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Constraining entrepreneurial development: A knowledge-based view of social networks among academic entrepreneurs

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ABSTRACT

While university spinoffs have become a well-accepted vehicle for regional economic dynamism, they face numerous developmental barriers associated with the unique academic context from which they are established. Recent research shows that homophilous social networks among faculty entrepreneurs constitute one such barrier, and yet few studies have investigated the specific characteristics of spinoff networks and their relationship to entrepreneurial development. This paper seeks to address this gap through a mixed-methods research design focused on the composition, contributions, and evolution of social networks among faculty entrepreneurs whose spinoffs are within various phases of entrepreneurship. Employing a knowledge-spillover conceptual lens, this study finds that social networks among early-stage academic entrepreneurs are important for spurring and supporting spinoff establishment, but if they do not evolve from their initial configuration, these networks can largely constrain subsequent stages of spinoff development. Social networks among successful spinoffs, however, evolve with the help of first-order—or boundary spanning—individuals who help socialize academic entrepreneurs to market-oriented motivations, values, and practices that they may not otherwise receive in an academic environment. Further, these individuals provide connections to other contacts who, in turn, provide additional spinoff-enabling resources and contacts. Based on these findings, a conceptual model is introduced that explains spinoff success as a function of network evolution. Implications for research and public policy are also discussed.

1. Introduction

University spinoffs—companies established to transfer and potentially commercialize technologies stemming from faculty research—constitute a unique type of entrepreneurial venture (Doutriaux, 1987; Shane, 2004). An emergent literature explores factors associated with spinoff success and finds, at least conceptually, that networks enable or constrain entrepreneurial development (e.g. Murray, 2004; Wright et al., 2007; O'Gorman et al., 2008; Hayter, 2013a). Academic entrepreneurs, defined here as university faculty who establish a spinoff company based on their research (Shane, 2004), play a particularly important role in the founding and development of university spinoffs. University spinoff companies are embedded within networks of social, professional, and exchange relationships with other actors (Granovetter, 1985) who provide resources important to venture success (Hoang and Antoncic, 2003; Jack, 2010). However, aside from a few, recent exceptions (Rasmussen et al., 2011, 2015), scholars have yet to undertake in-depth analyses of social networks among academic entrepreneurs.

A recent review relates this paucity of research to how theory has developed within the broader entrepreneurship network literature (Hayter, 2013b). Discussed in Section 2, at least three conceptual perspectives are used to frame empirical investigations of entrepreneurship networks. However, these predominant views do not account fully for the unique nature of knowledge, arguably the most important asset for technology-based ventures, including university spinoffs. Technology-based ventures are critical to regional economic growth (Feldman, 1994), but many ventures, especially within the early stages of entrepreneurial development, have yet to develop viable products, much less sales (Link and Ruhm, 2009; Audretsch and Link, 2012). Thus, related to academic entrepreneurship, network theory must not only account for the unique organizational, cultural, and geographic context associated with university spinoffs, it must also consider the inherent uncertainty, asymmetries, and transaction costs associated with economically useful knowledge (Audretsch et al., 2015).

Accordingly, the present investigation employs the knowledge spillover theory of entrepreneurship (KSTE) (Ács et al., 2004, 2009;

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Braunerhjelm et al., 2010). KSTE focuses on individual "agents of knowledge"—in the present case faculty entrepreneurs—and their specific role in knowledge spillover. With KSTE in its empirical adolescence, networks provide a contextual mechanism to explain *how* and *why* knowledge spillover occurs, along with its economic impact (Ács et al., 2009; Hayter, 2013b). Thus, a knowledge spillover approach is employed as an intellectual bridge that not only accounts for the unique nature of knowledge, it also aligns disparate themes in the empirical entrepreneurship network literature, an important step to accelerate the development of theory (Bonardi and Okhuysen, 2011).

This study seeks to address the following research question: What are the contact composition, contribution, and evolution of "business networks" among faculty entrepreneurs—and the relationships of these networks to entrepreneurial development among corresponding university spinoffs (Holm et al., 1999)? Given the aforementioned opportunities within the literature, a mixed-method, methodological approach is taken (Creswell, 2002): A social network analysis (SNA) survey is administered to a theoretically relevant population of academic entrepreneurs in New York State, an area of critical economic and scientific importance in the United States (U.S.). Subsequently, interviews are conducted with SNA survey respondents in order to understand the specific contributions of their network contacts and how their spinoffs evolved over time. Network data are then compared to the entrepreneurial development of the academic entrepreneur's spinoff company by employing Vohora et al.'s (2004) critical juncture framework.

In so doing, the paper makes three distinct contributions to the entrepreneurship network literature: (i) following the extant literature, the study affirms that social networks provide valuable resources and contacts within the unique context of academic entrepreneurship; (ii) however, because of this unique context, early entrepreneurship networks are generally constraining, widening the social distance between academic entrepreneurs and networks important to the success of their spinoff; and (iii) by constructing a taxonomy of network evolution, the study also shows that academic entrepreneurs must rely even more on network intermediaries—boundary spanners—and, potentially, policy innovations to improve entrepreneurial development among spinoffs.

The remainder of the paper is outlined as follows. Section 2 discusses the academic literature related to traditional scientific networks, entrepreneurship networks, and networks among academic entrepreneurs. Section 3 introduces the study methodology, the empirical results are presented in Section 4, including a network taxonomy for spinoff development, and the paper concludes in Section 5 with implications for research and public policy.

2. Previous research

2.1. Knowledge spillover entrepreneurship

Knowledge spillover perspectives of entrepreneurship presume that new knowledge is a critical source of innovation, economic dynamism, and growth (Ács and Audretsch, 1990). KSTE embraces Romer's (1990) assumption that new knowledge is the source of innovation, productivity, and economic growth. Knowledge is created by incumbent firms and research organizations, such as universities (Utterback, 1994), but often goes unexploited. In turn, knowledge spills over to knowledge-based ventures that, even though they may undertake little R&D, are particularly adept at utilizing new knowledge created by other sources (Audretsch et al., 2004, 2005).

KSTE also embraces geographic aspects of knowledge; once created, knowledge tends to spill over within geographically bounded regions, promoting clustering among firms in similar industries (Feldman, 1994; Jaffe et al., 1993; Jaffe, 1989). Integral to clustering is the formation of "entrepreneurial support networks" that aid in the transmission and absorption of knowledge (Saxenian, 1994; Kenney and von Burg, 1999; Piore and Sabel, 1984), otherwise termed an "incubator region" (Schoonhoven and Eisenhardt, 1989), a "social structure of innovation" (Florida and Kenney, 1988), or an innovation or entrepreneurial "ecosystem" (Clarysse et al., 2014; Bahrami and Evans, 2000). Recent research, however, calls into question the primacy of clustering effects, especially within the life sciences, an area particularly well-suited for university contributions (Kenney and Patton, 2005).

KSTE takes issue, however, with traditionally theoretical assumptions that all knowledge is economically useful and spills over "automatically." Knowledge is instead subject to institutional, geographic, and cost constraints (Bercovitz and Feldman, 2008; Feldman, 1994; Jaffe, 1989; Jaffe et al., 1993). Audretsch et al. (2015) posit that spillover is also affected by the properties of knowledge itself. First, the economic value of knowledge is relatively uncertain, especially compared to the more certain nature of information. Second, knowledge is characterized by asymmetry across economic agents; the same knowledge may be assigned different values—or have different expected values—by different economic agents. Third, while the transaction cost for sharing information across economic agents is trivial, the tacit nature of knowledge often requires face-to-face communication, increasing transaction costs.

As mentioned, more empirical research is required to develop KSTE, especially *how* and *why* knowledge spillover occurs (Ács et al., 2009). Due to the uncertain nature of knowledge, KSTE recommends that scholars investigate the role of individual knowledge agents in contrast to a focus on firms. For example, in the present case, academic entrepreneurs are not only responsible for the production of knowledge, they are also the progenitors of entrepreneurial action through which new knowledge is diffused and potentially transformed into useful applications (Ács et al., 2009; Braunerhjelm et al., 2010). In his review of the extant empirical entrepreneurship network literature, Hayter (2013b) recommends that scholars combine the KSTE with network approaches in order to link micro-level entrepreneurial behavior, especially knowledge-intensive entrepreneurship, with broader economic development outcomes and accelerate the development of theory (Bonardi and Okhuysen, 2011). Further, knowledge exchange is bi-directional; while the literature conceptualizes knowledge spill over as "one way," its economic impact relies upon knowledge input from other sources, especially related to its commercialization (Hayter, 2013a).

2.2. Quantifying university spinoff development

Recent research ties knowledge spillovers to the establishment and performance of university spinoffs (Audretsch et al., 2015; Hayter, 2013a). Scholars have used a number of output measures to proxy spinoff performance, including sales growth (Roberts, 1991), sales per employee (Blair and Hitchens, 1998), patents and scientific articles (Zucker et al., 2002), and profitability (Samson and Gurdon, 1993). More recent studies frame spinoff success in terms of technology commercialization (Link and Ruhm, 2009) and employment (Hayter, 2015). Despite their use, scholars lament the inability of output measures to account for technical and developmental progress among early-stage university spinoffs (Shane, 2004). Interestingly, Astebro et al. (2013) find that academic entrepreneurs (within a Swedish context) undertake much higher income risk compared to their university jobs yet realize negligible financial gains.

A spinoff's capability to achieve various performance milestones offers an alternative to output measures. Most common

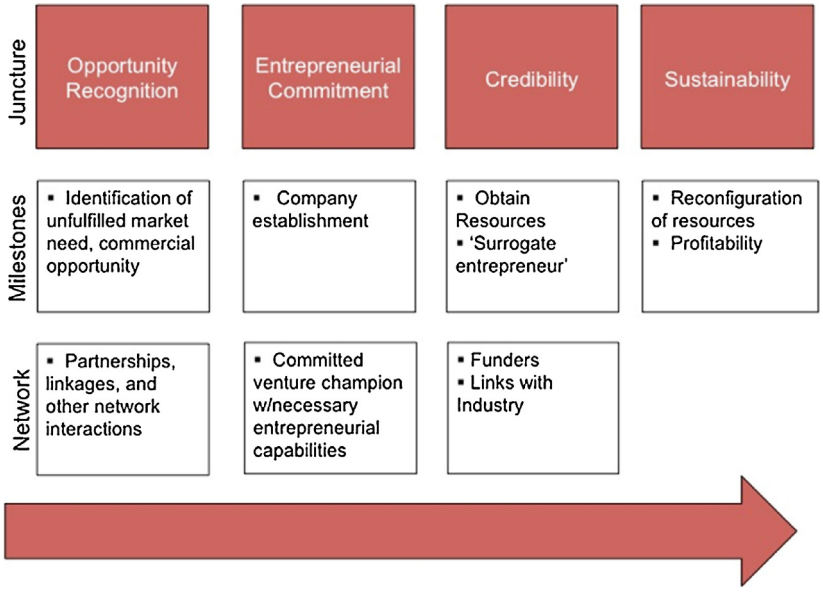

Fig. 1. The critical juncture framework of entrepreneurial development.
Adapted from Vohora et al. (2004).

among these milestones is a spinoff's ability to attract early-stage financing, especially venture capital (Lockett and Wright, 2005; Lockett et al., 2002; Shane and Stuart, 2002; Zucker et al., 2002). Goldfarb and Henrekson (2003) and Shane (2004) view success in terms of whether or not a firm had an initial public offering.

Vohora et al. (2004) view success as iterative and nonlinear, where spinoffs acquire and reconfigure necessary resources, capabilities, and network ties necessary to pass through a series of milestones that they term critical junctures (see Fig. 1). Spinoff development is defined as forward progression though each critical juncture, with the eventual goal of achieving enterprise sustainability. Progression from opportunity recognition to the commitment phase is measured through spinoff establishment while the primary criteria for advancement from commitment to credibility are receipt of early-stage capital and the presence of professional management. Finally, progression from the credibility to sustainability phases is determined by profitability.

2.3. Current conceptualizations of the entrepreneurship network literature

A robust empirical literature examines the social networks among entrepreneurs. Most network studies employ one of three conceptual perspectives (Hayter, 2013b). Early studies of entrepreneurship networks embraced the so-called "network approach to entrepreneurship": networks enable entrepreneurs to acquire information and resources important to their firm and thus have a per se positive benefit (Brüderl and Preisendorfer, 1998; Larson and Starr, 1993). Conversely, the absence of a connection to individuals important to enterprise success within a entrepreneur's social network demonstrates what Burt (1992) terms a "structural hole."

Other scholars frame the contributions of entrepreneurship networks in terms of social capital: high levels of trust mediate barriers to collaboration and receipt of resources (Coleman, 1988; Nohria and Eccles, 1992; Shane and Cable, 2002), typically leading to improved entrepreneurial performance (Aarstad et al., 2010; Pennings et al., 1998). Finally, the so-called relational view (Dyer and Singh, 1998) conceptualizes networks as a hybrid form of organization providing "relational rents" and competitive advantage to firms when they exchange, combine, or co-invest in resources and capabilities, thus reducing transaction costs (Kale et al., 2002; Walker et al., 1997). While most empirical studies view the role of social networks positively, Ruef et al. (2003) find that, due to homophily—the emergence of shared values, functional language, culture, and practices important to professional identities—specific network structures can also have a detrimental impact on entrepreneurial performance. For example, firms can be locked into homophilous relationships with other firms that have few new ideas, diminishing a firm's capacity for innovation (Gulati et al., 2000; Johannisson and Monsted, 1997).

Several commonalities exist among the disparate network perspectives described above. Most ubiquitous, networks provide resources and access to other contacts important for entrepreneurial development (Aarstad et al., 2010; Larson and Starr, 1993). Other shared commonalities (among at least two of the perspectives above) include (1) *network type*—to whom entrepreneurs are connected matters, although network contacts may not possess the resources required for success (Gulati et al., 2000; Human and Provan, 1997); (2) *relationship strength*—entrepreneurs may be connected to individuals with important resources but may or may not provide access (Kim and Aldrich, 2005; Tortoriello and Krackhardt, 2010); and (3) *network dynamism*—networks evolve over time to adapt to a firm's changing resource needs (Greve and Salaff, 2003; Partanen et al., 2008).

Despite relative cohesion among these views, conspicuous gaps exist in the entrepreneurship network literature. Recent exceptions withstanding (Rasmussen et al., 2015), few studies have empirically investigated entrepreneurship networks from an evolutionary perspective in order to explain differences in entrepreneurial development (Jack, 2010; Slotte-Kock and Coviello, 2010). The extant entrepreneurship network literature has also yet to account empirically for the unique nature of technology-based firms such as university spinoffs. Specifically, the aforementioned conceptual views typically treat knowledge as "another resource" without considering its unique spillover properties, its role in innovation and economic growth, or the unique nature of new knowledge generated within universities (Hayter, 2013b). Further, the value of early-stage, knowledge-based companies is difficult to determine given the intangible nature of knowledge and future knowledge production, their most significant asset (Audretsch and Link, 2012).

From the literature, we offer several propositions that help motivate the present study:

Proposition 1. To whom an entrepreneur is connected matters; contacts may (or may not) have access to resources and contacts important for entrepreneurial development.

Proposition 2. Development depends on the *receipt* of resources; entrepreneurs can be connected to contacts but never receive needed resources.

Proposition 3. Networks among successful entrepreneurs may evolve over time while other entrepreneurs may be "locked" into homophilous networks that constrain the entrepreneurial development of their spinoff.

2.4. Networks and spinoff success

The empirical spinoff literature shows networks to be *conceptually* important to the success of university spinoffs (e.g. Hayter, 2013a; Nicolaou and Birley, 2003; Shane and Cable, 2002). Discussed in greater depth below, Vohora et al. (2004) posit that networks are pathways through which opportunity recognition—market insights motivating spinoff establishment—is achieved. According to Wright et al. (2007), "social resources"—to whom network contacts are connected—enable firms to obtain technological, human, and financial resources needed for spinoff development and success (Shane and Cable, 2002). With regard to the receipt of resources, Shane and Stuart (2002) find that venture and angel investors are more likely to invest in spinoffs they know or to which they have been referred by reliable sources; mutual network connections and trust are important determinants of resource receipt (Krackhardt, 1999).

Recent research follows the broader entrepreneurship network research finding that networks can also have a detrimental impact on entrepreneurial performance (Gulati et al., 2000; Johannisson and Monsted, 1997; Ruef et al., 2003). Academic entrepreneurs come from the ranks of university faculty, a specific professional identity and culture subject to high levels of homophily (Bozeman et al., 2001; Crane, 1972; Ruef et al., 2003; Stephan, 2012a,b), which can create a barrier to entrepreneurial success (Hayter, 2013a, 2015). Specifically, academic entrepreneurs embedded within non-commercial academic research environments typically lack the skills and experience important for spinoff success (Druilhe and Garnsey, 2004; Franklin et al., 2001; Mosey and Wright, 2007; Wright et al., 2007).

Conversely, university scientists who have ties to industry, receive industry funding, or possess industry experience are more likely to patent, license, and establish a university spinoff (Audretsch et al., 2005; Dietz and Bozeman, 2005; Gulbrandsen and Smeby, 2005; O'Gorman et al., 2008; Roberts, 1991). Hayter (2013a), for example, finds that commercialization success among a sample of university spinoffs in the United States is dependent on the presence of "external knowledge networks," including the following: external licenses; joint ventures with other companies; experienced, professional managers; and the presence of faculty entrepreneurs with consulting experience.

Bozeman and Corley (2004) find that connections with individuals outside of one's research group, university, or region—so-called *cosmopolitan* networks—positively impact publishing productivity among faculty researchers. Related, Kenney and Patton (2005), in their study of spinoffs that have achieved an initial public offering (IPO), find that extra-regional "entrepreneurial support networks," including venture capitalists, lawyers, and accountants, are critical in the biotech industry, just as Davenport (2005) and Gertler and Levitte (2005) find that firms are increasingly sourcing ideas internationally. From this strain of literature, two additional propositions follow:

Proposition 4. Academic entrepreneurs with linkage to non-academic contacts may enjoy a higher likelihood of spinoff success.

Proposition 5. Cosmopolitan networks—networks outside an academic entrepreneur's group, university, or region—may be important for spinoff development.

3. Research approach

3.1. Research questions

It follows from the literature review above that KSTE offers a conceptual bridge between economic development and the micro-foundations of entrepreneurial action. It is assumed that the objective function of the individual academic entrepreneur is the dissemination and commercialization of new knowledge created in universities vis-à-vis her spinoff; the early-stage development of a university spinoff corresponds with progression toward the development and commercialization of new knowledge. Further, the social networks of founding academic entrepreneurs provide access to "in-flowing" knowledge, resources, and other contacts critical to spinoff development. Based on the literature review above, this paper therefore seeks to address the following research questions:

Q_1: What is the contact composition of social networks among academic entrepreneurs?
Q_2: What is the specific contribution of each network contact, and how does it relate to spinoff development?
Q_3: How do social networks among academic entrepreneurs evolve over time?

In an effort to address these questions, this study investigates social networks within the specific context of academic entrepreneurship in New York, a state of critical importance to the U.S. economy.[1] Important to the investigation is a comparison of network contact composition and contributions to the developmental status of the respective spinoff company.

Following Section 2.2, entrepreneurial development is conceptualized in terms of critical junctures. Fig. 1 illustrates the four critical junctures and the associated resource and network elements associated with each. Entrepreneurial development is further defined as forward progression through each critical juncture utilizing the criteria articulated above, with the eventual goal of achieving enterprise sustainability. Sustainability in the critical juncture framework is usually designated by profitability but, given the early-stage nature of most companies in the sample, this study instead uses commercialization in recognition of the well-documented lag between the two (Link and Ruhm, 2009;

[1] While ranked only 27th out of 50 American states in geographic area, New York ranks fourth in population and has the third-largest economy in the United States, following California and Texas, respectively (see www.census.gov, accessed 25.01.15). It is also home to New York City, the largest city in the United States and a global center for finance, fashion, media, and entertainment.
Despite its economic and cultural importance, the state also contains several regions, especially in the north (i.e. Upstate), that have been in relative decline. These regions include Buffalo, Rochester, and Syracuse. A legacy of their former industrial success, many Upstate regions (along with New York City) enjoy the presence of internationally renowned research universities (see, for example, Table 1) that attract high levels of sponsored research dollars; the state ranks second in total federal R&D funding. However, the state also scores relatively low on measures of innovation and high-tech employment, resulting in what many state policymakers have termed New York's "innovation gap" (see, for example, ITIF, 2012; Milken, 2013).

Table 1
New York research institutions represented in the sample.

Institution	City	Ownership	Enrollment (2012)	Medical school (=1)	Engineering school (=1)
Columbia University	New York City	Private	28,824	1	1
Cornell University	Ithaca	Public/private	22,400	1	1
New York University	New York City	Private	43,911	1	1
State University of New York at Albany	Albany	Public	17,142	0	1
State University of New York at Buffalo	Buffalo	Public	28,952	1	1
State University of New York at Stony Brook	Stony Brook	Public	24,149	1	1
Sloan-Kettering Medical Center	New York City	Private	1682	1	0
Syracuse University	Syracuse	Private	21,029	0	1
University of Rochester	Rochester	Private	10,510	1	1

Rothaermel et al., 2007; Shane, 2004).[2] Further, given that all academic entrepreneurs within the sample have established companies, no spinoff is currently within the opportunity-recognition phase.

Complementing KSTE's concern for various barriers to knowledge dissemination, Vohora et al. (2004) define each critical juncture as a barrier to growth, potentially preventing spinoff transition from one development phase to the next. Based on the literature review above, one might expect to find that progression from one critical juncture to the next is dependent on the presence of non-academic business contacts within the social networks of academic entrepreneurs, especially funders and professional managers, as well as the provision of specific resources important to spinoff success. Conversely, it may be reasonable to expect to find that homophilous social networks that lack critical business contacts may constrain entrepreneurial development among spinoffs.

3.2. Data collection

According to Vohora et al. (2004), the initial venture champion—the academic entrepreneur—plays a key role in initial startup development. In order to investigate their networks, a database of academic entrepreneurs is constructed, the names of whom were obtained from university technology transfer offices (TTOs) located in research universities within New York State. As illustrated in Table 1, nine research universities participated, public and private, submitting a broad range of spinoff companies that vary widely in development, technological focus, and location—from New York City and Rochester, to Ithaca and Syracuse.

The database was constructed in late 2011 based on information about 104 academic entrepreneurs who founded a spinoff between the years 1996 and 2011. A total of 79 individuals agreed to participate in the study, resulting in an effective response rate of 76 percent.[3]

An SNA survey was administered to academic entrepreneurs agreeing to participate in the study. According to Borgatti and Foster (2003), SNA has emerged as an effective method for analyzing networks. SNA enables scholars to view individual or collective agents as social entities embedded within a web of relationships thereby fitting the goals of our investigation (Scott, 2000). Ego-centric network data are collected using a so-called name-generator technique (Renzulli and Aldrich, 2005). Accordingly, academic entrepreneurs within the sample were asked to list their most important "business contacts" with whom "you have collaborated for the purpose of establishing your company and/or commercializing your company's technology."[4] Respondents were also asked to include the full name, position, and organization for each contact. In recognition of Bozeman and Corley's (2004) concept of cosmopolitanism discussed in the literature review, the contact's location is also requested,.

After social network surveys were completed, 127 interviews among 79 academic entrepreneurs were conducted (i.e. most academic entrepreneurs were interviewed twice). Data were collected in person or over the phone over the course of a 14-month period, utilizing an open-ended interview template based on the literature review and the accompanying research questions above. Interviews ranged in length from one-half hour to two and half hours; most were approximately one hour in duration.

Interview preparation and conduct reflect the theoretical themes of the study, including the role of social networks in the bi-directional flow of knowledge important to spinoff development with the eventual goal of enterprise sustainability and, thus, economic development. Prior to the interview, academic entrepreneurs are provided with a brief interview template that focuses on (1) their academic and professional experience; (2) the establishment and operation of their spinoff, including descriptive questions concerning its history, size, and performance; (3) the current developmental state of their spinoff guided by the critical junctures framework (Vohora et al., 2004); and (4) the composition, contributions, and evolution of their social network—the specific focus of this paper. Specific to networks, academic entrepreneurs were asked to refer to their SNA survey and describe the specific contributions provided by their respective business contacts in order of importance. Finally, respondents were also asked to describe how social networks and their corresponding contributions had evolved over time.

Gartner (1989) and Carter et al. (2003) discuss the challenge of hindsight (or recall) bias among entrepreneurs. Roese and Olson (1996) define hindsight bias as the cognitive process by which individuals superimpose structure and simplicity on their recollections of the past. Hindsight bias assumes that antecedents more likely to be recalled are those that are promoted as having causal links to the outcome with other associated factors underreported (Hawkins and Hastie, 1990). Therefore, the study methodology was designed under the assumption that contacts that *were* important to spinoff development but not *currently* deemed "critical" may be underreported, especially among academic entrepreneurs associated with older spinoffs.

[2] Illustrated in Table 3, only two spinoffs within the sample have achieved profitability within the past two years, whereas seven have achieved commercialization.

[3] Potential self-selection bias is an important consideration when using a small, random sample like the one collected for this study. Davidsson (2004), for example, discusses selection bias among individual entrepreneurs, hypothesizing that nascent entrepreneurs are less likely to respond to survey requests compared to more established entrepreneurs. The year of spinoff establishment is available for the sample population of academic entrepreneurs, including non-respondents. As discussed in footnote 10, age is one determinant of spinoff development (among others) and thus appropriate for comparison among respondents and non-respondents. Tests for self-selection found that sample means for venture age did not differ between respondents and non-respondents.

[4] Several studies in the management literature ask respondents to list their five (5) most important contacts (e.g. Nicolaou and Birley, 2003). However, given that there have been few, if any, studies on network differences between faculty entrepreneurs and other types of entrepreneurs, we opt for a more open-ended request: we do not limit the number of network contacts reported.

Table 2
Description of contacts listed by academic entrepreneurs.

Contact	Academic/non	Description
Administration	Academic	University management position above department head, including dean, provost, and president, among others
Advisor	Non-academic	Individual who provides advice related to the establishment and operation of the spinoff but not financial resources
Company researcher	Non-academic	Individual employed by a for-profit company whose principal responsibility is the conduct of research or related activities
Faculty researcher	Academic	Tenured or tenure-track academic researcher employed by a university
Full-time manager	Non-academic	Professional, non-faculty manager assigned to manage a university spinoff
Graduate student/post-doc	Academic	Graduate student or post-doctoral fellow enrolled at a university
Investor	Non-academic	An individual providing financial resources; they may also provide other types of advice and services
Public entrepreneurship support	Non-academic	Individual employed by a government or government-sponsored organization whose main responsibility is to provide assistance to small, newly established companies
Service provider	Non-academic	Individual who provides a service important to the operation and function of the spinoff, including legal, accounting, market analysis, testing, and other services
Technology transfer officer	Academic	Individual working in a university technology transfer office
University entrepreneurship support	Academic	Individual employed by a university whose main responsibility is to provide assistance to university spinoff

Several steps were taken in an effort to account for this hindsight bias. First, most academic entrepreneurs were interviewed twice over a 12-month period and each time asked how the contact composition and contributions within their respective social networks had changed (if at all). The aforementioned interview questions are administered following a narrative approach (Polkinghorne, 1988); all interviews were recorded and analyzed with special attention paid to variation among individual responses. Discussed in greater depth below, reconstructed narratives are shared with respondents highlighting (any) variations among their multiple responses (including the original SNA survey).

3.3. Data analysis

The SNA surveys of academic entrepreneurs yielded the names, position (role), affiliated organization, and location of each reported business contact. From the subsequent interviews, responses were recorded and transcribed; transcripts were read as data were collected. Once the first round of interviews was completed, all responses were coded inductively according to procedures recommended by Kuckartz (2014) and Saldana (2012).[5]

From each initial interview, individual spinoff development narratives were constructed. Narratives reflected the current relative developmental state of each academic entrepreneur's spinoff, the concurrent development of a particular technology or product, and the corresponding composition, contribution, and evolution of the academic entrepreneur's social network. After the first round of interviews, the initial project narratives were compared, yielding multiple emergent themes regarding the specific contributions of network contacts. Following Creswell (2002), the emergence of robust themes enabled a shift from inductivity to a more deductive approach. As mentioned above, respondents were given their individual narratives during the second round of interviews (or shared via email) and asked to validate. Emerging study themes were also shared. This iterative data-collection approach improves the quality of individual responses while enabling triangulation among a disparate study population.[6] The results are reported in Section 4.

4. Empirical results

4.1. Network composition

Each spinoff is associated with an academic entrepreneur who has a social network of business contacts. The 79 faculty entrepreneurs in the sample reported a total of 366 business contacts important to their spinoff, for an average of 4.946 contacts per respondent (standard deviation: 1.293). The number of reported business contacts ranged from a minimum of 2 to a maximum of 8. Table 2 provides a brief description of reported social network contacts differentiating between academic contacts, defined as individuals employed by a university such as administrators and faculty researchers, and non-academic contacts such as investors and advisors.

Fig. 2 presents the 366 reported contacts by frequency, the majority (64 percent) of which are academic. Faculty researchers are by far the most commonly reported network contact type, followed by graduate students and TTOs, which are all academic contacts, defined here as individuals employed by a university. The most common non-academic contact type, advisor, represents the only non-academic counsel available within the social networks of at least 12 academic entrepreneurs. Fewer in number, full-time managers and company researchers follow. University administrators and entrepreneurial support functions are the least commonly reported contacts within the sample.[7]

Fig. 2 also categorizes network contacts by proximity to the academic entrepreneur. The majority of contacts (306) are regional, located with a 50-mile radius of the university spinoff; sixty contacts are located out of the region.[8] While out-of-region contacts constitute only 16.4 percent of social networks in the sample, a

[5] A total of three research team members coded the data, including the author and two colleagues. According to Krippendorff (2004), agreement among multiple coders increases the likelihood that data are reliable. The addition of a third coder allows for a decision to be made when there exist divergent interpretations of binary data between the two other coders. Further, a critical element of data validity is intercoder reliability, the extent to which independent coders evaluate reported data and reach the same conclusion (Neuendorf, 2002). Using (1) percent agreement and (2) Krippendorff's alpha, we find that all coded variables exceed accepted thresholds of intercoder reliability, 90 percent and 0.800, respectively.

[6] Triangulation is the use of multiple or mixed research methods (i.e. a survey and interviews) as well as multiple, iterative data approaches to collect and validate project findings. For an in-depth, foundational discussion of triangulation, see Jick (1979).

[7] These results do not imply that university spinoffs did not receive entrepreneurial assistance, only that academic entrepreneurs did not report them as the most important business contacts, a theme discussed at length later in the paper.

[8] Following Goldstein and Drucker (2006), regional is defined as a location within a 50-mile radius of the university spinoff. This also follows anecdotal reports that venture capitalists typically invest in companies that lie within a 1-h drive of their offices (Saxenian, 1994).

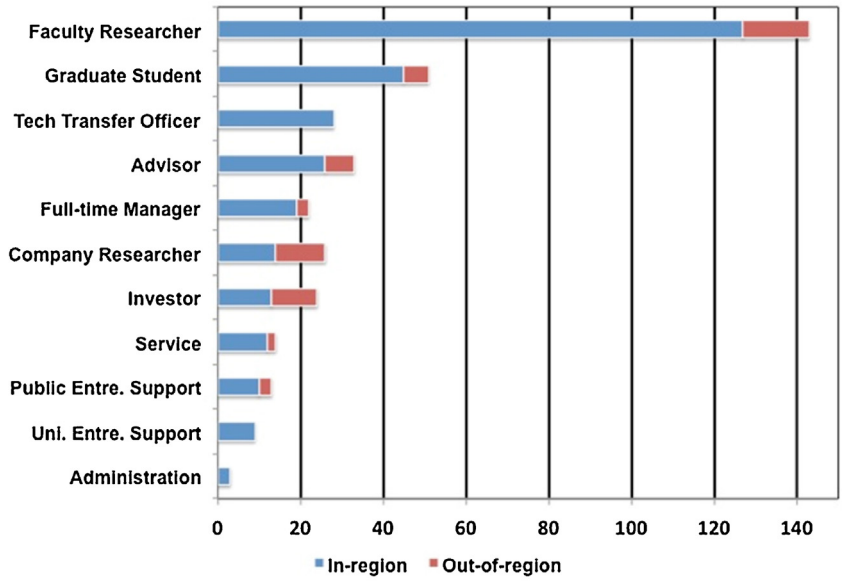

Fig. 2. Network contacts among academic entrepreneurs by frequency.

Table 3
Phase of entrepreneurial development among spinoffs in the sample ($n = 79$).

Juncture	Opportunity recognition	Entrepreneurial commitment	Credibility	Sustainability
Spinoffs	N/A	49 (62.03%)	23 (29.11%)	7(8.86%)
Differentiating factors	N/A	Spinoff established	Early-stage finance Surrogate Entrepreneur	Technology Commercialization, Sales (Profits)
Average spinoff age (in years)	N/A	4.63	6.13	9.86

relatively large proportion of investors (45.8 percent) and company researchers (46.2 percent) are designated as out-of-region.

4.1.1. Network composition by entrepreneurial development phase

Table 3 categorizes spinoffs in terms of a critical juncture framework (Vohora et al., 2004). All entrepreneurs in the sample established a spinoff company and were thus deemed to have achieved the entrepreneurial commitment phase. Entrepreneurial success (sustainability) in the framework is usually designated by profitability, but given the early-stage nature of most companies in the sample, commercialization—defined as sales of a related product or service—is used instead in recognition of the well-documented lag between the two (Link and Ruhm, 2009; Rothaermel et al., 2007; Shane, 2004).[9]

Table 3 also provides average spinoff age by critical juncture: spinoff development appears to be a function of age.[10] However, age variance is highest among spinoffs in the entrepreneurial commitment phase, ranging from 1 to 15 years, with 20 spinoffs older than 5 years. In short, some spinoffs and their associated networks do not necessarily develop as quickly as others within the sample.

Fig. 3 categorizes each network contact by its relative contribution by spinoff development phase (also see Appendix A). Academic contacts, especially faculty researchers and, to a lesser extent, graduate students, comprise the largest proportion of contacts among spinoffs in the entrepreneurial commitment phase. In contrast, later stage spinoffs are primarily associated with non-academic contacts, including company researchers, managers, and investors, while no faculty researcher contacts are reported among spinoffs in the sustainability phase.

4.2. Network contributions by spinoff development phase

In addition to network composition, the specific contributions of each contact are explored to help explain spinoff development. Table 4 presents the resource contributions among all network contacts reported in order of frequency. Following the entrepreneurship network literature (Jack, 2010; Hoang and Antoncic, 2005), advice—specified below within specific knowledge domains—is the most commonly reported contribution among academic and non-academic network contacts, followed by ties ("connections") to other contacts.

The next four contributions, including influence to establish a spinoff (basic) research assistance, co-founder, and establishment assistance, are primarily attributed to academic contacts (discussed below), reflecting the large proportion of university employees within social networks among academic entrepreneurs. Though lower in frequency, internal advocacy, IP services, university practices (from other universities), and time/energy are

[9] Only two spinoffs within the sample have achieved profitability within the past two years, whereas seven have achieved commercialization.

[10] A continuous ratio model is constructed for this paper whereby several factors are tested for their impact on progression through the critical juncture framework. Feinberg (1980) recommends the continuous ratio model when dependent variable categories represent a relative progression of stages or events through which an entity can advance. Given limitations with ordered logit (and probit) models, the progression logic of the continuous ratio model fits well the linear critical juncture model of entrepreneurial development. With age, other variables include the number of contacts, a dichotomous measure of academic and outside region, non-academic contacts, and consulting or industry experience among academic entrepreneurs. Specific to this discussion, the age variable is positive and significant in all versions of the model, though results are weak relative to the other variables of interest. For every unit (year) increase in age, the odds of advancing to the next category of development increase by a factor of approximately 1.1 (ranging from 1.084 to 1.117). Results available upon request.

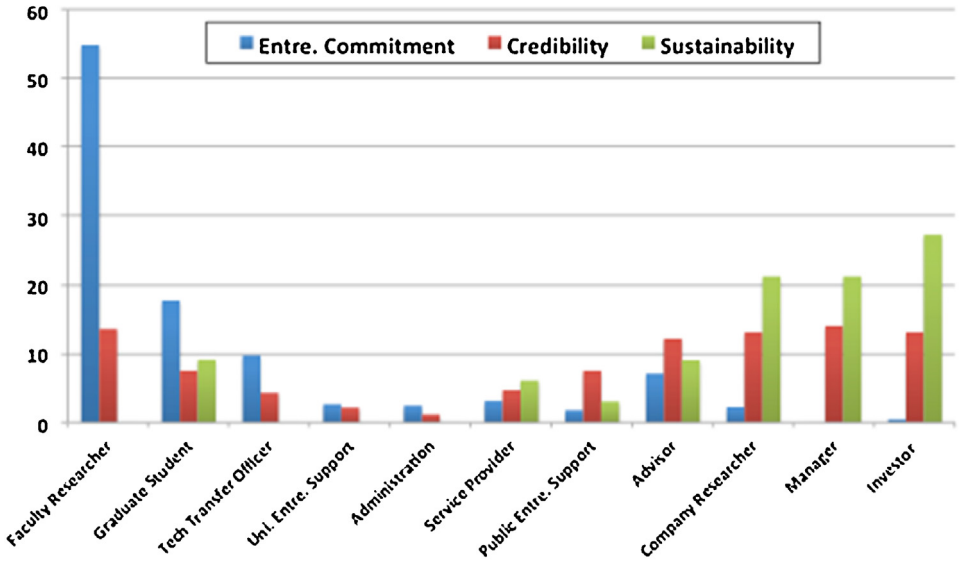

Fig. 3. Composition of network contact type by entrepreneurship development phase.

also contributions primarily ascribed to academic contacts. In contrast, commercialization and product development, funding, management, testing, and accounting are primarily attributed to non-academic contacts in both relative and absolute terms.

Table 5 reports the primary contributions of each reported individual contact. The sections below explore in greater depth the respective contributions of academic and non-academic network contacts.

4.2.1. Academic contacts

4.2.1.1. Knowledge spinoff establishment and early-stage technical knowledge. The primary contribution of the majority of academic contacts in the sample, including the 143 faculty contacts, 51 graduate students, and 3 administrators, is knowledge and assistance related to the establishment of a new spinoff company. Unique contributions among faculty include knowledge of university policies governing spinoff and the receipt of encouragement and tacit approval for the startup decision. Graduate students uniquely act as catalysts, convincing academic entrepreneurs to establish their spinoff company and then providing the time and leadership needed to do just that; in at least 23 cases, graduate students are reported as critical to the existence of an individual spinoff.

> [This company] would not exist today, were it not for [my graduate student]... who convinced me over time to start a company and do something with our technology. He really saw its potential...and what was really important was that he has the time and energy to do this.

Both faculty (29) and graduate students (25) are designated as co-founders, while the role of graduate students may also include overseeing company research efforts (25), recruiting other graduate students to the spinoff (7), or serving as CEO (6).

The second primary contribution of faculty and graduate students is research assistance focused, in the early phases of spinoff, on relatively fundamental scientific problems. Graduate students are typically involved in the academic research of faculty and work on research within a spinoff context similar to their role within a university laboratory. However, faculty researchers associated with more developed spinoffs—while fewer in number—are relatively new contacts sought out for their specific technical expertise. These individuals are often located outside the local region and

Table 4
Value attributed to contacts within the sample ($n = 366$).

Benefit Provided	Academic	Non-academic	Total	Percent of contacts providing	Percent of responses
Advice	114	86	200	54.64	21.01
Connections	80	65	145	39.62	15.23
Influence to establish	94	7	101	27.60	10.61
Research assistance	77	14	91	24.86	9.56
Co-founder	65	6	71	19.40	7.46
Establishment assistance	46	18	64	17.49	6.72
Commercialization/product development	21	33	54	14.75	5.67
Funding	11	40	51	3.93	5.36
Management	14	35	49	3.39	5.15
Internal advocate	31	0	31	8.05	3.26
IP services/polices	29	0	29	7.92	3.05
Testing	0	18	18	4.92	1.89
University practices	17	0	17	4.64	1.79
Time/energy	11	0	11	3.01	1.16
Accounting	0	5	5	1.37	0.53
Other	4	11	15	**	1.58
	614	338	952		100%

Table 5
Primary contact contributions by development phase.

	Entrepreneurial commitment	Credibility	Sustainability
Faculty researcher	Advice influence to establish research assistance	Research assistance commercialization and product development	[a]
Graduate student	Establishment assistance co-founder research assistance influence to establish	Research assistance	Research assistance
Technology transfer officer	IP services advice connections	IP services	[a]
Uni. entre. support	Advice, connections funding	Funding	[a]
Administration	Influence to establish internal advocacy publicity	Internal advocacy publicity	[a]
Advisor	Advice part-time management establishment assistance connections	Advice connections	Advice connections
Public entre. support	Funding connections advice	Funding connections	Funding
Company researcher	Research assistance	Commercialization and product development testing	Commercialization and product development
Full-time manager	[a]	Connections management advice	Management
Service provider	Advice	Advice	Testing prototyping/manufacturing
Investor	Advice	Connections advice funding	Connections advice funding

[a] Indicates that no contacts were present in the social networks of academic entrepreneurs whose spinoff was within this developmental stage.

focused primarily on later stages of technology development closer to commercialization.

4.2.1.2. Services, seed funding, and connections. TTOs and university entrepreneurship support personnel were often described as the first connections made relating to the mechanics of spinoff establishment. Academic entrepreneurs first interact with TTOs during the initial university technology disclosure process mandated by the Bayh-Dole Act of 1980.[11] TTOs (all 28 within the sample) provide intellectual property (IP) services and related knowledge, including an explanation of university, state, and federal IP policies, patent filing, IP maintenance, and IP ownership options relating to the establishment of a new spinoff. TTOs or university entrepreneurship support personal also help explain the range of university (and, at times, government) services available to the academic entrepreneurs, including incubator facilities and (internal) early-stage venture funds. Uniquely, university entrepreneurship services personnel help academic entrepreneurs understand the legal and regulatory requirements of establishing a small business.

Both TTOs and university entrepreneurship support personnel were also deemed important for their role connecting academic entrepreneurs to other contacts. TTOs connected academic entrepreneurs to other valuable contacts including advisors, university entrepreneurial assistance program officials, and public entrepreneurship support program personnel. In at least seven cases, TTOs also connected academic entrepreneurs to managers and investors who had yet to become valued business contacts. University entrepreneurship services personnel also connected academic entrepreneurs to public entrepreneurship support personnel able to provide to low-interest loans and training related to a number of specific business-related matters, including benefits selection, contracting, import/export assistance, and business plan development.

[11] The Bayh-Dole Act placed responsibility for managing technologies stemming from federally funded research in the hands of research universities. This responsibility includes ensuring that faculty inventors disclose technologies arising from their research. Further, universities can elect to claim title to the disclosed technology. If title is claimed, universities must file for patent protection and issue a paid-up, non-exclusive license to the government. See Bradley et al. (2013a,b) for a more in-depth discussion of Bayh-Dole and a review of related research.

4.2.2. Non-academic contacts

4.2.2.1. Bridging connections and technical and early-stage spinoff development. The contributions of advisors, public entrepreneurship support personnel, and some company researchers include the ability to connect academic entrepreneurs with other important contacts while providing knowledge and enabling resources critical to spinoff development that, in turn, strengthen relationship ties to the new contacts. In other words, these bridging contacts serve as network intermediaries helping academic entrepreneurs transition to a more commercial and product-oriented focus important for spinoff success, especially early in the development of the spinoff (between the commitment and credibility phases). Effective advisors and "entrepreneurs-in-residence" (EIRs), the latter a public program to pair advisors with academic entrepreneurs, do this by developing business strategies and handling many of the day-to-day managerial decisions of the spinoff; these individuals become part-time spinoff managers. Further, some public entrepreneurship support personnel provide complementary grants and services to help academic entrepreneurs establish their company and, in the case of one program, modest financial support to help spinoffs develop a technology proof-of-concept.

Several advisors and EIRs work with multiple spinoffs. For example, one individual advisor was listed as a common business contact among nine spinoffs located at three universities. A former executive at a large multinational technology corporation and himself an entrepreneur, the work of this particular individual highlights the intermediary role of many advisors and EIRs who connect academic entrepreneurs to other non-academic contacts who are especially important for further developing their technology. These connections, along with the accompanying developmental services, promote network knowledge exchange related to (1) the nature and potential of specific spinoff technologies; (2) markets, potential and existing, that may be a target for the aforementioned technology; and (3) guidance related to further spinoff development required to commercialize technology.

Though similar, the contributions of company researchers focus primarily on product and technology commercialization. Contributions early in the development of the spinoff come in the form of research assistance including sponsored/joint research projects, consulting arrangements (for the academic entrepreneur), and co-publication. As this relationship develops, however, the role of company researchers evolves to the provision of knowledge related to technology development, prototyping, product design,

Table 6
Previous and latent network contact type (by spinoff).

	Entrepreneurial commitment	Credibility (33)	Sustainability (7)
Previous ("diminished tie") contacts	N/A	Faculty researchers (21) Public entre. support (3) Tech transfer officer (7)	Advisor (4) Company researcher (3) Faculty researcher (7) Public entre. support (1)
Latent contacts	Advisors (7) Investors (4) Managers (2) Public entre. support (3)	Company researchers (11) Investors (8)	Company researchers (1) Faculty researchers (3) Investors (3)

testing, and market potential. Further, company researchers can connect academic entrepreneurs to other intra-company contacts, such as marketing personnel and corporate venture capitalists, who provided (or can provide) knowledge and financial resources important for later-stage spinoff success.

4.2.2.2. Connections for commercialization, along with management, early-stage funding, and services. In latter stages of development, spinoffs must capitalize on obtained knowledge and resources to develop a commercializable product. The contributions of full-time, professional managers, investors, some company researchers, and service providers best enable spinoffs within the sample to develop, transitioning between the credibility and sustainability phases. While academic entrepreneurs value professional managers' ability to manage strategic and day-to-day spinoff affairs (19 out of 22) and the financial resources provided by investors (18 out of 24), these contacts are most valued for their contacts, especially to company researchers and investors who can provide technology and market-related knowledge that can enable commercialization.

> Everybody always focuses on raising capital and getting a manager on board. . .that's important but the real value of these guys is their networks. Obviously they want to see you do well so they're always looking to see who to set you up with next. . .it's the people they know who really help you along. . .the funding is just a way to keep you going in the meantime.

Specific to the 24 investors within the sample, 14 are early-stage angel investors while 10 are venture capitalists. In at least four cases, angel investors worked with other network contacts to guide spinoffs toward product development (as described above) and then connected academic entrepreneurs to venture capitalists. In several cases, weak ties existed between investors and academic entrepreneurs for several years before a spinoff received funding. According to respondents, it was not until "[the part-time CEO] came on board and got us focused on developing our product did he [an angel investor] begin to take notice."

Funders and professional managers also connected academic entrepreneurs with service providers (14 within the sample) who provided knowledge and other resources critical to spinoff development. Specifically, these contacts provided knowledge relating to intellectual property, contract law, accounting, and policy. Specific services included product testing, quality control, and manufacturing.

To summarize, this paper finds that the primary contribution of academic contacts is knowledge that motivates the spinoff decision and supports actual spinoff establishment. Some non-academic contacts—here deemed network intermediaries—help bridge academic and non-academic networks while providing knowledge that relates to technology commercialization and markets allowing spinoffs to develop and demonstrate their potential to other critical non-academic contacts. Finally, other non-academic contacts, especially full-time, professional managers, investors, and service providers, provide knowledge and enabling resources that relate specifically to technology commercialization and product development, pushing spinoffs closer to sustainability.

4.3. Network evolution

In order to understand the role of social networks in spinoff success, the evolution of contacts and their contributions are examined over time. Table 6 captures network dynamism by contact type: individuals who, according to academic entrepreneurs, were active in spinoff development but are no longer reported as a critical business contacts in the social network survey. Contacts at the bottom of Table 6 are deemed latent; as discussed, academic entrepreneurs are loosely connected to these contacts but the relationship remains weak and no knowledge or enabling resources are provided. Based on this data and the sections above, we construct a general conceptual model (see Figs. 4 and 5) to explain how social networks among academic entrepreneurs (co)evolve with the development of university spinoffs.

Fig. 4 represents the ego-centric social networks of spinoffs within the entrepreneurial commitment phase (on the left) and the network for spinoffs that have progressed beyond (right). Ties to faculty researchers and graduate students are ubiquitous among academic entrepreneurs. These academic contacts are designated as *first-order* to reflect their early connective role within the network: first-order academic contacts connect academic entrepreneurs to *second-order* academic contacts, including other faculty entrepreneurs, TTOs, and university entrepreneurship services. While some relationships existed, others remained latent (represented by Tie A, the red dashed line) until connected.

As discussed, academic entrepreneurs associated with spinoffs in the entrepreneurial commitment phase have few non-academic contacts within their social networks. The majority of academic entrepreneurs with spinoffs in the entrepreneurial commitment phase were not connected to relevant, non-academic contacts thus demonstrating Burt's (1992) structural hole phenomenon illustrated by Tie B. Several entrepreneurs reported that they had met, and in many cases knew, investors, managers, and advisors either on their own or through second-order academic contacts. However, these relationships remained latent (Tie C) for the majority of academic entrepreneurs.

Illustrated by Tie D on the right side of Fig. 4, spinoffs that progress out of the entrepreneurial commitment phase do so through first-order, non-academic contacts, especially advisors and public entrepreneurship support personnel. In three cases among more developed spinoffs, however, first-order non-academic contacts included investors who, in turn, connected academic entrepreneurs to advisors. Thus, the value of first-order non-academic contacts is not only the knowledge and enabling resources they can provide academic entrepreneurs but also their connections, latent or realized, to second-order, non-academic contacts represented by Tie E.

Fig. 5 represents spinoffs that have achieved the credibility phase (left side) and spinoffs that have progressed to sustainability (right). Spinoffs in the credibility phase have received

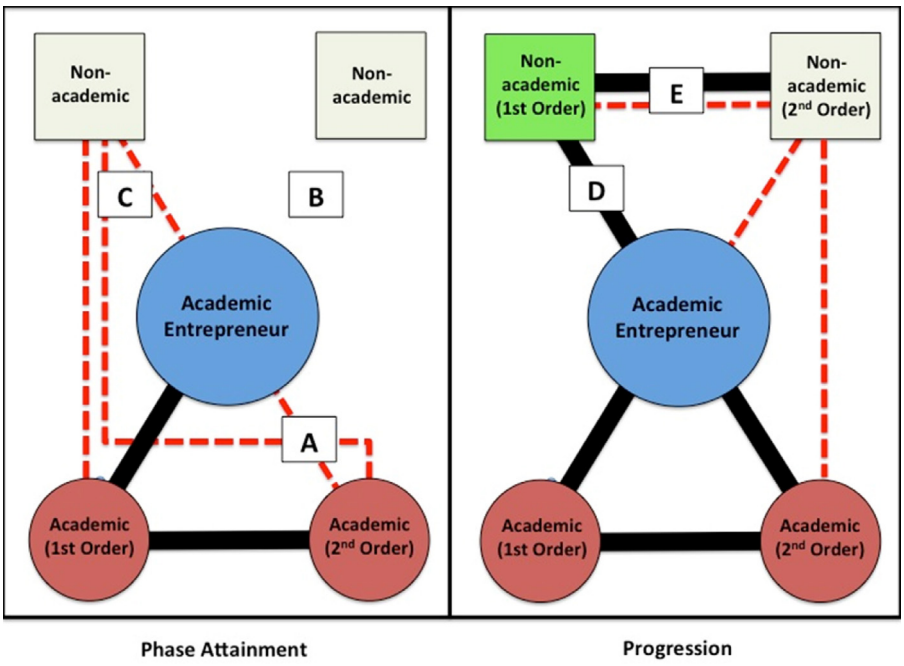

Fig. 4. Network evolution from entrepreneurial commitment to credibility.

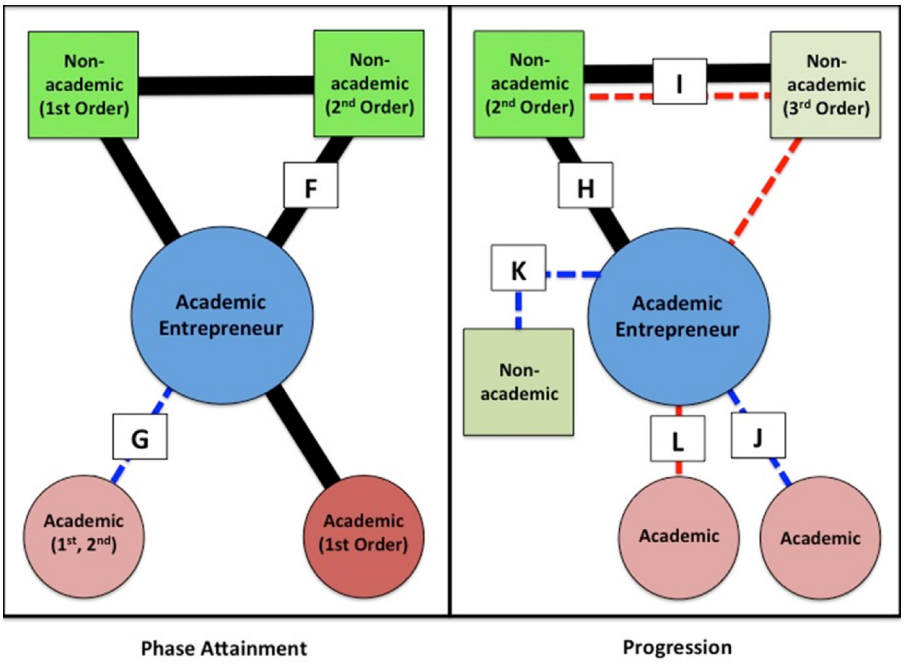

Fig. 5. Network evolution from credibility to sustainability.

significant knowledge and resources from first-order contacts; their relationship is strong. Interestingly, in cases where the academic entrepreneur knew a second-order, non-academic contact (but strong ties did *not* exist), working with a first-order contact who also knew the second-order contact resulted in a *de facto* endorsement for the academic entrepreneur, thus strengthening the relationship represented by Tie F.[12] Finally, as an academic entrepreneur's network evolves, some academic contacts (represented by Tie G), especially faculty researchers, TTOs, and university entrepreneurship support programs, become relatively less important and were thus not deemed critical business contacts.

Spinoffs that progress out of the credibility phase (right side of Fig. 5), have received knowledge and other resources from second-order contacts, in the form of a full-time manager, commercialization assistance, and angel and early-stage venture capital, represented by Tie H. As academic entrepreneurs and their spinoffs become increasingly technology commercialization-focused, they seek contacts—often vis-à-vis their second-order non-academic contacts—expert within their respective technological field represented by Tie I. In other words, second-order contacts connect

[12] This triadic relationship closely resembles what Krackhardt (1999) defines as a Simmelian Tie, whereby two individuals are reciprocally and strongly tied to one another and they are reciprocally and strongly tied to at least one third party in common.

spinoffs to other, *third-order* contacts who can provide resources important for spinoff success, similar to the role of first-order contacts in the progression from entrepreneurial commitment to credibility. While academic entrepreneurs with second- (and third-) order contacts seem to have successfully bridged academic and non-academic networks, the development of their spinoffs may still be constrained by geographic limitations.

Expertise relevant to the technical and commercial direction of the spinoff may not exist within the regions where universities and their corresponding spinoffs are located (e.g. Ithaca possesses relatively few resources for the development of medical devices compared to Minneapolis, Minnesota, a well-known development hub). This explains why, within our sample, many second- and third-order contacts, including investors and company researchers, are located outside the region of the spinoff. In relative terms, investors are the most likely contact type to be located out of region. For example, out of the 10 reported venture capital contacts, seven are located out of region (San Francisco area [3]; New York City [2]; Boston area [1], and; Minneapolis [1]), while the three in-region VCs are located in New York City. In at least four cases, out-of-region investors have provided connections to "local" contacts who could assist academic entrepreneurs. For example, a Minneapolis-based venture capitalist specializing in medical devices connected an academic entrepreneur to a precision manufacturing company in Minnesota to help the spinoff develop product prototypes.

As illustrated by Fig. 3, spinoffs that progress out of the credibility phase report no academic contacts among their current business networks with the exception of three graduate students. This does not mean, however, that academic contacts are not associated with successful spinoffs, it is only to say that their role, represented by Tie J, has diminished in relative importance. Similarly, some first- and second-order non-academic contacts, including advisors, public entrepreneurship support personnel, company researchers, and angel investors, also decline in relative importance (Tie K).

As a spinoff evolves, so does the role of the founding academic entrepreneur. Within most spinoffs in the credibility phases and all spinoffs in the sustainability phase, full-time professional managers had assumed operational responsibility from the academic entrepreneur. Subsequently, academic entrepreneurs often assumed the role of chief scientific officer (CSO) or external advisor/consultant.

From a network perspective, after some level of necessary spinoff development—here during the transition from credibility to sustainability—academic entrepreneurs maintain ties with a few "trusted individuals" related to their spinoff (i.e. professional manager and key funders) but cede management of other non-academic relationships to these individuals. As this happens, academic entrepreneurs (re)focus their efforts on basic research (albeit related to the long-term technological needs of the spinoff) and become interested in meeting and building ties with faculty researchers they do not know (represented by Tie L). In short, founding academic entrepreneurs associated with spinoffs that have successfully transitioned to the sustainability phase have developed entrepreneurship networks that allow them to step away from day-to-day spinoff operations, perhaps completing the evolution of their entrepreneurship network. Yet, their evolved social networks ensure that useful academic knowledge can more easily spill over and increase the likelihood for commercial application compared to prior circumstances.

5. Discussion

This study inductively investigates the composition, contributions, and evolution of social networks to develop a framework for evaluating the development of university spinoffs. Motivated by opportunities in the extant literature, the paper employs the knowledge spillover theory of entrepreneurship by incorporating multiple facets from the extant literature while accounting for the unique nature of new knowledge. Specifically, networks are conceptualized as a contextual variable: bi-directional conduits for the exchange of knowledge and other resources important to entrepreneurial and economic development.

The extant literature views entrepreneurship networks as a critical source of resources and other connections important to early-stage entrepreneurship. This study similarly shows that networks also facilitate access to knowledge and other important enabling resources, such as funding and management, along with other contacts within the context of academic entrepreneurship. However, unique challenges exist for university spinoffs relative to other, non-academic entrepreneurial ventures that may affect entrepreneurial development.

Related to the first research question (Q_1), this paper finds that academic entrepreneurs in the early stages of spinoff establishment define "business contacts" in a way that reflects their primary professional environment as university faculty. Nearly two-thirds of their network contacts are comprised of *other* academic contacts, especially faculty researchers and graduate students, typically located within the academic entrepreneur's home institution. In other words, faculty colleagues and graduate students provide the knowledge, influence, and human resources central to the motivation and support of the *initial* establishment of a university spinoff, and while they generate high levels of social capital, they do not generally possess the knowledge or networks necessary to accelerate spinoff development. In short, these academic entrepreneurs may not fully understand the limitations of relying on their colleagues and students to enable entrepreneurial success over the long term.

Beyond faculty colleagues and graduate students, academic entrepreneurs typically viewed TTOs or university entrepreneurship support services as the first point of contact related to the establishment and development of a spinoff. Related to the second research question (Q_2), these offices were viewed as a primary source of (nominal) resources and connections, in some cases several years after spinoff establishment. Although the role and influence of technology transfer personnel on academic entrepreneurship, for example, is well established within the literature (Rothaermel et al., 2007; Phan and Siegel, 2006), relationships between academic entrepreneurs and TTOs have yet to be framed in terms of a network opportunity cost, a point well made within the entrepreneurship network literature (e.g. Lechner et al., 2006; Hoang and Antoncic, 2003). In other words, connections to other contacts might better provide academic entrepreneurs with the resources and additional connections needed to develop their spinoff company.

The presence and impact of influential academic contacts comports well with the literature on strong homophilous networks within scientific communities (Bozeman et al., 2001; Crane, 1972; Bozeman and Corley, 2004) and the more recent literature on so-called peer effects (Aschhoff and Grimpe, 2014; Tartari et al., 2014). Within the sample, homophilous academic ties and their relatively homogeneous contributions—motivating and supporting the spinoff decision—further constrain entrepreneurial development due to their own limited access to resources and contacts important for entrepreneurial development. These findings support the aforementioned research related to the entrepreneurship challenges faced by faculty with long research careers (Goldfarb and Henrekson, 2003; Mosey and Wright, 2007; Murray, 2004; Franklin et al., 2001) as well as empirical entrepreneurship network studies that highlight the potential detrimental impact of specific network structures on firm performance (Ruef et al., 2003; Gulati et al., 2000; Johannisson and Monsted, 1997). In short, not only do university

spinoffs face challenges associated with all entrepreneurial ventures, they must also bridge a yawning social gap—Burt's (1992) structural hole—between traditional academic social networks and more market-oriented entrepreneurial networks. As discussed in Section 4.2 (and related to our second research question, Q_2), bridging is important because it connects academic entrepreneurs to non-academic contacts who can provide the resources and additional contacts necessary to advance to the credibility phase.

Related to our third research question (Q_3), we examine how bridging occurs by constructing a conceptual taxonomy of network evolution. First, supporting previous literature on absorptive capacity (Cohen and Levinthal, 1990) and more recent work on network competence (Ritter and Gemunden, 2003) or capability (Walter et al., 2006), this paper finds that non-academic contacts designated as "first-order"—otherwise known in the network literature as boundary-spanners—helped to socialize faculty entrepreneurs to market-oriented motivations, values, and practices that they may not otherwise receive in an academic environment. First-order contacts within the present sample include advisors and public entrepreneurship support personnel. Specific examples of assistance include business plans, elevator pitches, and product-focused development.

Second, this paper finds that first-order contacts connect—or, in some cases, reconnect—academic entrepreneurs to other important (2nd order) non-academic contacts, including professional managers, company researchers, and angel investors. The combination of these connections with the accompanying improvement in entrepreneurial skills (and related spinoff development) together create an endorsement effect reducing resource investment risk for other network contacts, especially angel and venture capitalists (Shane and Stuart, 2002). From a knowledge spillover perspective, an endorsement effect helps to mitigate asymmetries among economic actors, thereby increasing the bi-directional "flow" of knowledge.

Finally, there is decidedly spatial aspect associated with bridging these network gaps among spinoffs within our sample; a long-standing tradition in economy geography literature finds that places matter to innovation and entrepreneurship (Feldman, 1994; Audretsch and Feldman, 1996; Saxenian, 1994). The findings show that extra-regional social networks play a critical role in bridging geographies supporting a modest literature that deems extra-regional networks important for entrepreneurial success (Davenport, 2005; Gertler and Levitte, 2005; Kenney and Patton, 2005). Extra-regional networks are especially important for spinoffs within the credibility phase: knowledge and enabling resources needed to advance spinoff development (especially to the sustainability phase) may not exist within regions where spinoffs are located.

5.1. Implications for theory

Important to theory, disparate conceptual perspectives are reconciled within the extant entrepreneurship network literature by employing a knowledge spillover approach embodied in KSTE. In so doing, this paper not only addresses many conceptual shortcomings of the entrepreneurship network literature, it also provides an intellectual bridge between it and the extant spinoff literature that has yet to empirically analyze the specific contact composition or contributions of social networks among academic entrepreneurs. The present sample of university spinoffs varies greatly by age, technology, university, and location. Social networks are advanced here as at least one "missing link"—among others—necessary to explain the developmental success of these spinoffs and, theoretically, how and why knowledge spillover occurs (Ács et al., 2009). Further, the study demonstrates the utility of investigating individual-level social networks compared to more common investigations of inter-firm networks.

Augmenting a knowledge-based view with a social network approach adds empirical detail to the emergent KSTE. First, knowledge flows may be conceptualized as bi-directional. With the establishment of a new spinoff company, academic entrepreneurs create another pathway for knowledge dissemination beyond traditional publishing outlets, teaching, and service. However, the impact of that knowledge depends on spinoff development and the corresponding commercialization of technology. Supporting Hayter (2013a), this study shows that external sources of knowledge are critical to spinoff success, especially relating to technology development. Thus, network connections and their ability to provide in-flows of knowledge important to success, not just financial and management resources, constitute an important consideration for the emerging theory.

Related, the results show that within the context of academic entrepreneurship, firm establishment—an oft-cited measure of the contributions of research universities: the *number* of spinoffs—must be conceptually disentangled from the *exploitation* of university knowledge. In other words, even though academic entrepreneurs may establish a company, they may not have the capability to be appropriately opportunistic until they possess the skills and networks to reduce knowledge asymmetries and improve their understanding of what is needed for technology commercialization. Following recent developments (Hayter, 2013b; Rasmussen et al., 2011; Rasmussen et al., 2015) scholars would do well to explore these themes further.

Finally, related to geography, knowledge spillover-based studies of regional economic development have yet to fully account for extra-regional networks at an individual level, viewing knowledge spillovers as a predominantly local phenomenon. As mentioned, Kenny and Patton (2005) show that individual board members for startups that have undertaken an IPO are located all over the United States, depending on the corresponding industry and technology. Future investigations can contribute to theory by investigating the extent to which academic entrepreneurs in other regions and within specific industry and technology contexts rely upon extra-regional networks. Further, a research greenfield remains for scholars to investigate the motivations, structure, and evolution of extra-regional networks utilizing a knowledge spillover lens. Specific to theory building, can tacit knowledge exchange occur over long distances and, if so, how does this occur and what are the mediating factors to its flow? Further, how does extra-regional knowledge exchange differ among specific regions?

5.2. Implications for policy

Research universities are increasingly valued for their contributions to regional economic development (Shane, 2004; Slaughter and Rhoades, 2004). University spinoffs are potential vehicles for economic development; companies established within the sample are no exception. Spinoffs within our sample employ over 500 individuals, and several spinoffs have received venture capital, with seven achieving technology commercialization.

With regard to entrepreneurial success, policymakers and scholars have placed much focus on the so-called "valley of death," a clever, if not overused metaphor to demonstrate the technical and resource-based challenges faced by university spinoffs (and other high-tech entrepreneurial ventures). Accordingly, national and regional governments have adopted entrepreneurship support policies and programs, including incubators, seed funds, and entrepreneur-in-residence programs, in hopes of providing spinoffs with technical, financial, and human resources needed for growth (Autio et al., 2014; Bradley et al., 2013a; Clarysse et al.,

2014). Given these findings, a programmatic focus on resource provision may be, at least in the case of early-stage university spinoffs, premature. In other words, rarely among policymakers are the performance and related economic impact of entrepreneurial ventures conceptualized in terms of social networks—or in terms of an overall network architecture—needed to provide the knowledge and resources important for entrepreneurial success.

Recent policy interest in so-called proof-of-concept centers (PoCCs) (Bradley et al., 2013b; Hayter and Link, 2015; Gulbranson and Audretsch, 2008), along with long-established regional networking programs such as UCSD CONNECT, may be exceptions. Further, inquiries that investigate organizational innovations within higher education, such as the robust literature that examines the structure and impact of the National Science Foundation Engineering Research Centers (ERCs), may be another venue by which to examine entrepreneurial behavior and how these research-related organizations relate to entrepreneurial development (e.g. Ponomariov and Boardman, 2010).

5.3. Limitations and research agenda

Future investigations will hopefully overcome some of the data limitations of this paper. First, while networks are conceptualized networks dynamically, this paper relies on data collected over a relatively short period of time; further network evolution and related spinoff outcomes will not be available without extensive follow-on research. Related, this study relies on the recollection of busy academic entrepreneurs who have established their spinoffs over the course of the last 18 years. As discussed above, well-established methodological concerns exist relating to recall bias of entrepreneurs (Carter et al., 2003; Gartner, 1989). Based on these concerns and absent cross-sectional data, this study assumes that prior network composition is under-reported while the contributions of existing contacts may be over-reported.

Future empirical work might seek to validate and strengthen the proposed conceptual model of network development within spinoff development. Further, scholars could undertake additional examinations of the composition, contributions, and evolution of entrepreneurship networks in other regions, taking a comparative approach. Network evolution is an area where longitudinal studies and case studies may both prove insightful. Regarding network contacts themselves, the role of graduate students in spinoff establishment and operations is a topic that, beyond a few recent exceptions (Lubynsky, 2013; Boh et al., 2012), has been largely neglected in the literature.

Future investigations should also examine the extent to which innovation ecosystems foster social and geographic proximity between academic entrepreneurs and contacts valuable to the future of their spinoff (Tartari et al., 2014). In other words, to what degree can academic entrepreneurship networks be engineered, especially given the technical and geographic heterogeneity among university spinoffs? Armed with this research, policymakers will be better equipped to help academic entrepreneurs bridge the network (and geographic) gaps that continue to plague academic entrepreneurship, and thus regional economic development.

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Appendix A. Type and number of business contacts by spinoff development phase (percent of contacts in that phase in parentheses).

	Entrepreneurial commitment	Credibility	Sustainability	Total
SPINOFFS	49	23	7	79
Faculty researcher	124	19	0	143
	[86.71]	[13.29]	[0.00]	*
	(54.87)	(13.57)	(0.00)	(39.07)
Graduate student	40	8	3	51
	[78.43]	[15.69]	[5.88]	*
	(17.70)	(7.48)	(9.09)	(13.93)
Technology transfer officer	22	6	0	28
	[78.57]	[21.43]	[0.00]	*
	(9.73)	(4.29)	(0.00)	(7.65)
Uni. entre. support	6	3	0	9
	[66.67]	[33.33]	[0.00]	*
	(2.64)	(2.14)	(0.00)	(2.46)
Administration	1	2	0	3
	[33.33]	[66.67]	[0.00]	*
	(2.44)	(1.14)	(0 .00)	(0.83)
Advisor	16	13	4	33
	[48.48]	[39.39]	[12.12]	*
	(7.08)	(12.15)	(12.12)	(9.02)
Public entre. support	4	8	1	13
	[30.77]	[61.54]	[7.69]	*
	(1.77)	(7.48)	(3.03)	(3.55)
Company researcher	5	14	7	26
	[19.23]	[53.85]	[26.92]	*
	(2.21)	(13.08)	(21.21)	(7.06)
Full-time manager	0	15	7	22
	[0.00]	[68.18]	[32.82]	*
	(0.00)	(14.02)	(21.21)	(6.01)
Service provider	7	5	2	14
	[50.00]	[35.71]	[14.29]	*
	(3.10)	(4.67)	(6.06)	(3.83)
Investor	1	14	9	24
	[4.17]	[58.33]	[37.50]	*
	(0.44)	(13.08)	(27.27)	(6.56)
Total	226	107	33	366
	[61.75]	[29.23]	[9.02]	[100.00]
	*	*	*	(100.00)

References

Aarstad, J., Haugland, S., Greve, A., 2010. Performance spillover effects in entrepreneurial networks: assessing a dyadic theory of social capital. Entrep. Theory Pract. 34 (5), 1003–1019.
Ács, Z.J., Braunerhjelm, P., Audretsch, D.B., Carlsson, B., 2004. The Missing Link: The Knowledge Filter and Endogenous Growth, Discussion Paper. Center for Economic Policy Research (CEPR), London.
Ács, Z.J., Braunerhjelm, P., Audretsch, D.B., Carlsson, B., 2009. The knowledge spillover theory of entrepreneurship. Small Bus. Econ. 32 (1), 15–30.
Ács, Z.J., Audretsch, D.B., 1990. Innovation and small Firms. MIT Press, Cambridge, MA.
Aschhoff, B., Grimpe, C., 2014. Contemporaneous peer effects, career age and industry involvement of academics in biotechnology. Res. Policy 43 (2), 367–381.
Astebro, T., Braunerhjelm, P., Brostrom, A., 2013. Does academic entrepreneurship pay? Ind. Corp. Change 22 (1), 281–311.
Audretsch, D.B., Lehmann, E.E., Hinger, J., 2015. From knowledge to innovation: the role of knowledge spillover entrepreneurship. In: Antonelli, C., Link, A.N. (Eds.), Routledge Handbook of the Economics of Knowledge. Routledge, New York.
Audretsch, D.B., Lehmann, E.E., Warning, S., 2005. University spillovers and new firm location. Res. Policy 34 (7), 1113–1122.
Audretsch, D.B., Link, A.N., 2012. Valuing an Entrepreneurial Enterprise. Oxford University Press, New York.
Autio, E., Kenney, M., Mustar, P., Siegel, D., Wright, M., 2014. Entrepreneurial innovation: the importance of context. Res. Policy 43, 1097–1108.
Bahrami, H., Evans, S., 2000. Flexible recycling and high-technology entrepreneurship. In: Kenney, M. (Ed.), Understanding Silicon Valley. Stanford University Press, Stanford, CA, pp. 165–189.
Bercovitz, J., Feldman, M.P., 2008. Academic entrepreneurs: organizational change at the individual level. Organ. Sci. 19 (1), 69–89.
Boh, W.F., De-Haan, U., Strom, R., 2012. University Technology Transfer Through Entrepreneurship: Faculty and Students in Spinoffs. Ewing Marion Kauffman Foundation.
Bonardi, J., Okhuysen, G., 2011. The challenges of theory building through the combination of lenses. Acad. Manage. Rev. 36 (1), 6–12.

Borgatti, S.P., Foster, P., 2003. The network paradigm in organizational research: a review and typology. J. Manage. 29 (6), 991–1013.
Bradley, S., Hayter, C.S., Link, A.N., 2013a. Methods and models of university technology transfer. Found. Trends Entrep. 9 (6), 571–650.
Bradley, S., Hayter, C.S., Link, A.N., 2013b. Proof of concept centers in the United States: an exploratory look. J. Technol. Transf. 38, 349–381.
Braunerhjelm, P., Ács, Z.J., Audretsch, D.B., Carlsson, B., 2010. The missing link: knowledge diffusion and entrepreneurship in endogenous growth. Small Bus. Econ. 34 (2), 105–125.
Bozeman, B., Corley, E., 2004. Scientists' collaboration strategies: implications for scientific and technical human capital. Res. Policy 33, 599–616.
Bozeman, B., Dietz, J.S., Gaughan, M., 2001. Scientific and technical human capital: an alternative model for research evaluation. Int. J. Technol. Manage. 22 (8), 616–630.
Brüderl, J., Preisendorfer, P., 1998. Network support and the success of newly founded businesses. Small Bus. Econ. 10 (3), 213–225.
Burt, R., 1992. Structural Holes: The Social Structure of Competition. Harvard University Press, Cambridge, MA.
Carter, N., Gartner, W., Shaver, K., Gatewood, E., 2003. The career reasons of nascent entrepreneurs. J. Bus. Ventur. 18, 13–39.
Clarysse, B., Wright, M., Bruneel, J., Mahajan, A., 2014. Creating value in ecosystems: crossing the chasm between knowledge and business ecosystems. Res. Policy 43, 1164–1176.
Cohen, W., Levinthal, D., 1990. Absorptive capacity: a new perspective on learning and innovation. Adm. Sci. Q. 35 (1), 128–152.
Coleman, J.S., 1988. Social capital in the creation of human capital. Am. J. Sociol. 94, 95–120.
Crane, D., 1972. Invisible Colleges: Diffusion of Knowledge in Scientific Communities. University of Chicago Press, Chicago.
Creswell, J.W., 2002. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, (2nd ed.). Sage, Thousand Oaks, CA.
Davenport, S., 2005. Exploring the role of proximity in SME knowledge-acquisition. Res. Policy 34 (5), 683–701.
Davidsson, P., 2004. Researching Entrepreneurship. Springer, New York.
Dietz, J., Bozeman, B., 2005. Academic careers, patents, and productivity: industry experience as scientific and technical human capital. Res. Policy 34, 349–367.
Doutriaux, J., 1987. Growth patter of academic entrepreneurial firms. J. Bus. Vent. 2, 285–297.
Druilhe, C., Garnsey, E., 2004. Do academic spin-outs differ and does it matter? J. Technol. Transf. 29 (3–4), 269–285.
Dyer, J.H., Singh, H., 1998. The relational view: cooperative strategy and sources of interorganizational competitive advantage. Acad. Manage. Rev. 23 (4), 660–679.
Feldman, M.P., 1994. The Geography of Innovation. Kluwer Academic Publishers, Boston.
Feinberg, B., 1980. Analysis of Cross-classified Data. MIT Press, Cambridge, MA.
Florida, R.L., Kenney, M., 1988. Venture capital, high technology and regional development. Reg. Stud. 22, 33–48.
Franklin, S., Wright, M., Lockett, A., 2001. Academic and surrogate entrepreneurs in university spin-out companies. J. Technol. Transf. 26 (1–2), 127–141.
Gartner, W.B., 1989. Some suggestions for research on entrepreneurial traits and characteristics. Entrep. Theory Pract. 14 (1), 27–38.
Gertler, M.S., Levitte, Y.M., 2005. Local nodes in global networks: the geography of knowledge flows in biotechnology innovation. Ind. Innov. 12 (4), 487–507.
Goldfarb, B., Henrekson, M., 2003. Bottom-up versus top-down policies towards the commercialization of university intellectual property. Res. Policy 32, 639–658.
Goldstein, H., Drucker, J., 2006. The economic development impacts of universities on regions: do size and distance matter? Econ. Dev. Q. 20 (1), 22–43.
Granovetter, M.S., 1985. Economic action and social structure: the problem of embeddedness. Am. J. Sociol. 91 (3), 481–510.
Greve, A., Salaff, J., 2003. Social networks and entrepreneurship. Entrep. Theory Pract. 28 (1), 1–22.
Gulbranson, C.A., Audretsch, D.B., 2008. Proof of concept centers: accelerating the commercialization of university innovation. J. Technol. Transf. 33, 249–258.
Gulati, R., Nohria, N., Zaheer, A., 2000. Strategic networks. Strat. Manage. J. 21 (3), 203–215.
Gulbrandsen, M., Smeby, J., 2005. Industry funding and university professors' research performance. Res. Policy 34, 932–950.
Hayter, C.S., 2013a. Harnessing university entrepreneurship for economic growth: factors of success among university spinoffs. Econ. Dev. Q. 27, 18–28.
Hayter, C.S., 2013b. Conceptualizing knowledge-based entrepreneurship networks: perspectives from the literature. Small Bus. Econ. 41, 899–911.
Hayter, C.S., 2015. Social networks and the success of university spinoffs: toward an agenda for regional growth. Econ. Dev. Q. 29, 3–13.
Hayter, C.S., Link, A.N., 2015. On the economic impact of university proof-of-concept centers. J. Technol. Transf. 40, 178–183.
Hawkins, S.A., Hastie, R., 1990. Hindsight: biased judgments of past events after the outcomes are known. Psychol. Bull. 107, 311–327.
Hoang, H., Antoncic, B., 2003. Network-based research in entrepreneurship: a critical review. J. Bus. Ventur. 18 (2), 165–187.
Holm, D.B., Eriksson, K., Johanson, J., 1999. Creating value through mutual commitment to business network relationships. Strat. Manage. J. 20, 467–486.
Human, S., Provan, K., 1997. An emergent theory of structure and outcomes in small-firm strategic manufacturing networks. Acad. Manage. J. 40 (2), 368–403.
Information Technology and Innovation Foundation, 2012, December. 2012 State New Economy Index, Washington, DC.
Jack, S.L., 2010. Approaches to studying networks: implications and outcomes. J. Bus. Ventur. 25 (1), 120–137.
Jaffe, A.B., 1989. Real effects of academic research. Am. Econ. Rev. 79 (5), 957–970.
Jick, T.D., 1979. Mixing quantitative and qualitative methods: triangulation in action. Adm. Sci. Q. 24, 602–611.
Jaffe, A.B., Trajtenberg, M., Henderson, R., 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. Q. J. Econ. 108 (3), 577–598.
Johannisson, B., Monsted, M., 1997. Contextualizing entrepreneurial networking. Int. J. Manage. Organ. 27, 109–137.
Kale, P., Dyer, J.H., Singh, H., 2002. Alliance capability, stock market response, and long-term alliance success: the role of the alliance function. Strat. Manage. J. 23 (8), 747–767.
Kenney, M., Patton, D., 2005. Entrepreneurial geographies: support networks in three high-technology industries. Econ. Geogr. 81 (2), 201–228.
Kenney, M., von Burg, U., 1999. Technology and path dependence: the divergence between Silicon Valley and Route 128. Ind. Corp. Change 8 (1), 67–103.
Kim, P., Aldrich, H.E., 2005. Social capital and entrepreneurship. Found. Trends Entrep. 1 (2), 55–104.
Krackhardt, D., 1999. The ties that torture: Simmelian tie analysis in organizations. Res. Sociol. Organ. 16, 183–210.
Krippendorff, K., 2004. Reliability in content analysis: some common misconceptions and recommendations. Hum. Commun. Res. 30, 411–433.
Kuckartz, U., 2014. Qualitative Text Analysis: A Guide to Methods, Practice and Using Software. Sage, Thousand Oaks, CA.
Larson, A., Starr, J., 1993. A network model of organization formation. Entrep. Theory Pract. 17 (2), 5–15.
Lechner, C., Dowling, M., Welpe, I., 2006. Firm networks and firm development: the role of the relational mix. J. Bus. Ventur. 21 (4), 514–540.
Link, A.N., Ruhm, C.J., 2009. Bringing science to market: commercializing from NIH SBIR awards. Econ. Innov. N. Technol. 4, 381–402.
Lockett, A., Wright, M., 2005. Resources, capabilities, risk capital and the creation of university spin-out companies. Res. Policy 34 (7), 1043–1057.
Lockett, A., Wright, M., Franklin, S., 2002. Technology transfer and universities' spin-out strategies. Small Bus. Econ. 20, 185–201.
Lubynsky, R., 2013. Critical Challenges to Nascent Academic Entrepreneurs: From Lab Bench to Innovation. University of Maryland (unpublished dissertation).
Milken Institute, 2013. 2012 State Technology and Science Index. Santa Monica, CA.
Mosey, S., Wright, M., 2007. From human capital to social capital: a longitudinal study of technology-based academic entrepreneurs. Entrep. Theory Pract. 31 (6), 909–935.
Murray, F., 2004. The role of academic inventors in entrepreneurial firms: sharing the laboratory life. Res. Policy 33 (4), 643–659.
Neuendorf, K., 2002. The Content Analysis Guidebook. Sage, Thousand Oaks, CA.
Nicolaou, N., Birley, S., 2003. Social networks in organizational emergence: the university spinout phenomenon. Manage. Sci. 49 (12), 1702–1725.
Nohria, N., Eccles, R.G., 1992. Networks and Organizations: Structure, Form and Action. Harvard Business School Press, Cambridge, MA.
O'Gorman, C., Byrne, O., Pandya, D., 2008. How scientists commercialise new knowledge via entrepreneurship. J. Technol. Transf. 33, 23–43.
Partanen, J., Moller, K., Westerlund, M., Rajala, R., Rajala, A., 2008. Social capital in the growth of science-and-technology-based SMEs. Ind. Mark. Manage. 37 (5), 513–522.
Pennings, J., Lee, K., van Witteloostuijn, A., 1998. Human capital, social capital and firm dissolution. Acad. Manage. J. 41 (4), 425–440.
Phan, P., Siegel, D.S., 2006. The effectiveness of university technology transfer: lessons learned. Found. Trends Entrep. 2 (2), 77–144.
Piore, M., Sabel, C., 1984. The Second Industrial Divide: Possibilities for Prosperity. Basic Books, New York.
Polkinghorne, D., 1988. Narrative Knowing and the Human Sciences. State University of New York Press, Albany.
Ponomariov, B., Boardman, C., 2010. Influencing scientists' collaboration and productivity patterns through new institutions: university research centers and scientific and technical human capital. Res. Policy 5 (39), 613–624.
Rasmussen, E., Mosey, S., Wright, M., 2011. The evolution of entrepreneurial competencies: a longitudinal study of university spin-off venture emergence. J. Manage. Stud. 48 (6), 1314–1345.
Rasmussen, E., Mosey, S., Wright, M., 2015. The transformation of network ties to develop entrepreneurial competencies for spin-offs. Entrep. Reg. Dev. 27 (7–8), 430–457.
Renzulli, L.A., Aldrich, H., 2005. Who can you turn to: tie activation within core business discussion networks. Soc. Forces 84, 323–342.
Ritter, T., Gemunden, H., 2003. Network competence: its impact on innovation success and its antecedents. J. Bus. Res. 56, 745–755.
Roberts, E.B., 1991. Entrepreneurs in High Technology. Oxford University Press, New York.
Roese, N.J., Olson, J.M., 1996. Counterfactuals, causal attributions, and the hindsight bias: a conceptual integration. J. Exp. Soc. Psychol. 32, 197–227.
Romer, P.M., 1990. Endogenous technological change. J. Polit. Econ. 98, 71–102.
Rothaermel, F.T., Agung, S.D., Jiang, L., 2007. University entrepreneurship: a taxonomy of the literature. Ind. Corp. Change 16, 691–791.
Ruef, M., Aldrich, H.E., Carter, N.M., 2003. The structure of founding teams: homophily, strong ties, and isolation among US entrepreneurs. Am. Sociol. Rev. 68 (2), 195–222.

Saldana, J., 2012. The Coding Manual for Qualitative Researchers. Sage, Thousand Oaks, CA.
Samson, K.J., Gurdon, M.A., 1993. University scientists as entrepreneurs: a special case of technology transfer and high-tech venturing. Technovation 13 (2), 63–71.
Saxenian, A., 1994. Regional Advantage. Harvard Business School Press, Boston, MA.
Schoonhoven, C.B., Eisenhardt, K., 1989, August. The Impact Of Incubator Region on the Creation and Survival Of New Semiconductor Ventures in the U.S. 1978–1986, Report to the Economic Development Administration. U.S. Department of Commerce.
Scott, J., 2000. Social Network Analysis. Sage, Thousand Oaks, CA.
Shane, S.A., Cable, D., 2002. Network ties, reputation, and the financing of new ventures. Manage. Sci. 48 (3), 364–381.
Shane, S., Stuart, T., 2002. Organizational endowments and the performance of university start-ups. Manage. Sci. 48 (1), 154–170.
Shane, S.A., 2004. Academic Entrepreneurship: University Spinoffs and Wealth Creation. Edward Elgar, Northampton, MA.
Slaughter, S., Rhoades, G., 2004. Academic Capitalism and the New Economy: Markets, State and Higher Education. Johns Hopkins University Press, Baltimore.
Slotte-Kock, S., Coviello, N., 2010. Entrepreneurship research on network processes: a review and ways forward. Entrep. Theory Pract. 34 (1), 31–57.
Stephan, P.E., 2012a. Economics of science. In: Hall, B., Rosenberg, N. (Eds.), Handbook of the Economics of Innovation. , New York: North Holland.
Stephan, P.E., 2012b. How Economics Shapes Science. Harvard UP, Cambridge, MA.
Tartari, V., Perkmann, M., Salter, A., 2014. In good company: the influence of peers on industry engagement by academic scientists. Res. Policy 43, 1189–1203.
Tortoriello, M., Krackhardt, D., 2010. Activating cross-boundary knowledge: the role of Simmelian ties in the generation of innovations. Acad. Manage. J. 53 (1), 167–181.
Utterback, J., 1994. Mastering the Dynamics of Innovation. Harvard Business School Press, Boston, MA.
Vohora, A., Wright, M., Lockett, A., 2004. Critical junctures in the development of university high-tech spin-out companies. Res. Policy 33, 147–175.
Walker, G., Kogut, B., Shan, W., 1997. Social capital, structural holes and the formation of an industry network. Organ. Sci. 8 (2), 109–125.
Walter, A., Auer, M., Ritter, T., 2006. The impact of network capabilities and entrepreneurial orientation on university spin-off performance. J. Bus. Ventur. 21 (4), 541–567.
Wright, M., Clarysse, B., Mustar, P., Lockett, A., 2007. Academic Entrepreneurship in Europe. Edward Elgar, Northampton, MA.
Zucker, L.G., Darby, M.R., Armstrong, J.S., 2002. Commercializing knowledge: university science, knowledge capture, and firm performance in biotechnology. Manage. Sci. 48 (1), 138–153.