame that is consistently favored in recent research on science production and productivity. While the collaborative team is of clear importance to production, individual characteristics are also important.

This also has implications for practice. First, illusion of control and overconfidence are beneficial as they facilitate decision making under uncertainty and aid in the search for valuable opportunities. At the same time, the entrepreneurs should recognize that building a beneficial network of collaborators is not just about growing the network larger, but about paying careful attention to one's own position in that set of relationships and the strength of relationships being built. Universities should seek to identify those scientists strong in these cognitive abilities, recognize and reward these behaviors as they indicate a researcher's ability to assess the opportunity in the field, confer with collaborators, and effectively commit resources to obtain funding and advance science.

REFERENCES

Adler, P.S. & Kwon, S.W. (2002). Social capital: Prospects for a new concept. *Academy of Management Review*, *27*(1), 17–40.

Aldrich, H., Rosen, B., & Woodward, W. (Eds.). (1987). The impact of social networks on business foundings and profit: A longitudinal study. In N.S. Churchill (Ed.), *Frontiers of entrepreneurship research* (pp. 154–168).

Aldrich, H., Zimmer, C., Sexton, D., & Smilor, R. (1986). Entrepreneurship through social networks. In D. Sexton & R. Smilor (Eds.), *The art and science of entrepreneurship* (pp. 3–23). Cambridge, MA: Ballinger Publishing Company.

Aldrich, H.E. & Kim, P.H. (2007). Small worlds, infinite possibilities? How social networks affect entrepreneurial team formation and search. *Strategic Entrepreneurship Journal*, *1*(1–2), 147–165.

Audretsch, D.B. & Stephan, P.E. (1996). Company-scientist locational links: The case of biotechnology. *The American Economic Review*, *86*(3), 641–652.

Baron, R.A. (1998). Cognitive mechanisms in entrepreneurship: Why and when entrepreneurs think differently from other people. *Journal of Business Venturing*, *13*, 275–294.

Baron, R.A. (2004). The cognitive perspective: A valuable tool for answering entrepreneurship's basic "why" questions. *Journal of Business Venturing*, *19*(2), 221–239.

Bazerman, M. (2006). *Judgment in managerial decision making*. Hoboken, NJ: John Wiley and Sons, Inc.

Becher, T. (1994). The significance of disciplinary differences. *Studies in Higher Education*, *19*(2), 151–161.

Birley, S. (1985). The role of networks in the entrepreneurial process. *Journal of Business Venturing*, *1*(1), 107–117.

Bozeman, B. & Gaughan, M. (2007). Impacts of grants and contracts on academic researchers' interactions with industry. *Research Policy*, *36*(5), 694–707.

Brown, B. & Butler, J.E. (1995). Competitors as allies: A study of entrepreneurial networks in the U.S. wine industry. *Journal of Small Business Management*, *33*(3), 57–66.

Bruderl, J. & Preisendörfer, P. (1998). Network support and the success of newly founded business. *Small Business Economics*, *10*(3), 213–225.

Burt, R.S. (1992). *Structural holes: The social structure of competition*. Cambridge, MA: Harvard University Press.

Burt, R.S. (2000). *Creating careers: Women's paths through entrepreneurship*. Chicago, IL: University of Chicago.

Burt, R.S. (2005). *Brokerage and closure: An introduction to social capital*. Oxford: Oxford University Press.

Burt, R.S. & Minor, M.J. (1983). *Applied network analysis: A methodological introduction*. Beverly Hills, CA: Sage Publications.

Busenitz, L. (1999). Entrepreneurial risk and strategic decision making: It's a matter of perspective. *Journal of Applied Behavioral Science*, *35*(3), 325–340.

Busenitz, L.W. & Barney, J.B. (1997). Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making. *Journal of Business Venturing*, *12*(1), 9–30.

Casson, M. (1982). *The entrepreneur: An economic theory*. Oxford: Martin Robertson.

Cohen, J., Cohen, P., West, S.G., & Aiken, L.S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.

Cole, S.S. (2007). Research behavior that leads to success in obtaining grant funding: A model for success. *Research Management Review*, *15*(2), 16–32.

Cooper, A.C., Dunkelberg, W.C., & Woo, C.Y. (1988). Entrepreneur's perceived chances for success. *Journal of Business Venturing*, *3*, 97–108.

Corbett, A.C. (2005). Experiential learning within the process of opportunity identification and exploitation. *Entrepreneurship Theory and Practice*, *29*(4), 473–491.

Crane, D. (1972). *Invisible colleges: Diffusion of knowledge in scientific communities*. Chicago, IL: University of Chicago Press.

Cross, R. & Sproull, L. (2004). More than an answer: Information relationships for actionable knowledge. *Organization Science*, *15*(4), 446–462.

Davidsson, P. & Honig, B. (2003). The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, *18*(3), 301–331.

De Carolis, D.M., Litzky, B.E., & Eddleston, K.A. (2009). Why networks enhance the progress of new venture creation: The influence of social capital and cognition. *Entrepreneurship Theory and Practice*, *33*, 527–545.

De Carolis, D.M. & Saparito, P. (2006). Social capital, cognition, and entrepreneurial opportunities: A theoretical framework. *Entrepreneurship Theory and Practice*, *30*(1), 41–56.

Defazio, D., Lockett, A., & Wright, M. (2009). Funding incentives, collaborative dynamics and scientific productivity: Evidence from the EU framework program. *Research Policy*, *38*(2), 293–305.

Diamond, A.M. (1985). The money value of citations to single-authored and multiple-authored articles. *Scientometrics*, *8*, 312–320.

Duhaime, I.M. & Schwenk, C.R. (1985). Conjectures on cognitive simplification in acquisition and divestment decision making. *Academy of Management Review*, *10*(2), 287–295.

Eckhardt, J. & Shane, S. (2003). Opportunities and entrepreneurship. *Journal of Management*, *29*(3), 333–349.

Emmert, M.A. & Crow, M.M. (1989). The cooperative university research laboratory. *Journal of Higher Education*, *60*(4), 408–422.

Fischoff, B., Gilovich, T., Griffin, D., & Kahneman, D. (2002). Heuristics and biases in application. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 730–748). Cabmridge: Cambridge University Press.

Forbes, D.P. (2005). Are some entrepreneurs more confident than others? *Journal of Business Venturing*, *20*(5), 623–640.

Fox, M.F. & Mohapatra, S. (2007). Social-organizational characteristics of work and publication productivity among academic scientists in doctoral-granting departments. *Journal of Higher Education*, *78*(5), 542–571.

Gavin, N.I., Adams, E.K., Manning, W.G., Raskind-Hood, C., & Urato, M. (2007). The impact of welfare reform on insurance coverage before pregnancy and the timing of prenatal care initiation. *Health Services Research*, *42*(4), 1564–1588.

Granovetter, M.S. (1973). The strength of weak ties. *American Journal of Sociology*, *78*, 1360–1380.

Granovetter, M.S. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, *91*(3), 481–510.

Greve, A. (1995). Networks and entrepreneurship—An analysis of social relations, occupational background, and use of contacts during the establishment process. *Scandinavian Journal of Management*, *11*(1), 1–24.

Heffner, A.G. (1981). Funded research, multiple authorship, and subauthorship collaboration in four disciplines. *Scientometrics*, *3*(1), 5–12.

Hilbe, J.M. (2007). *Negative binomial regression*. Cambridge: Cambridge University Press.

Hoang, H. & Antoncic, B. (2003). Network-based research in entrepreneurship: A critical review. *Journal of Business Venturing*, *18*(2), 165–187.

Hogarth, R.M. (1987). *Judgment and choice*. New York: John Wiley & Sons.

Houghton, S.M., Simon, M., Aquino, K., & Goldberg, C.B. (2000). No safety in numbers: Persistence of biases and their effects on team risk perception and team decision making. *Group and Organization Management*, *25*, 325–353.

Hsu, D.H. (2007). Experienced entrepreneurial founders, organizational capital, and venture capital funding. *Research Policy*, *36*(5), 722–741.

Katz, J.S. & Martin, B.R. (1997). What is research collaboration? *Research Policy*, *26*(1), 1–18.

Keh, H.T., Foo, M.D., & Lim, B.C. (2002). Opportunity evaluation under risky conditions: The cognitive processes of entrepreneurs. *Entrepreneurship Theory and Practice*, *27*(Winter), 125–148.

Kenkel, D.S. & Terza, J.V. (2001). The effect of physician advice on alcohol consumption: Count regression with an endogenous treatment effect. *Journal of Applied Econometrics*, *16*(2), 165–184.

Kirzner, I. (1973). *Competition and entrepreneurship*. Chicago, IL: University of Chicago Press.

Krabel, S. & Mueller, P. (2009). What drives scientists to start their own company? An empirical investigation of Max Planck Society scientists. *Research Policy*, *38*(6), 947–956.

Krueger, N.J. (2003). The cognitive psychology of entrepreneurship. In Z.J. Acs & D.B. Audretsch (Eds.), *Handbook of entrepreneurship research* (pp. 105–140). Lancaster, U.K.: Kluwer Academic.

Langer, E.J. (1975). The illusion of control. *Journal of Personality and Social Psychology*, *32*(2), 311–328.

Langer, E.J. & Roth, J. (1975). Heads I win, tails it's chance: The illusion of control as a function of the sequence of outcomes in a chance event. *Journal of Personality and Social Psychology*, *32*(6), 951–955.

Larson, A. (1992). Network dyads in entrepreneurial settings: A study of the governance of exchange relationships. *Administrative Science Quarterly*, *37*(1), 76–104.

Lee, S. & Bozeman, B. (2005). The impact of research collaboration on scientific productivity. *Social Studies of Science*, *35*(5), 673–702.

Lin, N. (2001). *Social capital: A theory of social structure and action*. Cambridge: Cambridge University Press.

Louis, K.S., Blumental, D., Gluck, M.E., & Stoto, M.A. (1989). Entrepreneurs in academe: An exploration of behaviors among life scientists. *Administrative Science Quarterly*, *34*(1), 110–131.

Lowe, R.A. & Ziedonis, A.A. (2006). Overoptimism and the performance of managerial firms. *Management Science*, *52*, 173–186.

March, J.G. (1994). *A primer on decision making: How decisions happen*. New York: Free Press.

Marin, A. (2004). Are respondents more likely to list alters with certain characteristics? Implications for name generator data. *Social Networks*, *26*(4), 289–307.

Mars, M. & Metcalfe, A. (2009). The entrepreneurial domains of American higher education. *ASHE Higher Education Report*, *34*(5), 1–111.

Mars, M. & Rios-Aguilar, C. (2009). Academic entrepreneurship (re)defined: Significance and implications for the scholarship of higher education. *Higher Education*, *59*(4), 441–460.

Marsden, P.V. & Campbell, K.E. (1984). Measuring tie strength. *Social Forces*, *63*, 482–501.

McArthy, S.M., Schoorman, F.D., & Cooper, A.C. (1993). Reinvestment decisions by entrepreneurs: Rational decision-making or escalation of commitment? *Journal of Business Venturing*, *8*(1), 9–24.

Monge, P.R. & Contractor, N.S. (2003). *Theories of communication networks*. New York: Oxford University Press.

Mouw, T., Cook, K.S., & Massey, D.S. (2006). Estimating the causal effect of social capital: A review of recent research. *Annual Review of Sociology*, *32*(1), 79–102.

Nahapiet, J. & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review*, *23*(2), 242–266.

Palich, L.E. & Bagby, D.R. (1995). Using cognitive theory to explain entrepreneurial risk-taking: Challenging conventional wisdom. *Journal of Business Venturing*, *10*(6), 425–438.

Plous, S. (1993). *The psychology of judgment and decision making*. New York: McGraw-Hill, Inc.

Portes, A. (1995). *The economic sociology of immigration: Essays on networks, ethnicity, and entrepreneurship*. New York: Russell Sage Foundation.

Powell, W.W., Cummings, L.L., & Staw, B.M. (1990). Neither market nor hierarchy: Network forms of organization. *Research in Organizational Behavior*, *12*, 295–336.

Rhoten, D. & Pfirman, S. (2007). Women in interdisciplinary science: Exploring preferences and consequences. *Research Policy*, *36*(1), 56–75.

Roux, I., Pretorius, M., & Millard, S. (2009). The influence of risk perception, misconception, illusion of control and self-efficacy on the decision to exploit a venture opportunity. *Southern Africa Business Review*, *10*(1), 51–69.

Rowley, T., Behrens, D., & Krackhardt, D. (2000). Redundant governance structures: An analysis of structural and relational embeddedness in the steel and semiconductor industries. *Strategic Management Journal*, *21*(3), 369–386.

Sandstrom, U. (2009). Combining curriculum vitae and bibliometric analysis: Mobility, gender and research performance. *Research Evaluation*, *18*(2), 135–142.

Santos, J.A. (1999). Cronbach's alpha: A tool for assessing the reliability of scales. *Journal of Extension*, *37*(2), 1–5.

Saxenian, A. (1991). The origins and dynamics of production networks in Silicon Valley. *Research Policy*, *20*, 423–437.

Schwarz, N. & Mark, P.Z. (1994). Judgment in a social context: Biases, shortcomings, and the logic of conversation. *Advances in Experimental Social Psychology*, *26*, 123–162.

Schwenk, C.R. (1986). Information, cognitive biases, and commitment to a course of action. *Academy of Management Review*, *11*(2), 298–310.

Scott, J. (2004). *Social network analysis: A handbook*. London: Sage Publications.

Shane, S. (2003). *A general theory of entrepreneurship: The individual-opportunity nexus*. Northampton, MA: Edward Elgar.

Shane, S. (2004). *Academic entrepreneurship: University spinoffs and wealth creation*. Cheltenham, U.K.: Edward Elgar.

Shane, S. & Cable, D. (2002). Network ties, reputation, and the financing of new ventures. *Management Science*, *48*(3), 364–381.

Shane, S. & Venkataraman, S. (2000). The promise of entrepreneurship as a field of research. *Academy of Management Review*, *25*(1), 217–226.

Simon, M. & Houghton, S.M. (2002). The relationship among biases, misperceptions and introducing pioneering products: Examining differences in venture decision contexts. *Entrepreneurship Theory and Practice*, *27*(2), 105–124.

Simon, M. & Houghton, S.M. (2003). The relationship between overconfidence and the introduction of risky products: Evidence from a field study. *Academy of Management Journal*, *46*(2), 139–149.

Simon, M., Houghton, S.M., & Aquino, K. (1999). Cognitive biases, risk perception, and venture formation: How individuals decide to start companies. *Journal of Business Venturing*, *15*(2), 113–134.

Singh, R.P., Hills, G.E., Lumpkin, G.T., & Hybels, R.C. (1999). *The entrepreneurial opportunity recognition process: Examining the role of self-perceived alertness and social networks*. Academy of Management Meeting.

Slaughter, S. & Leslie, L.L. (1997). *Academic capitalism: Politics, policies, and the entrepreneurial university*. Baltimore, MD: Johns Hopkins University Press.

Starr, J.A. & MacMillan, I.C. (1990). Resource cooptation via social contracting: Resource acquisition strategies for new ventures. *Strategic Management Journal*, *11*, 79–92.

Stephan, P.E. (1996). The economics of science. *Journal of Economic Literature*, *34*, 1199–1235.

Stephan, P.E. & El-Ganainy, A. (2007). The entrepreneurial puzzle: Explaining the gender gap. *Journal of Technology Transfer*, *32*, 475–487.

Stevenson, H.H. & Jarillo, J.C. (1990). A paradigm of entrepreneurship: Entrepreneurial management. *Strategic Management Journal*, *11*, 17–27.

Stuart, T.E., Hoang, H., & Hybels, R.C. (1999). Interorganizational endorsements and the performance of entrepreneurial ventures. *Administrative Science Quarterly*, *44*(2), 315–349.

Stuart, T.E. & Sorenson, O. (2005). Social networks and entrepreneurship. In S.A. Alvarez, R. Agarwal, & O. Sorenson (Eds.), *Handbook of entrepreneurship research* (pp. 233–251). New York: Springer.

Taylor, R. (1975). Age and experience as determinants of managerial information processing and decision making performance. *Academy of Management Journal*, *18*(1), 74.

Terza, J.V., Basu, A., & Rathouz, P.J. (2008). Two-stage residual inclusion estimation: Addressing endogeneity in health econometric modeling. *Journal of Health Economics*, *27*(3), 531–543.

Thorsteinsdottir, O. (2000). External research collaboration in two small science systems. *Scientometrics*, *49*, 145–160.

Torres, L. & Huffman, M.L. (2004). Who benefits? Gender differences in returns to social network diversity. *Research in the Sociology of Work*, *14*, 17–33.

Tversky, A. & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124–1131.

Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly*, *42*(1), 35–67.

Venkataraman, S. (1997). The distinctive domain of entrepreneurship research: An editor's perspective. In J.S. Katz & R.H.S. Brockhaus (Eds.), *Advances in entrepreneurship, firm emergence, and growth* (pp. 119–138). Greenwich, CT: JAI Press.

Wasserman, S. & Faust, K. (1994). *Social network analysis: Methods and applications*. Cambridge: Cambridge University Press.

Wooldridge, J.M. (2003). *Econometric analysis of cross section and panel data*. Cambridge, MA: MIT Press.

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